# Emerging Research in Engineering and Technology

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MANGLAM

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# Preface

We are glad to present the book entitled *"Emerging Research in Engineering and Technology" - ERET 2021* to the students, faculty members and researchers of Engineering and Technology. We have observed that eminent professors and active researchers from various technical institutions across the Nation contributed to the book chapters which are focused on state-of-the-art areas related to Electrical and Electronics Engineering, Computing Sciences, Civil Engineering and Mechanical Sciences.

We hope the readers benefit from the research problems addressed in the book. We are thankful to all the authors and publisher who have helped to bring out the First Edition of the book Emerging Research in Engineering and Technology.

*– Editors*

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# Contents

# 1

# Knowledge Transfer through Transfer Learning—A Machine Learning Approach for Image Classification

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## ABSTRACT

Machine learning and deep learning are widely used today in computer science field and are more popular nowadays. In the field of Artificial Intelligence, more researches are ongoing and are mainly focused on the sub areas like Machine Learning and Deep Learning. Transfer learning a technique, which can provide a successful outcome in the field of Deep Learning. This chapter aim to provide an outline about transfer learning and its mass benefits in image classification. It also reviews some architectures, which support Transfer Learning and the story of successful implementations.

**Keywords:** Machine Learning, Deep Learning, Transfer Learning, Computer Vision, VGG16.

## Introduction

The concept of machine learning is emerged from a question like can we program a computer to learn from the available input. The answer is yes, using machine learning technique. It is an automated learning with no human intervention or little. The main purpose of machine learning is to develop algorithms, which can learn from previous data and enable them to predict something using new data. The input is called training data sets and using testing data set we can test the accuracy of our model continuously.

Sometimes machine learning is not useful when we are using large number of input or high dimensional data. It also fails to recognize images and Artificial Intelligence problems like Natural Language Processing (NLP). Here comes Deep

Learning to help to solve image recognition problems. Deep Learning is a subset of Machine Learning that can mimic the human brain and capable to focus on the features of input images. Deep learning is implemented through neural network and the main motivation behind the neural network is biological neuron. In traditional programming, we give data and some rules as input to produce output. In the case of machine learning, we will give data and answers as input, which produces some rule or a mathematical function as output.

Deep Learning recognize the objects using Convolution Neural Network (CNN), a feed forward network for analyzing the visual images. CNN contains Convolution Layer, ReLU Layer, Pooling Layer and fully connected Layer. Convolution helps to extract the basic features in an image like enhancing edges, sharpen the image and edge detection. The output of convolution layer is called feature map and the pooling layer helps to reduce the dimensionality of the feature map. Pooling is down-sampling operation. The final layer is a fully connected layer, which helps to classify the images.

## Transfer Learning

In Deep Learning, Transfer Learning is a technique to decrease the model training time and error rate. It aims to extract the knowledge and experience from a source task and apply it in to a target task.[1] The idea behind transfer learning is to reuse previously learned knowledge and it follows learning to learn or Meta learning.
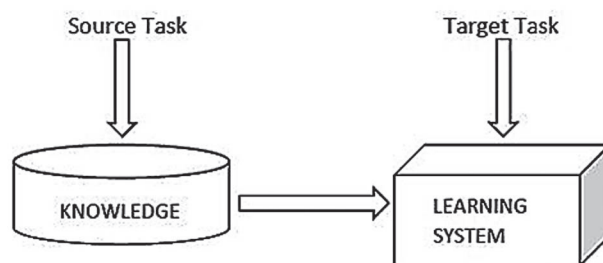


**Fig. 1:** Learning process of Transfer Learning

To train a model we can follow either training from scratch or fine tuning. Transfer Learning or Fine tuning has widely used in medical imaging. In most cases, fine-tuning outperforms training from scratch.[2] Transfer learning in medical field has a tremendous value and can achieve high accuracy with smaller training data set because medical images are difficult to get easily. If we have a limited number of image data set, we can use transfer learning to perform fine-tuning other than training from scratch. The following are some models for transfer learning.

Transfer learning technique is the capability of the system to recognize and implement the knowledge acquired from the past tasks to result in a novel technique. Artificial Intelligence has now a major in automatic disease recognition. Several methods are adopted using machine learning, deep learning concepts. However, there are challenges too. The major challenges arise upon trying to develop a classifier system for disease recognition. The first drawback is the limited availability of labelled data and resulting in less accuracy in disease detection by classifier due to lack of training data. The second drawback is the lack of knowledge in medical domain to identify the features or attribute for detecting a target disease. These challenges can be overruled by the technique transfer learning.

The two composite models of neural networks are deep learning and deep convolutional neural network. Deep learning concept shows its success in the field of image processing, speech and audio data classification. But these all models require a very huge amount of data for training to overcome the issue of over-fitting.

The feature representation and data scarcity for training is tackled using transfer learning. Transfer learning concept can be implemented through unsupervised codebook development. A codebook can be constructed from Image Net (largest data set for images) images. The image representation from a very large data set could be obtained from a variant of deep CNN. Using the codebook, feature vectors are obtained. The image information moves to output layer from the input layer through the inner layers. Each layer can be assumed as a previous layer-weighted combination and results in a feature representation of the input layer. As the computation in CNN is hierarchical, higher layers shows higher concepts. The lower layer represents the basic perceptual elements like corners and edges and higher layers represent part of objects like categories and contours. Higher level abstraction can be captured by extracting transfer-learned features from the higher layers (like layer 5, 6, 7). The outer layer will not be used for this because it only represents the class prediction of the input image and not its representation.

After the extraction of feature vectors, we could implement supervised learning by applying support vector machine classifier. Here the features are scaled to similar range and parameters can be identified by cross validation. The classification accuracy can be improved through two fusion schemes of future. As a first scheme approach, this features extracted from the codebook is combined with hand-crafted features by the human heuristics. So transfer learned features and hand crafted features will form a fusion feature vectors. Now we utilizes supervised learning on fused feature vectors to train classifier SVM. As a second scheme approach, we can utilize a two-layer classifier fusion structure. In the first layer all features sets are utilized to train different classifiers and this output is deployed to train the classifier in the second layer.

This approach will tackle the twin problems of labelled training data scarcity and shortage of medical domain knowledge. The codebook construction of large data set like Image Net and obtained feature representation of images via transfer learning approach. An accuracy of 89% is obtained using feature representation approach on traditional SVM classifier.

## Convolutional Neural Networks

The capability of CNN to extract local features from an input image via convolution makes it distinct from other approaches. In CNN, each node in CNN layer is associated with neurons that are spatially connected. The convolutional layer is followed by a max pooling layer to reduce the complexity of computation which in turn reduces the size of feature maps by mapping from a local neighbourhood with maximum feature response. A number of fully connected layers follow pairs of max pool and convolutional layers and in this the neuron present in one layer is associated to the activations in the previous layer. The non-linear relationship among the features extracted by convolutional layer can be learned using fully connected layers. The fully connected layer is followed by soft max layer that helps normalizing the results to expected level.

CNNs use back propagation for training, so the weight of the neuron in convolutional layers are updated in each iteration such that it reduces the cost function. As the training begins from scratch, the weights associated with neuron are randomly initialized, distracting from a normal distribution. When the training data set is limited, the cost function gets stuck and leads to problems of under fitting/over fitting. In such situations the transfer learning can be adopted. In transfer learning, the pre-trained weights extracted from same architecture and applied on a very large data set from similar or different domain is used to activate the network layers. The outer layer of the fully connected layer is reinforced by the training data. Some of the architectures to familiarize:

### VGG16

VGG stands for Visual Geometric Group from Oxford University developed by Simonyan and Zisserman. This architecture is the first runner up of Image Net Large Scale Visual Recognition Challenge (ILSVRC), which is a yearly competition that evaluates object detection in images. The minimum VGG is VGG11 and the maximum is VGG19. This architecture group shows the relationship between the depth of CNN and accuracy.[3] In VGG16, the 16 layers contains trainable parameters in which 13 layers for convolution and 3 for fully connected layers. VGG16 predicts 1000 image category in the image Net data set and we can alter the last layer for our needs.
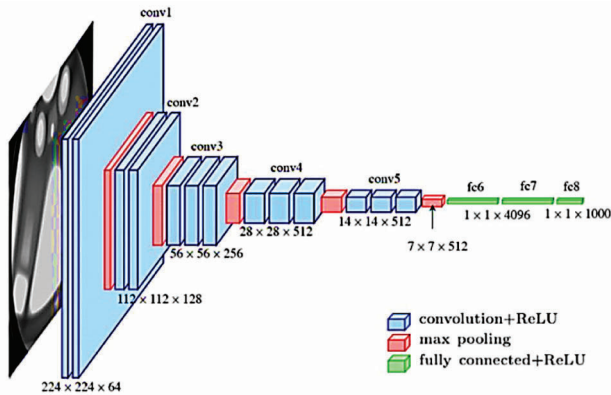
**Fig. 2:** VGG16 Architecture

The following table[4] shows Convolutional Network configurations. The depth of the configurations increases from the left (A) to the right (E), as more layers are added (the added layers are shown in bold). The convolutional layer parameters are denoted as "conv (receptive field size) – (number of channels)". The ReLU activation function is not shown for brevity

| ConvNet Configuration | | | | | |
|---|---|---|---|---|---|
| A | A-LRN | B | C | D | E |
| 11 weight layers | 11 weight layers | 13 weight layers | 16 weight layers | 16 weight layers | 19 weight layers |
| input (224 × 224 RGB image) | | | | | |
| conv3-64 | conv3-64 | conv3-64 | conv3-64 | conv3-64 | conv3-64 |
|  | LRN | **conv3-64** | conv3-64 | conv3-64 | conv3-64 |
| maxpool | | | | | |
| conv3-128 | conv3-128 | conv3-128 | conv3-128 | conv3-128 | conv3-128 |
|  |  | **conv3-128** | conv3-128 | conv3-128 | conv3-128 |
| maxpool | | | | | |
| conv3-256 | conv3-256 | conv3-256 | conv3-256 | conv3-256 | conv3-256 |
| conv3-256 | conv3-256 | conv3-256 | conv3-256 | conv3-256 | conv3-256 |
|  |  |  | **conv1-256** | **conv3-256** | conv3-256 |
|  |  |  |  |  | **conv3-256** |
| maxpool | | | | | |
| conv3-512 | conv3-512 | conv3-512 | conv3-512 | conv3-512 | conv3-512 |
| conv3-512 | conv3-512 | conv3-512 | conv3-512 | conv3-512 | conv3-512 |
|  |  |  | **conv1-512** | **conv3-512** | conv3-512 |
|  |  |  |  |  | **conv3-512** |
| maxpool | | | | | |
| conv3-512 | conv3-512 | conv3-512 | conv3-512 | conv3-512 | conv3-512 |
| conv3-512 | conv3-512 | conv3-512 | conv3-512 | conv3-512 | conv3-512 |
|  |  |  | **conv1-512** | **conv3-512** | conv3-512 |
|  |  |  |  |  | **conv3-512** |
| maxpool | | | | | |
| FC-4096 | | | | | |
| FC-4096 | | | | | |
| FC-1000 | | | | | |
| soft-max | | | | | |

The VGG16 architecture contains two-convolution layer then one pooling layer, again two-convolution layer with a pooling layer. Then three convolution layer with a pooling layer, again three convolution layer with a pooling layer and then three convolution layer with a pooling layer finally three dense (fully connected) layers. VGG16 accepts 224×224 size image as input and after every max-pooling, the size gets half.

**INPUT**
⇩

| 3×3 Conv+ReLU 64 | 224×224 |
| 3×3 Conv+ReLU 64 | |
| 2×2 Max-Pool 64 | |

⇩

| 3×3 Conv+ReLU 128 | 112×112 |
| 3×3 Conv+ReLU 128 | |
| 2×2 Max-Pool 128 | |

⇩

| 3×3 Conv+ReLU 256 | 56×56 |
| 3×3 Conv+ReLU 256 | |
| 3×3 Conv+ReLU 256 | |
| 2×2 Max-Pool 256 | |

⇩

| 3×3 Conv+ReLU 512 | 28×28 |
| 3×3 Conv+ReLU 512 | |
| 3×3 Conv+ReLU 512 | |
| 2×2 Max-Pool 512 | |

⇩

| 3×3 Conv+ReLU 512 | 14×14 |
| 3×3 Conv+ReLU 512 | |
| 3×3 Conv+ReLU 512 | |
| 2×2 Max-Pool 512 | |

⇩

| FC 4096 | 7×7 |
| FC 4096 | |
| FC OUTPUT 1000 | |

⇩
**OUTPUT**
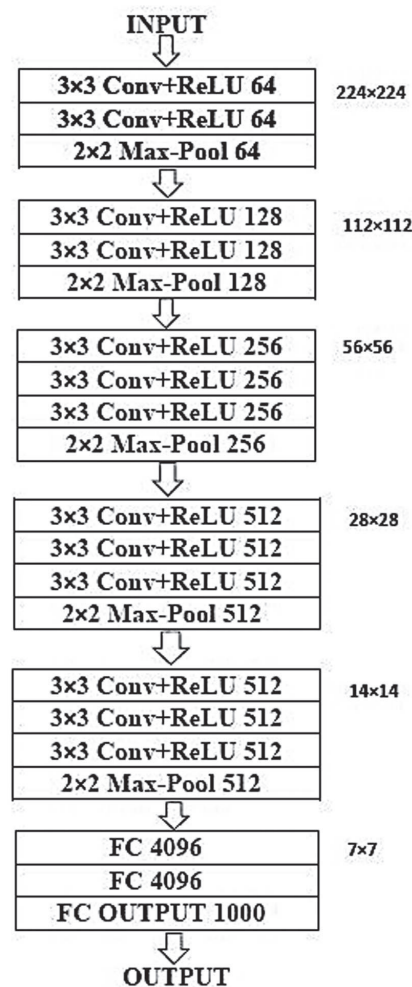
**Fig. 3:** VGG16

In VGG16, the input layer accepts 224×224 color images with three channels (Red, Green and Blue). The image passes through convolution layer stack, which has the receptive field of 3×3 and stride 1. The main advantage is that after convolution the resolution persist. The max-pooling windows are non-overlapping

one. The output size from each convolution layer depends on the equation given by $[(N - F)/S] + 1$ where N is input size of image, F is the size of filter and S denotes stride. As convolution layer increases, more sharp features will be extracted from the given input.

### Inception

Inception is an alternative of deep learning architecture constructed by Google. The idea of this architecture arises from the concept that the non-linear function could be learned by changing the connections of convolution layers. So the fully connected layers are neglected and adopt a global average pooling that averages the feature maps and classification is done with softmax layer.

## Transfer Learning for Image Classification

Transfer learning revamps the pre-trained network architecture for classification of images. The network architectures can be compared for performance and a study on performance of VGG-19 architecture with VGG-16 and AlexNet.

Network architectures are divided into 3 parts.

The first part of the network comprises of two units and each unit consist of normalization and pooling layer, relu and convolution layer. Second part comprises of 4 units and each unit comprises of convolution and pooling layers. The last part of the network comprises of non-linear activation unit that represents relu, drop out and fully-connected layer. The overfitting of data upon training can be avoided using drop out layer.
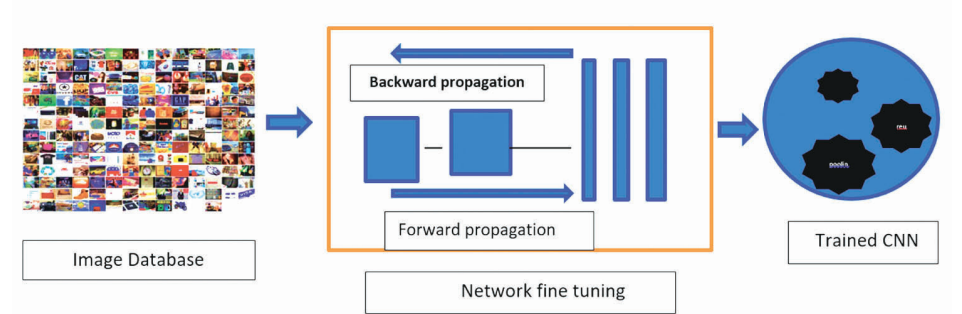


**Fig. 4:** CNN Training phase
*Courtesy:* WebLogo-2M dataset(eecs. qmul. ac. uk)

The accuracy of CNN architecture depends on three factors such as network depth, high end computational unit and large scale database. The robustness of the CNN architecture could be analysed using classification of images using Support

Vector Machine. This finely tuned network architecture can be used for performing high level tasks in various areas like human action recognition, detection of objects etc.
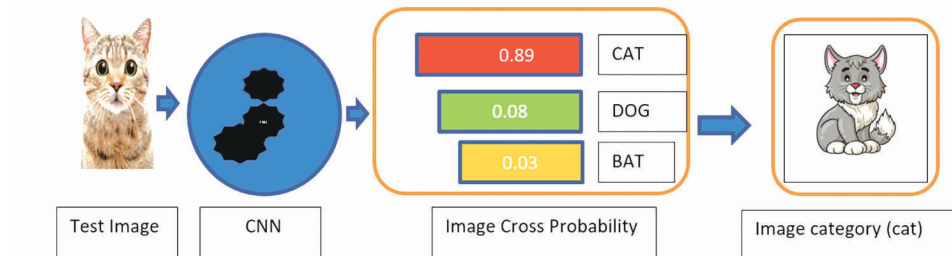


**Fig. 5:** CNN Testing phase
*Courtesy:* freepik.com

## Applications of Transfer Learning

Transfer Learning (fine-tuning) can be applied in various fields like Medical, Agricultural, E-Commerce and many real-time applications. In most cases, transfer learning performs in better way than training from scratch. To achieve high accuracy with smaller training data set, it a better way to do. Data set can be augmented by flipping, rotating, changing brightness, contract and hue. Image quality affects deep neural networks performance and preprocessing is must before doing any training, because the images captured in real-time will be noisy.

### DR Classification Using Transfer Learning

Diabetic Retinopathy (DR) is an eye complication generated in diabetic patients, which creates damages of blood vessels in retina. Due to the scarcity retinal image data set availability, we can use transfer learning with a small number of data set. In the work,[5] a convolution neural network model is trained with transfer learning technique. The model accepts binocular fundus images as input and make predictions. The model was trained with 28104 images and tested with 7024 images, which obtains 0.951 accuracy and sensitivity of 82.2%.

### Alzheimer's Disease Classification Using Transfer Learning

The work[6] utilized the MRI images from OASIS MRI data set for transfer learning. The system used VGG16 and Inception V4 architecture for their purpose and up on training with VGG16, 92.3% accuracy obtained. 96.25% accuracy is obtained using Inception V4 architecture. At first, the model was created using VGG16 scratch and results in poor performance (accuracy 74.12%). Model was again

created with transfer learning technique, results 92.3% accuracy that is far better than training from scratch. The model was trained with 6400 images, which was extracted from MRI scans of 200 subjects.

The following figure shows a sample model accuracy. When validation loss is high and validation accuracy is low, the model is cramming values not learning. When validation loss and validation accuracy are high, the model is in over fitting stage and this model is fit for training and not fit for testing. When validation loss is low and validation accuracy is high, the model built is learning and it working fine.
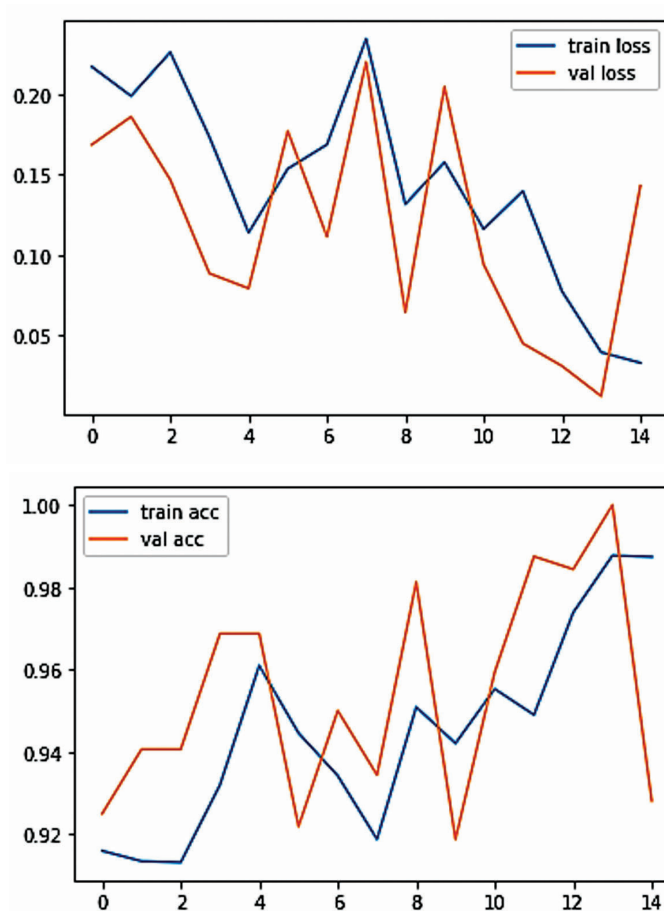


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# 2

# IoT Based Energy Meter Monitoring System

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## ABSTRACT

Lack of resources in the present world is initiating everyone towards energy efficient technologies. Amongst all these resources, power is one which needs to be controlled and monitored as per the use since consumption of electricity is increasing day-by-day. We now in a situation where almost everything is running on electricity. Most. Energy is the soul of world which is related to the electricity and "electricity" is the term which now rules the entire world. So, proper utilization of these resources should be done. Even though many innovations are taking place in this world, the existing energy consumption billing process seems in India to be very old fashioned and it does not meet the latest technology now available. The assessment of meter reading is still carried out manually. This requires a huge manpower. The incorrectness in this assessment leads to high revenue loss for the electricity board. This paper presents a newly designed digital meter based on a very cheap distributed components like microcontroller architecture and current sensors. The already existing power lines and connect every household in a particular area as it does not even require a new installation It uses WIFI to communicate with the users servers and. By measuring current and voltage, energy consumption can be measured, makes the world smarter place and also makes better decisions using Internet of Things.

The presented system gives ubiquitous and continuous access to energy consumption to the consumer by using the advancement of IoT technology. This work can also be expanded to a large area from which load distributed in the area can be estimated.

## Introduction

In recent years, due to the improvement in the field of Internet technology computerized electricity billing and online payment of the has become possible. But still Meter reading is still carried out by a representative from the electricity board. This require a huge manpower. Even if there is any incorrectness in assessment it

may leads to high revenue loss. AMR (Automated Meter Reading) is a technology that combines automatic assessment of consumption of energy, analysis on the assessed data for billing and payment. To achieve this AMR, assignment of IP address to each energy meter is essential. This technology of bringing any device online and connecting it to the internet is termed as Internet of Things.[1]

A ton of frameworks have been planned and created to decrease the vitality utilization in the mechanical condition and in the private family units. These customary vitality administration frameworks can be isolated into two kinds. These are alluded to as nosy and non-meddlesome frameworks. For nosy frameworks, sensors are introduced at each machine, furthermore, a correspondence arrange is required to control, screen what's more, speak with the sensors. Nosy vitality observing frameworks are exorbitant to send since a different number of sensor gadgets are required to be appended to each apparatuses. Something else, just costly apparatuses. Redesigning each no compatible gadget with an extra system interface in a private family unit can be excessively costly Curiously, this system prompts another complex test of deteriorating/disaggregating the information to perceive the power and vitality utilized by every person apparatuses. Strategies for disaggregation are conceivable due to the one of a kind examples/fingerprints of vitality utilization for a machine type.[3]

Nowadays, many solutions are available in the market for this monitoring of energy purposes. OpenEnergyMonitor.com introduces a system that has the capability to monitor various kinds of parameters of an electrical system such as alternating current (AC) power, temperature and humidity with hopes of extending the value measurements to include other air measurements like moisture. Web of things has helped numerous authoritative frameworks to improve proficiency, increment the speed of procedures, limit blunder and anticipate robbery by coding and following the items. Both the Computing and communications has its future in the transformation brought by the technology IOT. The consumption of power can be reduced to a great extent if we can monitor our daily power usage and switch off appliances which are unnecessary consuming electricity. There by this system focuses on developing a monitoring the energy system more effectively and hence it can be utilized effectively by using the technological advancement in IoT technology.[4]

A basic technique for propelling progressively definite administration of the benefits and for growing new mindfulness about the costs of the vitality is keen metering. Brilliant meter is incredibly proposed for checking vitality usage and telling each electronic hardware. IoT items can be incorporated in all vitality devouring hardware (cooling frameworks, electrical switches and attachments,

lights, machines, plumbing, and so on.) or in building envelope components, for example, entry ways and windows, offering clients the likelihood to advance vitality productivity, small scale climatic conditions and wellbeing. The intensity of electrical gadget is determined by using insightful meter and it sends the conscious data over the web for observing and ordering the electronic gadgets. Tremendous associations over the globe are doing work on smart meters for enhancing effectiveness of the power use and into reducing power utilization in different buildings.[5]

## Existing System

The present system provides only the feedback to the customer at the end of the month that how much power is consumed in the form of a bill. A representative from the electricity board has to come and provide the customers with the bill amount. The customer has no real way to follow their vitality utilization on a progressively quick premise. The shoppers are becoming exponentially quick and burden on power giving divisions is quickly rising In the existing system meter tampering can be done easily and it's one of the major drawbacks for an energy crisis.

## Proposed System

In the proposed system, consumer can do power management by knowing energy usage time to time. The Customer needs to pay the bill on schedule, if couldn't, the electric power connectivity can be turned off autonomously from the distant host.

IOT: The Internet of Things (IoT) is the system of physical items or "things" inserted with hardware, programming, sensors, and system network, which empowers these articles to gather and trade information. IoT enables items to be detected and controlled remotely crosswise over existing system framework, making open doors for more straightforward combination between the physical world and PC based frameworks, and bringing about improved proficiency, precision and financial advantage. 3 "Things," in the IoT sense, can allude to a wide assortment of gadgets, for example, heart checking inserts, biochip transponders on homestead creatures, electric mollusks in beach front waters, vehicles with inherent sensors, DNA examination gadgets for natural/sustenance/pathogen observing or field activity gadgets that help firemen in pursuit and salvage tasks. These gadgets gather valuable information with the assistance of different existing innovations and after that self-sufficiently stream the information between different gadgets.

The system consisting a server where it will store the information about the usage of electricity and the amount will be calculated and added and stored in the server database. From this server the information is exchanged between the devices like mobile and computers. Every day the user can access the day to day information required about the amount of electricity utilized and the cost estimation from the server. So, from this the user can get alert of the power consumed and tries to reduce the usage of power by this automatically we can reduce the cost and save the money and it also helps in more usage of resources for further. Smart Meter is used to monitor the power consumption and displays total power consumed and it is sent to server periodically. Server is used to store the data of individual homes for future analysis and also we can access data through mobile app and by PC through web page. The whole system is mainly divided in three modules:

1. Sensing module
2. Computing module
3. Monitoring module

**Sensing Module**

The sensing module includes the LDR that senses the counts from the LED and thereby gives out the counting part within the sensing module through the serial monitor of Arduino IDE. The light coming upon the LDR is the output value of the system. The resistance variation in the LED is presented in numerical values. These values are analysed to find the sensing level of the system.

**Computing Module**

The computing module is the microcontroller unit. Node MCU collects the value from the sensing module and calculates the counting from the sensor. The counting can be viewed in the serial monitor. The counting is related to billing section within the computing module. The values are passed to the server section so as to make it available in the database.

**Monitoring Module**

The output of the system can be monitored in the database given by the serial monitor. The url and also the PHP side provides the monitoring function. The analytics portion is visualized with the help of Things peak. The graphs are plotted that shows the variation in the output of the sensing module. The graphical representation can be viewed there. Account is to be created and also channels are added as per the requirement.

Smart metering has many advantages like it collects time-wise consumption readings, can control the amount of power given to a particular house and can be used to lower the losses due to theft. The system provides rapid access to all customer transaction and payment records which allow with quick and efficient solution of customer. Day to day bill is available and thus effective load management by using appliances at off peak hours which will also result in lesser bill.

## Proposed System Architecture
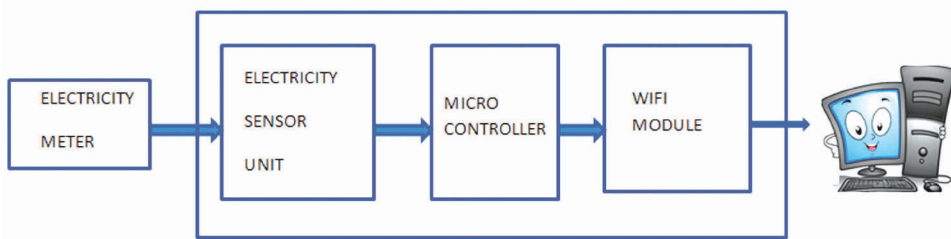


**Fig. 1:** Block Diagram of Proposed System

The whole hardware system can be divided into four parts. The first part is an electricity sensor unit whose function is to detect several energy data of the electricity meter such as current, voltage, power and etc. The second and the third part are combined and working together which consist of a microcontroller and a Wi-Fi network module. Their job is to take the collected data out from the electricity sensor unit and then send them to the target server through the Internet with the help of Wi-Fi network module. The fourth part is a small data convertor. It is able to convert the data getting from the electricity sensor unit through the RS-485 port to the standard Transistor Transistor Logic (TTL) signal. So this works just like abridge to communicate between the electricity sensor unit and the microcontroller. The four parts work together in the process.

The overall architecture consist of ESP28266 Node MCU it will collects the amount of energy consumed into the iot cloud where it will stores the data. Then the data is then displayed in the webpage. The no. of units and power to display are shown in the webpage from there it will be accessible to the consumers and hence they can know about the amount of units consumed by them. It will helps them to understand the amount of units consumed and then they could pay the online. No unscheduled power cuts and instead of complete black out some electricity can be provided to every customer which can be used for running some important appliances as in case of inverters. This will minimize use of inverters, their charging burden and battery problems.
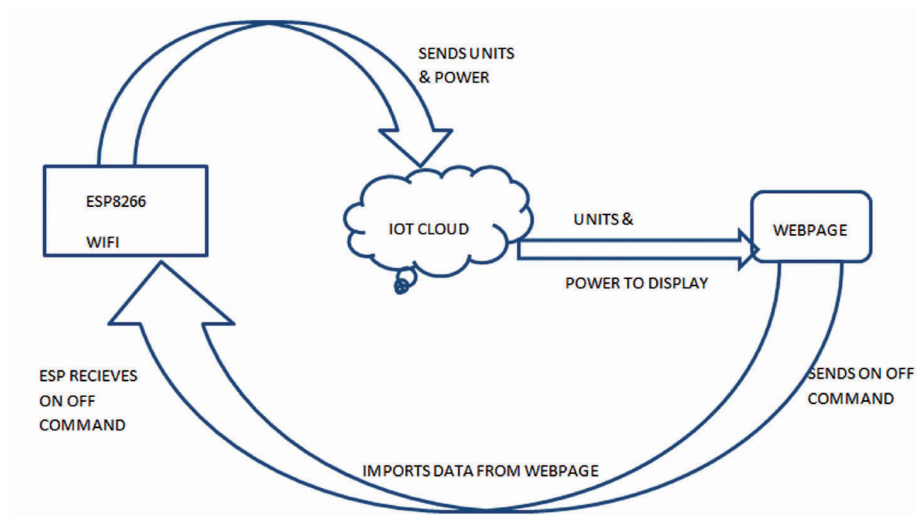
**Fig. 2:** Overall architecture

## Advantages

• Low energy consumption
• Integrated support for WIFI network
• Reduced size of the board
• Low Cost

## Conclusion

Thus the presented internet connected energy monitoring and controlling system that increases awareness of energy consumption amongst devices and users. Energy awareness enables the user to control the power state of the devices as per there needs which minimizes the energy use. In the coming future, each individual devices will have their own identity that can share and communicate the information over the IP network. It explains the basic structure and system design for IOT based energy meter billing and monitoring system emergency system. And also the basic blocks and components used in this system. The system is very much helpful for reduction in energy wastage and prevention in electric shortage. In this system consumer can do power management by knowing energy usage time to time this will help them to monitor the use of power in their day to day life. Using this system can provide real time bill monitoring system and time reduced billing system.

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# 3

# Foundations of Data Science

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## ABSTRACT

This chapter provides an insight to the basics of Data Science by describing the importance of Data Science which is essential for this universe comprised with big data. Also the various tools, process and analysis involved in Data Science are described. The significance of Mathematics techniques in Data Science are exhibited in this chapter so that one can understand very well about Data Science to get involved.

**Keywords:** Big data, BI tools, Unstructured data, Machine learning.

## Introduction

Traditionally, the data that we had was mostly structured and small in size, which could be analysed by using the simple Business Intelligence (BI) tools. In today's digital world, the massive amounts of data are growing considerably in all kinds of government and private organizations. The main challenge is to store and extract lots of information from the data for further analysis to find a solution for their future work. Hence we required some powerful, efficient algorithm and technology to handle, process and analysis this huge amount of data. The technology came in to existence as Data Science and plays a vital role in finding meaningful perceptions in the above said purpose from raw and unstructured data. Data Science helps to obtain meaningful insights from raw and unstructured data which is processed through analytical, programming and business skills. The various companies like Google, Amazon, Netflix, etc, are using Data Science technology to handle the huge amount of data. Data science is working for automating transportation

such as creating a self-driving car, which is the future of transportation. Also Data science can help in different predictions such as various survey, elections, flight ticket confirmation, etc. It was the main challenge and concern for the enterprise industries until 2010. The main focus was on building framework and solutions to store data. In this chapter, the key components, phases, operations and tools of Data Science are portrayed.

## Basic Terminologies Involved in Data Science

- • Structured data
- • Unstructured data
- • Big Data

### Structured Data

The conventional data which are small in size and interpreted in a tabular form with rows and columns are considered as structured data. The elements of structured data are addressable for effective analysis and it has been organized into a database. Those data are processed mostly in the development and to manage information. Before the existence of Data Science, these types of data are analysed by simple BI tools

### Unstructured Data

Unstructured data is a data which is not organized in a pre-defined manner or does not have a pre-defined data model. Today more than 80% of the data in any type of organization comes under unstructured data. That is data files which are not only in tabular form but also consistent and multimedia content. For example, videos, photos, audio files, messages in e-mail, word processing documents, presentations and webpages. Even though these files have internal structure, they are considered as unstructured because these data cannot be fitted neatly in a database. Earlier unstructured dataare stored and managed in IT systems and is used by organizations in a variety of business intelligence and analytics applications.

### Big Data

The term big data is closely associated with unstructured data. Big data refers to extremely large data sets that are difficult to analyse with traditional tools. Big data can include both structured and unstructured data. Recently, there is a huge development in the field of "IOT" (Internet of Things) due to which 90% of the data

has been generated in the current scenario. Every day, 2. 5 quintillion bytes of data are generated and it is more accelerated with the growth of "IOT". For example, shopper's information from sensors used in shopping malls, posts on social media platforms, digital pictures and videos captured in our phones, purchase transactions made through e-commerce have come under big data.

## Purpose of Data Science

The principal purpose of Data Science is to find patterns within data. Data Science is the extraction of knowledge from large volumes of data that are structured or unstructured. It is a continuation of the fields of data mining and predicting analytics.

## Difference between Business intelligence (BI) and Data Science

- BI deals with structured data whereas Data Science deals with structured and unstructured data.
- BI follows analytical method whereas Data Science follows Scientific method.
- Statistics and Visualization are the two skills required for BI, but for Data Science the required skills are Statistics, Visualization and Machine learning.
- BI focuses on both past and present data whereas Data Science focuses on past data, present data, and also future predictions.

## Components/Tools for Data Science

Following are some of the tools required for data science
- **Mathematics knowledge: Linear Algebra, Statistics and Probability**
- **Data Analysis tools:** R, Python, Statistics, SAS, Jupyter, R Studio, MATLAB, Excel, RapidMiner.
- **Data Warehousing:** ETL, SQL, Hadoop, Informatica/Talend, AWS Redshift
- **Data Visualization tools:** R, Jupyter, Tableau, Cognos.
- **Machine learning tools:** Spark, Mahout, Azure ML studio.

## Operations of Data Science

1. Discovery
2. Data preparation
3. Model planning
4. Model building

5.  Operationalize
6.  Communicate results

**1. Discovery:** In this phase, the problem is formulated with initial hypothesis to test. Before beginning the project, the following aspects must be considered.

•  Various specifications, requirements and priorities must be analysed.
•  Required budget should be finalized.
•  Assessment of required resources like people, technology, time and datato support the project.

**2. Data preparation:** In this phase, the following are to be done.

•  Extraction, transformation, loading and transformation are to be performed to get data into the desired model.
•  The Statistical Analysis to be done in this phase is given below.

For data cleaning, transformation, and visualization, the software tool 'R' is used commonly. Using 'R' we can spot the outliers and establish a relationship between the variables. Once the data has been cleaned and prepared, it's time to do exploratory analytics on it.

**3. Model planning:** Following are the process to be carried out in this phase.

•  The methods and techniques to draw the relationships between variables must be determined. These relationships will set the base for the algorithms which will be implemented in the next phase.
•  Exploratory Data Analytics using various statistical formulas and visualization tools are to be explored.
•  **'R'** software has a complete set of modelling capabilities and provides a good environment for building interpretive models.
•  **SQL Analysis services** can perform in-database analytics using common data mining functions and basic predictive models.
•  **SAS/ACCESS** can be used to access data from Hadoop and is used for creating repeatable and reusable model flow diagrams.

Though many tools are available, R is the most commonly used tool.

**4. Model building:**

•  Datasets for training and testing purposes are developed in this phase.
•  Whether existing tools will be sufficient for running the models or it will need a more robust environment like fast and parallel processing should be analysed here.

- Various learning techniques like classification, association and clustering to build the model to be analysed.
- Matlab, Statistica and SPCS modeller are some of the common tools for model building.

**5. Operationalize:** In this phase, final reports, briefings, code and technical documents will be released.

**6. Communication of results:** In this phase, it is important to evaluate whether the goal that has planned in the first phase is achieved. So, one must identify all the key findings and mustcommunicate to the stakeholders and determine if the results of the project are a success or a failure.

Data Science is processed through analytical, programming, and business skills. So Data Science includes the knowledge of Mathematics, Computer Science, Domain expertise, Statistical approach, Machine learning and Data Processing.

## Applications of Data Science in Various Field

### Image Recognition and Speech Recognition

Data science is currently using for Image and speech recognition. When you upload an image on Facebook and start getting the suggestion to tag to your friends. This automatic tagging suggestion uses image recognition algorithm, which is part of data science. When you say something using, "Ok Google, Siri, Cortana", etc., and these devices respond as per voice control, so this is possible with speech recognition algorithm.

### Gaming World

In the gaming world, the use of Machine learning algorithms is increasing day by day. EA Sports, Sony, Nintendo, are widely using data science for enhancing user experience.

### Internet Search

When we want to search for something on the internet, then we use different types of search engines such as Google, Yahoo, Bing, Ask, etc. All these search engines use the data science technology to make the search experience better, and we can get a search result with a fraction of seconds.

### Transport

Transport industries also using data science technology to create self-driving cars. With self-driving cars, it will be easy to reduce the number of road accidents.

### Healthcare

In the healthcare sector, data science is providing lots of benefits. Data science is being used for tumour detection, drug discovery, medical image analysis, virtual medical bots, etc.

### Recommendation Systems

Most of the companies, such as Amazon, Netflix, Google Play, etc., are using data science technology for making a better user experience with personalized recommendations. Such as, when we search for something on Amazon, and we started getting suggestions for similar products, so this is because of data science technology.

### Risk Detection

Finance industries always had an issue of fraud and risk of losses, but with the help of data science, this can be rescued. Most of the finance companies are looking for the data scientist to avoid risk and any type of losses with an increase in customer satisfaction.

### Summary
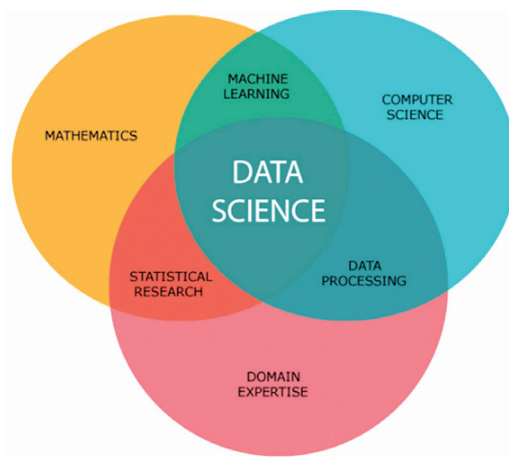
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# 4

# Mathematics Towards Data Science

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## ABSTRACT

Data Science projects are driving with certain mathematical models. These models involve various areas of the mathematical domain including statistics, logistic and linear regression, differential and integral calculus. This chapter focus on to deliberate the importance of mathematics towards data science and discussed some of the basic tools, process and analysis involved in Data Science to create a satisfactory result.

**Keywords:** Data Science, Statistics and Probability, Multivariable Calculus, Linear Algebra.

## Introduction

Data Science is a detailed study of the flow of information from the huge amounts of data present in an organization's repository. It involves obtaining meaningful insights from raw and unstructured data which is processed through analytical, programming, and business skills. As the world entered the era of big data, the need for its storage also grew. It was the main challenge and concern for the enterprise industries until 2010. The focus was on building framework and solutions to store data. Data Science is the future of Artificial Intelligence. Therefore, it is very important to understand what Data Science is.

## Mathematical Models

Data Science projects have certain mathematical models driving them. These models are planned and built by the Data Scientists in order to suit the specific need of the business organization. This might involve various areas of the mathematical domain including statistics, logistic and linear regression, differential and integral calculus, etc. Various tools and apparatus used in this regard could be R statistical

computing tools, Python programming language, SAS advanced analytical tools, SQL, and various data visualization tools like Tableau and QlikView.

One model is not enough to generate a satisfactory result. We need to use two or more models. In this situation, a Data scientist will create a group of models. After measuring the models, revise the parameters and fine-tune them for the next modeling run. This process will continue until the Data Scientist has found the best model. In this stage, a Data Scientist, build mathematical models based on the business needs and profitability of the product.

Communicating the findings is the last but not the least step in a Data Science endeavor. In this stage, the Data Scientist needs to be a connection between various teams and should be able to flawlessly communicate his results to key stakeholders and decision-makers in the organization so that actions can be taken based on the recommendations of the Data Scientist.

## Data Science Components

Some of the key components of Data Science are

- **Data (and Its Various Types):** The raw data set is the foundation of Data Science, and it can be of various types like structured data (mostly in a tabular form) and unstructured data (images, videos, emails, PDF files, etc. )
- **Programming (Python and R):** Data management and analysis is done by computer programming. In Data Science, two programming languages are most popular: Python and R.
- **Statistics and Probability:** Data is manipulated to extract information out of it. The mathematical foundation of Data Science is statistics and probability. Without having a clear knowledge of statistics and probability, there is a high possibility of misinterpreting data and reaching at incorrect conclusions. Thus statistics and probability play a crucial role in Data Science.
- **Machine Learning:** Data Scientist using Machine Learning algorithms such as regression and classification methods for predicting valuable insights from available data.
- **Big Data:** In the current world, raw data is compared with crude oil, and the way we extract refined oil from the crude oil, by applying Data Science, we can extract different kinds of information from raw data. Different tools used by Data Scientists to process big data are Java, Hadoop, R, Pig, Apache Spark, etc.

## Significance of Mathematical Skills

Data science is a very hands-on and practical field. Data science requires a solid foundation in mathematics and programming. As a data scientist, it is essential that

you understand the theoretical and mathematical foundations of data science in order to be able to build reliable models with real-world applications.

In data science and machine learning, mathematical skills are as important as programming skills. There are so many good packages that can be used for building predictive models. Some of the most common packages for descriptive and predictive analytics include

- Ggplot2
- Matplotlib
- Seaborn
- Sci-kit learn package
- Caret package
- Tensor flow
- PyTouch Package
- Keras Package

## Mathematical Foundations for Data Science

To understand the functioning of machine learning models, it is needed to understand the theoretical and mathematical foundations behind every model. Data scientist have ability to build reliable and efficient models that can be applied to real-world problems depends on how good your mathematical skills are.

Some of the theoretical and mathematical foundations essential for data science practice are discussed here.

### Statistics and Probability

Statistics and Probability is used for visualization of features, data preprocessing, feature transformation, data imputation, dimensionality reduction, feature engineering, model evaluation, etc. Mean, Median and Mode, Standard deviation/variance, Correlation coefficient and the covariance matrix, Probability distributions (Binomial, Poisson, Normal), p-value, Baye's Theorem (Precision, Recall, Positive Predictive Value, Negative Predictive Value, Confusion Matrix, ROC Curve), Central Limit Theorem, R_2 score, Mean Square Error (MSE), A/B Testing and Monte Carlo Simulation are plays a vital role in the mathematical modelling.

**Mean**, **Median,** and **Mode** are used for displaying summary statistics for a given dataset. They are also used for data imputation (mean imputation, median imputation, and mode imputation).

**Correlation coefficients** and **covariance matrix** are used to study relationships between various features in the dataset and can be used also for feature selection and dimensionality reduction.

**Probability distributions** are used for feature scaling, for example, normalization and standardization of features. Probability distributions and Monte-Carlo simulation are also used for simulating data. For example, if the sample data is distributed according to the normal distribution with known mean and standard deviation, then a population dataset can be generated using the random number generator for the normal distribution.

**Baye's theorem** is used for model testing and evaluation, and for calculating accuracy score.

**Central Limit Theorem (CLT)** is one of the most important theorems in statistics and data science. According to CLT, using a sample dataset with larger number of observations for model building is advantageous because a larger sample is a better approximation of the population. Find out more about CLT from here: **Proof of Central Limit Theorem Using Monte-Carlo Simulation**.

**R_2 score** and **MSE** are used for model evaluation. Here is an article in which R_2 score and MSE are used for model evaluation:

## Multivariable Calculus

Most machine learning models are built with a dataset having several features or predictors. Hence, familiarity with multivariable calculus is extremely important for building a machine learning model. Functions of several variables, Derivatives and gradients, Step function, Sigmoid function, Logit function, ReLU (Rectified Linear Unit) function, Cost function, plotting of functions and Minimum and Maximum values of a function are used in the machine learning process.

## Linear Algebra

Linear algebra is the most important math skill in machine learning. A data set is represented as a matrix. Linear algebra is used in data preprocessing, data transformation, dimensionality reduction, and model evaluation. The most important topics of Linear Algebra are Vectors, Norm of a vector, Matrices, Transpose of a matrix, the inverse of a matrix, The determinant of a matrix, Dot product, Eigenvalues and Eigenvectors are helpful for model evaluation.

The **covariance matrix** is a very useful matrix that displays correlations between features. Using the covariance matrix, one can select what features to use as predictor variables. The example of the covariance matrix can be used for feature

selection and dimensionality reduction: **Feature Selection and Dimensionality Reduction Using Covariance Matrix Plot.**

Other advanced methods for feature selection and dimensionality reduction are **Principal Component Analysis** (PCA), and **Linear Discriminant Analysis** (LDA). To understand how PCA and LDA work, it is needed to understand linear algebra topics such as transpose a matrix; the inverse of a matrix; the determinant of a matrix; dot product; eigenvalues; and eigenvectors.

## Optimization Methods

Most machine learning algorithms perform predictive modeling by minimizing an objective function, thereby learning the weights that must be applied to the testing data in order to obtain the predicted labels. Some of the optimization methods perform the machine learning process are Cost function/Objective function, Likelihood function, Error function and Gradient Descent Algorithm and its variants (e.g. Stochastic Gradient Descent Algorithm).

## Summary

This chapter discusses the importance of mathematical skills that are needed in data science and machine learning. Data Science is a very hands-on in the real-world field. It requires a solid foundation in mathematics and Programming. As a data scientist, it is important to keep in mind that the theoretical foundations of data science are very crucial for building efficient and reliable models with real-world applications.

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# 5

# Single Window Monitoring of all Rural Welfare Development Schemes

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## ABSTRACT

A number of countries are considering establishing a "Single Window" for the exchange of information between trade and government. The purpose of this publication is to provide these countries with concrete examples of the operation, costs and benefits of such facilities in other countries. A Single Window is a facility that allows parties involved in trade and transport to lodge standardized information and documents with a single entry point to fulfil all import, export, and transit-related regulatory requirements. If information is electronic, then individual data elements should only be submitted once. The Single Window is a practical application of trade facilitation concepts intended to reduce non-tariff trade barriers and deliver immediate benefits to all members of the trading community.

## Introduction

Establishing a Single Window facility is one means of addressing this problem. It can enhance the availability and handling of information, and can simplify and expedite information flows between trade and government. It can also bring about greater harmonization and better sharing of the relevant data across governmental systems, bringing meaningful gains to all parties involved in cross-border trade. It can result in improved efficiency and effectiveness of official controls and reduce costs both for Governments and for traders due to better use of resources.

In the Recommendation and Guidelines on Establishing a Single Window, it is recommended that Governments and those engaged in the international trade and movement of goods should actively consider the possibility of implementing

a Single Window facility in their country. The Recommendation and Guidelines were developed by the International Trade Procedures Working Group.

## Study about the System

### Existing System

When it comes to Single Window implementation, governments often face complicated challenges. These challenges concern not only the technicalities of the implementation, but also organizational, managerial, financial, legal, and political issues. Single Window is about integrating data and business processes used by different stakeholders in different phases of the international supply chain. While integrating data requires the harmonization of their attributes such as definition, format, and position in the message with relevant international standards, integrating business processes may require changes and additions to laws and regulations. Because the integration is made possible by automation, new information systems that are capable of inter-operating with other information systems have to be developed. Legacy information systems that have been introduced by different stakeholders to support different business processes in different phases of the international supply chain have to be made interoperable with others.

### Proposed System

A Single Window is an inter-organizational information system that, when operated in a full scale, connects information systems of stakeholders engaged in various business processes of the international supply. A Single Window brings meaningful gains to all parties engaged in cross-border trade. In the proposed system, a single window monitoring system is developed for rural area monitoring. Here there will be the admin who will maintain the government facilities, government related issues and guidelines. The grievances of this area will be known with the implemented monitoring system. The predictive analysis of this data monitoring system with management of the complete single window system is developed.

### *Advantages*

- Easy single window monitoring system is developed
- The system will be made use of the identification of the special identification of the government schemes
- The user will know the complete government schemes which are needed.

## Main Modules of the System

- Admin
- Rural Head
- User

## Admin

Admin is the one who will manages the complete details of the user and the rural areas where the admin is the meaning of the government.

### *Add Government Facilities*

Admin will view the government facilities which are provided from both the central and the state government. The schemes with the complete description will be added to the rural head and the user

### *Add Guidelines*

The admin will add the guidelines where the rules and regulations to be followed in India will be added here by the government.

### *Grievances*

Admin will view the grievances which will be lot in the side of the rural areas. These grievances will not be monitored in a good mode where these are left aside. The developed web portal makes the admin to take care of the rural area grievances too.

## Rural Head

Rural head is the head of the particular area where they will be provided with an account where they need to register themselves. Thus the developed system will be made with the analysis of the rural areas monitoring with a login system.

### *Add Grievances*

The rural head will add the grievances in their area where they will be provided with a problem to be added. The rural head will complaint the entire problem and see the notification their using the web portal

### *Government Facilities and Guidelines*

Rural head will view the complete guidelines and the government facilities which are needed.

The rural head with the information will be added here with the management of the guidelines added.

## User

User will be provided with a separate login session and they need to create an account to be handled. The will make login with their registered information

### *Government Facilities*

The user will view the facilities and the schemes which are added from the admin side so that they can wish apply to the system they can do. Thus this helps in the reaching out of the government schemes to all the people.

### *Grievances Notification*

The grievances which are added from the admin side will be known by the user with the developed notifications. Thus the actions taken will be known here.
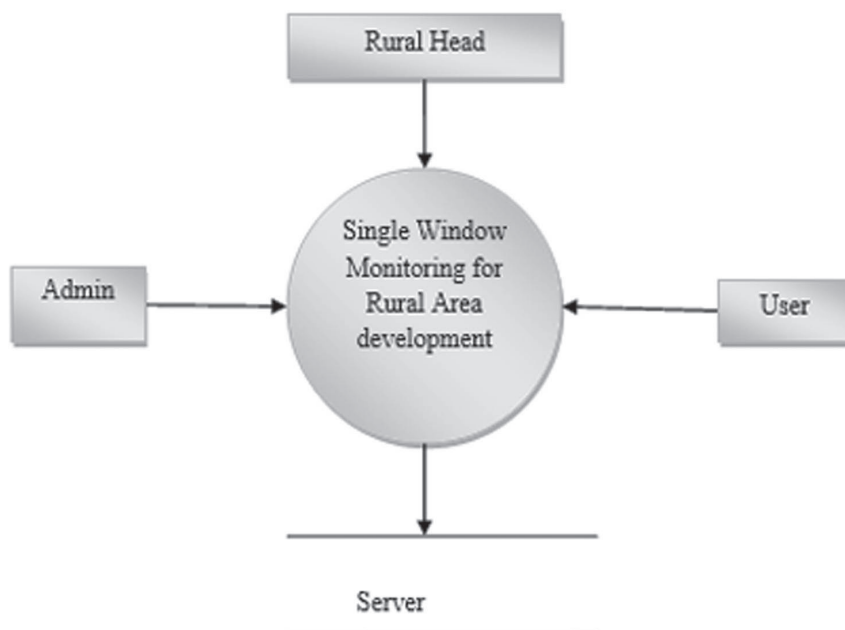


**Fig. 1:** Data Flow Diagram
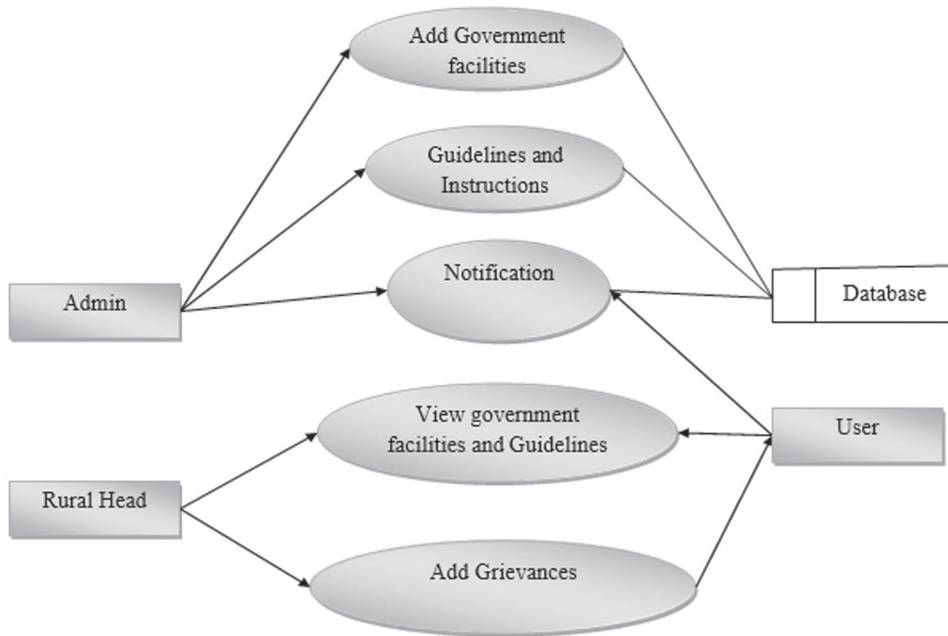
**Fig. 2:** Data Flow Diagram

## System Implementation

Systems implementation is the process of:

1. Defining how the information system should be built (i.e., physical system design),
2. Ensuring that the information system is operational and used,
3. Ensuring that the information system meets quality standard (i.e., quality assurance).

Systems operators must be trained properly such that they can handle all possible operations, both routine and extraordinary. The operators should be trained in what common malfunctions may occur, how to recognize them, and what steps to take when they come.

Training involves creating troubleshooting lists to identify possible problems and remedies for them, as well as the names and telephone numbers of individuals to contact when unexpected or unusual problems arise. Training also involves familiarization with run procedures, which involves working through the sequence of activities needed to use a new system.

A software application in general is implemented after navigating the complete life cycle method of a project. Various life cycle processes such as

requirement analysis, design phase, verification, testing and finally followed by the implementation phase results in a successful project management. The software application which is basically a Windows based application has been successfully implemented after passing various life cycle processes mentioned above.

As the software is to be implemented in a high standard industrial sector, various factors such as application environment, user management, security, reliability and finally performance are taken as key factors throughout the design phase. These factors are analyzed step by step and the positive as well as negative outcomes are noted down before the final implementation.

Maintenance means restoring something to its original conditions. Enhancement means adding, modifying the code to support the changes in the user specification. System maintenance conforms the system to its original requirements and enhancement adds to system capability by incorporating new requirements.

Thus, maintenance changes the existing system, enhancement adds features to the existing system, and development replaces the existing system. It is an important part of system development that includes the activities which corrects errors in system design and implementation, updates the documents, and tests the data. The purpose of the implementation process is to design and create (or fabricate) a system element conforming to that element's design properties and/or requirements. The element is constructed employing appropriate technologies and industry practices. This process bridges the system definition processes and the integration process.

## Experimental Results

### Forms – Home Page

## Admin Login Page



## Grievances Notification Page



## Guidelines and Instruction Adding Page

## Admin - Add Government Facilities



## Rural Head - Register Page



## Rural Head - Login Page

## Government Facilities View Page
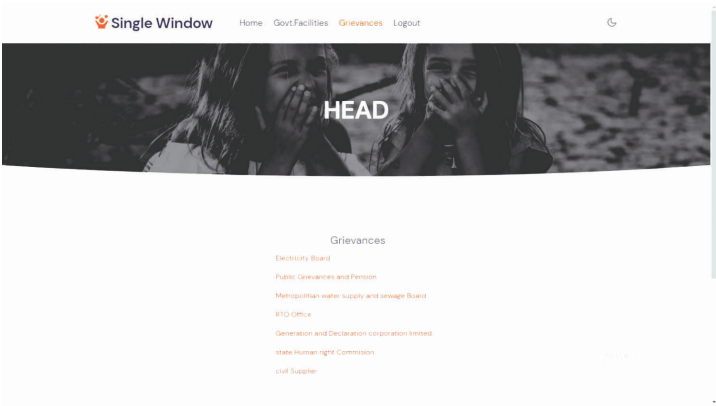


## Grievances Selection Page
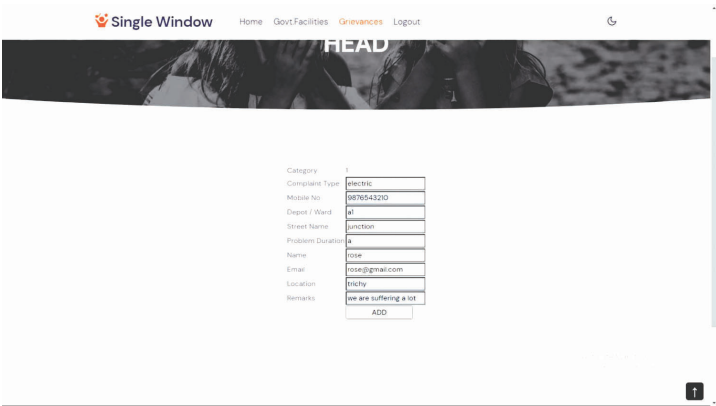


## Grievances Adding Page

## User Register

Single Window   Home   Admin   Rural Head   User

USER

UserLogin

Username mani

Password ••

Login

New User Register Here...

## User Login

Single Window   Home   Govt.Facilities   Notification   Logout

Government Facilities

| facility_name | target_length | target_people | total_fund | fund_person | description | cdate | status | report |
|---|---|---|---|---|---|---|---|---|
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## Government Facilities Page

Single Window   Home   Govt.Facilities   Notification   Logout

Notification

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| Metropolitian water supply and servage Board | drainage water | 7845961230 | 25 | Bheemakaali street | 3 months | Kaalinathan | Kaali@gmail.com | trichy | we are suffering a lot |

## Grievances Notification



## Conclusion

The greatest obstacle has been establishing the co-operation between authorities and real commitment. Initially it was very difficult. Once those obstacles were removed, problems vanished. In fact co-operation is getting better all the time. We have seen it time and time again that without this co-operation the idea does not work, no matter how good the system is technically. Thus the developed single window application development system helps the rural area people to get know the facilities and schemes added. The rural head will manage the grievances in their area where they can be overcome. Thus the system maintains an storage system in server where multiple access can be used. However there is no such single platform where all the domains are carried out simultaneously. So we have come up with a new idea of combining all the domains in a single platform and monitor it. The application we propose also has the ability to monitor different parameters under single website and customize the representation of the parameter values according to the user required format.

## Scope for Future Enhancement

In future system, the grievances necessity action taken will be made notified to the user. The scheme application system can be added where the user can directly apply to the scheme with the single web system. Our project adds to impact on society as it can be used to improve the quality of life by ensuring water quality, air quality and other factors affecting society. The applications of this can be used for weather monitoring, irrigation system monitoring and control, water plant monitoring, factory automation or any other application in which sensors are

capable of sensing physical parameters and sending those data to remote location through internet.

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# 6

# Surface Engineering for Enhanced Tribological Performance

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## ABSTRACT

Economic and technological progress, as well as environmental concerns, requires that modern equipment be designed with ever more stringent performance criteria, frequently pushing components to the very limits of their capabilities. One major consequence of this increased demand on performance is that tribological deficiencies, such as lubrication breakdown excessive wear and tribo-corrosion, can be significantly amplified, leading to unnecessary operational costs, decreased efficiency and premature failure. Because tribological processes result from the interaction of two or more bodies in relative motion in a particular environment, surface engineering can be used to confer to surfaces the high performance needed for demanding operational conditions. In this context, the design of the appropriate material system must be guided by an accurate understanding of the degradation mechanisms and the surface response to loading and deformation, frequently acting in synergy.

Solid Particle Erosion (SPE) occurs in situations where hard solid particles present in the environment are entrained in a fluid stream, and impact component surfaces. This type of damage is most prominent in the first stage of the aircraft engine, where the compressor blades can be eroded to such an extent that aerodynamic performance and even structural integrity are compromised. Consequently, much work has been done in academia and industry in order to understand the material loss mechanisms present in SPE and to develop protective technologies that will increase component lifetimes. One such technology is the use of hard protective coatings to impede the erosion of the predominantly metallic engine components.

**Keywords:** Solid particle erosion, Scanning electron microscope, Particle size, Sputtering, X-ray diffraction.

## Introduction

The design of the appropriate material system for a given tribological solicitation must be guided by an accurate understanding of the degradation mechanisms and

the surface response to loading and deformation. In this chapter, the focus was put on surface wear by solid particle erosion (SPE) that can occur when aircraft operate in harsh environments where hard particulate matter is entrained by the air flow into the operating engine. In fact, this type of damage is most prominent in the first stage of the aircraft engine, where the compressor blades can be eroded to such an extent that aerodynamic performance and even structural integrity are compromised.

It is not always possible to select a bulk material to protect surfaces from tribological degradation because of structural integrity requirements of the affected component or simply because the required properties cannot be obtained in any structural material. Therefore, surface treatments have been used for centuries to improve the tribomechanical performance of surfaces. Modern surface engineering techniques can be classified into two groups.

The first one involves local modification of the component's surface to increase hardness. This can be achieved through the formation of hard phases by heat treatment, strain hardening through mechanical means (*e.g.* shot peening) or diffusion-controlled processes where atoms (typically nitrogen or carbon) are diffused into the surface and react to create a hard protective layer.

The second group of surface engineering techniques involves the deposition of a hard coating system on the surface to be protected. In general, the design and fabrication of protective coating systems is complex due to the multi-layer nature of the final structure most often consisting of a surface layer, followed by the hard coating and other functional interfacial layers in order to ensure proper adhesion, corrosion resistance and/or thermal conductivity. A large number of deposition techniques are available for hard coating deposition, and they can be classified into three categories:

1) Wet chemical plating techniques involve the deposition of a coating in an electrolytic bath. These techniques are widely used most notably in the aerospace industry for the deposition of thick hard chrome and cadmium protective coatings. Much work is underway to replace these wet techniques because the electrolytes that are used are often harmful to humans and the environment (*e.g.* hexavalent chromium).

2) Thermal and cold spray coatings are deposited by the projection of a powder feedstock onto the substrate to be coated. In thermal spraying, the particles are heated during projection by electrical or chemical means and the coating is formed by the accumulation of the deformed impacted particles (splats). Thick thermal sprayed coatings are being increasingly studied for their use as protective coatings in many different tribological applications such as thermal

barrier coatings for jet engine turbines and anti-galling coatings in industrial valves. They are industrially interesting because of their high deposition rate and relatively low implementation costs.

3) Vapor phase techniques are used for the deposition of a very large variety of coatings used in many applications such as optical interference filters on ophthalmic lenses, thin film photovoltaic solar cells, erosion resistant coatings in aircraft jet engines and even wear resistant drill bits for household use. Vapor deposited coatings are relatively thin (typically from below 1 μm to 10 or 20 μm) but can be deposited on many types of substrates in a highly controlled manner. These techniques are generally regarded as being environmentally friendly and have been recently used to replace polluting techniques such as electrolytic deposition of hard chrome coatings.

## Vapor Deposition Techniques

Vapor deposition methods can be separated into two classes depending on the source of the vapour phase. Chemical Vapor Deposition (CVD) techniques use a gas-phase primary source, which can be activated in many ways including a glow discharge in the case of Plasma Enhanced Chemical Vapor Deposition (PECVD). CVD techniques can be difficult to implement industrially because of the often hazardous gaseous precursors that are used such as titanium tetrachloride (TiCl4), which is corrosive, and silane (SiH4), which is pyrophoric. Nonetheless, they have been used industrially for many years. With the increased understanding of the plasma physics and chemistry involved and because the resulting coatings present a highly controlled microstructure through the control of process parameters and may be deposited on components with complex geometries, PECVD is being used in a widening number of industrial applications.

The second type of vapor deposition techniques is by Physical Vapor Deposition (PVD) where the vaporized material originates from a solid target. There is a great variety of techniques to achieve this, and they can be classified into two sub-categories: evaporation and momentum transfer sputtering. In the case of evaporation, the source material can be vaporized using several methods including resistance heating, induction heating, electron beam evaporation, laser ablation and electric arc evaporation. In particular, the Cathodic Arc Deposition (CAD) method, where the target material (cathode) is vaporized using an electric arc, is widely used in the deposition of hard, dense and thick protective coatings. Because of historic reasons and high deposition rates, the use of CAD for the deposition of erosion resistant coatings for aerospace applications is widespread.

The second category of PVD techniques is the sputter deposition method where material is vaporized from the target through the momentum transfer from impinging ions which are generated in a glow discharge or from an ion beam. Nearly all target materials can be sputtered and compound films can be deposited by using a reactive atmosphere during the process. Like PECVD, this deposition technique is widely used because it is possible to control the microstructure and the resulting properties through the control of the process parameters.

## Sputter-deposition of Coatings and their Microstructure

In a planar diode DC sputtering configuration, a glow discharge is created between the target material to be vaporized which is held at a negative potential (cathode) and the substrate holder which is at a positive potential (anode). As the potential is applied, the electrons that are naturally present in the chamber are accelerated towards the anode and ionize atoms in the working gas (usually argon). The ionized atoms in the plasma are then accelerated to the cathode with high energies and impact the target material generating secondary electrons and, if their kinetic energy 20 is sufficient, ejecting target atoms or molecules by momentum transfer. These ejected particles then condense on the substrate surface following a line-of-sight trajectory. In planar diode DC sputtering the ionization efficiency is low and the discharge cannot be maintained at low pressures because the probability of primary electron collisions is significantly reduced. The secondary electrons extracted from the target serve to maintain the discharge but they cannot offset this effect. In order to curtail this problem, Magnetron Sputtering (MS) is used to increase ionization efficiency by applying magnetic fields to confine the electrons near the target surface. The sputtering yield is increased and the discharge can be maintained at lower pressures thus increasing deposition rates. In traditional DC sputtering, only metallic targets are used as it would be impossible to maintain a discharge over highly resistive insulating materials due to charge accumulation on the target surface. The same can be said when depositing compound films in a reactive environment with metallic targets: an insulating oxide or nitride layer is formed, leading to increased charge accumulation, thus lowering sputtering rate and increasing the probability of arcing. The PDCMS technique is used to bypass this problem. Instead of applying a constant negative potential to the cathode, a cyclic potential is applied where the sputtering occurs during the negative part of the cycle and the accumulated charge is removed during the positive part of the cycle. In this way, the effects of target poisoning are significantly reduced. The film growth and microstructure are directly related to the mobility of the condensing atoms (adatoms) once on the substrate surface. Adatom mobility will

depend on process parameters such as pressure, substrate temperature, substrate bias and the proportion of condensing atoms that are ionized. In conventional MS techniques, the ionization proportion is very small and energy must be injected into the growth process by other means such as surface heating or through ion bombardment using an external ion source such as ion beam or additional glow discharge. The effects of process parameters on the resulting microstructure have been studied extensively and are described by various Structure Zone Models (SZMs) proposed by Movchan and Demchishin for evaporated films[1], Thornton[2], Messier *et al.*[3], and Kelly and Arnell[4] for sputtered films, and more recently by Anders[5] for sputtered films taking into account the ionization of the condensing atoms. In **Figure 1**, the SZM proposed by Anders is presented, where the effects of generalized substrate temperature ($T^*$) and normalized delivered energy flux ($E^*$) on the coating microstructure can be seen.

Four characteristic coating microstructures can be found (illustrated in Figure 2 for more clarity). When adatom mobility is low, coatings will be under-dense and present columnar structures with important defect and porosity densities due to open grain boundaries and shadowing effects (Zone 1 to Zone T). As temperature and ion energy fluxes increase, mobility is enhanced leading to grain and surface diffusion processes that enable increased densification and competitive growth (Zone T to Zone 2). Finally, further increases in mobility led to bulk diffusion which promotes a transition from a columnar structure to a coarse grain structure (Zone 2 to Zone 3). In protective coatings for tribological applications, microstructural parameters such as density, crystallinity and grain size will greatly influence performance by affecting material parameters such as hardness, toughness, corrosion resistance and residual coating stresses.

While an important component of the overall residual stress is the difference in thermal expansion coefficient between the coating and the substrate, it has been shown that the residual stress in coating systems is also related to microstructure. Open microstructures presenting voids such as in Zone 1, and to a lesser extent in Zone T, will generally have tensile intrinsic residual stresses due to attractive atomic forces acting across the voids[6]. On the other hand, denser films obtained through ion bombardment generally present compressive stresses which strongly depend on the energy of the impinging ions controlled through the species ionization and the substrate bias. These bombarding particles are implanted in the forming coating, causing lattice distortion which can lead to very important compressive residual stresses (up to -10 GPa)[6]. The high compressive stresses that are generally found in hard protective coatings can be beneficial to stall fracture processes by acting to close forming cracks.
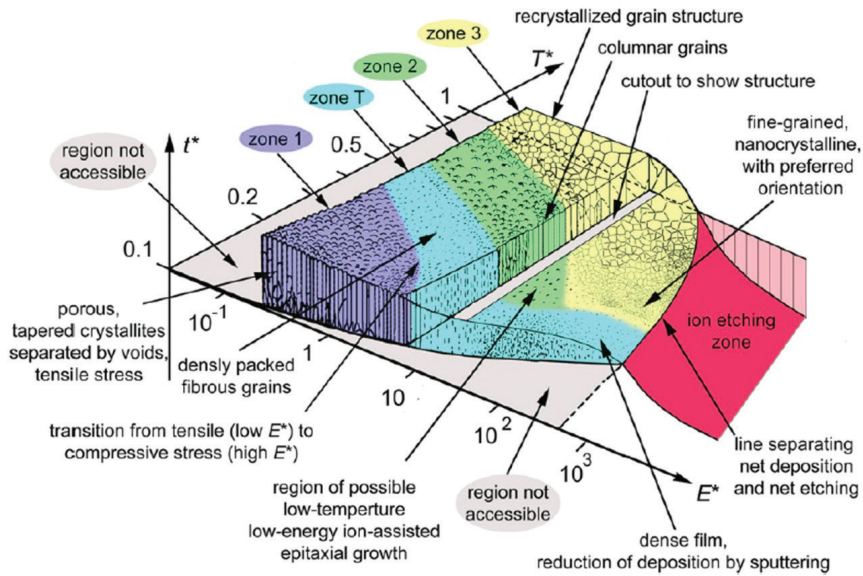
**Fig. 1:** Representation of the structure zone model proposed by Anders[36] showing the effects of deposition parameters on the coating microstructure
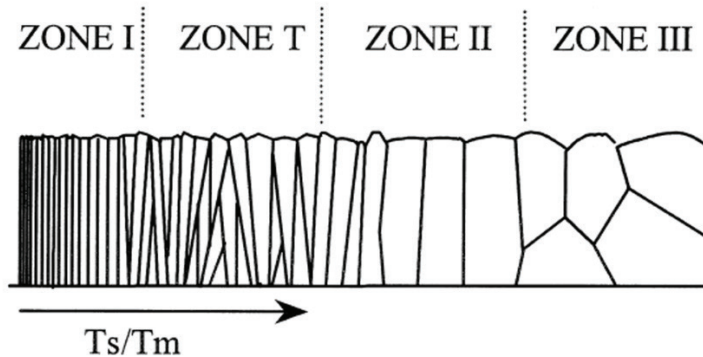


**Fig. 2:** Illustration of the four characteristic coating microstructures[3]

On the other hand, high stresses, be they tensile or compressive, can lead to coating delamination. Therefore, in such situations, interface engineering to maximize adhesion is crucial.

The hardness of the coating can also be controlled through the microstructure. First of all, the elastic component of hardness will be affected by the residual stress in a coating by changing the average interatomic distance in the stressed lattice. For example, high hardness is generally observed in highly compressively stressed coatings. On the other hand, defects such as voids, dislocation and incorporated

atoms will negatively affect material strength and thus reduce hardness. Finally, since plastic flow can be limited by impeding dislocation movement, grain boundaries can be used to enhance yield strength. Thus by refining the microstructure, a higher hardness can be obtained.

## Nanocomposite Coatings

Hardness depends in part on the nature of the interatomic bond where covalently bonded materials present the highest hardness values. Thus, only a few materials can be classified as being super hard ($H > 40$ GPa), such as diamond ($H = 70$ to 100 GPa) and several variants of the B-C-N system ($H \geq 50$ GPa) such as c-BN, BC and β-C3N4. As these materials are relatively rare and present certain shortcomings like being difficult to synthesize, several methods exist to improve material strength through other means.

The first approach is through alloying by adding different elements to a crystalline structure. Hardening is achieved by changing the nature of the interatomic bonds and by deforming the crystal lattice. Examples of this type of hardening are TiAlN, TiCN and to a certain extent CrSiN. Another approach is to limit dislocation motion by introducing grain boundaries, flaws, precipitates and/or other dislocations. In fact, it has been shown independently by Hall[7] and Petch[8], that the yield strength is inversely proportional to the square root of the grain size. Applied to hardness, the Hall-Petch equation can be expressed as[6]:

$$H = H_i + kd_g^{-1/2}$$

Where $H_i$ is the intrinsic hardness, $k$ is a material constant and $dg$ is the grain size. Thus, this hardening mechanism can be achieved by controlling the microstructure as described by the various SZMs and in certain cases by controlling the nanostructure.

Nanocomposite coatings are heterogeneous structures composed of nanometric crystalline particles in an amorphous or polycrystalline matrix. In these materials, hardness is enhanced by blocking dislocation motion through grain size reduction. Greater cohesive forces at the grain boundaries prevent grain slip and maintain the validity of the Hall-Petch relation[6]. However, under a critical grain size an inverse Hall-Petch effect can be observed because of grain boundary slipping[7].

The research on nanocomposite materials has matured over the last 15 years and a great variety of nanocomposite materials have been developed. Their design largely depends on the application, and the composition of the crystalline phase and the matrix are selected accordingly. One of the most studied nanocomposite systems is composed of nano-crystalline TiN in an amorphous SiN matrix[8,10-13].

For such as system, Veprek et al.[14] demonstrated that maximum hardness is achieved at the percolation limit of the amorphous phase in the three dimensional network of nanocrystalline grains (typically between 5 and 10 nm in size). In addition, transmission electron microscopy studies have shown that maximum hardness is achieved when particle sizes and shapes are relatively regular, and randomly oriented. This nanostructure is presented in **Figure 3**. It should be noted that more recently Jedrzejowski *et al.*[13] proposed a new realistic microstructural model where grains would be partially interconnected, and large enough to contain a limited number of defects.
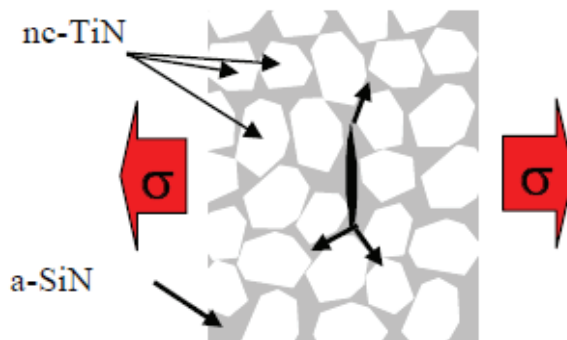


**Fig. 3:** Schematic representation of a nanocomposite system where a defect in the amorphous matrix is shown. The material is composed of nanocrystalline grains typically 5 to 10 nm in size separated by an amorphous matrix one or two monolayers thick

In such nanocomposite systems, particles smaller than 10 nm cannot accommodate plastic deformation because dislocations cannot form and thus, the mechanical strength of the grains will tend toward the theoretical strength of the material. Therefore, the strength of the system can only be limited by defects in the amorphous phase that is only one or two monolayers thick[14].

## Effect of Solid Particle Erosion on the Protective Coatings

Much work has been conducted to develop protective approaches to increase component lifetimes. One such technology is the use of hard protective coatings to impede the erosion of the predominantly metallic engine components. However, in order to select the appropriate coating system, the material loss mechanisms must be properly understood.

In the first place, the metallic surfaces to be protected erode in a predominantly plastic mode of material removal through micro-cutting or ploughing mechanisms.

On the contrary, the hard ceramic protective coatings are brittle in nature and will present much more complex erosion behaviors. In fact, brittle materials exhibit surface removal mechanisms very similar to those encountered during indentation such as elastic Hertzian cracks under large rounded particle impact and elasto-plastic deformation and fracture for sharp particle impacts. Transitions between these mechanisms occur depending on the coatings' corresponding elastic, plastic and fracture properties and on the fragmentation of the erodent particles upon impact.

Many different coating systems have been proposed for protection against Solid Particle Erosion (SPE). Multilayer systems have been used because their multilayer design offers the possibility of depositing thicker coatings by relaxing residual stresses and enhancing erosion resistance through the crack tip blunting effect of the ductile layers and the deflection of cracks at interfaces. On the other hand, monolithic coatings are more durable under SPE by small, hard and angular particles because the damage is generally confined to a small volume in the top layer and therefore, the ductile interlayers of the multilayer coating would not be beneficial to erosion resistance.

The SPE resistance of monolithic coatings can be enhanced by using materials with high toughness to prevent crack growth, and high hardness to inhibit crack initiation by dissipating the particle kinetic energy through fragmentation and minimizing the penetration of the particle on impact. However, while it has been observed that hard monolithic coatings exhibit the different brittle fracture modes when impacted by large and/or highly energetic particles, a review of the literature has revealed that no description has been proposed for the mechanism of material loss when erosion by small angular particles with relatively low velocities (<100m/s) occurs. A preliminary study was accomplished on the effect of the addition of silicon (Si) on the microstructure, mechanical properties and, more specifically, on the SPE resistance of thick CrN-based coatings. It was found that the addition of Si significantly improved the erosion resistance and that the SPE results showed a very strong dependence on the surface hardness. These findings led to three interrogations: i) what is the material loss mechanism of hard protective coatings during erosion; ii) what is the role of toughness on the erosion mechanism; and iii) what is the role of particle properties on the strong dependence of ER on the hardness of the target material?

## Conclusions

The effects of the particle properties on the SPE behavior of brittle bulk materials by using glass and alumina powders to erode the materials at varying velocities

was undertaken. First, the elasto-plastic and fracture characterization techniques were employed in order to apply a robust methodology to accurately measure and then correlate the materials' mechanical properties to the measured ER. With the help of a morphological study and an analysis of the quasi-static elasto-plastic erosion models, it is understood that the tests using both types of powders led to a material loss mechanism related to lateral fracture. However, higher than predicted velocity exponents were observed pointing towards a velocity-dependent damage accumulation mechanism which are correlated to target yield pressure. This damage accumulation effect is more pronounced for the softer glass powder because of larger kinetic energy dissipation through different means. This dependence of velocity exponent on the surface mechanical properties has not been reported. In order to understand the effects of impact on the particles themselves and to study the energy dissipation related to fragmentation, it was decided to analyze, the particle size distributions of the powders before and after erosion testing **(Fig. 4)**.
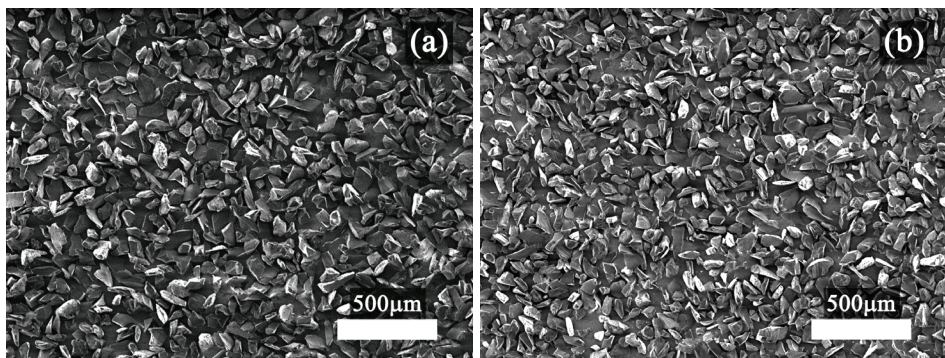


**Fig. 4:** Micrographs of the alumina powder before (a) and after (b) SPE testing at $Vp = 60$m/s on TiSiN-1 deposited on c-Si

This revealed that particle breakup and deformation were correlated to the ratio of particle hardness over target hardness but did not find sufficient evidence to support the hypothesis that the disparity between erosion rates when using different powders was due to kinetic energy being dissipated through particle fracture. In fact, the large difference in brittleness between the alumina and glass powders may be obscuring the real effect of target hardness on particle fragmentation. In order to gain more insight into the energy dissipation mechanisms related to particle impact, testing using a single powder with a much smaller particle size distribution and wider variety of target materials would be needed.

A new methodology for the accurate measurement of volume loss, clearly showed the importance of optimizing the testing parameters in order to obtain results free from experimental artefacts. In fact, it was shown that the particle
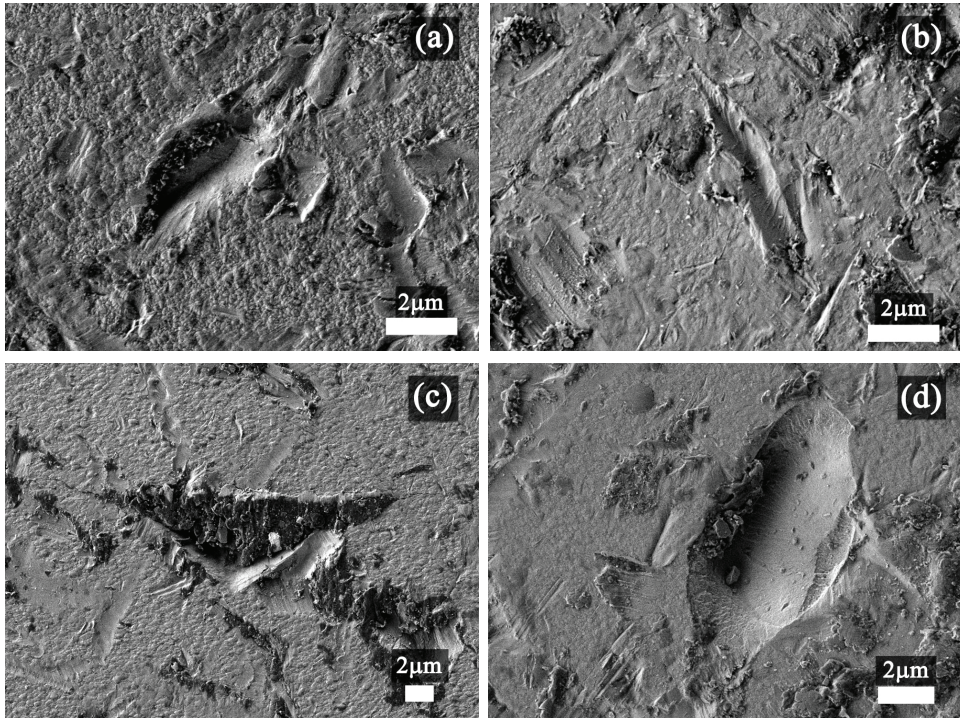
**Fig. 5:** Single impact morphology of (a) CrN at $Vp = 60$ m/s on, (b) TiSiN at $Vp = 60$ m/s, (c) CrN at $Vp = 120$ m/s and (d) TiSiN at $Vp = 100$ m/s

feed rate and working distance could affect the measured erosion rate by as much as 50%. This new technique for the evaluation of volume loss was shown to be accurate, highly repeatable and quick but could only be applied to erosion tests conducted for a particle flow with normal incidence to the surface because of the necessity of an axisymmetric wear profile. However, normal incidence tests are the standard for materials showing brittle mechanisms of erosion thus making this testing methodology valuable for future research.

The tests were conducted on all the coatings using the optimized conditions and correlated the measured erosion rates to the material properties measured by depth-sensing indentation. It was found that the measured erosion rates were much more dependent on the target hardness than what had been predicted by the brittle erosion models proposed in the literature. Therefore, in order to fully understand the material loss mechanisms, an in-depth study on the coating systems was conducted.

With the help of fracture characterization and a morphological study of the eroded surfaces, it is understood that the coating erosion did do not correlate with

coating toughness but only with the coating surface hardness thus excluding the material loss mechanism by brittle fracture. This finding was confirmed by the morphological study which showed the material removal mechanism to occur through repeated ductile indentation and cutting of the surface by the impacting particles.
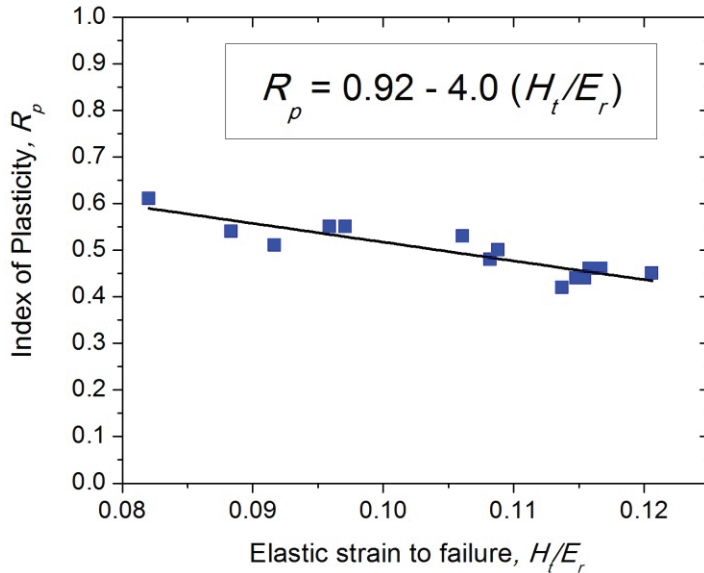


**Fig. 6:** *Rp* as a function of *Ht/Er* for all the tested coatings. Finally, the particle size distributions measurements of the powders before and after erosion testing showed that particle breakup was not sufficiently large to explain the strong dependence on target hardness. From these results, it is concluded that it was likely that the amount of material displaced by each particle impact decreased as the hardness of the surface increased. Consequently, the number of subsequent impacts needed for material removal would increase significantly, explaining the observed dependence on surface hardness

## Acknowledgements

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# 7

# Introduction to Block Chain and 5G Enabled IoT Devices

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## ABSTRACT

A block chain is a distributed secure log file or shared ledger enabled with technology to carry out transactions in a secure manner without centralized authority. The shared ledger technology will store all the viable transactions and allow any participant in the network to visualize the record system. The transactions are placed in blocks linked by hashes and the system operates in a peer-peer mode. The block chains are deployed on a distributed databases platform with built in technical and business logic criteria which are synchronized through consensus algorithms called as block chain ledgers.

Thus the block chain technology can be understood as decentralized peer to peer network maintaining public ledger of transactions and hence it is also called as distributed ledger technology. Block chains can be used in different contexts like a ledger which stores different types of information. Block chains are used to transfer crypto currencies such as bitcoin by maintaining a database to record how every bitcoin is spent thereby tracking the digital objects. The ledgers are decentralized as the transactions are stored on large number of computers that are connected in a common network and each node maintains the transaction history that was carried out on the blocks of the block chain.

5G or fifth generation wireless cellular technology comes with 3 key features such as high speed, lower latency and ability to connect more devices simultaneously and promises a faster and efficient network. 5G includes latest technologies like cognitive radio, internet of things, nano technology and cloud computing. Machine to machine communications over wireless network on a larger scale can be enhanced using 5G technology.

IOT will enable interconnection of massive communication between heterogeneous smart objects. Most of the existing IOT and current mobile networks which are based on centralized models, the fact these models will face lot of challenges to meet the 5G requirements cannot be ignored. Block chain stands as a promising technology to address this issue and bridge the gap as it offers immutability, integrity and privacy features. Block chain integrated with 5G enabled IOT will definitely improve the features like scalability of heterogeneous applications, privacy issues, performance and other potential benefits such as optimized network resource

usage. This chapter will focus on to elaborate and emphasize the key aspects of block chain and 5G enabled IOT devices and applications.

The devices that require low power or produce high volumes of data transmission can easily be supported with the integration of these technologies. The convergence of block chain and 5G technologies with IoT applications will provide enterprise and retail customers, solutions enabled with immutability, security, smart automation, scalability. The accelerated rise in IOT devices and the emerging block chain technologies have forecasted that there will be 21 billion IOT devices online by 2025.

**Keywords:** Block chain, 5G Technology, IoT.

## Introduction

Blockchain is a decentralized database platform for storing blocks of transaction data linked together in chains[1], using peer-to-peer networking. Its high-level encryption provides greater protection from hacking and decentralization of data serves as a resistant to most security issues[2]. IoT is a network of sensor-enabled devices that can collect data, execute transactions or take actions based on a predetermined set of conditions and communicate via the internet[3]. IoT devices can send data to private blockchain ledgers for inclusion in shared transactions with tamper-resistant records. Business partners can access and supply IoT data without the need for central control and management with the help of blockchain. Each transaction can be verified to prevent disputes and ensure each party involved is held accountable for their roles. 5G is designed to connect virtually everyone[4] and everything together including machines, objects, and devices with high speed mobile network.

5G is expected to unleash a **massive IoT ecosystem**, with networks that can serve communication needs of billions of connected devices, with balanced trade-offs between speed, latency, and cost. The **latency rate** which is the delay between the sending and receiving of information is extremely **low**. IoT and 5G combined with the blockchain technology together have great potential. Connectivity cover for IoT devices and transactions are provided by 5G and the blockchain handles security by ensuring transaction data protection. 5G-motivated massive increase in adoption of smart devices, increases the volume of data to be handled by blockchain technology causing scalability issues. While 5G provides speed for IoT devices, integration with blockchain might actually result in slower processing of data and transactions. This is an anticipated challenge of infusing 5G and IoT with blockchain. Blockchain infused IoT applications will disrupt processes across variety of industries[5] including manufacturing, trading, shipping, education, financial sector and healthcare. security is a prior concern for the IoT ecosystem as it exposes multiple devices, huge amounts of data, supply chain partners and the community as a whole to security breaches.

## Blockhain Overview

A blockchain is defined as a distributed ledger of transactions, stored as immutable blocks that are connected to another to form a chain. The validity of the chain is been agreed upon by peers on a decentralized network secured by cryptography[6].

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Blockchain offers transparency, immutability, and security and has many features including being open, distributed, ledger, P2P and permanent. Blockchain term was first introduced in the white paper of Bitcoin in 2009 by Satoshi Nakamoto.

Let's take a look at some of the terminologies associated with a blockchain.

1.  *Node:* It refers to the client who owns the block and it contains the copy of the ledger operated by the participant of the blockchain network.
2.  *Transaction:* Transfer from A to B.
3.  *Block:* Bundle of Transactions linked and all the blocks are linked using their hash. Data cannot be changed in a block without breaking the chain.
4.  *Miners:* Burns energy to create blocks and gets rewarded by block reward and transaction fees.
5.  *Block reward:* New coins created with each block, goes to miners.
6.  *Transaction fees:* A small percentage of the transaction value which goes to the miner.
    1.2. Pillars of Blockchain Technology

The features of the blockchain which has made it very popular are[7]

- *Decentralization:* Information is not stored in a single computer but owned by all in the network
- *Transparency:* A Person's identity is hidden by complex cryptography and represented only by their public address.
- *Immutability:* The data entered in the blockchain cannot be changed or tampered.

## Overview of 5G

In telecommunications, 5G is the fifth generation technology standard which is meant to deliver high data speeds with low latency, increased network speed and availability. The cellular companies started deploying this since 2019. This will enable the future of the Internet of Things (IoT)[8]. 5G plays a crucial role as IoT is totally dependent on network devices that are more energy efficient, more reliable

and use a mobile network supporting a much higher device density. 5G technology will ensure the convergence of networks, technologies, applications and services, and can serve as a flexible platform.

*5G Mobile Network Layer Architecture*

| Application(Service) |
|---|
| Open Transport Protocol |
| Upper Network Layer |
| Lower Network Layer |
| Open Wireless Architecture |

**Fig. 1:** 5G Architecture

The open wireless architecture layer defines the wireless technology to be used (Physical and data link layer). Network layer is divided into upper and lower network layers used to route the data from source to destination. Open transport layer will perform the operation of transport layer and session layer. Application layer is responsible for providing the best quality of service by selecting the best wireless connection for a given service[8]. 5G uses Ultra wide band (UWB) networks with higher bandwidth of 4000 Mbps which is 400 times faster than the existing network speeds and uses smart antenna and CDMA(Code division multiple access).

*Features of 5G*

- High resolution for the mobile users
- Bi directional large bandwidth
- Enhanced and available connectivity
- High uploading and downloading speed.

*Applications of 5G*

- Autonomous vehicles
- Smart city and Traffic management
- Industrial automation
- Health care automation
- Augmented and virtual reality

## Blockchain Architecture

The important elements of a blockchain architecture are node – a computer with the complete copy of the blockchain ledger, block – a data structure that holds a set of transactions, and transaction - the smallest building block of a blockchain system

(records, information, etc.). The term blockchain was first described back in 1991[9]. A group of researchers wanted to create a tool to timestamp digital documents so that they could not be backdated or changed. Further, the technique was adapted and reinvented by Satoshi Nakamoto. The blockchain-based project called Bitcoin, the first cryptocurrency was created by Nakamoto in 2008.

In a distributed blockchain network, new entries are maintained, approved, and updated by each participant within the network[10]. The blockchain is represented by a list of transaction blocks in a particular order.

## Blockchain Categories

- *Public blockchain:* All participant of the Blockchain network can access both data and system. Bitcoin, Ethereum, and Litecoin are public blockchain systems. It is a pure decentralized technology.
- *Private blockchain:* Is controlled by a group of authorized users belonging to a specific organization or those who have an invitation to participate in the network. It depicts the behavior of a centralized system since it is administered and controlled by a select group of users.
- *Consortium blockchain:* consists of a group of organization and a selected user group who take control of the procedures that are set for the system.

## Blockchain Working
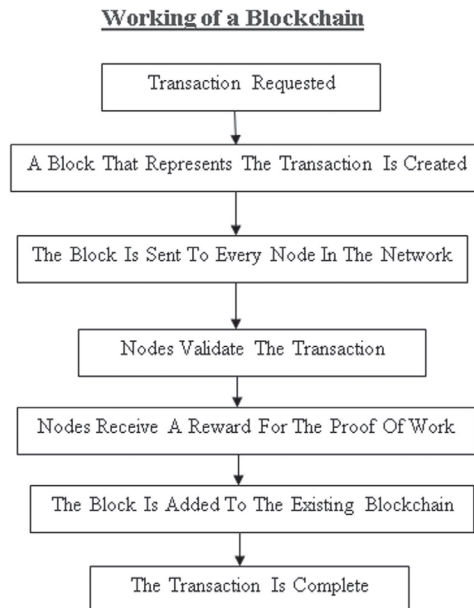


**Fig. 2:** Working of Blockchain

Each block in a blockchain consists of:

- *Data:* The data in a public block chain will contain information of the sender, receiver, and the number of coins. The block's data are influenced by the blockchain architecture.

- *The hash of the block:* A hash is a unique key constituting of digits and letters SHA256 – cryptographic hash algorithm is used to create each block. Once a block is created, a hash key is generated. Any changes made to the block will automatically alter its hash key. Thus block hash helps to detect any modifications made to a block the hash from the previous block- Apart from its unique hash key, a block must also contain the hash of the block immediately before it. It is this feature that helps create a connected chain in the architecture and is the main element behind blockchain security. Since all the validated blocks in a Blockchain are derived from the Genesis Block, any attempt to corrupt or violate a single block will create a chain reaction, promoting all the blocks to change. All changed blocks with incorrect information is forwarded, thereby rendering the whole Blockchain as invalid. However, changes can be made possible via the Consensus Algorithm. The Consensus Algorithm refers to the mechanism or protocol that ensures that the local copy of the Blockchain ledger possessed by individual members are consistent with each other and are updated to the latest version. Thus uniformity and synchronicity is maintained within the blockchain architecture.

## Key Characteristics of Blockchain

- *Cryptography:* Each Blockchain transaction is secured through complex cryptographic computations validated by all the stakeholders involved.
- *Decentralization:* Complete database can be accessed by each member of the Blockchain network.
- *Provenance:* Tracking and monitoring the origin of every transaction contained in the Blockchain ledger.
- *Immutability:* Once a transaction is recorded in a Blockchain, it cannot be deleted or altered without the consent of all parties involved.
- *Anonymity:* There is no specific identity for Each user in the blockchain network. They are assigned with an address generated by the system. Thus, enabling users to maintain their anonymity.
- *Transparency:* Since each member of the Blockchain can access the system and monitor the operations, there's complete transparency in the process. Altering one block would mean that the whole chain has to be changed, and this is highly unlikely to happen.

- *Complexity involved in IoT devices:* Deployments can be handled with a distributed ledger well suited to provide IoT device identification, authentication and seamless secure data transfer.
- IoT sensors can exchange data though a blockchain, eliminating the need for a third party to establishing trust.
- A distributed ledger within the IOT ecosystem removes a single source of failure, shielding device data from tampering.

## Overview of Major Enterprise Blockchains (Hyperledger, Ethereum)

**Public Vs Private blockchains:** Before discussing in detail about public and private blockchains The key similarities between public and private blockchains are as follows:

- Decentralized eco system and peer-to-peer network.
- A copy of the blokchain must be downloaded by every participating node in the network.
- Consensus protocols keep block chain updated and also guarantee immutability.

Open public blockchains have practical implementation difficulties for enterprise purposes as the openness of the public chains is itself a detriment and are not implementable to go forward for enterprises.

Private blockchain is not accessible for everyone and access permission for new participants in private block chain could be given by the following:

- The existing participants in the ecosystem.
- A regulated authority.
- A consortium.

These private blockchains are specifically designed for enterprise needs as they offer a wide array of features such as high performance, high resilience and privacy[11].

### The Enterprise Blockchain: Hyperledger and Ethereum

"Hyperledger hosted by The Linux Foundation[12], is an open source global collaborative effort created to escalate blockchain technologies by integrating leaders from different frontiers such as finance, banking, Internet of Things, supply chains, manufacturing, and Technology."

It's an environment where software developer communities and companies coordinate to build blockchain framework. Airbus and Daimler, IT-companies like

IBM, Fujitsu, SAP, Huawei, Nokia, Intel and Samsung, financial institutions like Deutsche Börse, American Express, J.P. Morgan, BBVA, BNP Paribas and Well Fargo, as well as Blockchain startups like Blockstream, Netki, Lykke, Factom, bloq and Consensys are the popular members of this group. Hyperledger plays the role of greenhouse for block chain as it brings together all developers, users, and vendors across the world under one platform. Each enterprise company having their special own requirements would want to customize it in their own way to meet their requirements. Hyperledger expects to develop and help develop blockchains with different features for every enterprise[13].

Hyperledger is a private and permissioned network[14], with a group of participants with network access permissions. Hyperledger allows nodes to choose between No-op (no consensus needed) and an agreement protocol (PBFT) whereby two or more parties influence the outcome, by agreeing on a key. Key choice cannot be forced on the agreeing parties by a third party. Hyperledger provides fine grained control over consensus and limited access to transactions resulting in enhanced performance scalability and privacy.

## Hyperledger Architecture

The hyperledger architecture has a design philosophy that includes a modular extensible approach, interoperability, security, and an easy-to use Application Programming Interface (API). The Hyperledger Architecture WG has distinguished the following business blockchain components[15]:

- *Consensus Layer:* Generates order agreement and esnures the correctness of the set of transactions that constitute a block.
- *Smart Contract Layer:* Processes transaction requests and determines transactions validity by executing business logic.
- *Communication Layer:* Transports peer-to-peer message among the nodes which participate in a shared ledger instance.
- *Data Store Abstraction:* Allows usage of different data-stores by other modules.
- *Crypto Abstraction:* Allows different crypto algorithms or modules to be swapped out without affecting other modules.
- *Identity Services:* Responsible for trust establishment during blockchain setup and the management of changes like drops, adds, and revocations. It also provides authentication and authorization.
- *Policy Services:* Manages endorsement policy, consensus policy, or group management policy which are specified in the system.

- *APIs:* Enables clients and applications to interface to blockchains.
- *Interoperation:* Enables the interoperation between different blockchain instances.

### *Benefits of Hyperledger*

1. *Enhanced Productivity:* Hyperledger enhances the productivity by adopting divison of of labor to improve project development by enabling people to work in the specific fields by identifying their expertise.
2. *Handling of Intellectual property:* The intellectual property is taken care by the greenhouse architecture and also makes us of Creative Commons Attribution 4. 0 International license and Apache 2. 0 license of code to protect intellectual property.
3. *Data on demand:* The data portioning on the blockchain helps in data privacy and the hyperledger supported channels allow data distribution to the entities which need the data.
4. *Performance, scalability and trust:* The modular architecture of hyperledger divides the transaction processing into three stages as distributed knowledge processing and agreement, transaction validation and commitment, and transaction ordering which enhances performance, scalability and levels of trust[16].

### *Ethereum*

Ethereum which was launched in 2015 is a global, open-source platform for decentralized applications. Ethereum is a programmable blockchain platform which allows anyone to code and control digital value, and can launch new types of applications. Its native cryptocurrency called Ether (ETH), is a digital money and can be sent to anyone anywhere in the world instantly. ETH is used by people all over the world to make payments, as a store of value, or as collateral.

These decentralized applications (or "dapps") run without any downtime, fraud, control, or interference from a third party. The Ethereum community constitutes core protocol developers, cryptoeconomic researchers, artists, cypherpunks, mining organizations, ETH holders, gamers, app developers, anarchists and it is controlled by a centralized organization but maintained and improved over time by a diverse global community of contributors.

Ethereum can be either public or private network and anyone can participate without any access permissions by reaching on a consensus over all the transactions irrespective of whether a node takes part in a particular transaction or not. It is

established by mining mechanism based on the Proof-of-Work (PoW) algorithm. The Ethereum nodes will agree upon a common ledger with access to all the ledger entries. Contract oriented language called Solidity is used to develop smart contracts in Ethereum. Development languages include Golang, C++ and Python.

*Ethereum Architecture*
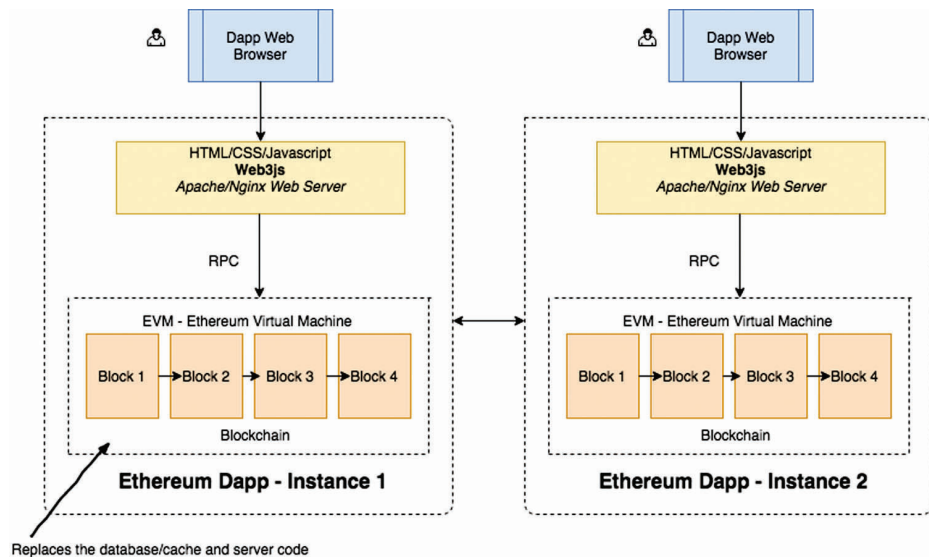


**Fig. 3:** Ethereum Architecture

The browser communicates with its instance without any central server. Every person who wants to interact with a dapp (decentralized application) will require a full copy of the blockchain executing on their computers or smartphones and hence the application can be used only after downloading the entire blockchain.

The Ethereum blockchain has 2 main components:

1. *Database:* All the transactions in the network are stored in the blockchain database. For example in a voting application, a vote of every candidate is stored as a transaction. The same copy of the data is made available to all the networks by ensuring no invalid data is written in the database by using an algorithm called Proof of Work.

2. *Code:* The database stores the transactions which are made functional by the code part by using logic/application using a language called as solidity which is compiled by solidity compiler into Ethereum byte code and deployed into blockchain. The Ethereum blockchain stores the data and code and executes the code in EVM(Ethereum Virtual Machine).[17]

*Benefits of Ethereum*

The decentralized apps and DAOs installed in Ethereum platform deployed within the network can't be accessed by any third party at all[18] thus eliminating fraud and corruption as the network is tamper-proof. The decentralized platform is decentralized, ensures no single point of failure thus making all apps active all time. This also prevents the network from any hacking or fraudulent activities.

## Verticals of Block Chains—Finance, Healthcare, Education, Transportation

The occurrence of a single point of failure can interrupt the flow of goods/process and can cause total systemic failure. The impact of points of failure in the value chain must be limited by making the data available through digital means. In the current COVID-19 pandemic, governments and businesses with strong digital infrastructure and enabling regulations such e-signature and e-transactions laws, are dealing with the supply chain disruptions much better than those without. On the basis of vertical, Banking, Financial Services, healthcare, education and transportation accounted for the largest share of the global blockchain market. The major factors contributing to market growth are the growing need to simplify financial transactions, increasing demand to minimize fraud and rising interest of companies to adopt blockchain.

### Blockchain in Finance

One of the major use of Blockchain technology is to administer trade finance transactions for banks. The blockchain, distributed ledger technology (DLT), has the potential to transform well-established financial institutions and bring lower costs, faster transactions, improved transparency, auditability of operations, and other benefits[19]. Massive duplication of information that creates delays, conflicts and confusion in many aspects of financial services would be reduced by this technology.

*Blockchain Use Cases in Financial Services*

| Capital markets | Asset Management | Banking & Lending |
|---|---|---|
| 1. Insurance | 1. Fund launch | 1. Credit prediction & Scoring |
| 2. Sales and Trading | 2. Fund Administration | 2. Loan Disbursement |
| 3. Asset Servicing | | |
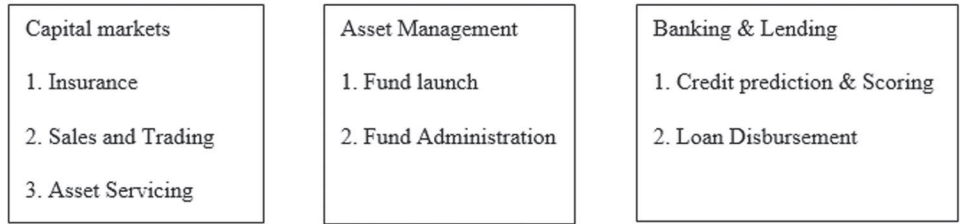
**Fig. 4:** Blockchain use cases in finance

## Blockchain in Healthcare Sector

Blockchain has wide range of applications and uses in healthcare domain. The ledger technology enables secure transfer of medical records of patient, manages medicine supply chain and assist healthcare researchers unlock genetic code. It will enhance medical record management, insurance claim process, improve clinical and biomedical research, and advance biomedical and healthcare data ledger. These benefits ar attributed to blockchain technology features, such as decentralized management, immutable audit trail, data provenance, robustness, and improved security and privacy[20].

In 2012, Estonia, a country that has great potential for blockchain healthcare, started to use blockchain technology[22] to protect health data and process transactions. Now all of the healthcare billing is done on a blockchain, 95% of health data is ledger-based, and 99% of all drug data is digital.

### *Blockchain Use Cases in Healthcare Sector*
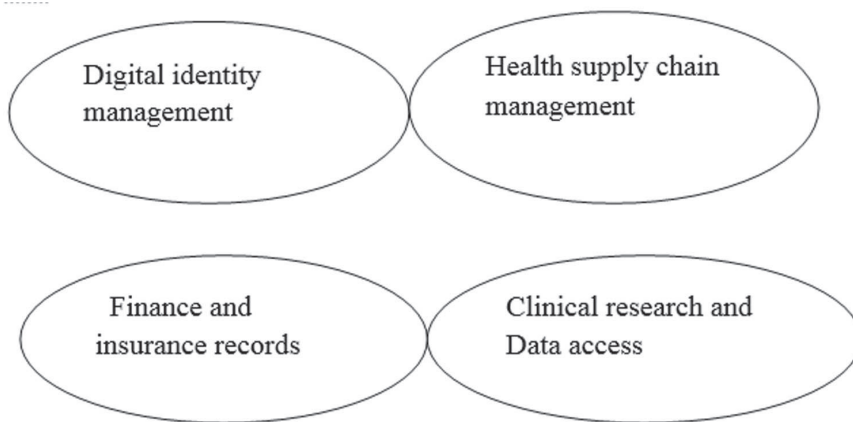


**Fig. 5:** Blockchain use cases in health care

Digital identity management is for identity management of patients, participants, unique device identifiers in the health supply chain. Health care financials, insurance aligns the needs and challenges to handle escalating cost of healthcare. Clinical data sharing helps the research participation to explore new discoveries.

## Blockchain in Education

In the years to come, the blockchain will become an important part of the education market. It would be a great tool for saving, monitoring and using the credentials

of students. Blockchain diplomas enable learners to view their records easily and conveniently and to share this information with potential employers.

Not only does Blockchain act as transparent record storage, but it will also include an entire sharing and communication network. During the course of their studies, universities and colleges want to ensure that students have a successful experience. For instance, the Education Ecosystem network, is one of the first project to link educators, learners, developers and content creators using block chain which can be used by colleges and schools to access study materials and share their projects and ideas[23].

Blockchain has the potential to be the backbone of educational data, giving the credibility of the CV of the applicant to employers. Crucially, the credentials required to get into a dream job can be determined by this technology. Using Blockcerts Wallet to obtain and exchange official certificates, a wide range of institutions such as government agencies, universities and employers allow graduates to securely share a verifiable and tamper-proof digital version of their diplomas with prospective employers and other institutions. Instant verification of academic records is provided by emerging universities offering digital certificates through blockchain or new educational companies like Gradbase.

Blockchain applications use smart contract to provide students with the capacity to gain greater control over their education by offering flexible access to content and courses suggested based on previous successes or failures and attainment, thus pave way for Smart learning. Having a fool proof system that documents the academic history of a student before and during a working life can not only assist in fighting dishonesty, but can also help solve the problems of personalised learning. In 2017, the University of Melbourne started using blockchain to issue digital credentials[25], enabling students to share verified copies of their qualifications with employers and other third parties in a tamper proof system.

### Blockchain Use Cases in Education

- Transcripts, Diplomas, Certifications
- Security and File Storage
- Publishing

## Blockchain in Supply Chain and Fintech Sectors

### Blockchain Enabled Supply Chain Management

Supplychains can be made more efficient and transparent when implemented using blockchain as it can highly influence everything from warehousing to delivery to

payment. Product tracking in supply chain using blockchain reduces the overall cost of moving items in a supply chain. Payments can be processed by customers and suppliers within the supply chain by using cryptocurrencies. Blockchains in supply chain eliminate duplicative and error prone transactions thereby helping to create digital identity.

The elements of blockchain that affect supply chain management are

- *Scalability:* Blockchain scales well by providing a networked and decentralized database for all supply chain parties to join. The supply chain data is recorded on a ledger, shared among all participating network peers and conceals any single point of failure in the network.
- *Performance:* The majority activities of blockchain can be represented as electronic transactions submitted on the ledger and hence they execute faster and without errors increasing system performance. A smart contract can be invoked to do automatic pay to the exact amount within a short span of time independent of their geo-location to the consumers. Data validation and integration attributes are built in block chains in contrast to the traditional systems. The digital signatures of a recipient party are automatically and verified during a freight's journey, thereby accelerating performance and decreasing system's workload.
- *Privacy:* Blockchains ensures privacy and makes the information immutable. Public blockchains offers pseudonymity to its users thereby enabling every user to communicate with the ledger through a newly created address without negotiating the real identity.
- *Location:* The functionalities and attributes offered by blockchain are independent of the geo-location of its users. Thus, a blockchain enables supply chain global as stakeholders and companies from inconvenient-to-do-business parts of the globe could participate to render services.
- *Cost:* Block chain provides economic solution for supply chain by reducing cost in a supply chain system with crytpcurrency technology[26].

## How Blockchain Expedites Fintech Adoption

Blockchain streamlines various complicated processes obstructing the adoption of Fintech by drastically reducing settlement times, providing secured global currency exchange speeds, and increasing transaction speed. Blockchain is very reliable in correcting the inefficiencies in most banks' back-office set-ups notably in procedures like clearing and settlement, and has significantly reduced fraud and cyber attack in the financial world. Blockchain helps in curbing data breaking and other comparable fraudulent operations to enable fintech businesses to share or transfer safe and unaltered information through a decentralised network[27].

Benefits of using blockchain in Fintech include

- Faster syndicate formation
- Digitization of documents
- Quicker KYC for clients
- Security
- Document immutability
- Fund raising

## Introduction to 5G

5G Technology stands for 5th Generation Mobile technology which has made drastic changes in the ways of mobile phones usage with a very high bandwidth what the users have never experienced ever before. 5G comprises the enhancement of various key wireless communication technology standards[28]. The expansion involves both technological advancement and social interaction. An user can also connect their 5G technology mobile phone with their Laptop to get broadband internet access. 5G technology including camera, MP3 recording, video player, large phone memory, dialing speed, audio player which will have a tremendous impact on its usage. The major features of 5G, include extraordinary data capabilities, ability to integrate unrestricted call volumes and infinite data broadcast within latest mobile operating system. High connectivity is possible through the Router and switch technology used in 5G network, which distributes internet access to nodes within the building and can be deployed with union of wired or wireless network connections[29]. 5G is designed to be used in a range of application scenarios[30]. These scenarios have severe heterogeneous needs that will be achieved by enrichments on the radio access network and a set of advanced wireless technologies. 5G radio access and core networks will be created on an SDN/NFV infrastructure capable of coordinating resources and managing the network in order to deliver network services competently and in a compliant and scalable manner[28].

### Functional Architecture of 5G

Research and advancement activities on 5G technologies have invited lots of attention in both academia and industry worldwide over the last several years. The 5G technology is being seen as consumer-centric concept instead of operational-centric as in 3G and service-centric as seen for 4G. Instead of being more accessible and adaptable, 5G networks are not based on routing and switching technologies, and would be able to evolve more effortlessly than conventional networks. 5G can allow convergent network connectivity through multi-technology networks

and helps to communicate with satellite systems, wireless networks, clouds, data centres, home gateways and many more open networks and devices via an open communication framework. In order to handle application-driven networks in active and versatile settings, 5G systems would be self-sufficient and sufficiently capable of modifying their behaviour that differs under user conditions. Protection, stability, robustness and data integrity will therefore be one of the core needs of future networks[31].
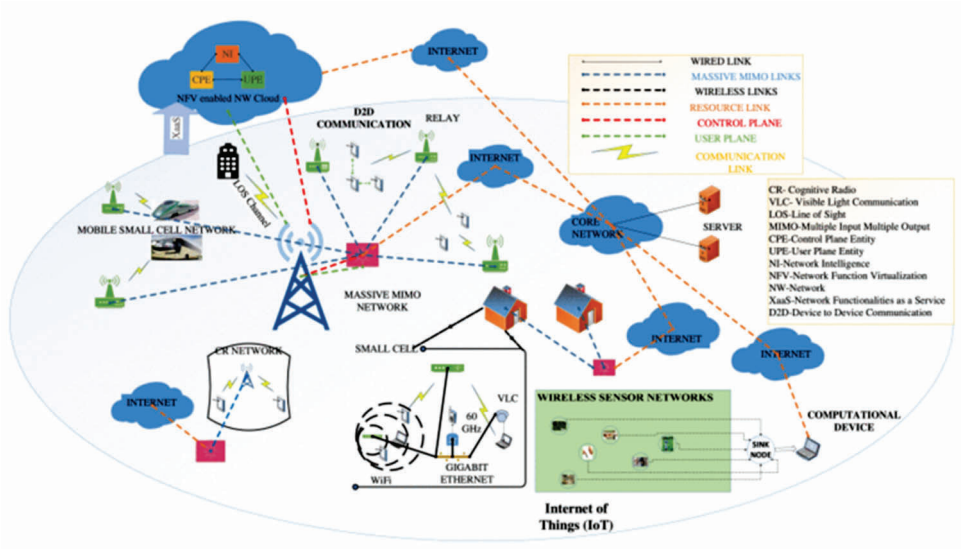


**Fig. 6:** 5G enabled IoT
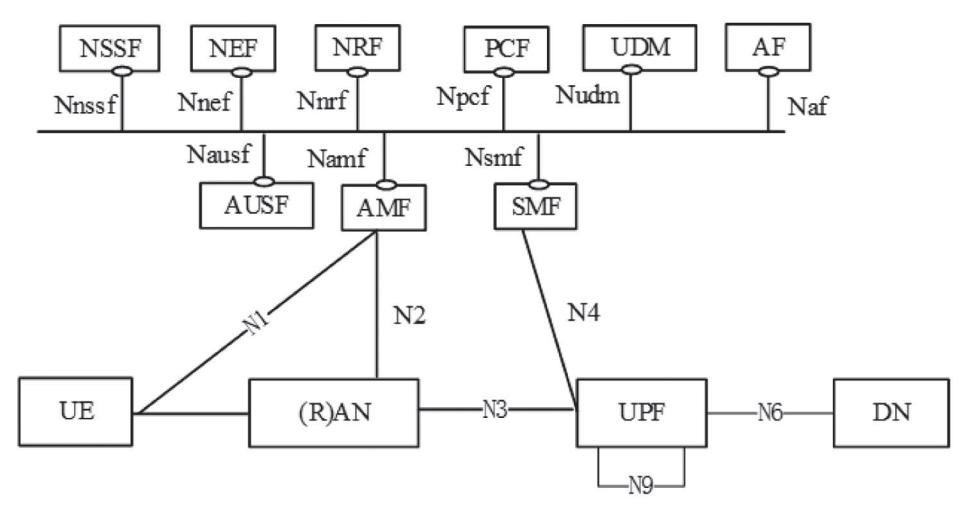


**Fig. 7:** Functional Architecture of 5G

The actual end-device is consumer equipment (UE):

(Radio) Access Network ((R)AN)-can be made up of various technologies; the gNB is the next generation 5G-specific radio controller and transceiver;

Its primary functions are Intercell Radio Resource Management, Resource Block Control, Radio Entry and Link Mobility, Dynamic Resource Allocation (Scheduler), and Measurement Configuration and Provisioning.[2]

Access and Mobility Management Function (AMF), User Plane Function (UPF), and Session Management Function are the 5G Core segment components of the new network (SMF).

User Plane Function (UPF) provides packet routing, forwarding, and inspection; it is the mobility management newscaster point, and it is the client plane portion of the implementation of policy rules, among other roles; Mobility Anchoring and PDU Handling are therefore the main functions of UPF.

Access and Mobility Management Feature (AMF), which provides access authorization and authentication functions, manages mobility, registration, connections and accessibility, is the end point for non-access stratum ciphering and integrity protection. NAS Defense and Idle State Mobility Handling are thus the basic functions of AMF.

The Session Management Function (SMF) is responsible for various session-related control features, including tunnel maintenance, as well as session creation, alteration, and release. Thus, UE IP Address Allocation and PDU Session Control are important functions of the SPF.

Operator services, Internet connectivity and 3rd party services are offered by the Data Network (DN).

AUSF (Authentication Server Function) encourages 3GPP access authentication and untrusted non-3GPP access;

The Network Slice Selection Feature (NSSF) selects the slice commands to serve the UE and determines the Network Slice Selection Assistance Information (NSSAI) relevant information;

The Network Exposure Function (NEF) takes care of features such as the coverage of facilities and activities, the secure provision of data from outside applications and the translation of internal-external communication.

Network Repository Role (NRF): validates the function of service discovery and provides the profile of the network function;

The Policy Control Function (PCF) provides a single policy structure for regulating the conduct of the network and making policy decisions.

Unified Data Management (UDM) is responsible for managing user information for many services, including access authorization, development of authentication credentials, handling of user identity, subscription management, SMS management, etc.

Application Feature (AF)-relates to the challenging core network to provide services such as application effects on traffic routing or policy management system collaborations[30].

## Features of 5G

- *Low Latency:* Latency is a calculation of how long a signal takes, and then back again, to go from its source to its receiver. One of the main objectives for each wireless generation is to reduce latency. With round-trip data transmission taking less than five milliseconds, modern 5G networks would provide even lower latency than 4G LTE. The 15G latency would be quicker than human visual processing, enabling devices to be managed remotely in near real time. This 5G functionality is useful for agriculture, production and logistics.
- *Enhanced Capacity:* 5G will deliver up to 1, 000x more capacity than 4G and give tremendous support for IoT development. 5G and IoT combination will redefine wireless networks and the internet usage. Smart homes and cities will emerge big in the future of 5G.
- *Increased Bandwidth:* The combination of improved speed and network bandwidth on 5G networks would build the opportunity for transmission of greater volumes of data than 4G LTE networks have been able to do. This helps to maximise network traffic and to control spikes in use. For companies, the effect of increased bandwidth in the form of big data would have a higher impact in multiple departments and divisions. Today, more data is obtained from clients, suppliers, and teams by businesses than they can process and analyse for insights. These companies will turn vast amounts of data into actionable knowledge with 5G access and big data analytics[32].

## Advantages and Disadvantages of 5G

5G technology allows improved number of connections, Low Latency and High Throughput.

The drawback of 5G is several older user devices would be incompetent to work under 5G, high cost to be invested in expanding infrastructure, Security and privacy issues to be guaranteed.

## Applications of 5G

5G is a new paradigm. Delivering Enhanced Mobile Broadband (eMBB), Ultra-Reliable and Low-Latency Communication (URLLC) and Massive Machine-Type Communication (mMTC), 5G applications represent tremendous opportunities for consumers, homes, businesses and communities. 5G is expected to generate USD 12 trillion in revenues in 2035. 80% of telecom revenues generated through broadband, equipment and value-added services will be linked to 5G in the future. 5G helps in increasing access and lowering the cost of essential services, such as healthcare and education. By expanding the scope of wireless technologies and making devices more autonomous, 5G will help to reduce our carbon footprint and conserve natural resources. Last, economic growth will boost direct and indirect employment in all economies.

Community applications include connection of billions of devices for smart cities, smart schools and smart homes, smart and safer vehicles, enhance health care and education, and provide a safer and more efficient place to live.

Businesses and Industry application, 5G and IoT will provide a wealth of data allowing Businesses to operate and make key decisions driven by data, innovate in agriculture, smart farms and manufacturing, paving the way for cost savings, better customer experience and long term growth.

Emerging new technologies such as virtual and augmented reality will be accessible to everyone. With VR we can travel to favourite city, watch a live football match like being at the ground, inspect real estate and walk through a new home all from comfort zone.

New 5G applications are emerging, supported by national strategies[36]:

Telecom 5G for home (e.g. Fixed Wireless Access) and mobile, Healthcare (e.g. telemedicine), education, autonomous driving, Media AR/VR gaming

## IoT Overview

IoT is an ecosystem of things, sensors, devices, people connected through network connectivity to enable communication via data and information exchange which can be intelligently analysed to automate decision making. The term IoT was firstly proposed by Kevin Ashton in 1999. The Internet of Things, or "IoT" is about extending the power of the internet beyond computers and smartphones to our environment. It is the physical object network that allows these objects to collect and share data with computers, instruments, cars, buildings and objects integrated with electronics, circuits, software, sensors and network communication. It allows objects to be sensed and controlled remotely across existing network infrastructure,

creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency and accuracy.

## Seven Essential IoT Characteristics[38]

1. **Connectivity:** With everything going on in IoT devices, hardware, sensors, electronics and control systems there needs to be a connection between various levels. Four common communications models include: Device-to-Device, Device-to-Cloud, Device-to-Gateway, and Back-End Data-Sharing. These models indicate the flexible ways through which IoT devices can connect and provide value to the user.
2. **Things:** Anything that can be tagged or connected as in an IoT Ecosystem.
3. **Data:** The first step towards action and intelligence, is data. Data is the main component of the Internet of Things.
4. **Communication:** Devices get connected so they can communicate data and this data can be analyzed to take appropriate decisions. Communication can occur over short distances or over a long range to very long range.
5. **Intelligence:** The aspect of intelligence relies on the sensing capabilities in IoT devices and the intelligence gathered from big data analytics as well as artificial intelligence.
6. **Action:** Action is the result of intelligence. Actions are taken based on the decisions.
7. **Ecosystem:** The place of the Internet of Things from a perspective of other technologies, communities, goals and the picture in which the Internet of Things fits.

## Features of Internet of Things (IoT)[39]

1. *Connectivity:* Connectivity is the most relevant feature. It is not possible to conduct a proper business use case without coordination between the interrelated components of the IoT ecosystems.
2. Electrochemistry, gyroscope, vibration, light sensors, GPS, pressure, RFID, etc. are used by the IoT to collect data based on a specific problem. A proper choice on sensing paradigm is to be made in order to make use case efficient.
3. *Active Engagements:* The IoT framework links different goods, cross-platform technologies and services that work together by creating an active relationship with them. In blockchain, cloud computing is used to create successful IoT component interaction.
4. *Scale:* IoT devices should be configured on demand to quickly be scaled up or down.

5. *Dynamic Design:* In order to allow business decision-making, data must be collected and transformed. Various IoT components need to dynamically alter their state based on ecosystem change.

6. *Intelligence:* Data is used to create significant business insights and drive significant business decisions. With the enormous data available to obtain useful insights, machine learning/deep learning models are developed. Proper data architecture must always be adopted on the basis of business needs.

7. *Energy:* The IoT systems need a great deal of energy from end components to networking and layers of analytics. It is important to choose a design methodology with minimal energy consumption.

8. *Protection:* Security is one of the IoT ecosystem's key features as sensitive information is transferred through communication components from endpoints to the analytics layer. In order to keep the data away from misuse and abuse, an IoT device design must adhere to proper protection, safety measures, and firewalls.

9. *Integration:* To enrich user experience by ensuring proper trade-off between infrastructure and operating costs, IoT incorporates various cross-domain models.

## How IoT Works

A Complete IoT system is an integration of four distinct components:

- *Sensors/Devices:* Collect data from their environment. The data can be a simple temperature reading or a complex full video feed. sensors/devices are used because multiple sensors can be bundled together or sensors can be part of a device. For example, a smart phone is a device that has multiple sensors (camera, accelerometer, GPS, etc), but the phone is not just a sensor since it can also perform many actions.

- *Connectivity:* The collected data is sent to the cloud, through a variety of methods including cellular, satellite, WiFi, Bluetooth, low-power wide-area networks (LPWAN), connecting via a gateway/router or connecting directly to the internet via ethernet.

- *Data processing:* The data in the cloud is processed by the software. This could be very simple, such as the temperature reading check is within an acceptable range.

- *User interface:* Processed data is somehow made useful to the end-user. This can be a user warning to the (email, text, notification, etc). For example, a text warning in the company's cold storage when the temperature is too high.

A consumer may have an app that allows them to check in on the system proactively.

## IoT Architecture
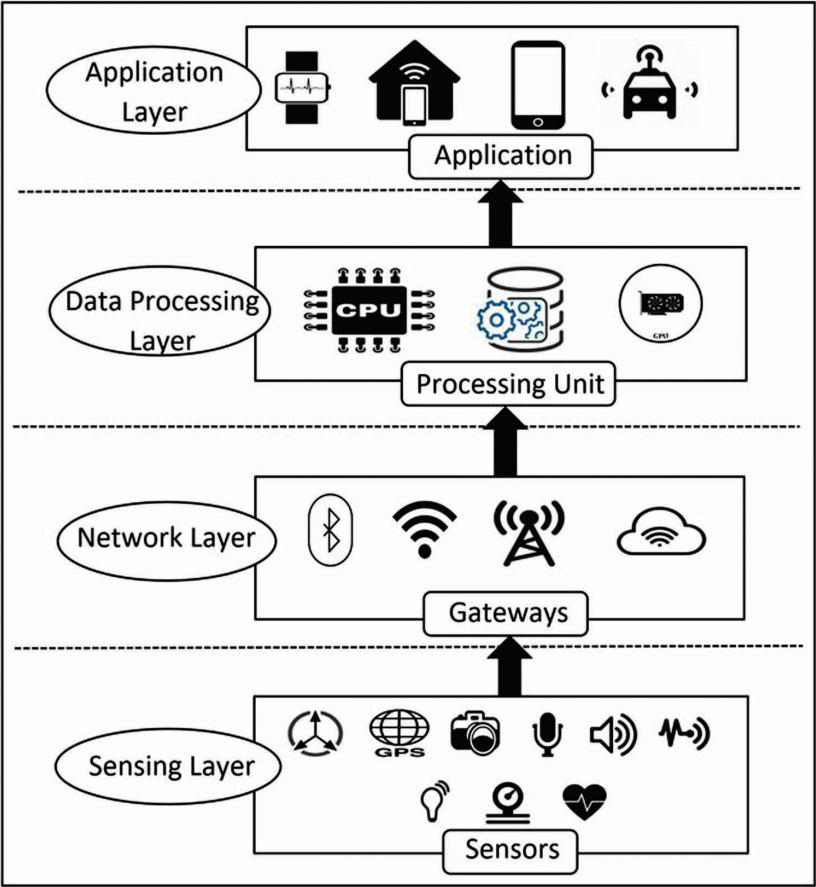


**Fig. 8:** IoT Architecture

The architecture of the IoT framework must guarantee IoT operations, linking the physical and virtual worlds. The three main factors involved in the networking, connectivity, methods, etc. of IoT Design architecture Extensibility, scalability, and operability are the three key features to be considered among the devices when designing the IoT architecture.

The smart systems on tags or sensors in the sensing layer are able to automatically sense the environment and share data between devices. Things can be individually defined and it is possible to track the surrounding environments for different purposes and applications. The Universal Unique Identifier (UUID)

is used to assign an object's unique identity. Names and addresses can be included in the identifiers. A UUID is a 128-bit number which is used on the Internet to uniquely identify any object or person.

The IoT network layer links all objects across the network layer and enables them to be aware of their environment and to exchange data with the related things, which is important for IoT intelligent event management and processing. Apart from data sharing, the network can also automatically discover and map stuff. The following problems should be resolved by the network layer: Network management technologies for fixed and wireless networks

- Data searching and preprocessing technologies
- Security
- Privacy

The service layer allows for IoT services and applications. It is a cost efficient platform where it is possible to reuse software and hardware. Services operate directly on the network in the service layer to quickly identify new services for an application and to automatically retrieve data about services. A minimum set of software, application programming interfaces (APIs) and protocols supporting the appropriate applications and services are included in the ideal service layer[40].

The functions of service layer includes

1. *Service discovery:* Find objects that can provide required service.
2. *Service composition:* Enable the interaction between connected things.
3. *Service APIs:* Provide interface between services required by users.

A large number of devices belonging to various individuals are linked to the interface layer and therefore do not necessarily mean the same standards. Compatibility requires the sharing of information, communication and processing of events, which is necessary for interaction between the IoT network participants. In the application frontend or API (Application Program Interface), the interface layer functions to simplify management and interconnection of items.

## Key IoT Issue Areas[41]

**Security:** Poorly secured IoT devices and services can serve as potential cyber-attack entry points and expose user data to exploitation by leaving insufficiently protected data streams. It affects the protection and resilience of the Internet globally, as it is linked online. During the large deployment of homogeneous IoT devices, this problem is multiplied by the ability of some devices to automatically attach to other devices, and the possibility of fielding these devices in unsecure environments.

**Privacy:** While IoT data and user specificity is amazing and exclusive to IoT users, privacy concerns and potential harms can act as an obstacle to full Internet of Things adoption. To maintain consumer interest and trust in the Internet, connected devices and related services, privacy rights and compliance with user privacy standards are important.

**Interoperability/Standards:** Full interoperability across products and services is not always feasible, purchasers may be hesitant to buy IoT products and services if there is integration inflexibility, high ownership complexity, and concern over vendor lock-in. The use of generic, open, and widely available standards as technical building blocks for IoT devices and services will support greater user benefits, innovation, and economic opportunity.

**Legal, Regulatory and Rights:** The usage of IoT devices poses many new legislative and legal concerns as well as amplifies the Internet's current legal issues. When IoT devices gather data about individuals in one jurisdiction and move it to another jurisdiction with different data protection rules, the key problem is the handling of cross-border data flow problems. Other legal concerns include contradictions between surveillance by law enforcement and human rights; plans for data preservation and destruction; and legal responsibility for unintended uses, breaches of security or lapses in privacy.

**Economy and Development:** The IoT holds significant promise for delivering social and economic benefits to emerging and developing economies. This includes areas such as sustainable agriculture, water quality and use, healthcare, industrialization, and environmental management etc.

## IoT Applications

### Wearables

Wearable technology is a trademark of IoT applications[42] and is one of the earliest industries to have deployed the IoT at its service. Wearables include Fit Bits, heart rate monitors and smartwatches/. The Guardian glucose monitoring unit, which can benefit people suffering from diabetes, is among the lesser-known wearables.

### Smart Home Applications

Smart homes allow all your home appliances to be controlled from one location[43]. An example of smart home devices is the use of a surveillance camera under the IoT facility to deter burglary and theft.

### Health Care

IoT technologies may transform a reactive medical-based system into proactive wellness-based systems. Through research, real-time field data, and testing, IoT opens pathways to a sea of useful data. Fitness trackers help you control your everyday activities, such as sleeping habits, heart rate, exercise patterns, workout numbers, burned calories, etc.

### Smart Cities

Smart City improves urban infrastructure by converting them more efficient, cheaper and better to live in. The sectors such as Government services, transport and traffic management, energy, health care, water, innovative urban agriculture, and waste management will benefit from smart city.

### Industrial Automation

Industrial Automation is one of the areas where the critical factors for a greater Return on Investment are both faster advances and the quality of goods. With IoT, products and their packaging may also be re-engineered to achieve better efficiency in both cost and consumer experience. IoT plays a major role in domains such as Factory Digitalization, Product flow Monitoring, Inventory Management, Safety and Security, Quality Control, Packaging optimization, Logistics and Supply Chain Optimization.

## Advantages of Using Blockchain in IoT

There are several paybacks that can be obtained by building smart machines able to communicate and function via blockchain. It is much simpler and easier to track data or physical products and switch between points in the supply chain by combining blockchain technology with IoT. Apart from this, building trust, reducing risk with superior security, reducing costs, and acceleration of transaction are other perks to take into account.
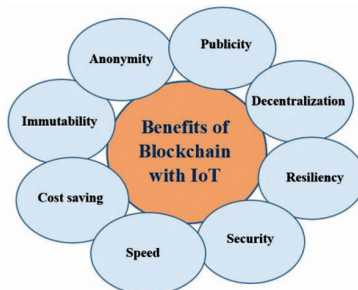


**Fig. 9:** Benefits of Blockchain with IoT[45]

Blockchain can address the two important challenges faced by IoT such as security and privacy. The increasing security concern of the IoT technology adopters is resolved by integrating it with blockchain which has got robust encryption standards and ensures much needed layer of the security in the IoT stack. This prevents any entity or malignant user from intruding as they have to bypass this security layer to access IoT devices or data. Privacy is another primary concern when blockchain is integrated with IoT.

Both participants can see all transactions and blocks that engage in the blockchain, as every participant has its own ledger. The transaction content is secured by the private key of the participant, so they are protected even though all the participants can see them.

Since most of the network members have to reach an agreement to confirm a transaction, the decentralisation aspect of blockchain brings about a huge amount of confidence. The blockchain would therefore provide IoT devices with a stable network by removing centralised traffic flows and the existing centralised IoT architecture's single point of failure. The blockchain's robust nature is the ability to withstand any attack. Even though one node is compromised, any other node that has a copy of data and information would preserve the blockchain.

## Impact of Blockchain and 5g/IoT on Supplychains

Without upgrading the telecommunication infrastructure, the development and adoption of some blockchain solutions involving logistics will be limited to pilots and other deployments at reduced scale. Blockchain technology is exceptionally well-suited for reacting to both the challenges and opportunities of a 5G-enabled IoT. With a secure 5G/IoT network, supply chains can leverage the integrity of a blockchain's logs (or ledger), which, when properly implemented, are nearly impossible to alter.

The use of 5G power-integrated blockchain technology would not only help to save running costs of businesses and also future litigation bills resulting from conflicts that could have been avoided by the use of smart contracts. The supply chain process is streamlined by smart contract and facilitate automatic payment of goods upon receipt and remove the need to deal with receivables from accounts.

The blockchain integrated 5G/IoT will have the following features:

1. **Trust building:** One of the most critical criteria in most industries is the establishment of trust. As the trust members of the regulatory concepts in effect, smart contracts are recognisable. It is possible to describe smart contracts as software codes that implement regulatory requirements and make them accessible transparently.

2. **Lowcost:** The operating costs can be decreased in different ways. The data transmission overheads for the request round trips to the centralised nodes such as cloud instances in the centralised systems can be removed. In every IoT-based device, including 5G-connected systems, efficient data use is a critical necessity.

3. **Improved security:** Security is improved by hashing and extending digital signatures to the individual transaction. In addition, to maintain clear integrity across the network, the Blockchain system uses cryptographic techniques such as Merkle trees.

4. **Accountability:** One of the main benefits of Blockchain-based smart contracts is accountability. The distributed ledger offers the ability to record logged events transparently and the ledger is secured by the use of digital signatures against alterations.

## Use Cases of Blockchain with 5G Enabled IoT

5G next generation of mobile networks, promises drastic performance improvements as well as creation of new value chain. The Internet of Things (IoT) has also evolved in tandem with 5G as well as a modern model for the interconnection of heterogeneous smart devices capable of massive communication. 5G is envisaged to broaden IoT's scope and fields of applicability. The integration of Blockchain with 5G and IoT still needs important insights in terms of specific application domains, scalability, privacy issues, performance and potential financial benefits.
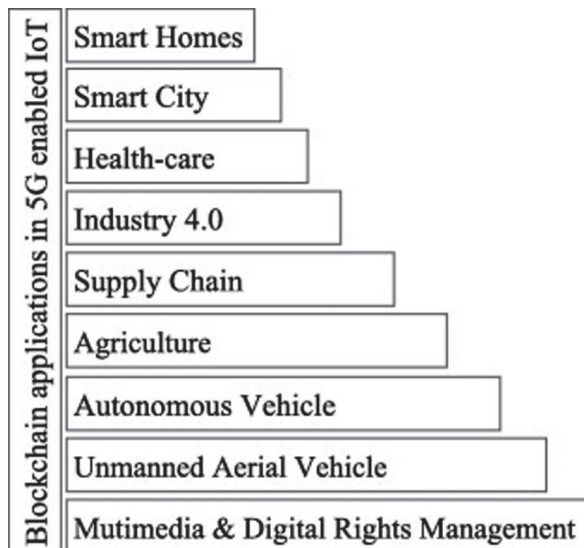


**Fig. 10:** Blockchain with 5G Enabled IoT use cases

**Smart Home:** The smart homes automate the entire home environment by providing services such as smart home monitoring, remote accessing and energy optimization, of home appliances and devices, surveillance of home and so on

**Smart City:** Smart cities utilize advanced modern techniques in the urbanization to improve the quality of human life. Services such as payments, e-Governance, security, and surveillance of the smart cities is enabled through blockchain technology.

**Healthcare:** Medical Healthcare demands monitoring patient data for detecting symptoms leading to early diagnosis, healthcare data access control and sharing securely medical documents for treatments and research.

**Industrial IoT:** The way industrial production, supervision, resource management, etc, are carried out can be revolutionized by IIoT. Use cases such as smart manufacturing, automated maintenance, warehousing, etc., can be made secure with blockchain.

**Asset tracking and Remote Monitoring:** Asset tracking focuses on monitoring the location and distribution of assets[47] and people over large areas, such as people tracking and goods in transit. Together with remote monitoring, asset tracking gathers assets data and uses it to enable automatic alerts and actions, such as remote diagnostics, maintenance requests and other operational processes.

**Smart Agriculture:** Smart Agriculture increase the agricultural productivity while minimizing cost, requires continuous ambient parameter acquisition, smart aggregation and processing of large volume of data, can be possible by combining blockchain with 5G enabled IoT. The combined technology enables the lifecycle transparency, autonomous management and establish regulatory requirements of agri foods.

**Autonomous Vehicles:** Fully automated vehicles require accurate sensing and processing with ultra low latency a boon of 5G supported IoT. Services such as secure and personalized ambient in electric vehicles, automated toll calculation can be possible through blockchain.

**UAV (Unmanned Aerial Vehicle):** UAVs have enormous potential in enabling new applications in military, commercial, government sectors, security, medicine and surveillance to traffic-monitoring applications.[48] Environmental monitoring applications in civilian sector include pollution, health of plants, and industrial accident monitoring. When disaster or attack takes place Military and governmental areas, have surveillance and delivery applications that provide real time information at locations after attack and can help with search and rescue missions, distribute

medicine and other essential items. Commercial applications deliver goods in urban and rural areas.

**AR/VR:** The interactivity, the experience of immersiveness[49] and practical application of Augmented Reality(AR)/Virtual Reality(VR) can be enhanced by combining 5G and IoT. This technonogy when combined with blockchain can revolutionize business processes and enhance gaming and entertainment activities.

**Energy Conservation:** Huge potential energy savings, for all currently unconnected, energy-consuming devices via 5G IoT grid connections, are possible and will facilitate better energy management. 5G and smart grid technologies can assist with early diagnosis, improve repairs, and decrease downtime when outages occur. When no one is around, smart lighting technology dims street lights.

## Challenges of Integrating Blockchain with 5G Enabled IoT

This section focuses on the challenges that may hinder the integration of blockchain with 5G enabled IoT. Limitations and challenges faced when integrating blockchain technology to 5G enabled IoT are energy consumption, scalability, slower data transaction, lack of standardization, low storage capacity and computational power. Heterogeneous networks need support for security principles, such as authentication, control of access, protection of data, confidentiality, prevention of cyber-attacks and a high level of authorization.

1. **Scalability:** The latency rate for payload and transmitted data is less than 1 millisecond which necessitates the requirement of configuration and setup transactions at a very high rate of throughput.

2. **Storage capacity:** Blockchain technology's primary requirement is the continuous storage of transactions and blocks[49]. The emerging device-scaling transactions need substantial storage in the IoT ecosystem, which will affect the functionality of the entire system.

3. **Processing Power and Time:** There are few cryptographic operations in the Blockchain ecosystem for computational-resource-intensive activities such as transaction verification and block creation. Because of the resource-limited existence of the IoT and some computer limitations, security threats will arise.

4. **Security:** In every device, integrity, availability and access control are the key security issues. Each blockchain technology transaction is checked with a digital signature. IoT computing technology limitations make the verification of transactions a resource-intensive process. There will be scalability constraints on transaction verification and block creation for Blockchain Cryptographic operations.

5. **Privacy:** IoT devices with resource-restricted hardware disclose wider threat surfaces and major privacy compliance limitations. In Blockchain, data protection is not built-in as the transactions are publicly added to the ledger upon verification. Privacy security is a big problem, with widely used encryption methods. A further challenge that is difficult to solve is throughput. Transaction throughput and latency are continually challenged and can not be handled by the IoT system as the size of transactions increases.

6. **Smart contracts:** The key challenge lies in the method of converting current massive contracts into smart 5G ecosystem contracts. The loyalty and protection of the smart contract are other issues to be addressed as smart contract code can contain certain bugs that may lead to hacker exploitation. Therefore, it becomes important to devise new methods to update smart contracts to fix the problems.

7. **Interoperability:** Interoperability between various blockchains is a difficult problem as 5G stakeholders can be related to any sort of. 5G blockchain consisting of a range of new technologies like mmWave, small cells, massive MIMO, full duplex, SDN, and beamforming, and each of these technologies operates in a different methodology.

8. **Naming, Registration and Reputation:** In order to manage many participants in a 5G-enabled blockchain system, a decentralised registration system with confidence, performance, efficiency and scalability using smart contracts and decentralised storage must be developed. The decentralised system must be associated with blockchain addresses, public keys and account for the identity of the network participants.

The challenges faced in major uses cases of blockchain enabled 5G and IoT are:

- *Smart Cities:* Heavy computational power requirement is a significant drawback for mining.
- *Smart Home:* Data privacy is a major problem. Hijacking the smart contracts require to eliminate since it will expose the system into vulnerability.
- *Healthcare:* A malicious attacker can take over all mining nodes and this can be disastrous as the patient data will be exposed.
- *Autonomous Vehicles:* The security and access control mechanisms require to eliminate session hijacks and requires to ensure data privacy of individual users.
- *AR/VR:* The interoperability of Blockchain and VR IoT applications is a significant requirement.
- *Industrial IoT:* The scalability, data privacy and data storage overheads forces challenge.

- *Smart Agriculture:* The data integrity is highly important aspect of the agri foods and requires a special attention on the ledger.
- *UAV:* The operational overheads of Blockchain may affect the airtime of UAVs. Physical damage to the devices may occur due to issues caused by communication.

## Conclusion

### Chapter 1

This chapter discuses about the importance of Block chain, 5G and IOT as well as the potential of IoT and 5G combined blockchain technology. The basics concepts behind 5G, IoT and Blockchain technology has been briefly discussed. The features of Blockchain such as Decentralization, Transparency and Immutability, features of 5G such as High resolution and Speed, large Bi-directional Bandwidth and Enhanced Connectivity combined with IoT is going to rule the world in the near future.

### Chapter 2

Node, Block, Transaction, Chain, Miners are the important components of blockchain and Consensus and characteristics of this technology has been given. The hash of the block, the hash from the previous block and the three most widely used Consensus Algorithms, Proof-of-Work (POW), Proof of Stake (POS) and Simplified Byzantine Fault Tolerance (SBFT) are the elements behind blockchain security. The Key Characteristics of Blockchain- Cryptography, Decentralization, Provenance, Immutability, Anonymity and Transparency and advantage of this technology has been discussed.

### Chapter 3

Public, Private and Consortium are the three categories of Blockchain structure available. Public blockchains are open ecosystems whereas Private blockchain is not accessible for everyone. Private blockchains are particularly designed for enterprise needs and they offer features such as high performance, high Resilience and Privacy. The two major enterprise blockchains are Hyperledger and Ethereum. Hyperledger is a private and permissioned network, with a predefined community of participants, who are allowed to access the network.

## Chapter 4

The Verticals of block chains such as Finance, Healthcare, Education and Transportation has been discussed in this chapter. One major use of Blockchain technology is to administer trade finance transactions for banks. Blockchain use cases in financial services include Capital market venues like Insurance Sales and Trading, Asset Management venues like Fund Launch and Administration and Banking and Lending venues like Credit Prediction and Scoring and Loan Disbursement.

## Chapter 5

Blockchain technology can be used to automate supply chain and fintech. The elements are scalability, Performance, privacy, location, cost. Blockchain also expedites fintech by reducing settlement times, providing secured global currency exchange speeds, and increasing transaction speed.

## Chapter 6

5G mobile network connects virtually everyone and everything together including machines, objects and devices. In 5G connection establishment, User device is connected to both 4G and 5G network to provide control signalling and to provide high speed data connection. MIMO Beam steering technology increases efficiency by directing the radio signal to the users and devices rather than in all directions and also determine the best path for the radio signal to reach the user.

## Chapter 7

IoT is an ecosystem of Things, Sensors, Devices, People connected through network and helps to automate decision making. Seven essential characteristics - Connectivity, Things, Data, Communication, Intelligence, Action and Ecosystem and various features of IoT has been discussed. IoT plays a major role in Industry domains. The IoT holds significant potential for delivering social and economic benefits to emerging and developing economies.

## Chapter 8

By integrating blockchain with IoT, tracking of data or goods in the supply chain becomes easy as well building trust, reducing risk and costs and acceleration of transaction are other perks. Trust building, Lowcost, Improved security and Accountability are the important features of blockchain integrated 5G and IoT. Blockchain with 5G Enabled IoT important usecases are Smart Home, Smart City,

Healthcare, Industrial IoT, Tracking and Remote Monitoring, Smart Agriculture, Autonomous Vehicles, UAV, Augmented and Virtual Reality and Energy Conservation. Limitations and challenges of integrating blockchain and 5G enabled IoT are energy consumption, scalability, slower data transaction, storage capacity, computational power, lack of Standardization, Interoperability, low Security and Privacy.

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# 8

# Hybrid Evolutionary Algorithms for Localization Error Minimization in Wireless Sensor Networks

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**ABSTRACT**

Node Localization in Wireless Sensor Networks (WSNs) has evolved in the recent years as one of the most significant research issue. The objective behind localization is determining the physical co-ordinates of a group of sensor nodes distributed along its sensing field. The location information plays a vital role for coverage, deployment of sensor nodes, routing and target tracking applications. Still several researchers are trying to find an optimal solution for this localization problem in WSN. The scope of the proposed work is to determine the location of the sensor nodes with high precision. Initially, the sensor node Localization is performed by Mobile Anchor Positioning (MAP), a range-free localization method. As the anchors move through the network, they broadcast their location as beacon packets. The sensor nodes use the location information of beacon packets obtained from mobile anchors as well as the location packets from neighbouring nodes to calculate their location. In order to enhance the location accuracy, the proposed algorithms are Differential Evolution with MAP (DE-MAP)**,** Genetic Algorithm with MAP (GA-MAP) and Simulated Annealing **-** Differential Evolution with MAP (SA-DE-MAP). The scope of the chapter is to compare the performance of SA-DE-MAP algorithm to DE-MAP as well as with GA-MAP algorithms. Root Mean Square Error (RMSE) is used as the performance metric to compare between DE-MAP, GA-MAP and SA-DE-MAP approaches. Simulation result demonstrates that out of the three proposed approaches, Simulated Annealing**-**Differential Evolution with MAP (SA-DE-MAP) approach achieves agreeable performance in minimizing the localization error when compared to DE-MAP and GA-MAP approaches.

**Keywords**: Localization, Mobile Anchor,Differential Evolution, Genetic Algorithm, Simulated Annealing, Root Mean Square Error.

## 1. Introduction

Wireless Sensor Networks (WSNs) are a kind of Ad hoc networks, which are often infrastructure independent. A WSN is a network comprised of numerous small

independent sensor nodes or motes. A sensor node, also known as a mote, is a node in a wireless sensor network that is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network. Typically, a WSN consists of spatially distributed autonomous sensors to monitor physical or environmental conditions such as temperature, sound, vibration, pressure, motion or pollutants and to cooperatively pass their data through the network to a main location[1].

Location awareness plays an important role in high-level WSN applications like locating an enemy tank in a battlefield and locating a survivor during a natural calamity and in certain low-level network applications like geographic routing and data centric storage. Localization is the process of making every sensor node in the sensor network to be aware of its geographical position[2]. The sensor data becomes meaningless without performing localization.

It is important to note there is an uncertainty on the exact location of sensor nodes. One trivial solution is, equipping each sensor with a Global Positioning System (GPS) receiver that can provide the sensor with its exact location. As WSNs normally consist of a large number of sensors, the use of GPS is not a cost-effective solution and also makes the sensor node bulkier. GPS has limited functionality as it works only in open fields and cannot function in underwater or indoor environments. Therefore, WSNs require some alternative means for localization.

Sensor Node Localization is considered today as one of the most important issues in a Wireless Sensor Network (WSN) as it is formulated as an NP-Hard optimization problem[3]. This work aims at determining the location of the sensor nodes with very high precision. Range-free algorithms sometimes use the mobile anchors for localization. Range-free methods use the content of messages from anchor nodes and other nodes to estimate the location of sensor nodes. As the anchors move through the network, they broadcast their location as beacon packets. The sensor nodes use the location information of beacon packets obtained from mobile anchors as well as the location packets from neighbouring nodes to calculate their location.

Localization in Wireless Sensor Networks is intrinsically an unconstrained optimization problem. Evolutionary algorithms are local search methods, capable of efficiently solving complex constrained or unconstrained optimization problems. The proposed algorithms use the results of Mobile Anchor Positioning (MAP) algorithm as input to each of them in order to enhance the location accuracy further and to analyse the performance of all the proposed approaches with regard to MAP.

## Classification of Localization Methods

The Localization methods[4] can be broadly divided into two categories: range-based and range-free. Range-based approach uses absolute distance estimate or angle estimate, meaning that a node in a network can measure its distances from itself to the beacons. In a range-free approach, only through connectivity and proximity, a node can estimate its regions or areas where it stays in. Range-based algorithms use some hardware for performing localization whereas the range-free algorithms use messages passed among the sensor nodes for localization.

Range-based localization can also be divided into another two categories. One is distance estimation by one-hop; another is by multi-hop, meaning that a node in the network cannot directly communicate with beacons. Localization in WSN is a multi-hop approach[5] because a node may not communicate directly with beacons. Only through multi-hop routing, a node can send or receive messages to or from beacons. Some of the commonly preferred range-based localization techniques are Received Signal Strength Indicator (RSSI)[6], Time of Arrival (ToA)[7], Time Difference of Arrival (TDoA)[8] and the Angle of Arrival (AoA)[9]. Rangebased methods give fine-grained accuracy but the hardware used for such methods are expensive. Thus the range based methods are generally not preferred.

Range free or proximity based localization schemes rely on the topological information (e.g., hop count and the connectivity information), rather than range information. Range free localization schemes may be used with anchors or beacons. They do not require complex hardware and they are cost effective when compared to range based schemes. The Range-free (or) Proximity based localization techniques does not depend on distance (or) angle information but they depend on the topology and connectivity information to determine the unknown sensor node's position Centroid Algorithm[10] and Distance Vector Hop (DV-Hop) Algorithm[11] are examples for range free algorithms. Range free algorithms sometimes use mobile anchors for localization.

## Motivation Behind Localization in WSN

The following are the reasons[12] that motivated to work on localization in WSN:

**(i) Localization enables efficient routing:** A typical sensor network has large number of nodes, which communicate at very short distance (a few meters). The data sensed by a node has to be communicated to the sink through several other nodes. Thus, multi-hop routing is necessary. In order to implement multi-hop routing, it is necessary that the nodes are of their locality i.e. they know their

relative position with respect to their neighbours. Thereby, Localization becomes important.

**(ii) Localization provides power saving:** Assume that we have deployed the sensor network for pollution monitoring. The neighbour sensor nodes will have data that will not be dramatically different from each other. In order to save power, it makes sense in combining the data from neighbouring nodes and then communicate the combined, reduced data set, thereby conserving power (since communication takes a lot more power than local processing). Thus in order to do this local data fusion, location information i.e. localization becomes vital.

**(iii) Localization assists in the applications such as target tracking:** This application typically requires in determining the range, speed and the direction of the target. Sensors are deployed in regions, which sense the signals from the moving target, using which the range, speed and the direction of the target are monitored. Thus, in order to calculate the global orientation of the target, it becomes necessary to know the location of the sensor nodes.

**(iv) Localization useful in locating the source of data:** In many applications, an event based sensor network is used. Here, the nodes are normally in sleep mode and when an event occurs, (for example, when sudden vibrations take place), the nodes are awakened. The nodes then sense and transmit the data. Such data requires a location stamp and therefore Localization becomes mandatory.

From the aforementioned examples, it is clear that Localization is indeed necessary for sensor networks.

## Organization of the Chapter

The scope of this chapter is limited to minimizing the error in localization process and thereby enhancing location accuracy. In order to minimize the error in localization, initially a range-free Localization method known as Mobile Anchor Positioning (MAP)[13] is applied for localizing the unknown sensor nodes, which is presented in Section 2.1 of the chapter. To further minimize the error in localization, the proposed evolutionary optimization algorithms are applied over the initial location estimation obtained using MAP. The proposed evolutionary algorithms namely, Differential Evolution with MAP (DE-MAP)[14], Genetic Algorithm with MAP (GA-MAP) and Simulated Annealing-Differential Evolution with MAP (SA-DE-MAP)[15] are dealt in Sections 2.2.1, 2.2.2 and 2.2.3 respectively. The summary and discussion are dealt in Section 3 of the chapter.

## 2. Localization Strategies

In this section, the localization strategies can be visualized in two phases. In the first phase, a range-free algorithm namely Mobile Anchor Positioning (MAP) is outlined for determining the location of the unknown sensor nodes. Since a rangefree algorithm offers coarse-grained accuracy, the obtained location will be just as an estimate. In the second phase, evolutionary algorithm**s** are applied over MAP for fine-tuning the results of the sensor nodes obtained using MAP and to enhance localization accuracy.

### 2.1 Sensor Node Localization Using Mobile Anchor Positioning Algorithm

Assume that the sensor nodes are randomly deployed in the sensing field. Mobile anchors are location aware nodes that move in the sensing field, fitted with GPS. As they move around the sensing field, they periodically broadcast messages containing their current location at fixed time interval to all the nodes, which are at a hearing distance from it. The mobile anchors traverse around the field with a specific speed and their directions are set to change for every ten seconds. All the nodes in the communication range of the mobile anchor will receive the beacons. A sensor node will collect all the beacons in its range and store it as a list. Communication range of the sensor nodes and the mobile anchor nodes are assumed as the same.

Every sensor node in the field maintains a visitor list. After collecting enough beacon packets, the node finds first and last beacon packets in the visitor list. The beacon points are considered as an approximate endpoint on the sensor node's communication circle .These are assumed as the two extremes of a node's communication range. These points are considered the center points and two circles are drawn. Two possible locations for the sensor node are the intersection points of the two circles, which are computed as follows:

The positions ($x$, $y$) of two intersection points of the circles can be calculated by simple algebraic calculation as stated by the following set of equations:

$$\left(x - a_1\right)^2 + \left(y - b_1\right)^2 = r^2 \qquad\qquad ...(1)$$

$$\left(x - a_2\right)^2 + \left(y - b_2\right)^2 = r^2 \qquad\qquad ...(2)$$

The coordinates of two intersection points are the solutions obtained from Eq. (1) and Eq. (2).

Assume that the sensor node has received and stored four beacons (locations of the mobile anchor) in its list $\{T_1, T_2, T_3,$ and T4$\}$ (refer **Fig. 1**). From the list,

two beacons, which are farthest from each other, are chosen ($T_1$, $T_4$). These points are known as Beacon points. These two points are marked as the end of the sensor node's communication range since the sensor node has not received a beacon farther from this point. Hence $T_1$ and $T_4$ (Beacon points) represent either two positions of the same mobile anchor or positions of two different mobile anchors when they were at the end of the sensor node's communication range. With these two Beacon points as centers and the communication range of a sensor node as radius, two circles are constructed (refer **Fig. 1**). Each circle represents the communication range of the mobile anchor, which has sent the beacon. The sensor node has to fall inside this communication range, as it has received the beacon. Since the sensor node has received packets either from both anchors or from the two positions of the same anchor, the node has to fall inside both the circles. Hence, it can be concluded that the circles will intersect each other.

The intersection points of both circles are determined (S', S''). The intersection points are the possible locations of the sensor node. The reason is as follows: The two farthest points (Beacon points) are the ends of a sensor node's communication range. Therefore, in the circle with the mobile anchor's position as the center and the communication range of a node as the radius, the sensor node will be in the circumference of the circle. The sensor node lies on the circumference of the other circle since it is the same with the other mobile anchor position. Therefore, the sensor node lies on the circumference of both the circles. The only points satisfying the above condition are the two intersection points. Hence, by means of MAP, the location of the sensor node has been approximated to two locations as shown in **Figure 1**.

### *Identifying the Sensor Locations Using MAP with Mobile Anchor (MAP-M)*

It is assumed that the communication range of a mobile anchor is R. The MAP-M maintains the visitors list after receiving the beacon packets from the mobile anchor. The information from the visitor list is used to approximate the location of the sensor node. Let the visitor list of a sensor node S consists of various location information represented as $\{T_1, T_2, T_3 \ldots T_n\}$. The beacon points are the two extreme points i.e., $T_1$ and $T_n$. Two circles with radius R and center $T_1$ and $T_n$ are constructed and their intersection points of two circles are found to be S′ and S″. If there is any $T_i$ ($2 \leq i \leq n - 1$), such that the distance between $T_i$ and S′ is less than R and that between $T_i$ and S″ is greater than R, then we can conclude the location of the sensor node is S′. This is because of the fact that the sensor node should lie inside the communication range of mobile anchor to receive the beacon packets. Consequently, the distance between the sensor node S and beacon packet $T_i$ should be less than R.
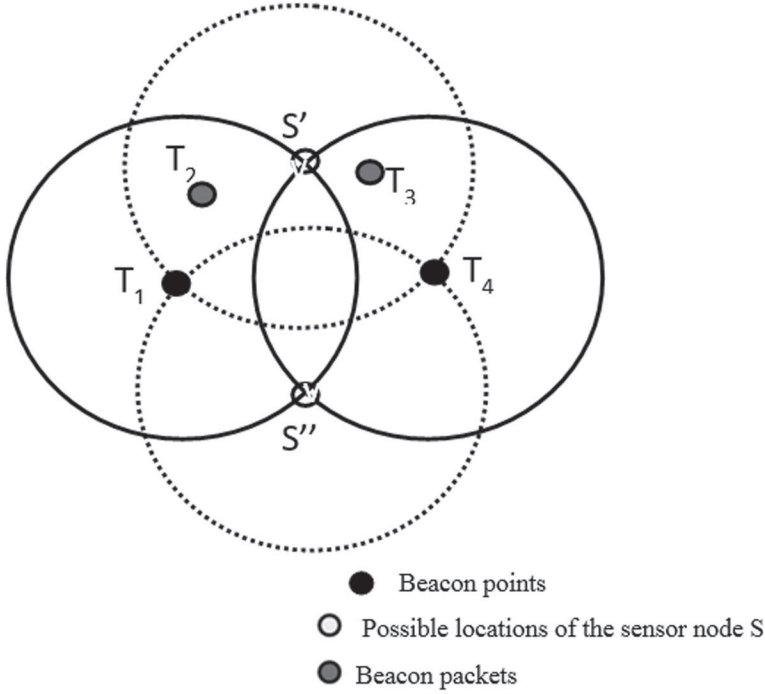
**Fig. 1:** Possible location of the sensor nodes using MAP

There is an area named as the shadow area. The shadow area refers to the intersection of the two circles with centers S' and S". If a beacon packet lies inside the shadow area, it means that the distance of the beacon packet from both S' and S" is less than R. Hence, it is not possible to determine the location of the sensor node S using that beacon packet. If none of the beacon packets in the visitor list lies outside this shadow area, then the sensor node S cannot determine its location as the shadow area comes under the range of both the intersection points. In that case, the node keeps the two possible locations S' and S". Later when the sensor node S receives another beacon packet T from the mobile anchor, it checks whether the beacon packet T can assist in determining its location. The sensor node calculates the distances $d_1$ and $d_2$, where $d_1$ = distance (S', T) and $d_2$ = distance (S", T). If $(d_1 \leq R$ and $d_2 \geq R)$ or $(d_1 \geq R$ and $d_2 \leq R)$, the sensor node can be sure of its location. Hence, in order to estimate the location of the sensor node there is a need that at least one of the beacon packets in the visitor list must lie outside the shadow area as shown in **Figure 2**.

Figure 2 below illustrates that when the sensor node receives a new beacon packet $T_6$ from the mobile anchor (outside the shadow area) it can determine its location. If no further beacons are obtained further, then a single position of

○S' and S'' indicate possible locations of the sensor node

●Beacon packets
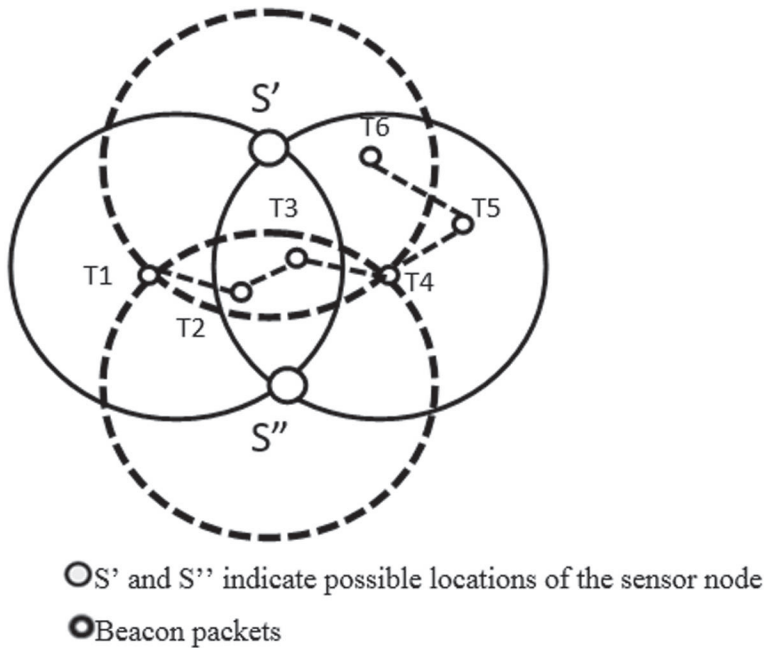
**Fig. 2:** Node seeking information from neighbour sensors

sensor node S cannot be determined. The node will have two positions S' and S''. To overcome this problem, the Mobile Anchor Positioning with Mobile Anchor &Neighbour (MAP-M&N) method is being applied.

### Forming Additional Anchors and Identifying Sensor Locations with MAP-M&N

The location estimation done for sensor nodes using MAP-M method gives a single position for few sensors and for the other nodes, it gives two positions. Thus by using MAP-M&N method it is possible to produce outputs with a single position for each sensor node. It is possible for the sensor nodes that have already determined their location to assist other nodes in determining their locations. The MAP-M&N method assumes that the sensor nodes, which already have a location, would broadcast their location to their one-hop neighbours. As soon as the location is identified, the localized nodes start acting like anchors. They embed their calculated location inside the packet and then broadcast the beacons. Nodes, which are at its hearing range and waiting for additional beacons to finalize their location, can make use of these beacons. However, if the sensor node has already determined its location, then it simply discards the beacon packet. Consequently,

by using MAP-M&N method, the cost of movement of the mobile anchor can be reduced.

## Simulation Environment

The following parameters namely Number of Mobile Anchors, Speed of Mobile Anchors, Number of Sensor Nodes and Execution time are varied in NS-2 simulator and the results were analysed for each of the parameter variation.The simulation settings used in NS-2 simulator is as shown in **Table 1**. The simulation settings mentioned in **Table 1** serves as the basis for MAP as well as for the proposed evolutionary approaches in this chapter for experimental purpose.

| Table 1: Simulation Settings | |
| --- | --- |
| *Parameter Description* | *Value* |
| Number of Sensor Nodes | 100 |
| Area of the Sensing Field | $1000 \times 1000$ m$^2$ |
| Number of Mobile Anchors | 3 |
| Speed of Mobile Anchors | 100 m/sec |
| Time interval between successive Anchors | 1 sec |
| Execution time | 500 sec |
| Transmission range | 250 m |
| Routing Protocol | AODV |
| MAC Protocol | IEEE 802.11 |

## Performance Metric for Localization Accuracy

The Performance metric used to evaluate the accuracy in localization process is Root Mean Square Error (RMSE).The localization error for the existing MAP method and all the proposed approaches was calculated using the RMSE formula defined as,

$$RMSE = \sqrt{\sum_{i=1}^{n} \frac{(x_{act(i)} - x_{obt(i)})^2 + (y_{act(i)} - y_{obt(i)})^2}{N}} \qquad ...(3)$$

Where, $x_{act\ (i)}, y_{act\ (i)}$ – denote the actual x and y coordinates of sensor nodes, $x_{obt(i)}$, $y_{obt(i)}$ – denote the obtained values of x and y coordinates of sensor nodes and N – represents the total number of localized nodes.

This Eq. (3) is used throughout this chapter for calculating the average error encountered during localization process, when the proposed evolutionary approaches are applied over the results of MAP.

## 2.2  Introduction to Optimization Algorithms

Optimization is the process of making something better. In other words, optimization is the process of adjusting the inputs to or characteristics of a device, mathematical process, or experiment to find the minimum or maximum output or result. The input consists of variables: the process or function known as the cost function, objective function, or fitness function; and the output known as the cost or fitness. There are different methods for solving an optimization problem. Some of these methods are inspired from natural processes. These methods usually start with an initial set of variables and then evolve to obtain the global minimum or maximum of the objective function. Genetic Algorithm (GA) has been the most popular technique in evolutionary computation research. GA is a procedure that is used to find approximate solutions to search problems through application of the principles of evolutionary biology. Genetic Algorithms are search algorithms based on the mechanics of natural selection and natural genetics. Differential Evolution is a stochastic, population-based optimization algorithm for solving nonlinear optimization problem. Differential Evolution (DE) is a simple[16] but powerful evolutionary optimization algorithm with many successful applications.

The proposed evolutionary strategies considered for localization in this chapter are Differential Evolution with Mobile Anchor Positioning (DE-MAP), Genetic Algorithm with Mobile Anchor Positioning (GA-MAP), and Simulated Annealing-Differential Evolution with MAP (SA-DE-MAP).

### 2.2.1  Differential Evolution with Mobile Anchor Positioning (DE-MAP)

DE is a simple evolutionary algorithm that creates new candidate solutions by combining the parent individual and several other individuals of the same population. A candidate replaces the parent only if it has better fitness. In general, DE[17] adapts a greedy selection strategy. The steps used for localization using Differential Evolution algorithm with MAP are as follows:

1. The algorithm takes the results of Mobile Anchor Positioning (MAP) as its input. The results of MAP-M&N, giving the approximate solution of the location of each sensor at each specified time instance is given as the input to the post optimization method.
2. Each node will separately undergo the process of differential evolution to produce a fine grained accurate location.
3. The initial population P of random individuals is the output from MAP-M&N method for each node.
4. Check for the stopping criteria and continue if the stopping criterion is not met.

5. For each individual $N_i$ (i = 1, 2 ..., pop Size) from N, repeat the following:
   a) Create the new location from the chosen locations which acts as the parents. Choose three parents from the population.
   b) The calculation of the new location (child) is as stated in Eq. (4) below:
      $$(x, y) = Parent\ 1 + F \cdot (Parent\ 2 - Parent\ 3) \qquad ...(4)$$
   c) Calculate the fitness for the new location (child). If its fitness is better than that of the parent's, then the new location replaces the parent. Otherwise, the new location is discarded.
5. Repeat the procedure until the stopping criterion is met.

The localization steps involved in DE-MAP algorithm can be pictorially depicted as shown in **Figure 3**:
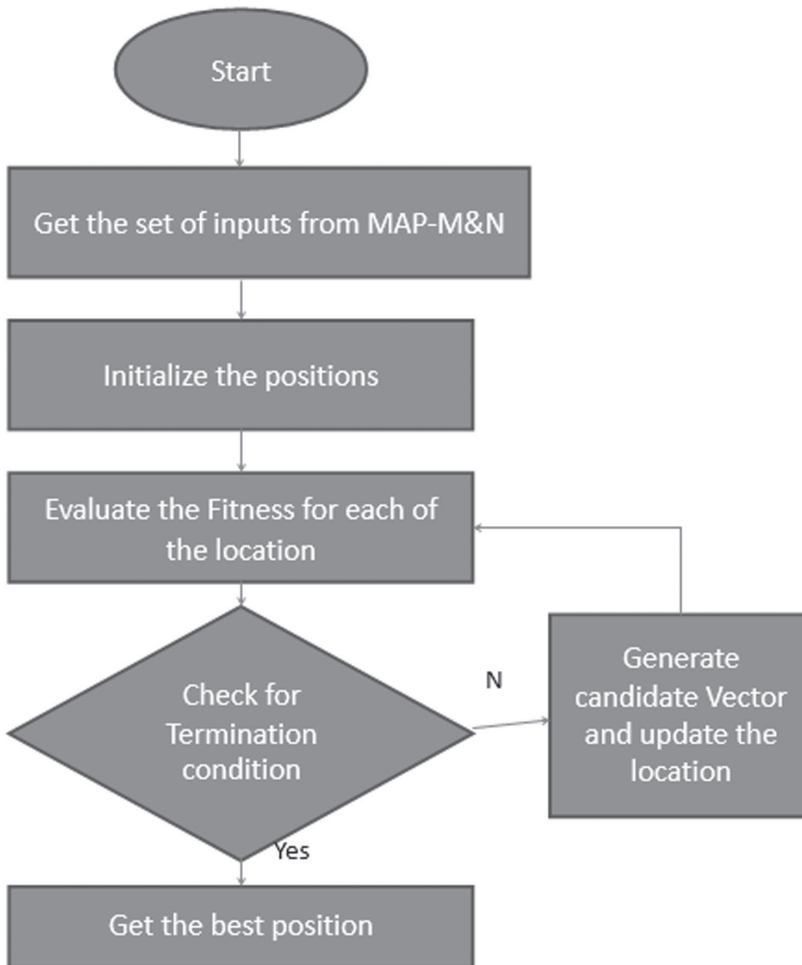


**Fig. 3:** Flowchart for Localization steps used in DE-MAP Algorithm

### 2.2.2  Genetic Algorithm with Mobile Anchor Positioning (GA-MAP)

The uses of evolutionary strategies begin with two possible locations of the sensor node. The two locations are the basis of the initial population. The chromosomes are generated in and around the two locations. The approach is based on the assumption that each sensor node measures its distance to mobile anchor when it sends a beacon using RSSI technique.

The location of the sensor nodes are roughly estimated with the help of Mobile anchor positioning. The two possible locations of the sensor node are considered to determine the location of the sensor node. Genetic Algorithms[18] generate a sequence of populations by using selection mechanisms. It uses crossover and mutation as search mechanisms, which are probabilistic and useful exchange of information among solutions to locate better solutions.

The following are the steps necessary for genetic algorithm:

**Initialization:** The solution space is constructed in and around the two possible locations of the sensor node determined at the end of mobile anchor positioning technique. Each individual in the population is a possible solution.

**Genetic Encoding:** Each individual is encoded as a real valued chromosome with two genes. First gene represents the location at x-axis and second gene represents the location at y-axis.

**Fitness Function:** Let m be the number of measured distances between the sensor node and the mobile anchor, when the mobile anchor is at various locations and $d_i$, i = 1 to m are the actual distances between the sensor node and mobile anchors when the anchors are at various locations (measured using any technique like RSSI). Finally $(x_i, y_i)$, i = 1 to m are the absolute locations of the respective mobile anchors (obtained from the beacon packet).

Let $(a_i, b_i)$, i = 1 to n be estimated or possible locations of the sensor node (initial population), where n is the size of initial population. Eq. (5) gives the distance between an individual in the population and a mobile anchor, i.e. estimated distance.

$$\sqrt{\left(x_i - a_i\right)^2 + \left(y_i - b_i\right)^2} \qquad \qquad ...(5)$$

Fitness function is defined as, minimizing the difference between estimated distance and the actual distance between the sensor node and the mobile anchor as stated in Eq. (6).

This is given by minimum of $\sum_{j=1}^{n} \sum_{i=1}^{m} \left( \sqrt{\left(x_i - a_j\right)^2 + \left(y_i - b_j\right)^2} - d_i \right)^2$ ...(6)

**Selection:** Selection is done on the population at hand to choose the fit parents. In this approach, Roulette wheel selection is used to determine the parents. Fitness function described above is used. Once the parents are chosen, arithmetic mutation and single point cross over are used for reproduction.

**Arithmetic mutation:** A small number of individuals are chosen from the selected population; for each individual, on any one of the axis Δd is either added or subtracted. Δd for that particular individual is calculated as shown in Eq. (7) with respective $(x_i, y_i)$ and $(a_j, b_j)$.

$$\Delta d = \alpha \times \left( \sqrt{\left(x_i - a_j\right)^2 + \left(y_i - b_j\right)^2} - d_i \right) \qquad \ldots(7)$$

where α ranges between 0 to 1.After mutation, single point crossover is done on the parents to produce the children. Selection, Reproduction is done iteratively until the termination condition is reached.

**Simulation Results of Genetic Algorithm with MAP (GA-MAP):** With the experimental setup in NS-2 simulator as shown in **Table 1**, the results were analyzed for MAP and Localization using Differential Algorithm with MAP (DE-MAP). The RMSE was calculated for MAP as well as for Genetic Algorithm (GA) over the results of MAP i.e. GA-MAP, using the formula stated in Eq. (3). The values of RMSE obtained for DE with MAP and GA with MAP algorithms are as shown in **Table 2.** It is observed that RMSE obtained for DE-MAP is very less compared to GA-MAP.

From the experimental results, it is noted that DE-MAP gives good localization accuracy as well as does not require extensive searching as in traditional MAP algorithm. Both DE-MAP and GA-MAP does not require expensive hardware as in range based methods and also does not require flooding of messages as in traditional range-free algorithms. Thus it is inferred that DE-MAP is a non-expensive and an efficient strategy that gives very high localization accuracy.

### 2.2.3  Simulated Annealing-Differential Evolution with MAP (SA-DE-MAP)

Simulated Annealing (SA)[19] exploits an analogy between the way in which a metal cools and freezes into a minimum-energy crystalline structure (the annealing process) and the search for a minimum in a more general system. The notion of slow cooling is implemented in the Simulated Annealing algorithm as a slow decrease in the probability of accepting worse solutions as it explores the solution space. The major advantage of SA over the other heuristic search methods lies in the mechanism of avoidance of local minima. The algorithm employs a random search which not only accepts better solutions that decrease the objective function

f (in case of a minimization problem), but also some inferior solutions that increase it. The latter are accepted with a probability as in Eq. (8):

$$P = \exp(-\frac{\Delta f}{T})$$

...(8)

where $\Delta f$ is the change of the objective function over two successive iterations and T is a control parameter, which by analogy with the original application is known as the system 'temperature'.

**Motivation behind SA-DE for Localization:** The SA-DE[20] is an optimization algorithm that integrates Differential Evolution algorithm with Simulated Annealing. SA-DE makes complete use of the advantage of DE and SA, and can improve the calculation efficiency. The advantages of DE are its simplicity of implementation, ease of use, speed, and robustness. SA can find the local optimization fast; In some cases, the DE and SA can be combined to resolve the optimization problem.

**Localization in Simulated Annealing-Differential Evolution with MAP (SA-DE-MAP):** The steps to follow in Simulated Annealing-Differential Evolution with MAP (SA-DE-MAP) (i.e. Hybrid DE algorithm) are as listed below:

1. The algorithm takes the results of MAP as its input. The results of MAP-M&N, giving the approximate solution of the location of each sensor at each specified time instance is given as the input to the post optimization method.

2. Each node separately undergoes the process of differential evolution to produce a finely accurate location.

3. For each individual $N_i$ (i = 1... pop Size) from N, Initialize location points and optimal points.

4. Randomly select the local best solution from parent chromosomes.

5. At time step t, the i-th parent chromosome is $\overrightarrow{Xi}(t)$ and its offspring, created through the DE-type mutation and crossover operations at the next time step, is $U_i(t+1)$.

6. If the offspring is better than the parent with respect to the objective function [ $f(\overrightarrow{Ui}(t+1)) < f(\overrightarrow{Xi}(t))$ )], then $\overrightarrow{Xi}(t)$ is surely replaced in the next generation with $U_i(t+1)$. Otherwise $\overrightarrow{Xi}(t+1) = \overrightarrow{Xi}(t)$

7. But even if $f(\overrightarrow{Ui}(t+1)) > f(\overrightarrow{Xi}(t))$ ), $U_i(t+1)$ may replace the parent chromosome $\overrightarrow{Xi}(t)$ with a probability $P_i$ if:

$$P_i\,(\text{rand}(0,1)) < \exp[-(\frac{f\left(\overrightarrow{Ui}\left(t+1\right)\right)-f(\overrightarrow{Xi}\left(t\right)}{T})$$

8.  Check for the stopping criteria and continue if the stopping criterion is not met.

**Simulation Results of DE-MAP, GA-MAP and SA-DE-MAP:** RMSE is calculated for DE-MAP, GA-MAP and SA-DE-MAP approaches on an average pertaining to 100 nodes scenario. The values of RMSE obtained are shown in **Table 2**.

| Table 2: RMSE values for DE-MAP, GA-MAP and SA-DE-MAP | | | |
|:---:|:---:|:---:|:---:|
| *No. of nodes* | *RMSE for DE with MAP* | *RMSE for GA with MAP* | *RMSE for SA-DE with MAP* |
| 10 | 7.99 | 31.33 | 8.65 |
| 20 | 7.97 | 31.21 | 9.15 |
| 30 | 8.94 | 26.55 | 7.87 |
| 40 | 8.76 | 25.28 | 8.44 |
| 50 | 8.83 | 25.88 | 7.81 |
| 60 | 8.36 | 25.50 | 8.49 |
| 70 | 8.57 | 25.40 | 8.35 |
| 80 | 8.92 | 25.11 | 8.08 |
| 90 | 8.66 | 24.82 | 8.03 |
| 100 | 8.74 | 25.53 | 8.29 |

   **Table 2** illustrates that SA-DE-MAP gives the best result in localization. The error of localization is least while combining MAP with Hybrid DE. RMSE gets drastically reduced when SA-DE optimization algorithm is used along with MAP when compared to DE-MAP and GA-MAP used for estimating the location of sensors.

   Hence from the simulation results, it is clear that DE-SA offers the best optimization result when compared to DE and GA algorithms applied for mobile anchor based localization.

### 3. Summary and Discussion

Localization in wireless sensor networks can be performed using a range free technique known as Mobile anchor positioning (MAP). From the simulation results it can be noted that Mobile anchor positioning (MAP) is an efficient algorithm for localization as it uses no additional hardware and uses only messages for

localization but the error in localization was found to be higher when compared to MAP optimized with evolutionary strategies.

This chapter has outlined three evolutionary optimization approaches (DE-MAP, GA-MAP and DE-SA-MAP) in order to make the location estimation process more accurate in WSN. Root Mean Square Error (RMSE) is used as a performance metric to compare between these proposed evolutionary approaches. The simulation results obtained for the proposed evolutionary approaches are encouraging. This will motivate the researchers to explore further in this area.

From the Simulation results, it can be observed that on an average pertaining to 100 nodes scenario, DE - MAP algorithm significantly reduces the percentage of localization error by 65.64 % when compared to GA-MAP algorithm. Simulated Annealing-Differential Evolution with Mobile Anchor Positioning (SA-DE-MAP) algorithm significantly reduces the percentage of localization error by 97.92% when compared to MAP algorithm alone used for localization pertaining to 100 nodes scenario. It can be observed that MAP with evolutionary strategies is better than using MAP alone. However, among the proposed evolutionary strategies, Hybrid DE i.e. SA-DE algorithm optimizes the localization process better than GA and DE algorithms while applying them with existing Mobile Anchor Positioning. Thus it is clear that hybrid evolutionary algorithms provide better result while performing localization in WSN.

In order to further minimize the error in localization, the researchers can explore further by applying meta-heuristic optimization approaches such as Tabu Search, Artificial Bee Colony algorithm etc. with mobile anchor positioning and also hybridization of optimization such as Tabu Search with Simulated Annealing (TSSA) and the localization error of the new hybrid evolutionary algorithm can be compared with the pure Differential Evolution algorithm to validate its performance. To provide a new dimension in this area, the researchers must focus on reducing the localization time and on energy optimization by minimizing the number of messages exchanged during localization process.

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# 9

# A Systematic Literature Review about Big Data Analytics

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## ABSTRACT

The age of big data is upcoming recently. But the conventional data analytics may not be able to manage such bulky quantities of real time information. The recent query is, how to enhance a elevated performance platform to resourcefully analyze big data and how to propose an suitable mining technique to find the useful concepts from big data. To extremely discuss this problem, this article begins with a clear introduction about big data analytics. As the information technology spreads fast, most of the data were born digital as well as migrated from internet. Newly generated data stored in digital media devices have previously been more than 92% in the year 2012, while the size of these novel data was also greater than five exabytes. In fact, the obstacles of analyzing the greater scale data were not unexpectedly occurred but have been for many years because the formation of data is usually much simpler than discovering useful things from the data. Even though, today computer systems are much quicker than those in the year 1930's, the outsized scale information will make damage the entire analysis. With the unexpected increase of social media web sites and explosion of digital computing devices and internet access, enormous quantity of public data is being produced on a day by day basis. Well organized techniques and algorithms to analyze this enormous quantity of information can bring near real time data about promising trends and afford untimely warning in case of an forthcoming emergency. The paper reviews and discusses about the recent opportunities, trends and pitfalls of big data and how it has facilitates organizations to generate successful business strategies and remain competitive, based on available literature. Furthermore, the review presents the various applications of big data and business analytics, data sources generated in these applications and their key characteristics.

## Introduction

The speedy expansion of information communication through the Internet has direct to enormous amounts of information accessible online. Additionally, Government,

Army and Business firms generate huge amounts of information in the form of structured and unstructured which requires for analyzing, linking and processing. Handling these kinds of large volumes of dynamic datasets required additional techniques. The technique of Cloud computing plays a vital role in providing on demand services of data analysis.

Consequently, high-dimensional data and multivariate data are becoming commonplace as the number of applications increases, such as statistical and demographic computation, digital libraries and so on. Though it can provide flexible and cost-saving IT solutions for the end users, it is much easier in causing a great deal of problems such as network and system security issues due to its sharing and centralizing computing resources. As the information technology grows rapidly, most of the conventional information were migrated to digital as well as exchanged on internet nowadays. Accordingly the estimation of the novel data stored in digital media devices have already been more than 92% in 2002, while the size of these new data was also more than five exabytes, Lyman and Varian[1].

In fact, the obstacles of investigating the bulky range of data were not unexpectedly appeared but have been there for numerous years because the making of data is usually much easier than discovering helpful things from the data. In response to the obstacles of analyzing large-scale data requires an efficient method such as data sampling, data streaming, data condensation, density-based approaches, grid-based approaches, divide and conquer, incremental learning, and distributed computing. Of course, these techniques are constantly used to upgrade the performance of big data analytics. The methods of dimensional reduction method is used to analyze the large scale data in a reasonable time and aimed at reducing the data input volume to accelerate the big data analytics process. One more reduction method referred as sampling method that decreases the data computations of data clustering, which can also be used to improve the computation time of big data analytics.

## Literature Review

Even though the processing of computer techniques and internet concepts have eye witnessed the growth of computing hardware, the obstacles of managing the large scale data still survive when the world entering the age of big data. Fisher et al. referred that big data denotes that the data is incapable to be processed and managed by the most recent information systems because information the big data era will not only become excessively huge to be loaded into a single computer, it also implies that most established data mining techniques or data analytics process may not be able to be applied directly to big data[2].

In recent years the emerging trends are Big data analytics and Big data which have become fashionable in worldwide. To facilitate the analysis of the whole real time data by using and developing machine-to-machine algorithms for predictive modeling and to appear at decisions. Big data is referred as the datasets that challenge the capability of typical technologies and applications in handling and analyzing the information. And also big data makes the challenges the human imagination[4]. Dealing of enormous amounts of data through a similar IT architecture is a noise at the present time. Several reports recommend that data creation will continue to develop at a rate among 40% and 60% a year, while a quick look at Google Trends, a Google analytic tool aggregating search queries, reveals that big data queries have grown tenfold in a matter of some 2.5 years.

Internet companies have been pioneering booming big data investment projects, due to the enormous quantity of approximately real time data that they are handling. While Google was indexing a million pages for a few million searches in 1998, it was indexing more than a trillion pages ten years later, for more than 3.5 billion search queries performed every day, or 1.2 trillion searches a year, according to the tracking website, Internetlivestats.com.

Similarly, Facebook is managing billion content of information queries day by day, and Netflix has collected billions of viewer ratings, with members exploring and including millions of items each day. Netflix has utilized the recent efficient concepts of big data to develop its content recommendation engine, first using a crowd-sourced algorithm using consumer rating, afterward machine – learning – based algorithms which are able to improve novel insights from the mash ups of a extensive range of data. With the help of big data produced recommendations, TV Series and Netflix consumption has been improved by a factor of four big data analysis. Google is generating a huge amount of researches in order to encourage quicker search query clicks on its field, with a few micro-seconds interpreting into additional millions of dollars being spent out. Many of the conventional companies have also accepted big data analysts, however with mixed accomplishment, if the outcomes from public case studies are analyzed.

Recently, big data techniques are applied in various fields/business domains for handling vast amounts of data. At present, most of the case studies concentrate on big data investments for sales improving process and marketing functions, like improvement of upcoming product to purchase, enhanced on line process recommendation tools. In **Figure 1**, Role of Big data in various domains of real time applications. This denotes six kinds of various real time domains namely Social media used to collect and processed all kinds of social media queries in day by day manner. Further domain is OTT (Over the Top) Media Service, which is any streaming service that delivers content over the internet. OTT is a

new phenomenon; lots of active firms are entering the OTT space for consumers and increasing quantity of advertisements. In the OTT media service platform, big data analytics play a vital role for boosting the task of video watching. The next role of big data analysis is corporate supply chains used for the purpose of leveraging RFID data to optimize the stock replacement. Subsequently, the domain of Business intelligence process will be associated with the prominent concept of big data analysis in the course of anticipating likely competitor actions through web news casting process. Consequently, one of the active real time domains of internet companies interlinked with big data analysis for handling and managing the massive amount of real time data. Finally, the eminent domain of search engines is combined with big data analysis for the process of indexing and searching of web pages. Like this way big data analysis plays a vital role in various kinds of real time applications.

## Role of Big Data Analysis

Big data incorporates a broad variety of data types, including image, text, audio and video that are constantly generated from various sources such as the social media, web, sensor devices, mobile apps, networks, and data storage, in addition to the internal data generated by the organization itself. Due to the unstable development in the volume of global data in recent days, many enterprises, not only outsized but also medium and small sized, are aware of the importance of extracting key information from big data. In business, investing money to buy new technologies for extracting precious information from big data is not alone a way to improve the firm, but also required to apply more efforts to accelerate big data research and applications[6].



**Fig. 1:** Role of Big data in Various Domains

Generally the eminent concept of big data id classified into four major categories namely structured, unstructured, semi-structured and mixed. A preferable proportion of data produced is either semi-structured or unstructured. Conventional database management systems deal with structured data and that might not manipulate unstructured and the rest of data types. Consequently, in parallel with database management systems, more number of big data analysis techniques are being enhanced to handle with semi-structured and unstructured data.

Possibly, there are seven major high level dimensions of big data namely variety – data types, velocity – data creation and processing speed, volume – size of the data, veracity – reliability and trust of data, validity – data accuracy and correctness with respect to the future usage, volatility – big data is destroyed and volatile when it meets the expiry period of warranty period and retention policy, value – worth derived from exploiting big data. The collections of these high level dimensions are referred as 7 V big data model. The most important development of efficient and successful methods for high dimensional data analysis are to gain insight into the relationships between several features of the data and their impact for various purposes in business as well science, and also to predict perfectly future interpretations in order to make proper timely decisions.

| High Level dimensions of Big Data | Characteristics | Real Time User Behavior |
|---|---|---|
| Volume | How much data measured in Yotta bytes | 4 Billion Social Network active users |
| Velocity | Data processing speed | 5 Billion contents are posted every day and 2-5 new users are introduced per second |
| Variety | Organizing data in meaningful way, even though rapid change may occur | Posts contains texts, images, videos |
| Variability | Constantly change the meaning, it can have a huge impact on the data homogenization | Post contents is quite heterogeneous |
| Veracity | Making sure the data is accurate | Contents has to be checked as they come mainly from not verified sources |

| Validity | Similar to veracity, it refers how accurate and correct the data | Social media data could be properly understandable |
|---|---|---|
| Visualization | Using charts and graphs to visualize large amounts of complex data | Intuitively, makes sense of a phenomenon and triggers decisions |
| Value | Make Sure that the firm is getting meaningful value from the data | The market value is 20 Billion Dollar per year mainly spent for social media advertising |

**Table 1** Detailed description about high level dimensions of big data with its characteristics and real time user behavior. The determined distribution of Social Networks (SN) produced an extraordinary amount of heterogeneous and assorted data. Thus, conventional approaches rapidly became unpractical for real life applications due their essential properties, huge amount of user-generated data like text, image, audio and video, data heterogeneity and high speed generation rate. For example, the analysis of user generated data through familiar social networks it means Facebook (https://www.facebook.com/), Twitter (https://www.twitter.com/), Instagram (https://www.instagram.com/), LinkedIn (https://www.linkedin.com/) poses quite interesting challenges for both research and industry communities in the process of analyzing user interactions, user behavior, link evolution, opinion spreading and several other important aspects.

## Research Trends in Big Data Analytics

Naturally, the complexity of big data developed from many kinds of sources poses a foremost challenge for analytics. For example, inaccurate corrections, high dimensionality makes noise accumulation and incidental homogeneity. Additionally, high dimensionality associated with outsized sample size creates obstacles such as excessive computational cost and instability of algorithms. The enormous sample in big data is typically summative from multiple sources at various time points using different technologies, further contributing to the complexity.

### Context Definition

Various recent research studies have shown that the use of context in interactive applications is very helpful and significant. By taking into consideration context

in computer applications, it has been established that the number of inappropriate results is reduced and more accurate data are collected. Additionally, the word "context" has been implanted in business, information technology and other real time application domains for a long period, and has enhanced the efficiency and helpfulness of these applications.

Usually, context assessment can be performed in two ways evaluation of either a context model and or contextualized business process (i.e. a business process which embeds context into its bedrock). They are described in the following sections.

## Evaluation of a Context Model

Various kinds of context model structures utilized in numerous different applications, but how they were enhanced has not been discussed. Earlier than evaluating and concluding the effectiveness of context models for business applications, it is most significant stage is usually enhanced. To develop any context based methods, the first and foremost important stage is to model contextual information. To do this process, the basic and the most admired way is to construct a model based on monitor and investigating the attributes of a business system and its end users and physical environment. Generally, there are five major sequential and cyclic steps presented in context modeling namely,

- System requires what kind of learning information according to the activities of the system and users behaviors.
- To predict what kind of contextual information is needed.
- What information is required to be considered in the context model must be decided.
- Representing the relationship among the pieces/types of contextual information based on experience and practice.
- Constructing the relationship between contextual information, systems and end users.

The above said steps have been primarily applied to context modeling in information retrieval; they have also concentrated in other context based fields like business intelligence, real time analytics and business process.

In **Figure 2**, various kinds of context models are compared namely B2b Context Model, Business Context Model, User Context Model and Keyword Context Model with their features like contextual information, targeted application and purposes. Additionally, social media analytics refers to the task of analyzing the data exchanged by network users about the products, topics or brands. Particularly,

the major variation among social network analysis and social media analytics concerns which data are utilized to support various real life applications.

As the worth of data storage space has gone down and high performance computers have become more widely accessible, a growth of machine learning (ML) into a host of industries together with finance, law enforcement, entertainment, commerce, and healthcare. As theoretical research is leveraged into practical tasks, machine learning tools are gradually more seen as not just helpful, but essential to more business operations. With a growing amount of opportunities, the process of associating machine learning tools for big data can be complicated one. The available tools have pros and cons, and many have overlapping usages. The global data is growing rapidly, and conventional tools for machine learning are becoming inadequate to move towards distributed and real-time processing. This approach is projected to aid the professional or researcher who recognizes machine learning but is inexperienced with big data. Moreover this concept offers a list of criteria for making selections along with scrutinizes of the pros and cons of analyzing tools. The Hadoop ecosystem for a look at most of the projects that are element of a typical machine learning architecture and understanding of hoe data details might fit together. Landset et al discuss about the pros and cons of three various processing paradigms along with a comparison of engines that develop them, including MapReduce, Spark, Storm, Flink and $H_2O$.

## VARIOUS CONTEXT MODEL COMPARSION

| Context Model | Contextual Information | Targeted Application | Purpose |
|---|---|---|---|
| B2B Context Model | Supplier and their product information | Supply Chain Management | For evaluating & selecting the correct suppliers |
| Business Context Model | Product Information | Big data collection & Processing and Analyzing customer feedback | Understanding customer opinion of every product |
| User Context Model | User information | Information retrival | Managing customer and keeping in track with them |
| Keyword Context Model | Instances of keywords | Information & document retrieval | Finding best match sentence or document based on keywords |

**Fig. 2:** Comparison between various context models with their features

## MapReduce

The approach of MapReduce to machine learning performs batch learning, in which the preparation of data set is constructing a learning model with proper understanding. The major disadvantage of batch model is a lack of effectiveness in terms of speed and computational resources. The fault tolerance mechanism engaged by MapReduce is accomplished through data replication, which can distress scalability by increasing the size of data even further. The necessitate for data replication has been establish to be responsible for 90% of the running time of machine learning tasks in MapReduce and is possibly the prime impediment to fast data processing. Another deficiency of MapReduce is that it does not easily permit for iterative processing, making it unsuitable for many machine learning projects.

## Spark

Similar to HaLoop, it helps iterative computation and it develop on speed and resource problems by utilizing in-memory computation. The approach of Spark is to process the widespread acceptance of both research and industry. The significant abstraction used in this project is called Resilient Distributed Datasets (RDD), which accumulates data in-memory and offers fault tolerance without replication. The performance of Spark's was tested and proved its betterment through other machine leaning platforms, GraphLa, Giraph and SimSQL. Spark offers a special benefit called Spark Streaming, which uses micro-batching. This technique may be thought of as a replication of real time processing. Using this approach the incoming stream is packaged into progression of small chunks of data, which can then be developed by a batch system. This can makes easy load balancing and is more robust to node failures. And it also offers incorporation of its streaming and batch options for powerful interactive applications.

## Storm

Storm is employed for processing real time data and was initially considered to defeat deficiencies of other processors in gathering and analyzing social media streams. Storm is like a platform for mining big data streams, presently has accomplished for clustering and classification techniques of machine learning.

## Flink

Flink is graduated the Apache incubation stage and at present it is a top level project. It provides capability for mutually stream and batch processing, and also it is a scalable, in memory option. It has its own runtime, rather than being constructing

on top of MapReduce. Flink is very similar to Spark for handling the streaming process through their streaming API which is based on individual events, rather than the approach of micro batch that can handle by Spark.

## H$_2$O

It is an open source outline framework that provides a parallel processing engine, analytics, math, and machine learning libraries, along with data preprocessing and evaluation tools. Additionally, it proposes a web-based user interface, making learning tasks more reachable to statisticians and analysts who may not have strong programming surroundings. Using multiple execution methods, the H$_2$O's engine processes the data completely based on distributed fork/join, a divide and conquer technique, those techniques are most suitable and reliable for massively parallel tasks.

Most of the research work based on machine learning in big data has projected on algorithm implementation, processing paradigms and optimization. Some of the practical issues associated with real time big data. Conventional techniques and procedures could not able to handle that nature of bulky data. In the following points will argue about the overall look up about the future research direction of big data.

### Mislabeled Data

According to the rapid growth of real time domains data, the likelihood of having mislabeled instances grows as well. When handling with millions of data instances, it is not possible to effectively verify whether all of the training data is correctly labeled and training on wrong data will direct to minimal accuracy.

### Missing values

Like mislabeled data, missing values also lead to inaccurate models and less robust, predominantly with clustering and collaborative filtering algorithms which based on similarity computations. This problem is normally solved either through imputation techniques or by eradicating the example entirely.

### Noise

Meaningless and irrelevant data is termed as noisy data. This can direct to models that affect from the conception of overfitting. Data mining concepts of clustering or similarity measures can assist to discover noisy data points.

**Imbalance**

There are many more instances in one or more classes than in others referred as imbalanced data. This may occur in the classification problem and it leads to weak learners. This is improved and elevated by using data sampling techniques.

**High Dimensionality**

This happens when the feature to instance ratio is very bulky and is a common characteristic of big data. Algorithms for dimensionality reduction, most frequently Principal Component Analysis (PCA), are incorporated in the majority toolkits. Feature selection is a well-known method to handle high-dimensionality, and PCA is just one option of many that could be included.

## Conclusion

Big data and business analytics are trends that are positively impacting the business world. Past researches show that data generated in the modern world is huge and growing exponentially. These include structured and unstructured data that flood organizations daily. Unstructured data constitute the majority of the world's digital data and these include text files, web, and social media posts, emails, images, audio, movies, etc. The unstructured data cannot be managed in the traditional relational database management system (RDBMS). Therefore, data proliferation requires a rethinking of techniques for capturing, storing, and processing the data. This is the role big data has come to play. This paper, therefore, is aimed at increasing the attention of organizations and researchers to various applications and benefits of big data technology. Finally, the review not only outlines the challenges for successful implementation of big data projects but also highlights the current open research directions of big data analytics that require further consideration. The reviewed areas of big data suggest that good management and manipulation of the large data sets using the techniques and tools of big data can deliver actionable insights that create business values.

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# 10

# IoT based Auto Climate Monitoring System with Arduino UNO and Thingspeak

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## ABSTRACT

In this proposed system the room temperature is maintained constantly. According to the value set by the user the heater and Ac turned on or off. The system will get the temperature from the LM35 temperature sensor and DHT11 humidity sensor. The sensors LM35 measures temperature and DHT11 measures humidity level of the environmental climate. The value of temperature and humidity is displayed in Liquid Crystal Display (LCD). The entire system was controlled by the Microcontroller. The Microcontroller senses the temperature and it compares the data value set by the user. The controller turns on the cooling FAN when the current temperature is greater than the set data temperature and the controller turns OFF FAN when the current temperature is lower than the set temperature.

## Introduction

Climatic change and environmental monitoring have received much attention recently. Man wants to stay updated about the latest weather conditions of any place like a college campus or any other particular building. Since the world is changing so fast so there should be the weather stations. Here in this paper we present a weather station that is very helpful for any places. This weather station is based on IOT (internet of things). It is equipped with environmental sensors used for measurements at any particular place and report them in real time on cloud. To accomplish this we used Arduino Uno and different environmental sensors like DHT11, soil moisture sensor and rain drop sensor. The sensors constantly sense the weather parameters and keeps on transmitting it to the online web server

over a wifi connection. The climate parameters are uploaded on the cloud and then provides the live reporting of weather information. This chapter also focuses on the IOT application in the new generation of environmental information and provides a new paradigm for environmental monitoring in future. The system has been development particularly in the view of building smart city by giving the weather update of any particular place like a particular office or room.

## Related Work

Agrawal S., Shete R.[1] proposed a low cost, low power system for monitoring the environmental conditions remotely. Single board minicomputer Raspberry pi is used for implementing the system. Pollutants like carbon dioxide, carbon monoxide and barometric pressure and temperature are measured but particulate matter which has huge contribution in increasing air pollution is left.

Mukesh Jha et al.[2] proposed a complete system which included monitoring of environmental parameters, their modeling and manipulation of urban climate using the available data. According to the authors, after the proper analysis of urban climate there is a scope for improvement in urban infrastructure which in turn can reduce air pollution to some extent.

Elena, Baralis et al.[3] provides the framework of APA. The motivation behind the work is to create awareness among the general public about the deteriorating environment due to human activities, increasing industries, increasing vehicles etc. The intelligence engine proposed in this paper collected data regarding air pollution from different sources like authorities concerned with environment, toxic gases, pollutants etc.

Marin B., Marinov et al.[4] used microcontroller based on PIC for monitoring environmental conditions with the help of air quality and gas sensors. The setups are installed in different areas of city for better monitoring. To display the results, authors have made the use of google maps. Orlando, Xing Liu[5] performed a complete study on different objects, smart sensors, devices connected either with each other or with other things present in network over the internet which defines Internet of Things. Tables containing the differences and similarities are presented.

## Components Used

This project mainly includes a closed loop system in which the feedback element is the actual temperature of the heater that is to be monitored. On basis of this feedback, the temperature of the heater can be easily maintained within the required range. The basic of this project is to replace manual settings of fan in

accordance with temperature so that it detects temperature variation automatically and control its speed. The application dictates that temperature settings are usually kept constant for long periods of time. The following are the modules:

- Microcontroller
- LCD Display
- Temperature and Humidity Sensor
- Fan Control

## Microcontroller

NodeMCU is the microcontroller based kit. It was the main memory of the systems. It consist of both hardware and software device. Physical programmable circuit board has hardware and IDE has software the runs on the computer and it is used to write and upload our computer code to the physical code. NodeMCU consist of 10 digital input pins, 1 analog pin, USB connection, DC Voltage supply, power indication, voltage regulator and reset button. Arduino is used to read the input like lighting on a sensor and turn on to output like turning on the LED and activating the motor etc. all the devices are interfaced through the arduino and the decision was taken by the arduino. It consists of boot loader so we can directly load the program to the device.

## LCD Display

Liquid Crystal Display is used for purpose of displaying the temperature and humidity value. It is an electronic display module. $16 \times 2$ and $20 \times 2$ are the most commonly used LCDs. $16 \times 2$ LED means it displays 16 character of column's and 2 character of rows as same as $20 \times 2$. The displaying character has pixel of $5 \times 4$ matrix. The LCD consist of two registers one is command another one is data. The reason for choosing the LED is, it is easily programmable, economical, and it has a no limitation for displaying the character.

## Temperature and Humidity Sensor

The LM35 and DHT11 Sensor is used to measure the temperature and humidity. It produces a digital output signal. It consist of four pin. 1st pin is connected to the VCC on the power supply 3.5 to 5 V. 2nd pin is connected to the data. 3rd pin has no connection. 4th pin is connected to the ground. The sensor is interface with Arduino and produces an output. For the humidity measurement it consists of sensing component and IC at the back side. It consist of two electrode if any resistance changes occurs between these electrodes, the changes are processed by

sensing IC and then the microcontroller reads the value. Negative temperature coefficient sensors are used for temperature measurement.

## Fan Control

The AC gets ON because of the sensed temperature is above the fixed temperature, if the temperature gets lower than the fixed temperature heater will get ON, the switching function is done by single channel based BC547 driver circuit to control fan ON-OOF that we used in the project.

In this project, the room temperature is maintained and monitored continuously by using the dht11 temperature and humidity sensor with arduino. This project helps to keep the people always in comfort zone and it also helps the people to know the current temperature and humidity in the LCD display.

## Existing System

- Potentiometer is act as the regulator is connected to the microcontroller. The fan speed is controlled by the potentiometer.
- Depending on the variation in the temperature the speed of the fan is on or off. The fan speed is measured manually and the speed of the fan and temperature is displayed in the LCD display.
- The controller sends the data to the relay. Relay is act as the switching device. The temperature become beyond the level of data set by the user the relay gets triggered and activate. Than the relay switches the cooling device. In this way it controls and monitors the temperature control.

## Disadvantages

- The accuracy to a large extent owing to its low accuracy as a single parameter.
- The model has to be first trained with some training samples after which it can run smoothly for any number of test cases.

## Proposed System

- This framework to allow the residents of the Smart building to regulate over the heating or cooling controls. As such, the house owner can monitor and remotely control the system.
- The decision is then conveyed through the Internet of Things, who might be remotely monitored; wirelessly with the help of WiFi module technologies or any other IoT devices.

## Architecture Diagram

### Transmitter (Climate Monitoring Sensor Area)
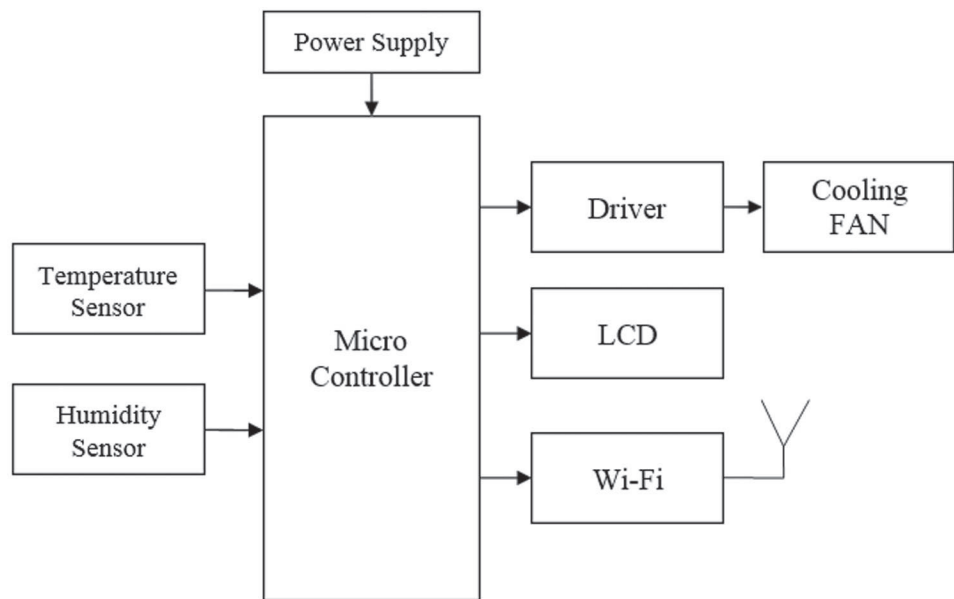


## Experimental Results

### Login Form
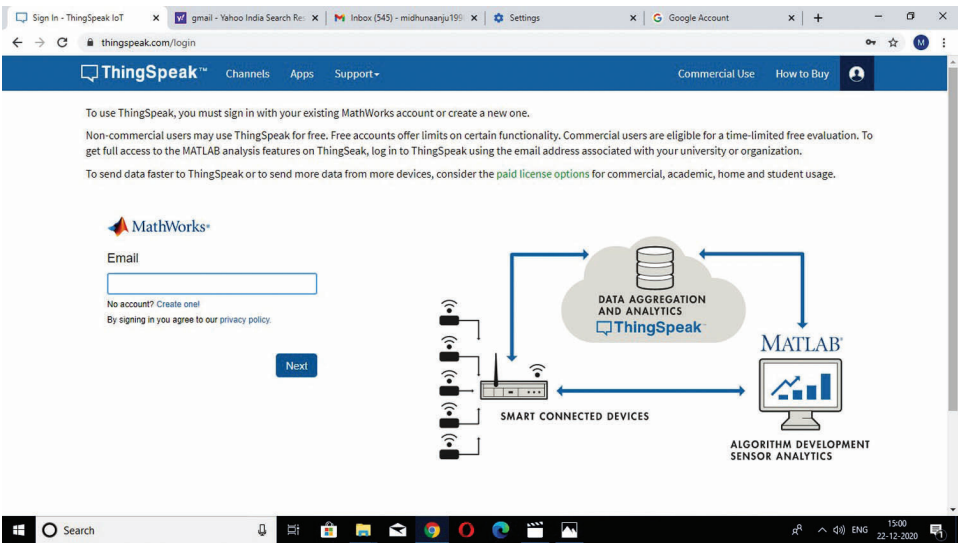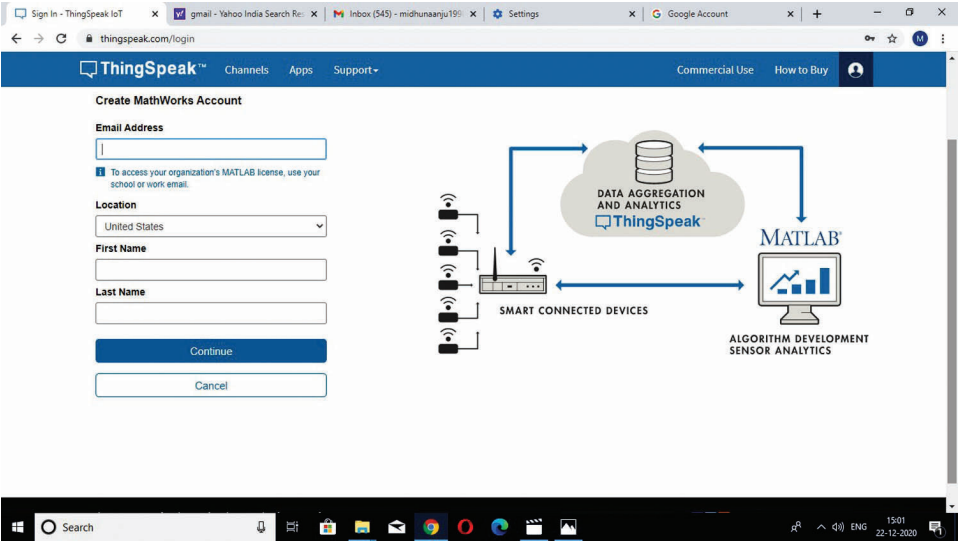
## Monitoring
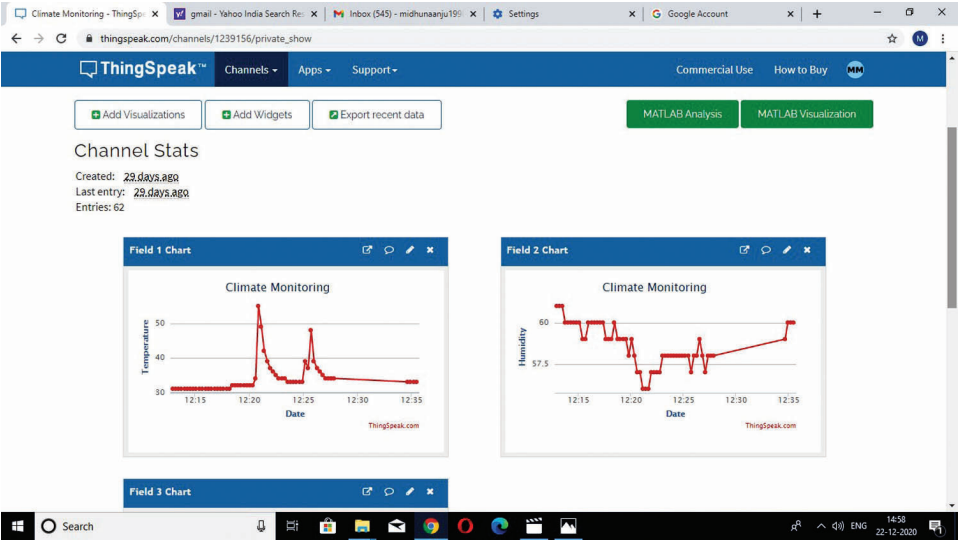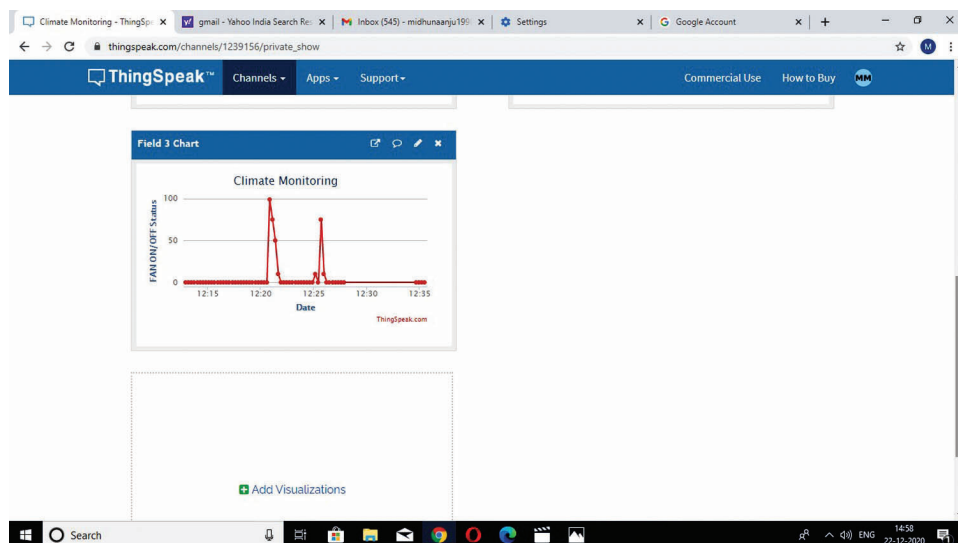
## Conclusion

In conclusion, the process in developing this innovative circuit is successfully done. The hardware implementation and its operation is functioning accordingly and smoothly following the procedure. High priority has been given to make the circuit simple but efficient with high reliability. Some slight of modifications have been made from the current and existing technology features to improve its performance. The circuit has fulfilled the main objective, which to control the speed of fan using the temperature controller with NodeMCU. It has a special safety feature by using a website interface to produce the graphical signal continuously if the temperature become overheats. This circuit is really practical to be applied, especially in today's hot condition.

### Scope for Future Enhancement

IoT technology, we proposed and implemented an extensive and novel architecture for a flexible, low-cost home control and monitoring system based on the Android OS that allows access to and control of the connected devices in the user's home using any Android-based smartphone.

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# 11

# Anti Malware Browser to Detect Fake URL Using Random Forest Model in Machine Learning

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**ABSTRACT**

This paper helps to detect malicious URL's with the help of machine learning. Malicious URL, or malicious website, is a common and serious threat to cyber security. Malicious URLs host unsolicited content (spam, phishing, drive-by downloads, etc.) and lure unsuspecting users to become victims of scams (monetary loss, theft of private information, and malware installation), and cause losses of billions of dollars every year. It is imperative to detect and act on such threats in a timely manner. Traditionally, this detection is done mostly through the usage of blacklists. However, blacklists cannot be exhaustive, and lack the ability to detect newly generated malicious URLs. To improve the generality of malicious URL detectors, machine learning techniques have been explored with increasing attention in recent years. Here I am introducing a new browser to identify malicious and fake URL's with the help of machine learning using Random Forest Classifier and is developed using python via this paper we can avoid fake URL and also secure our systems malware free.

## Introduction

The primitive usage of URL (Uniform Resource Locator) is to use as a Web Address. However, some URLs can also be used to host unsolicited content that can potentially result in cyber attacks. These URLs are called malicious URLs. The main motive for malicious URL detection is that they provide an attack surface to the adversary. It is vital to counter these activities via some new methodology. In literature, there have been many filtering mechanisms to detect the malicious URLs. Some of them are Black-Listing, Heuristic Classification etc. These

traditional mechanisms rely on keyword matching and URL syntax matching. Therefore, these conventional mechanisms cannot effectively deal with the ever evolving technologies and web access techniques. Furthermore, these approaches also fall short in detecting the modern URLs such as short URLs, dark web URL's. The human understandable URLs are used to identify billions of websites hosted over the present day internet. Adversaries who try to get unauthorized access to the confidential data may use malicious URLs and present it as a legitimate URL to naive user. Such URLs that act as a gateway for the unsolicited activities are called as malicious URLs. These malicious URLs can cause unethical activities such as theft of private and confidential data, ransom ware installation on the user devices that result in huge loss every year globally.

To overcome the limitations posed by the primitive classification methodologies like Black-Listing, Heuristic classification Research has been carried over the several areas and machine learning is one of the promising approaches to effectively classify the URLs [1] explains one of the several ways to leverage the machine learning in URL detection. Using the Supervised Machine Learning concepts such as Random Forest Model can classify at 89% without any tuning and feature selection.

Any machine learning technique typically comprises of two steps: one is to obtain the appropriate feature representation that it could provide the determining insights in finding the Malicious URLs, and the second is to use this representation to train a learning-based prediction mechanism. In the proposed approach, we have provided the feature representation of the URLs using Python.

## Methodology

Machine learning gives PCs the ability to learn without being unequivocally customized, fundamentally the same as working of a human being. The machine is learning from past encounters concerning a few classes of errands if the presentation of assignment improves with more insight. Learning can be classified as

1. Supervised
2. Unsupervised
3. Semi-Supervised
4. Reinforcement

### Supervised Machine Learning

Supervised learning is the types of machine learning in which machines are trained using well "labelled" training data, and on basis of that data, machines predict the

output. The labelled data means some input data is already tagged with the correct output.

In supervised learning, the training data provided to the machines work as the supervisor that teaches the machines to predict the output correctly. It applies the same concept as a student learns in the supervision of the teacher.

Supervised learning is a process of providing input data as well as correct output data to the machine learning model. The aim of a supervised learning algorithm is to find a mapping function to map the input variable (x) with the output variable (y).

In the real-world, supervised learning can be used for Risk Assessment, Image classification, Fraud Detection, spam filtering, etc.

### Working Supervised Learning

In supervised learning, models are trained using labelled dataset, where the model learns about each type of data. Once the training process is completed, the model is tested on the basis of test data (a subset of the training set), and then it predicts the output.

The working of Supervised learning can be easily understood by the below example and diagram:
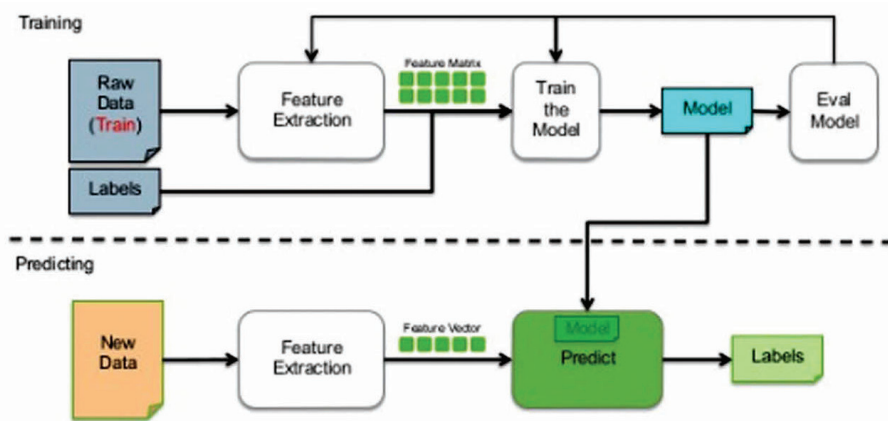


Supervised Learning

Suppose we have a dataset of different types of shapes which includes square, rectangle, triangle, and Polygon. Now the first step is that we need to train the model for each shape.

• If the given shape has four sides, and all the sides are equal, then it will be labelled as a Square.

- If the given shape has three sides, then it will be labelled as a triangle.
- If the given shape has six equal sides then it will be labelled as hexagon.

Now, after training, we test our model using the test set, and the task of the model is to identify the shape.

The machine is already trained on all types of shapes, and when it finds a new shape, it classifies the shape on the bases of a number of sides, and predicts the output.

### *Steps Involved in Supervised Learning*

- First Determine the type of training dataset
- Collect/Gather the labelled training data.
- Split the training dataset into training dataset, test dataset, and validation dataset.
- Determine the input features of the training dataset, which should have enough knowledge so that the model can accurately predict the output.
- Determine the suitable algorithm for the model, such as support vector machine, decision tree, etc.
- Execute the algorithm on the training dataset. Sometimes we need validation sets as the control parameters, which are the subset of training datasets.
- Evaluate the accuracy of the model by providing the test set. If the model predicts the correct output, which means our model is accurate.

## Random Forest Algorithm

Random Forest is a popular machine learning algorithm that belongs to the supervised learning technique. It can be used for both Classification and Regression problems in ML. It is based on the concept of ensemble learning, which is a process of combining multiple classifiers to solve a complex problem and to improve the performance of the model.

As the name suggests, "Random Forest is a classifier that contains a number of decision trees on various subsets of the given dataset and takes the average to improve the predictive accuracy of that dataset." Instead of relying on one decision tree, the random forest takes the prediction from each tree and based on the majority votes of predictions, and it predicts the final output.

The greater number of trees in the forest leads to higher accuracy and prevents the problem of overfitting.

The below diagram explains the working of the Random Forest algorithm:
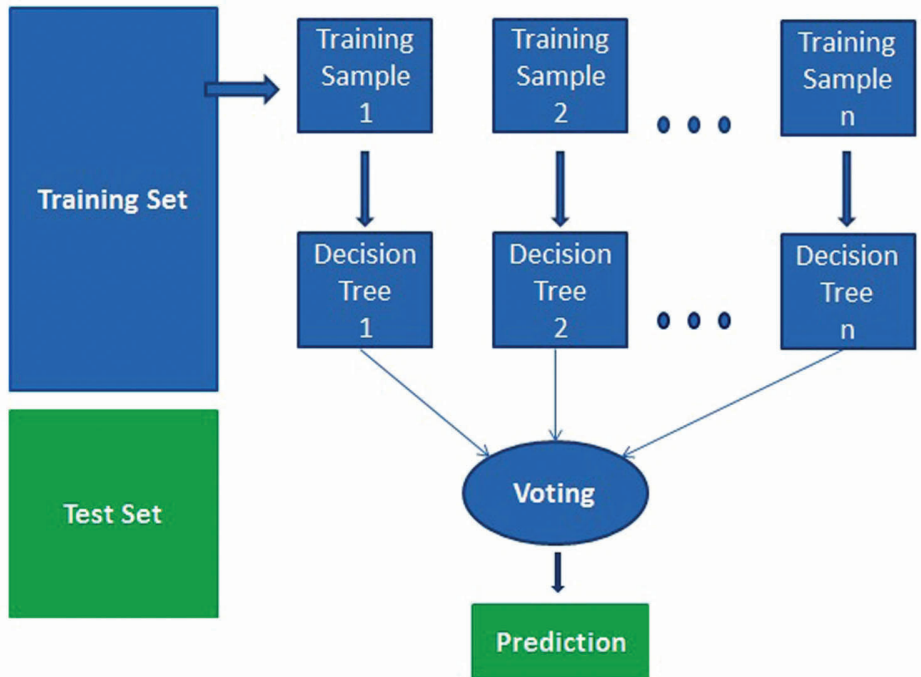


### Assumptions for Random Forest

Since the random forest combines multiple trees to predict the class of the dataset, it is possible that some decision trees may predict the correct output, while others may not. But together, all the trees predict the correct output. Therefore, below are two assumptions for a better Random forest classifier:

- There should be some actual values in the feature variable of the dataset so that the classifier can predict accurate results rather than a guessed result.
- The predictions from each tree must have very low correlations.

### Python Implementation of Random Forest Algorithm

Now we will implement the Random Forest Algorithm tree using Python. For this, we will use the same dataset "user_data. csv", which we have used in previous classification models. By using the same dataset, we can compare the Random Forest classifier with other classification models such as Decision tree Classifier, KNN, SVM, Logistic Regression, etc.

Implementation Steps are given below:

- Data Pre-processing step
- Fitting the Random forest algorithm to the Training set
- Predicting the test result
- Test accuracy of the result (Creation of Confusion matrix)
- Visualizing the test set result.

## Main Modules of the System

- Client
- Browser
- Detection Server
- Web Server

### Client

Client are the users of the project and are the people who benefit from the detection of malicious URL's. Client are the people or system who Requests the server for validating whether URL is malicious or not.

### Browser

Anti Malware Browser is the application for accessing information in the www. Browser receives request from client and delivers the result. when user inputs a URL into the Browser it passes to the detection server.

### Detection Server

This module contains the Machine Learning Algorithm to detect the malicious URL's. The process of validating whether the URL is malicious or not is done by this module it contains.

### *Dataset*

Experimental dataset includes malicious URLs and normal URLs, which are used for training and testing classifiers.

### *Training Set*

We train our system using pre defined database which contains signatures of the previously known malicious links and malwares using Random Forest Classifier.

*Validation Set*

A validation dataset is a sample of data held back from training your model that is used to give an estimate of model skill while tuning model's hyper parameters. The validation set compare their performances and decide to select a model among different models.

*Test Set*

Test dataset is used to provide an unbiased evaluation of a *final* model fit on the training dataset If the data in the test dataset has never been used in training.

## Web Server

Server responds to the request of the client. It is in this module the results of the validation are displayed that is whether the URL is malicious or not.

## Existing System

Currently, the risk of network information insecurity is increasing rapidly in number and level of danger. The methods mostly used by hackers today is to attack end-to end technology and exploit human vulnerabilities. These techniques include social engineering, phishing, pharming, etc. One of the steps in conducting these attacks is to deceive users with malicious Uniform Resource Locators (URLs). As a result, malicious URL detection is of great interest nowadays. There have been several scientific studies showing a number of methods to detect malicious URLs based on machine learning.

From the statistics of the increase in the number of malicious URL distributions over the consecutive years, it is clear that there is a need to study and apply techniques or methods to detect and prevent these malicious URLs. Regarding the problem of detecting malicious URLs, there are two main trends at present as malicious URL detection based on signs or sets of rules, and malicious URL detection based on behavior analysis techniques. The method of detecting malicious URLs based on a set of markers or rules can quickly and accurately detect malicious URLs. However, this method is not capable of detecting new malicious URLs that are not in the set of predefined signs or rules. The method of detecting malicious URLs based on behavior analysis techniques adopt machine learning or deep learning algorithms to classify URLs based on their behaviors.

## Proposed System

To overcome the limitations posed by the primitive classification methodologies like Black-Listing, Heuristic classification Research has been carried over the several areas and machine learning is one of the promising approaches to effectively classify the URLs explains one of the several ways to leverage the machine learning in URL detection. Using the Supervised Machine Learning concepts such as Random Forest Model can classify at 89% without any tuning and feature selection. Any machine learning technique typically comprises of two steps: one is to obtain the appropriate feature representation that it could provide the determining insights in finding the Malicious URLs, and the second is to use this representation to train a learning-based prediction mechanism. In the proposed approach, we have provided the feature representation of the URLs. Analogically, Blood of this Process is the features and heart is the machine learning mechanism. Every time the blood passes through the heart the refining will happen. In the same manner features of the URLs will pass through the machine learning engine and then based on the previous learning the classification develops. In this project, we clearly followed the random forest classifier Analysis Feature. Random Forest (RF) is the ensemble classifier, which collects the results of many decision trees by majority vote. In ensemble learning, the results of multiple classifiers are brought together, and a single decision is made on behalf of the community. Each decision tree in the forest is created by selecting different samples from the original data set using the bootstrap technique. Then, the decisions made by many different individual trees are subject to voting and present the class with the highest number of votes as the class estimate of the committee. In the RF method, trees are created by CART (Classification and Regression Trees) algorithms and boot bagging combination method. The data set is divided into training and test data. From the training data set, samples are selected as Bootstrap technique, which will form trees and data that will not build trees. 1/3 of the training set is divided into data that will not form trees, and 2/3 of them will be data that will build trees. m variables are selected in each node among all variables, and the best separations are provided by using the Gini index.

### Advantages

- Protection from tech support scammers
- Faster web page load times, Prevents visits to malicious pages
- Keeps your privacy private, Malware protection
- Scam protection, Advertising/Tracking protection
- Click bait protection and Pup protection

## Architecture Diagrams

## Experimental Results
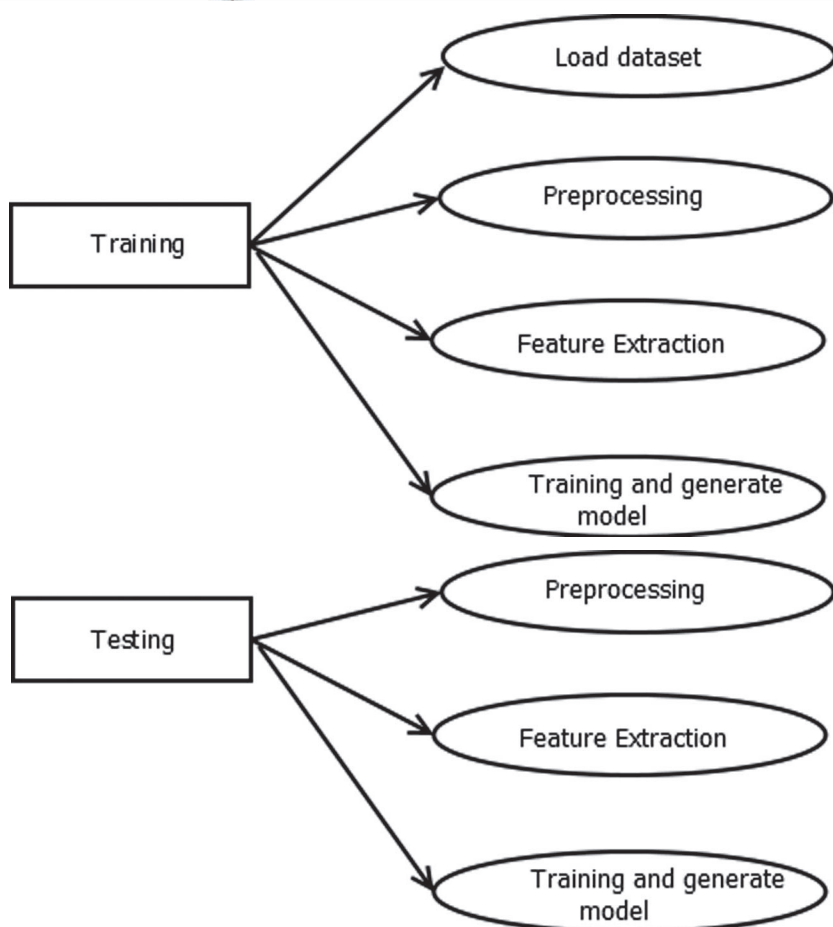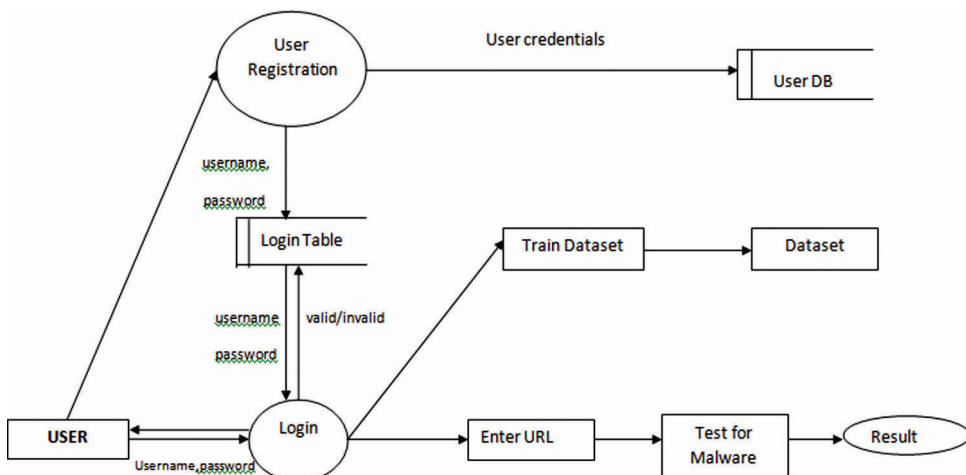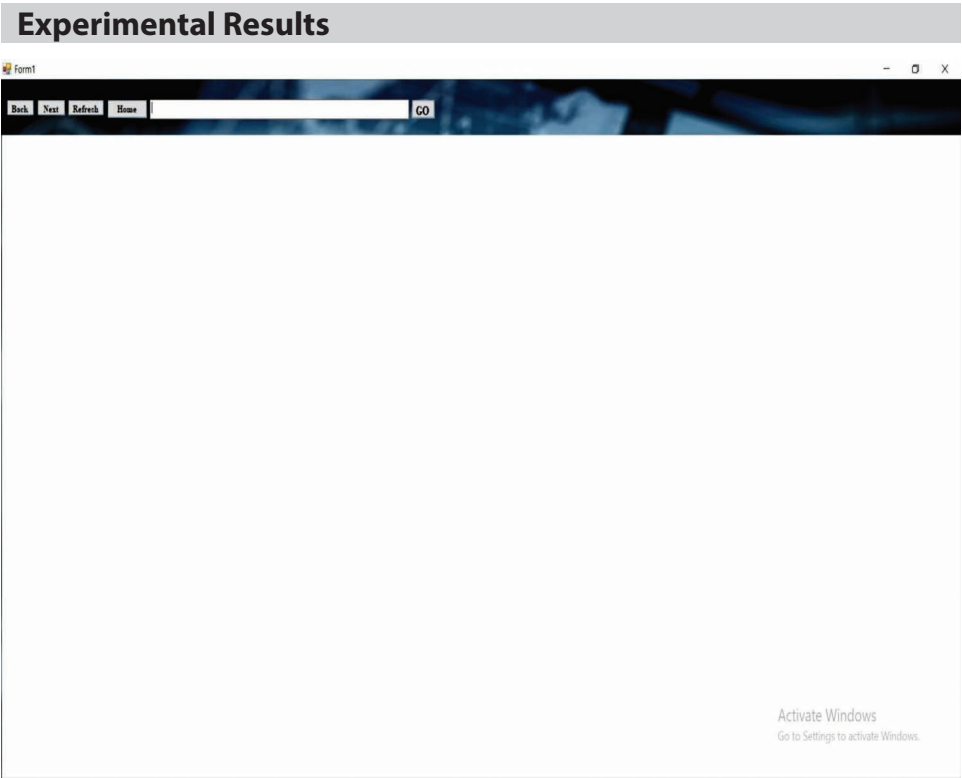


**Fig. 1:** Home page
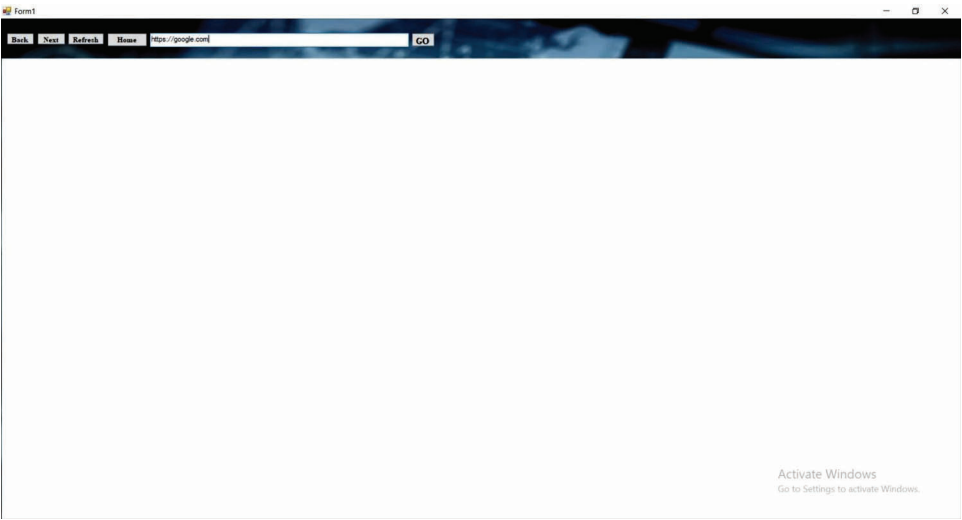


**Fig. 2:** Browsing Page
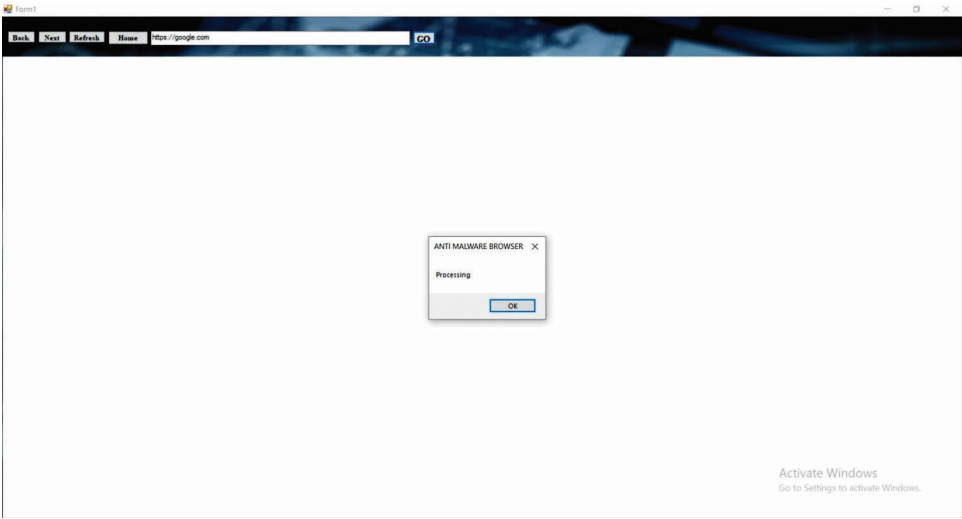
**Fig. 3:** Loading Page
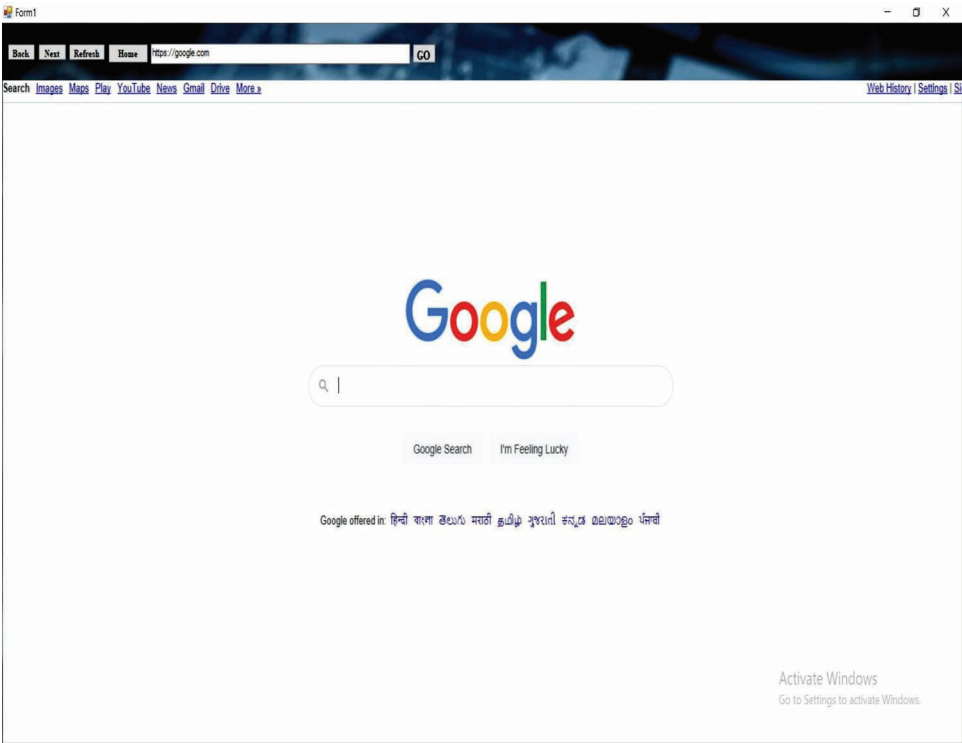


**Fig. 4:** Resultant Page of safe URL
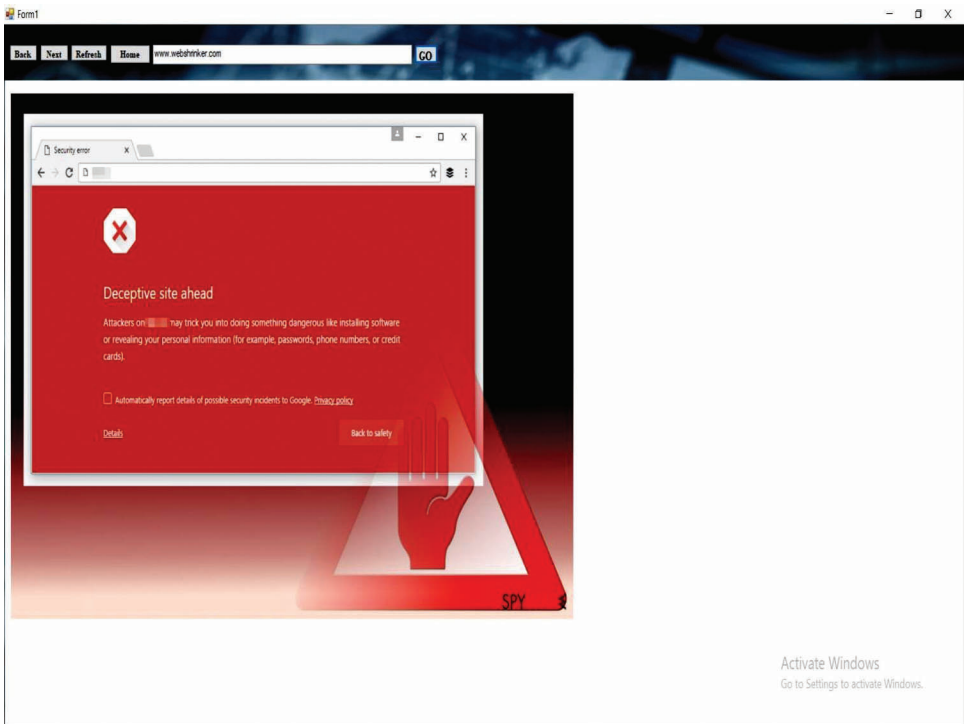
**Fig. 5:** Resultant Page of Malicious URL

URL - Notepad

File  Edit  Format  View  Help

```
http://google.co.jp,0
http://soso.com,0
http://instagram.com,0
http://ask.com,0
http://paypal.com,0
http://google.com.hk,0
http://google.ru,0
http://blogger.com,0
http://xvideos.com,0
http://google.it,0
http://tmall.com,0
http://imdb.com,0
http://google.es,0
http://craigslist.org,0
http://sohu.com,0
http://360.cn,0
http://go.com,0
http://bbc.co.uk,0
http://xhamster.com,0
http://stackoverflow.com,0
http://google.com.mx,0
http://amazon.co.jp,0
http://cnn.com,0
http://neobux.com,0
http://google.ca,0
http://fc2.com,0
http://imgur.com,0
http://youku.com,0
http://wordpress.org,0
http://vube.com,0
http://flickr.com,0
http://espn.go.com,0
http://alibaba.com,0
http://odnoklassniki.ru,0
http://conduit.com,0
http://thepiratebay.sx,0
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URL - Notepad

File  Edit  Format  View  Help

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http://akamaihd.net,0
http://huffingtonpost.com,0
http://adcash.com,0
http://t.co,0
http://amazon.de,0
http://google.com.tr,0
http://godaddy.com,0
http://pornhub.com,0
http://blogspot.in,0
http://about.com,0
http://ku6.com,0
http://ebay.de,0
http://reddit.com,0
http://bp.blogspot.com,0
http://google.com.au,0
http://adobe.com,0
http://uol.com.br,0
http://google.pl,0
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http://delta-search.com,0
http://dailymail.co.uk,0
http://rakuten.co.jp,0
http://aliexpress.com,0
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http://dce.edu,0
http://google.com,0
http://stackoverflow.com/questions/8551735/how-do-i-run-python-code-from-sublime-text-2,0
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http://civilwarvetswastate.com/gxy/,1
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http://beva.com,0
http://indeed.com,0
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http://clkmon.com,0
http://softonic.com,0
http://google.com.vn,0
http://nfl.com,0
http://mailchimp.com,0
http://allegro.pl,0
http://qtrax.com,0
http://tripadvisor.com,0
http://photobucket.com,0
http://google.be,0
http://mashable.com,0
http://skype.com,0
http://walmart.com,0
http://xvxv.net,0
```

```
http://google.com.ua,0
http://taringa.net,0
http://empowernetwork.com,0
http://bild.de,0
http://github.com,0
http://thefreedictionary.com,0
http://ask.fm,0
http://google.co.ve,0
http://onet.pl,0
http://leboncoin.fr,0
http://google.com.ng,0
http://yieldmanager.com,0
http://nicovideo.jp,0
http://pconline.com.cn,0
http://wordreference.com,0
http://php.net,0
http://telegraph.co.uk,0
http://wellsfargo.com,0
http://uploaded.net,0
http://wsj.com,0
http://usatoday.com,0
http://pandora.com,0
http://goo.ne.jp,0
http://shutterstock.com,0
http://pclady.com.cn,0
http://comcast.net,0
http://answers.com,0
http://google.com.ph,0
http://amazon.fr,0
http://google.se,0
http://rutracker.org,0
http://google.cn,0
http://aili.com,0
http://washingtonpost.com,0
http://google.ro,0
http://ikea.com,0
```

```
File   Edit   Format   View   Help
http://midominiogratis.com,1
http://1br.net,1
http://sitio.de,1
http://clic3.net,1
http://url.ie,1
http://dunesdugolf.eu,1
http://avsam.com.tr,1
http://avsaadasi.gen.tr,1
http://zoodl.com,1
http://abc1.eu,1
http://article19.eu,1
http://beira.us,1
http://besides.tv,1
http://blasphemy.asia.com,1
http://borderline.asia.com,1
http://buckhead.asia,1
http://careerbuilding.net,1
http://centralasia.asia.com,1
http://cepf.eu,1
http://chinese.uz,1
http://clickpage.net,1
http://cnlhotels.com,1
http://discover-places.com,1
http://e-shopping.asia.com,1
http://emcef.eu,1
http://emissions.asia.com,1
http://euromalt.eu,1
http://exclusive.asia.com,1
http://express247.com,1
http://fertile.mobi,1
http://finished.tv,1
http://gateway.us,1
http://ggeat.com,1
http://glitch.asia.com,1
http://holidaybug.com,1
http://homesaid.com,1
```

**Fig. 6:** Safe and Malicious URL

## Conclusion

With the developing computer and system technologies, people exchange information over the Internet that attracts people due to the convenience of services they offer day by day and beyond that, they do many other things related to daily life. During these processes, users have intelligence and critical information such as descriptive usernames and passwords. Most network applications detect their users with them. The rapid increase of the web pages and applications caused them to become the primary target for the attackers. Today, the number of malicious websites has increased considerably. Malicious behavior of trusted or malicious users threatens network applications. Users who are unaware of anything become a victim only by visiting these harmful pages. Attackers can exploit the web environment more easily by uploading or embedding malicious code on the web page instead of spreading the malware. According to the Google Research Center, over 10% of web pages contain malicious code. Therefore, the detection of harmful web pages has become very important to protect the users of the web environment from these threats. In this respect, determining whether web pages directed to users are used for malicious behavior is of great importance for the institution and

individual users to overcome the situation with minimum damage. Recent years have witnessed detecting Malicious URL has a significant role in cybersecurity applications. Malicious URL has been a severe threat to cybersecurity. Without any questions, CPS can be considered as a crucial step in the development of data-accessing and data-processing services available on the Internet.

## Scope for Future Enhancement

In this work, we have described how a machine can able to judge the URLs based upon the given feature set. Specifically, we described the feature sets and an approach for classifying the given the feature set for malicious URL detection. When traditional method falls short in detecting the new malicious URLs on its own, our proposed method can be augmented with it and is expected to provide improved results. Here in this work, we proposed the feature set which can able to classify the URLs. The Future work is to fine tuning the machine learning algorithm that will produce the better result by utilizing the given feature set. Adding to that the open question is how we can handle the huge number of URLs whose features set will evolve over time. Certain efforts have to be made in that direction so as to come up with the more robust feature set which can change with respect to the evolving changes.

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# 12

# Performing NLP for Finding Semantic Drift Using Naïve Bayes Machine Learning

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## ABSTRACT

Natural Language Processing (NLP) is an area of growing attention due to increasing number of applications like chatbots, machine translation etc. In some ways, the entire revolution of intelligent machines in based on the ability to understand and interact with humans.

In semantics and historical linguistics, semantic change refers to any change in the meaning(s) of a word over the course of time. Also called semantic shift, lexical change, and semantic progression. Common types of semantic change include amelioration, pejoration, broadening, semantic narrowing, bleaching, metaphor, and metonymy. Semantic change may also occur when native speakers of another language adopt English expressions and apply them to activities or conditions in their own social and cultural environment.

"Metaphor in semantic change involves extensions in the meaning of a word that suggest a semantic similarity or connection between the new sense and the original one. Metaphor is considered a major factor in semantic change...The semantic change of *grasp* 'seize' to 'understand,' thus can be seen as such a leap across semantic domains, from the physical domain ('seizing') to the mental domain ('comprehension')... Frequently mentioned examples of metaphoric extensions involve expressions for 'to kill': *dispose of, do someone in, liquidate, terminate, take care of, eliminate and others."*

## Naïve Bayes Machine Learning

Traditional machine learning algorithms often assume that the data values are exact or precise. In many emerging applications, however, the data is inherently uncertain. Sampling errors and instrument errors are both sources of uncertainty, and data are typically represented by probability distributions rather than by deterministic values. There are many learning algorithms used in the classification of

deterministic data points, but few algorithms have been proposed for classification of distribution-based uncertain data objects.

- Naïve Bayes algorithm is a supervised learning algorithm, which is based on Bayes theorem and used for solving classification problems.
- It is mainly used in text classification that includes a high-dimensional training dataset.
- Naïve Bayes Classifier is one of the simple and most effective Classification algorithms which helps in building the fast machine learning models that can make quick predictions.
- It is a probabilistic classifier, which means it predicts on the basis of the probability of an object.
- Some popular examples of Naïve Bayes Algorithm are spam filtration, Sentimental analysis, and classifying articles.
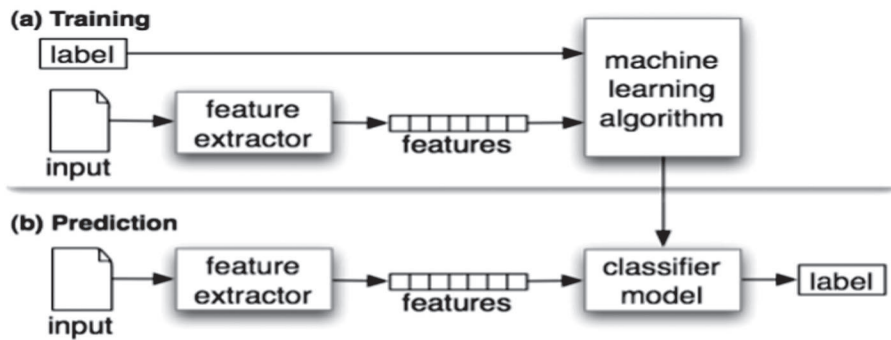


Block Diagram for a Natural Language Processing (NLP)
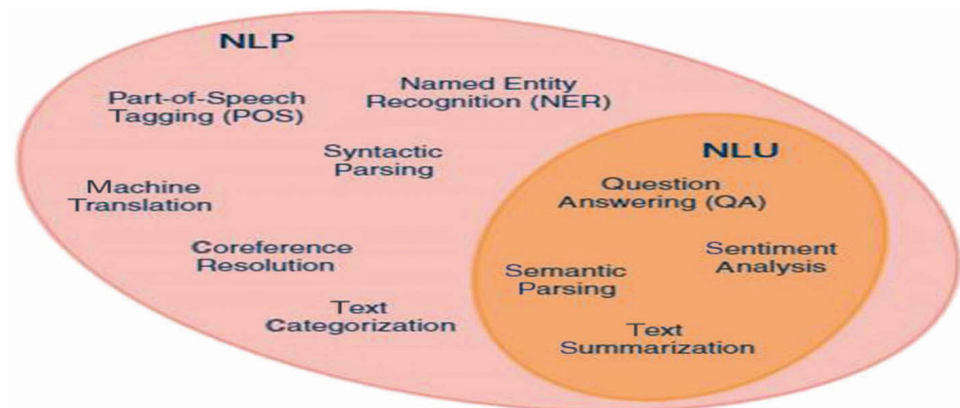


Natural Language Processing

## Naive Bayes' Theorem

- Bayes' theorem is also known as Bayes' Rule or Bayes' law, which is used to determine the probability of a hypothesis with prior knowledge. It depends on the conditional probability.
- The formula for Bayes' theorem is given as:

$$P(A/B) = (P (B/A) P(A))/P(B)$$

Where,

P(A|B) is Posterior probability: Probability of hypothesis A on the observed event B.

P(B|A) is Likelihood probability: Probability of the evidence given that the probability of a hypothesis is true.

P(A) is Prior Probability: Probability of hypothesis before observing the evidence.

P(B) is Marginal Probability: Probability of Evidence.

## Types of Naïve Bayes Model

There are three types of Naive Bayes Model, which are given below:

- *Gaussian:* The Gaussian model assumes that features follow a normal distribution. This means if predictors take continuous values instead of discrete, then the model assumes that these values are sampled from the Gaussian distribution.
- *Multinomial:* The Multinomial Naïve Bayes classifier is used when the data is multinomial distributed. It is primarily used for document classification problems, it means a particular document belongs to which category such as Sports, Politics, education, etc. The classifier uses the frequency of words for the predictors.
- *Bernoulli:* The Bernoulli classifier works similar to the Multinomial classifier, but the predictor variables are the independent Booleans variables. Such as if a particular word is present or not in a document. This model is also famous for document classification tasks.

Naive Bayes classifiers In probability theory, Bayes theorem relates the conditional and marginal probabilities of two random events. It is often used to compute posterior probabilities given observations. Let $x = (x_1, x2, \ldots, xd)$ be a d-dimensional instance which has no class label, and our goal is to build a classifier to predict its unknown class label based on Bayes theorem. Let C = {C1, C2, . . .,

CK} be the set of the class labels. P(Ck) is the prior probability of Ck (k = 1, 2, ..., K) that are inferred before new evidence; P(x|Ck) be the conditional probability of seeing the evidence x if the hypothesis Ck is true. A technique for constructing such classifiers to employ Bayes' theorem to obtain:

$$P(Ck|x) = P(x|Ck)P(Ck) \; P \; k' \; P(x|Ck')P(Ck') \tag{1}$$

A naive Bayes classifier assumes that the value of a particular feature of a class is unrelated to the value of any other feature, so that1 :

$$P(x|Ck) = Y \; d \; j = 1 \; P(x \; j|Ck)$$

## NLP Experimental Results

Two well-known examples of semantic shift have remained popular since the Vietnam War, when *hawk* came to be used frequently for supporters of the war and *dove* for its opponents, extending the meaning of these words from the combative nature of hawks and the symbolically peaceful role of doves. Today, computers users utilize a *mouse* and *bookmark* Internet addresses. These new meanings did not replace earlier ones but extended the range of application for the words *mouse* and *bookmark*

## Step 1: Input Text
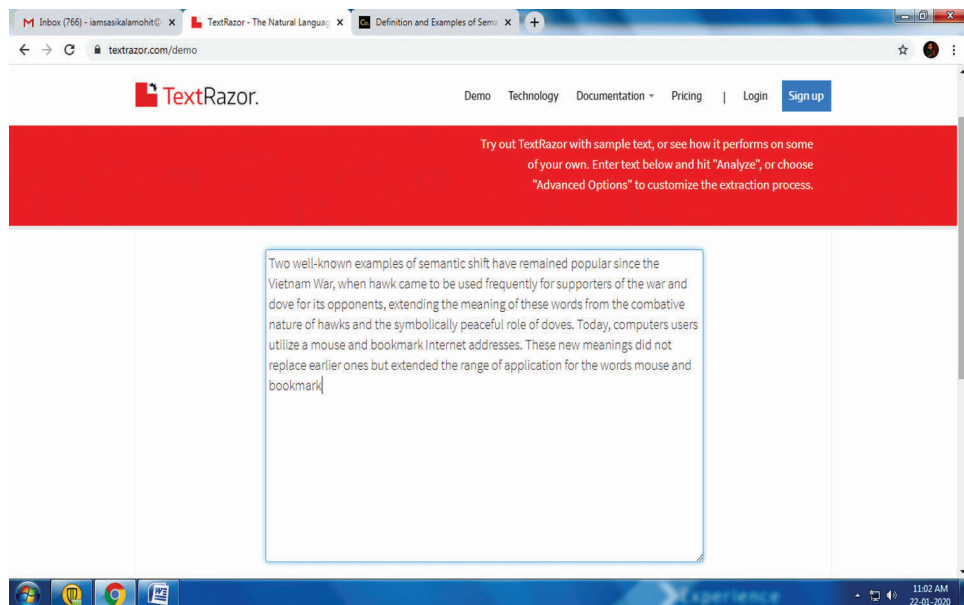
**Step 2: Text Processing as Tokens**

| Position | Token | Lemma | Stem | Part of Speech | Spelling Suggestions | Senses | Parent Position | Relation to Parent | Start Offset | End Offset |
|---|---|---|---|---|---|---|---|---|---|---|
| 64 | These | this | these | DT | | | 66 | det | 367 | 372 |
| 65 | new | new | new | JJ | | *raw.s.12* (0.1171) *new.s.10* (0.2103) *new.a.06* (0.3121) *new.s.11* (0.3123) *new.s.04* (0.3637) *new.s.05* (0.375) *fresh.s.04* (0.3899) *new.s.08* (0.3908) *modern.s.05* (0.4157) *newfangled.s.01* (0.4554) *new.a.01* (0.7002) | 66 | amod | 373 | 376 |
| 66 | meanings | meaning | mean | NNS | | *meaning.n.02* (0.4999) *meaning.n.01* (0.6901) | 69 | nsubj | 377 | 385 |
| 67 | did | do | did | VBD | | | 69 | aux | 386 | 389 |
| 68 | not | not | not | RB | | | 69 | neg | 390 | 393 |
| 69 | replace | replace | replac | VB | | *replace.v.03* (0.3706) *supplant.v.01* (0.4266) *substitute.v.01* (0.4912) *replace.v.01* (0.6893) | | | 394 | 401 |
| 70 | earlier | early | earlier | JJR | | *early.s.04* (0.06023) *early.a.02* (0.2296) *early.s.06* (0.2612) *earlier.s.01* (0.2636) *early.s.03* (0.3558) *early.a.01* (0.3617) *early.a.05* (0.4326) | 71 | amod | 402 | 409 |
| 71 | ones | one | one | NNS | | *one.n.02* (0.2441) *one.n.01* (0.4828) | 69 | dobj | 410 | 414 |
| 72 | but | but | but | CC | | | 69 | cc | 415 | 418 |
| 73 | extended | extend | extend | VBD | | *gallop.v.03* (0.2418) *carry.v.09* (0.2439) *stretch.v.02* (0.2469) *extend.v.15* (0.2499) *extend.v.13* (0.2608) *unfold.v.03* (0.2899) *prolong.v.01* (0.3019) *strain.v.03* (0.3067) *extend.v.17* (0.323) *extend.v.06* (0.3264) *exsert.v.01* (0.3286) *extend.v.09* (0.3356) *extend.v.04* (0.3388) *offer.v.05* (0.3455) *cover.v.03* (0.5004) *widen.v.04* (0.6941) *run.v.03* (0.7837) | 69 | conj | 419 | 427 |
| 74 | the | the | the | DT | | | 75 | det | 428 | 431 |

| Position | Token | Lemma | Stem | Part of Speech | Spelling Suggestions | Senses | Parent Position | Relation to Parent | Start Offset | End Offset |
|---|---|---|---|---|---|---|---|---|---|---|
| 75 | range | range | rang | NN | | range.n.06 (0.157) stove.n.01 (0.1928) range.n.04 (0.1977) range.n.05 (0.2173) compass.n.03 (0.2419) range.n.03 (0.288) image.n.07 (0.3331) range.n.02 (0.419) scope.n.01 (0.5725) | 73 | dobj | 432 | 437 |
| 76 | of | of | of | IN | | | 75 | prep | 438 | 440 |
| 77 | application | application | applic | NN | | application.n.06 (0.01544) lotion.n.02 (0.08323) application.n.03 (0.3149) application.n.07 (0.3482) application.n.04 (0.4048) application.n.02 (0.4392) application.n.01 (0.6594) | 76 | pobj | 441 | 452 |
| 78 | for | for | for | IN | | | 77 | prep | 453 | 456 |
| 79 | the | the | the | DT | | | 81 | det | 457 | 460 |
| 80 | words | word | word | NNS | | quarrel.n.01 (0.067) son.n.02 (0.2223) parole.n.01 (0.2448) bible.n.01 (0.2636) word.n.04 (0.2859) discussion.n.02 (0.3001) words.n.01 (0.3201) password.n.01 (0.3249) news.n.01 (0.3263) word.n.02 (0.3273) actor's_line.n.01 (0.3472) words.n.03 (0.3472) word.n.07 (0.4487) lyric.n.01 (0.4494) word.n.01 (0.7392) | 81 | nn | 461 | 466 |
| 81 | mouse | mouse | mous | NN | | shiner.n.01 (0.0883) mouse.n.03 (0.2084) mouse.n.04 (0.3198) mouse.n.01 (0.3336) | 78 | pobj | 467 | 472 |
| 82 | and | and | and | CC | | | 81 | cc | 473 | 476 |
| 83 | bookmark | bookmark | bookmark | NN | | bookmark.n.01 (0.4532) | 81 | conj | 477 | 485 |
| 84 | . | . | . | . | | | 69 | punct | 485 | 485 |

**Step 3: Retrieving Noun Phrases**

| *Noun Phrases* |
| --- |
| These new meanings |
| earlier ones |
| the range |
| application |
| the words mouse and bookmark |

**Step 4: Retrieving Subject, Predicate and Object**

| *Subject* | *Predicate* | *Object* |
| --- | --- | --- |
| These new meanings | did not replace but | earlier ones extended the range of application for the words mouse and bookmark |
| These new meanings | did not replace earlier ones but | extended the range of application for the words mouse and bookmark |

**Step 5: Retrieving Predicate and property**

| *Predicate* | *Property* |
| --- | --- |
| These meanings | new |
| ones | earlier |
| the range of | application for the words mouse and bookmark |
| application for | the words mouse and bookmark |

**Step 6: Evaluating Entities with confidence, relevance score and match with word databases**

**Entities**

| *Entity* | *Confidence Score* | *Relevance Score* | *DBpedia Type* | *Freebase Type* |
| --- | --- | --- | --- | --- |
| Computer mouse (/m/020lf) (Q7987) | 1.174 | 0.3676 | | /law/invention /computer/computer_ peripheral_class /computer/computer_ peripheral /cvg/input_method /award/ranked_item /law/us_patent /business/consumer_ product |

| Entity | Confidence Score | Relevance Score | DBpedia Type | Freebase Type |
|---|---|---|---|---|
| Bookmark (digital) (/m/0f7n6z) (Q875110) | 1.051 | 0.2927 | | |

**Step 7: Substantiating Semantic drift with contextual entailment and score with prior score**

| Words | Contextual Entailment | Contextual Score | Prior Score | Total Score |
|---|---|---|---|---|
| new | new | 1 | 1 | 1 |
| new | supplementary | 0.07992 | 0.001598 | 0.1639 |
| new | contemporary | 0.1211 | 0.004844 | 0.2453 |
| new | forthcoming | 0.11 | 0.000527 | 0.1545 |
| new | alternative | 0.3677 | 0.005782 | 0.3627 |
| new | subsequent | 0.4989 | 0.00563 | 0.4122 |
| new | modernized | 0.1388 | 0.0006103 | 0.1677 |
| new | dissimilar | 0.2441 | 0.0003465 | 0.2046 |
| new | additional | 0.3068 | 0.007281 | 0.3684 |

**Step 8: Dependency parse tree created for the input paraphrases**
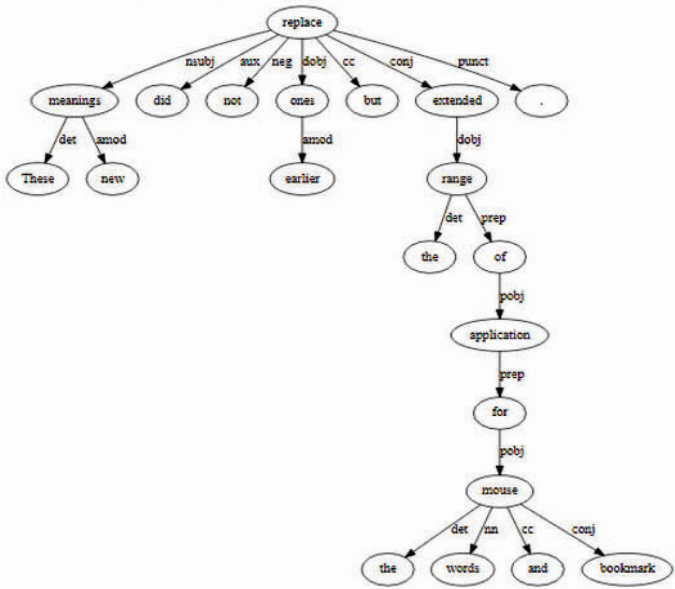
## Conclusion

Our results show that our novel local natural language processing measure of semantic change is more sensitive to changes in nouns, while the global measure is more sensitive to changes in verbs. This mapping aligns with the traditional distinction between irregular cultural shifts in nominals and more regular cases of linguistic drift reinforced by the case studies. This finding emphasizes that researchers must develop and use measures of semantic change that are tuned to specific tasks.

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# 13

# Protection of Child Rights

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## ABSTRACT

Every human being below the age of eighteen years is known as 'child'. Being the signatory of United Nations Conventions on the Rights of the Childs (1992). India globally recognized the significance of child rights covering basic issues, like 'Health', 'Education', and protection from 'hazardous employment' and 'exploitation'. Children have rights as human beings and need special case and protection. Thousands of children lose their lives each day, not only because of poverty but also because female infanticides are practiced with impunity. The main aim of protection of child rights is need to analysis the child thoughts and provide the forum to discuss with the user. Through some support and services the child can get benefits. These are the tools going to develop for the protection of child rights. In the world of smart phones right now, from city people to villagers each one carries a Smartphone. Considering this reality in mind, the significant issue of Children security can be resolved using Save Young India. A Child Security Mobile Application available in both Android and IOS and child security is the main aim of this application. The Save Young India Application helps to prevent children from this violence and to create awareness among the people about them.

## Introduction

As India races towards achieving super power, its children are still far behind in terms of healthcare, education and other facilities. Children especially girls are faced with lack of educational opportunities, malnourishment, infant mortality and early marriages. According to the latest data collated by the National Health Survey 2005-06 the all India average for malnourished children is 47%. Every second child under 5 years is malnourished. Even the prosperous states like Gujarat and Kerala there is rise in the number of malnourished children. Both states saw an increase of 2% between 1991-2001. Other states for instance Madhya Pradesh registered a rise from 54% in 1991 to 60% in 2001.

Nearly 3/4ths of all infants between 6-35 months of age are anemic in the 19 states for which NFHS-3 data are available. Among all the children up to 3 years age over 1/3 are stunted and more than 1/6th are wasted. Two out of five children are underweight. What is alarming that the situation is worsening or at best not improving over the years?

Comparison with NHFS-2 carried out five years ago shows that the production of wasted children has increased while underweight children are only marginally less. Similarly the proportion of anemic has jumped from about 49% to over 54% in these five years in these 19 states. The prevalence of anemia among infants has declined in several states but in has not improves or even worsened in AP, Assam, Karnataka, Kerala, Meghalaya, Orissa, Punjab and UP. In no state has the proportion falle below 50%. Up, Rajasthan, Punjab, Haryana, Karnataka, Gujarat and Assam all have shockingly high proportions of anemic infants - 80% or above.

Incidentally nearly a third of married men in the eastern states of West Bengal, Orissa, Assam and Meghalaya and in highly advanced Gujarat is anemic and has lower than normal BMI. Chattisgarh has the highest number of underweight children closely followed by Gujarat and Uttar Pradesh. However while the numbers have declined in the former, they are increasing in the latter two over the past five years. Another indicator is high infant mortality rate where India is bettered by Pakistan, China, Brazil and even Nigeria. All India average is 58 infant deaths for every 1000 live births and states like Uttar Pradesh (73), Rajasthan (65), Arunachal Pradesh (61) and Gujarat (50) top the list.

An immunization level is one of the indicators which show serious concern. The NFHS shows that only six of the 19 states for which data has been made public are more than 60% of children fully immunized. In 8 states the proportion of fully immunized children is less than half. Not only do children have fewer chances of surviving and are underfed they also lack educational opportunities. Literacy rate among girls from scheduled castes and scheduled tribes in 42% and 35% respectively, much lower than Muslim girls who have a literacy rate of 50%. In general too only 30 of 100 girls who enter school complete their primary education. The worst offenders in lack of educational opportunities for girls are Bihar (33%), Arunachal Pradesh (33.4%), Sikkim (37.2%) and Rajasthan (38.2%) as opposed to an all India average of 55.6% Meghalaya is an exception where female literates are actually much more than their male counterparts. Early marriages are far from being eradicated. In Rajasthan, 41% girls get married between 15-19 years of age while in Punjab; the proportion of girls being married before 18 has risen from 12% to 19% in seven years, between the years 1998-99 to 2005-2006. In the world of

smart phone right now, from city people to villagers each one carries a Smartphone. Considering this reality in mind, the significant issue of Children security can be resolved using Save Young India - A Child Security Mobile Application available in both Android and IOS and child security is the main aim of this application. Although how high our modern life develops, the incidents of violence against child rights like domestic violence, child abusement, maltreatment, child labor, child marriage, etc are still existing which make the safety of children at risk. The Internet has brought revolution in the field of communication. One can utilize the internet for various reasons but the main aim of the internet is sharing of information. The most useful application of the internet is web services where the internet plays a very important role. The Save Young India Application helps to prevent children from this violence and to create awareness among the people about them. The application is used by any people above 15 years of age. It will maintain all the users' database which stores the user personal information like name, DOB, etc. The users can also register complaints against the incidents violating the child rights and can also take part in volunteer camps.

Using this app, the users can key in their complaint in the 'How to Lodge a Complaint' section. To lodge a complaint, one would require detailing particular of the victim, the address, which police station they fall under and what kind of abuse or crime has taken place. Currently, the app has categories like child labor, child marriage, child sexual abuse, violation of rights and others. The benefits of this app usage include broader access to information about social services, educational resources and health information. As children and families use the Internet and mobile phones to seek information and assistance, and to report incidents of abuse, these technologies can help protect children from violence and exploitation. Information and communication technologies are also used to gather and transmit data by child protection service providers, facilitating.

## Literature Survey

Sinha said that the rights guaranteed to children under the constitution remained only on paper. He explained how hundred of children work under atrocious conditions is several parts of India, either exploited by their employers or tortured by the police. And other basic rights of a child, i.e., Child Health in India were scrutinized by Das and Dasgupta with respect to immunization program. Their analysis suggested a slacking of the initial thrust, which was a matter of concern from the point of view of Vaccine Preventable Diseases. According to their estimates, the worst affected states in child health are Bihar, Assam, Madhya Pradesh and West Bengal

respectively on the basis of the number of occurrences of VPDs like, DPT, Polio, BCG, and Measeales.

## Existing System

The study finds no consistently robust state-wise pattern of gender bias against girl children existing in India. However, high gender bias in child health outcome as well as health seeking behavior is visible in three Empowered Action Group of States and in Andhra Pradesh, Punjab and Gujarat as well. Above all the existing system our Save Young India app is useful for all states for the protection of child rights. In some existing system they provide only guiding principles and survival for the development rights. Sishu Suraksha is a mobile application to lodge complaints on child rights violations and address them in an appropriate and timely manner. Available on IOS and Android platforms, the app can be used by anyone in Assam to lodge complaints.

## Methodology

The Save Young India is a mobile application which mainly aims to secure the children from the violation against the child rights. The application is available on ios and Android Platforms, which is used by anyone to make complaints, discuss in a common forum and register themselves in volunteer actions.

The application of Save Young India included with some of the components which will be explained below.

*Module 1:* The users can login or register into their app using emailed social media accounts like Facebook and Twitter.

*Module 2:* The people who are above 15 years of age can register their accounts in his application.

*Module 3:* People above 18 years of age have full access to all the features of this application while the people between 15 and 18 years of age have only limited access.

*Module 4:* The laws of child rights are given in the home page, while the users can also make discussions about their opinions or any information related to child rights in the Forum Page.

*Module 5:* The importance events and volunteer camp dates and other information are given in the Events Page by the admin.

*Module 6:* The Profile Page shows the current users login information.

**User**
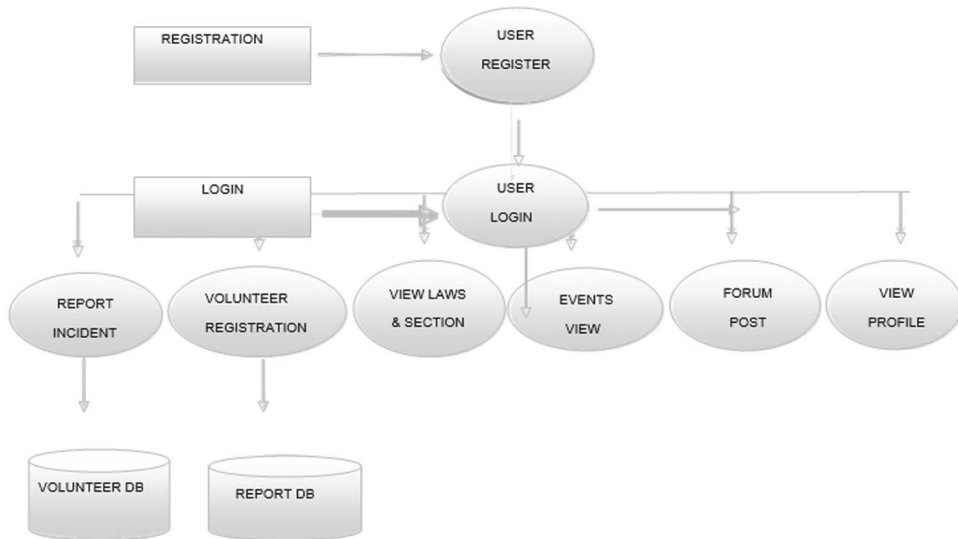


The users of the application is above 18 years of age can eligible to make complaints in the Report Incident Page by giving the valid information which is further reviewed by the administrator of the application.

## Experimental Results

The experimental results demonstrates that the outstanding performance of proposed application Save Young India.
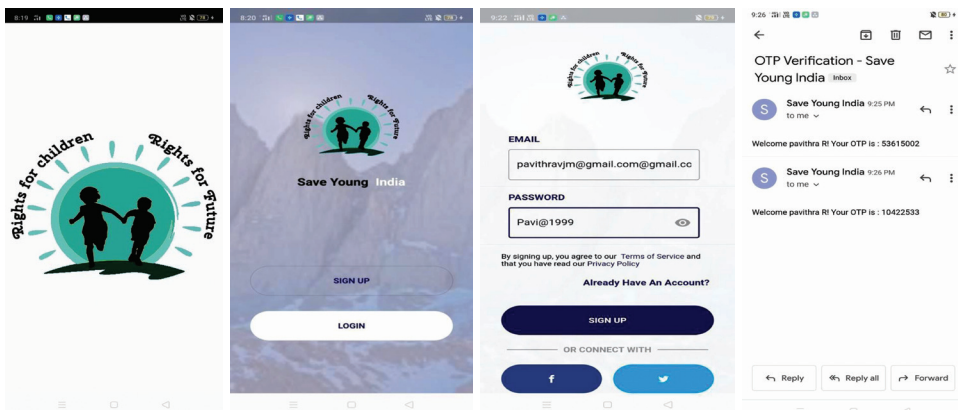


**Fig. 1:** Front, Login Page, User Sign up Page and OTP for user to Gmail Page of the Application Save Young India
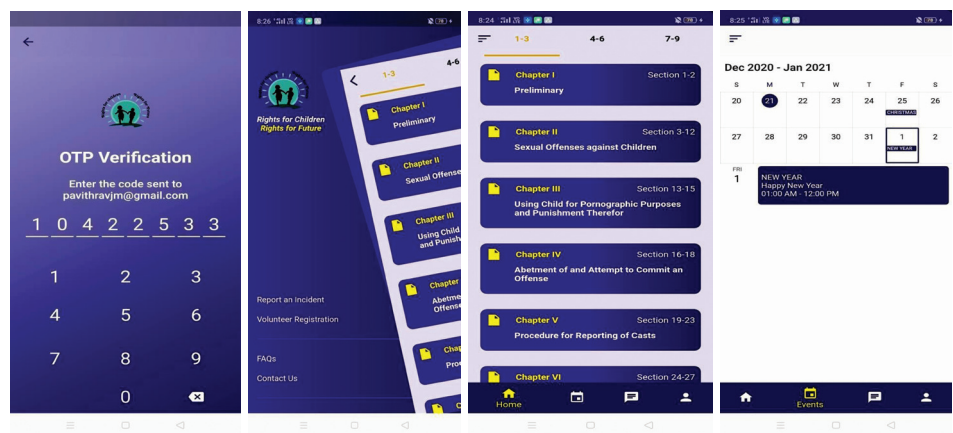
**Fig. 2:** Volunteer Registration Form, Report Incident's View, Laws and Sections and Event View of the application Save Young India
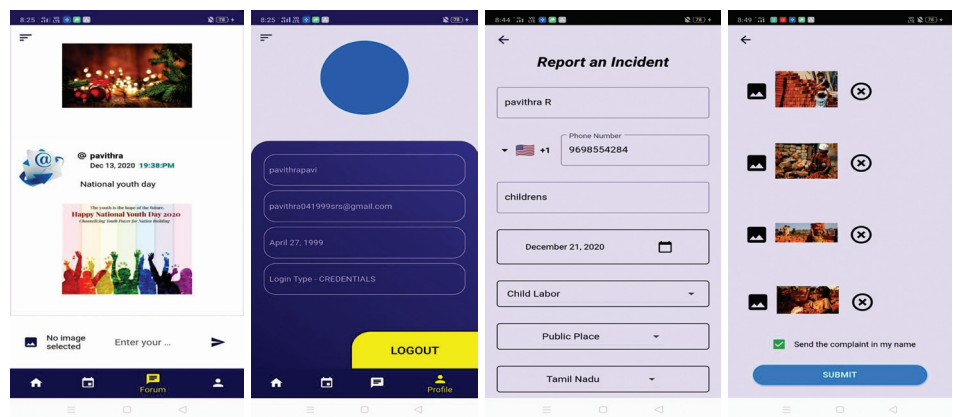


**Fig. 3:** Forum Post, View Profile and Report incident of the application Save Young India
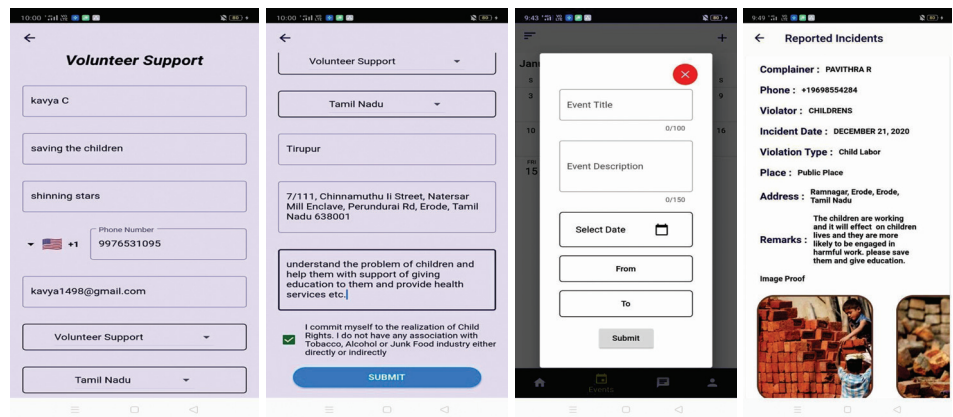


**Fig. 4:** Add Events, View Report Incident and Volunteer Registration of the application Save Young India

## Conclusion

In India approximately 20 percent are child in the overall population of the world. Here, nearly 100 million children fall in the poorest wealth quintile. Therefore, for any kind of inclusive growth, child population of the country needs adequate assimilation. Besides, these efforts must pay due attention to the gross disparities and the ground realities of the country. Disparity between girls and boys, between girls and boys belonging to various castes and classes, disparity between girls and boys belonging to different regions of the country must be taken into account for giving girl children their due position in India.

The Save Young India Application helps to prevent children from this violence and to create awareness among the people about them. The application is used by any people above 15 years of age. It is used to give volunteer to the children who are suffering from some problems through this application. We can report the children who are working as a domestic violence, child abusement, maltreatment, child labors, child marriage, etc, . through uploading photos about the child. Considering this reality in mind, the significant issue of Children security can be resolved using Save Young India. A Child Security Mobile Application available in both Android and IOS and child security is the main aim of this application.

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# 14

# SoC Implementation Using FPGA for ECG Signal Analysis

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**ABSTRACT**

Continuous monitoring of vital parameters is very important to detect the abnormal changes in body parameters which helps to predict the life threatening conditions. To accomplishing quick and accurate diagnosis, Electrocardiogram (ECG) analysis will contribute much, by detecting QRS peak. This paper proposes an efficient implementation of ECG analog front end design using NI Multisim and ECG peak detection using Vivado High Level Synthesis (HLS). A low power ECG analog front end acquisition system is designed under a power supply of 3V. The blocks present in the design are Instrumentation amplifier (IA), Low Pass Filter (LPF), notch filter and voltage follower. The acquired ECG signal is preprocessed and send to FPGA for peak detection. The characteristics of ECG analog front end like CMRR, Gain, input and output impedance are calculated and tabulated. The ECG signal processing and peak detection algorithm are optimized for implementation on FPGA board using VHDL language in Vivado HLS 2018.3. The peak detection is performed using Pan Tompkins algorithm on ECG database taken from Physionet. The utilization report and power report are obtained post synthesis and post implementation for each individual module.

**Keywords:** Electrocardiogram (ECG), Multisim, Vivado, High level synthesis, FPGA, peak detection, VHDL.

## Introduction

Cardiovascular disease is one of the largest threatening disease with highest mortality rate. The occurrence of cardiovascular diseases can be precisely diagnosed using ECG, which is acquired non-invasively; also the most precise outcomes can be obtained than other biosignals. For such continuous health monitoring, wearable devices are very important. The miniaturization in wearable

technology, face a challenge to design low power analog front end circuits. For long term monitoring, the device should operate continuously and consume low power. Electrocardiogram (ECG) is the electrical tool used for diagnosing heart's activity. The ECG wave has several components like: P wave, QRS complex and T wave. These wave components has their own importance related to cardiac activity and provides information for distinguishing the normal and the abnormal cases. In order to diagnose the ECG wave, there should be an accurate analog front end system for acquisition. The analog front end has blocks of amplifier and filter, which are power consuming in nature.

The wearable system are realized using reprogrammable devices like Field Programmable Gate Array (FPGA), they play a vital role in power consumption reduction also.[9] The ECG analog front end is designed using AD620, filters and finally analog to digital convertor (ADC). The post ECG signal processing approach was performed using Pan Tompkins algorithm with adaptive amplitude and time thresholding in Spartan 3E board. This approach was compared in 3 ways: (i) floating point and fixed point analysis in MATLAB and Xilinx IDE, (ii) comparison with electronic armband, (iii) performance with other methods.[13] The ECG signal processing is carried out using fixed point analysis in Simulink-MATLAB. The implementation of Pan Tompkins algorithm for peak detection is performed using VHDL in Xilinx Artix FPGA board. The resources utilization are minimized therefore the power consumption is reduced by a factor of 10.[20] The analog front end circuit is designed using AD8232 amplifier, low pass filter and high pass filter; entire system powered with 2.4V battery and a flexible solar energy harvester to recharge when the person is outdoor. ARM CORTEX microcontroller receives the acquired data through integrated Bluetooth. The overall power consumption of the circuit is 5.2mW.[1] The ECG analysis is done by discriminating the QRS complex, implemented using FPGA. The signal pre-processing, feature extraction and classification algorithms are simulated in MATLAB. The heart rate and heart rate variability are calculated after the R-peak detection. The simulations are performed using MIT-BIH database. The hardware implementation in VHDL is performed on Spartan 3A 700A FPGA board. The algorithms showed 100% sensitivity and specificity.[2] The Altera DE II FPGA board is used for implementing ECG signal processing for beat detection. The ECG signal passes through low pass filtering, high pass filtering, derivative filter and moving window integration as pre-processing. A finite state machine of 9 states is written for beat detection stage, where R-R average is computed and search back approach is implemented.[18] ECG analog front end is designed using a Differential Difference Amplifier (DDA), working under 1.8V supply. The DDA performs well, with good CMRR, PSRR, gain bandwidth, input referred noise and

input impedance. The power consumption of the AFE is 3.99µW.[22] The cardiac arrhythmia detection system is implemented in FPGA hardware, making use of MIT-BIH database. The QRS detection is performed based on slope, amplitude and width analysis of ECG wave. The filtering and peak detection algorithm are verified in MATLAB initially, then implemented in FPGA by VHDL synthesis. The filter coefficients and filter realization are done in FDATool.[19] The wireless bio-signal acquisition system is designed using ECG acquisition node, ZigBee system and RF transmitter. Acquisition node consists of pre-amplifier, filter, post-amplifier and 8-bit SAR ADC. The acquired ECG signal are transmitted to WBSA SoC which uses ARM based FPGA board.[14] Low power and low noise ECG acquisition system is designed with 40.3 µW power consumption on CMOS technology. The analog front end system has instrumentation amplifier (IA), low pass filter (LPF) and an ADC. A digital signal processing system is implemented to remove EMG muscle noise interferences and ST segment classification. The specifications and performance of the circuit are tabulated. The sensitivity and specificity of proposed system are validated under 2 conditions and tabulated. [8] A 3 channel ECG acquisition system and a single channel electrode-tissue-impedance (ETI) measurement are done using low power, low noise system with high signal quality. Filters are applied for motion artifact reduction; feature extraction and classification is done for ECG signal analysis.

## System Design

The methodology starts as designing an analog front end system to acquire ECG signal accurately, without any loss in information. The acquired ECG signal will pass through stages of amplification, filtering as pre-processing. Algorithms are written in VHDL and optimized in Vivado prior to implementation on hardware FPGA board.

The entire methodology has 2 major parts, (i) the ECG analog front end designing and (ii) ECG signal processing and peak detection. In the first part of the work, electronic circuit design is performed to acquire the ECG signal from electrodes accurately. The analog front end (AFE) is successfully designed and simulated in NI Multisim – student edition software. The AFE system is built using instrumentation amplifier (IA), low pass filter (LPF), notch filter and a follower circuit. The characteristics of bio-amplifier are calculated after simulation. The cutoff frequency of filters are calculated using specific formulae; also depends on the incoming signal's frequency range and noise levels present in the signal. The output from AFE is analog in nature and pre-processed in removing the high frequency noises and power line interference. The analog pre-processed output

is send to part 2 of the proposed system, for further processing in FPGA. The software implementation is done prior to hardware implementation using Vivado IDE 2018.3 web-pack. The analog signal is digitized with fixed sampling rate, using the ADC present in XADC block of FPGA board. The ECG signal is now band pass filtered to extract the QRS complex with the appropriate frequency ranges. The band pass filtered signal is send to peak detection core, which utilizes Pan Tompkins algorithm effectively. The steps followed in peak detection are derivative filter, squaring operation, moving average filter, fiducial marking and thresholding.

## Embedded System Design

The acquisition system is mainly designed for accurate capture of ECG from the electrodes. The raw signal coming from the electrodes has very low amplitude, prone to noises and suppressed peaks due to noise. So, the raw signal must be passed through certain stages like amplification and filtering, which helps in better visualization of information present in the signal. In this chapter, the system has an instrumentation amplifier, low pass filter, notch filter and a follower circuit. The output of the system should have the amplified and filtered signal, ready for digitization process.

## Amplification

The raw ECG signal is of very low amplitude in range 0.5 – 1 mV and sensitive to more noises like power line interference, high frequency noises and EMG motion artifacts. For this purpose, pre-amplification is very necessary step. The circuit has to amplify the acquired ECG signal and eliminate all possible noises. Generally, the pre-amplification step is carried out using an instrumentation amplifier of suitable characteristics. A good bio-amplifier should possess high CMRR, high PSRR, high input impedance, low output impedance, low noise sensitivity, and high gain. In this work, AD624 instrumentation amplifier is chosen due to its good characteristics and higher accuracy. One important characte8ristics is that, it is a variable gain amplifier whose gain can be tuned using a single external resistor. The gain of the circuit is given by $G = \dfrac{40K}{R_g} + 1$. The value of external resistor $R_g$

can be computed based on gain needed using the formula, $R_g = G - \dfrac{1}{40K}$ .

The system is validated using ECG wave as input. ECG input signal is represented in green color and the corresponding processed output ECG is

represented in blue color. The input waveform is amplified to high level and no new noises are imposed by amplifier.
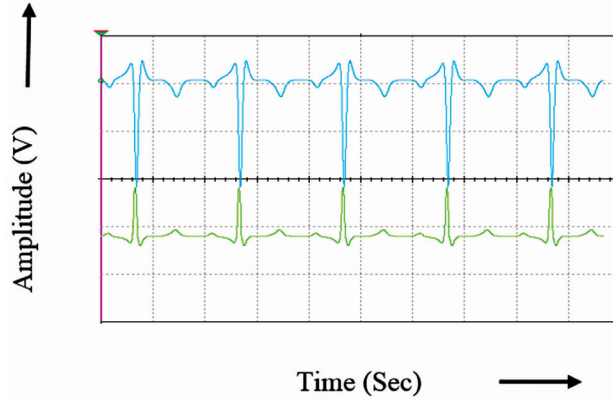


**Fig. 1:** ECG AFE output

## Low-pass Filter

The low pass filter is used in the system to eliminate the unwanted higher frequency noises, by fixing the desired cut off frequency. A second order Sallen key topology low pass filter is made use in the AFE system. The cut off frequency of low pass filter is made 106 Hz, using the formula,

$$f_c = \frac{1}{2 * \pi * R * C}$$

$$f_c = 106\, Hz$$

Obtained for the values of $R_1 = R_2 = R = 1\ K\Omega$ and $C_1 = C_2 = C = 1.5\ \mu F$.

## Notch Filter

A notch filter is used most commonly in biomedical instrumentation to suppress the power line interference coming with input signal. A twin T notch filter of 50 Hz cut off frequency is designed using the formula,

$$f_c = \frac{1}{4 * \pi * R * C}$$

$$f_c = 53.07\, Hz$$

Obtained for the values of $R = 15\ K\Omega$ and $C = 0.1\ \mu F$.

**Figure 2** shows the response of filter till cut off frequency 106 Hz as pass band and **Figure 3** shows the frequency response of notch filter designed with 53 Hz cut off frequency, confirming the proper function of filter.
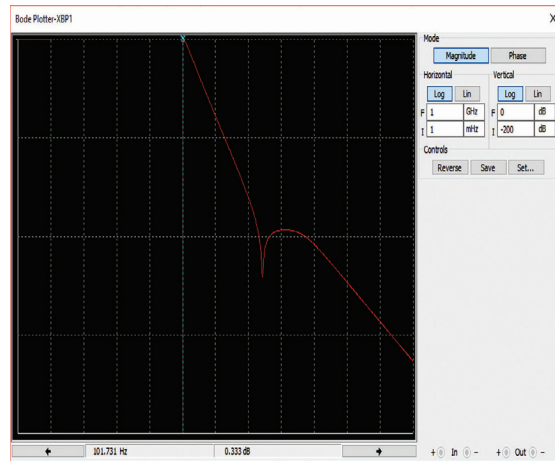
**Fig. 2:** Frequency response of low pass filter
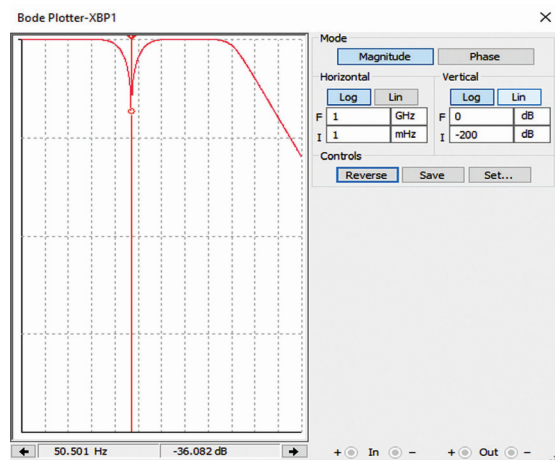


**Fig. 3:** Magnitude response of notch filter

## QRS Detection Algorithm

The Pan Tompkins algorithm is used to recognize the high frequency component, QRS complex The Pan Tompkins method uses certain steps that are listed below.

(i) Band pass filter
(ii) Derivative filter
(iii) Nonlinear transformation
(iv) Moving window integrator
(v) Thresholding
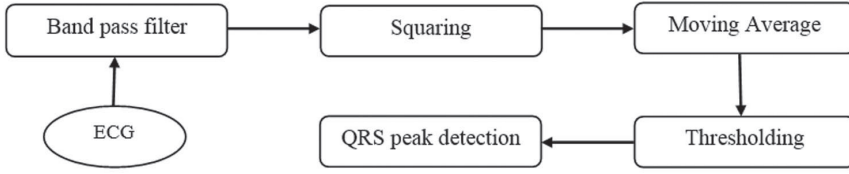
**Fig. 4:** Steps of QRS Detection

After pre-processing, the raw analog signal is converted to digital format. The continuous analog ECG input signal is sampled at a sampling rate of $f_s$ by the analog to digital converter (ADC) of XADC block present in Zynq FPGA board, converting it to discrete signal. The discrete signal is generally represented as,

$$x(n) = x(nT_s)$$

Where, $x(n)$ represents the original analog input signal, n is the integer and $T_s$ is the sampling period. The sampling theorem states that,

$$f_s \geq 2f$$

2f is Nyquist rate, the sampling frequency should be two times greater than the signal frequency. The analog input signal comes with a frequency of 106 Hz, so the minimum sampling frequency should be 212 Hz.

## Bandpass Filter

In order to remove noise, the signal passes through a band pass filter which is a cascade composition of high pass filter and low pass filter. The band pass filter attenuates noise due to muscular movement, baseline wander, 60 Hz interference and T wave interference. 5-15 Hz of pass-band frequency is chosen as the main energy of QRS complex lies in this range. The coefficients of band pass filter are obtained using FDATool in MATLAB, by defining the type, order and cut-off frequency of the filter. These coefficients are exported to VHDL code of band pass filter.



**Fig. 5:** Band pass filter output

The **Figure 5** shows the ECG output after bandpass filtering step. It can be noticed that the 60Hz interference or the higher frequency noises are attenuated.

## Derivative Filter

The derivative filter is applied next to band pass filtering, to get the information about the slope of QRS complex. The numerical differentiation to get the derivative of ECG signal is given as,

$$y(n) = x(n) - x(n-1)$$
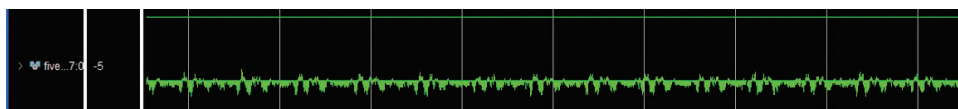


**Fig. 6:** Derivative filter output

## Squaring Function

The squaring operation is a non-linear function in QRS detection.It makes all the new data points obtained from previous step to positive and also amplifies the output. It highly differentiates the QRS complex from other existing peaks. The squaring operation is performed as,

$$z(n) = [y(n)]^2$$



**Fig. 7:** Squaring operation output

The squaring step also amplifies the output from derivative part in a non-linear manner. This operation mainly focuses on the higher frequency components of ECG wave, the QRS complex respectively.

## Moving Window Integrator

The slope of R wave is not enough to detect the QRS event, because many abnormal QRS complexes have large amplitude and larger duration. So there is a need to extract more information in addition to the slope obtained in previous steps. This step gives a single maximum for each QRS complex present in the signal. The mathematical equation of moving window integrator is,

$$Y(n) = \sum_{k=0}^{N} x(n-k)$$

Where N is the window size. For accurate information extraction, the window size is very crucial. It should be chosen as twice the average width or same as the

width of QRS complex. If the window size is chosen to be larger, the resulting output will be a merged QRS and T wave together. While the window size is small, numerous peaks appears at the output wave. The number of samples integrated in this step, also depends on the sampling frequency used.
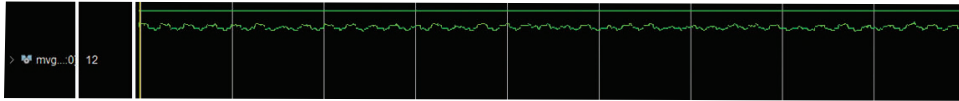


**Fig. 8:** Moving average filter output

The moving window integrator output is displayed in **Figure 8**, making use of the fixed window size the single maximum of each QRS complex is detected.

## Adaptive Thresholding

The available output signal of previous step has a single maximum for each QRS complex and local peaks (single minimum) with lower amplitude which are either T-waves or noise. To detect the peaks accurately, this part uses an adaptive thresholding, thereby differentiating noise and peaks. The adaptive amplitude thresholding distinguishes the R-wave maxima from other T-waves or noise. Before performing thresholding, the local maxima has to be detected from the output signal of moving window integrator. To accomplish this, fiducial mark is done; each detected peaks of fiducial output is compared with the set threshold.

The set threshold level depends on detected QRS level and the noise level,

Threshold 1 = Noise level 1 + 0.25 (Signal level 1 – Noise level 1)

If a detected peak level is greater than the threshold, then the peak is considered as QRS complex and the signal level is updated. If a detected peak level is lower than the threshold, then the peak is considered as noise and the noise level is updated.
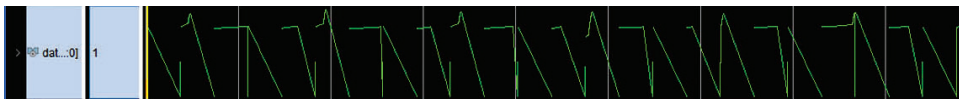


**Fig. 9:** Fiducial marker output

The fiducial marker output in **Figure 9** shows the single maximum peaks differentiated from other lower amplitude peaks. The **Figure 10** shows the out of peaks detected in adaptive thresholding step. The signal is accurately processed and peaks are correctly detected.
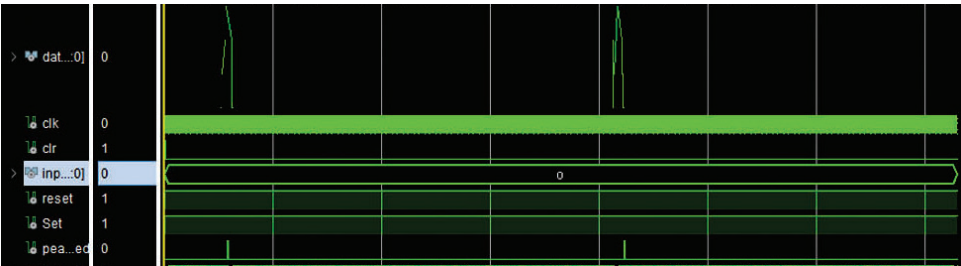
**Fig. 10:** Peak detection output

The **Table 1** shows the utilization report obtained post synthesis and post implementation for each module of digital signal processing. The utilization can also be obtained separately in post synthesis and post implementation. The utilization of resources like look up table (LUT), IO pins, slices are made use by the user's programmable logic written in VHDL.

| Table 1: Utilization report | | | | |
|---|---|---|---|---|
| *Module* | *Slice Logic Utilization* | *Used* | *Available* | *Utilization (%)* |
| Band pass filter | LUT | 986 | 53200 | 1.85 |
| | IO | 17 | 125 | 13.60 |
| Derivative filter | LUT | 137 | 53200 | 0.26 |
| | IO | 19 | 125 | 15.20 |
| Squaring Operation | LUT | 26 | 53200 | 0.05 |
| | IO | 16 | 125 | 12.80 |
| Moving Window Integrator | LUT | 2094 | 53200 | 3.94 |
| | IO | 19 | 125 | 15.20 |
| Fiducial marker | LUT | 158 | 53200 | 0.30 |
| | IO | 30 | 125 | 24.00 |
| Threshold | LUT | 234 | 53200 | 0.44 |
| | IO | 32 | 125 | 25.60 |

## Conclusion

In this work, the analog front end circuit is designed for ECG signal acquisition with amplifier for amplifying the lower level signal to higher level; filters are designed based on the noise to be removed. The low pass filter is used to remove high frequency noise; notch filter is used to remove power line interference. The AFE of ECG has their own filter ranges and design specification. The characteristics of

amplifier and filter are calculated and tabulated. Next, the pre-processed analog wave has to be processed in FPGA board. For this, the signal processing method and peak detection algorithm are written in VHDL, synthesized and implemented in Vivado 2018.3. This is performed to optimize the programmable logic to be implemented in FPGA board. The Pan Tompkins algorithm is chosen for peak detection of ECG by adaptive thresholding. The utilization report post synthesis and post implementation are tabulated.

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# 15
## Kanban

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**ABSTRACT**

Agile methodologies provide a set of methodologies among which one is Kanban which can either be used alone or with some other models. Kanban was first introduced in a production environment but the values, principles and its characteristics were so appreciated that it easily got adapted by other areas like software industries. Kanban is a framework that uses the features like visualization of the work, limiting the work in progress and thereby achieving maximum efficiency. Kanban provides a proper workflow management which gives an understanding of the work to be done, the amount of work to be handled at a time and also manages the delivery of work. The features like Flexibility in Planning, limited work in progress, pull approach, efficiency through focus etc are the key attractions for an organization to accept it for it production or for software development. It has a nature of not only be used for a new project but also to work on an existing work and bring an evolutionary change in it. It provides a visual satisfaction to keep a tab on the flow of work through the process. Once a clear understanding is obtained, the organization can increase its quality, productivity and cooperation among the teams.

**Keywords:** Kanban, Kanban board, Service Delivery Manager, Service Request Manager.

## Introduction

The emerging software trends demands for a software development method that can overcome the challenges which has to be faced while delivering a work in a quick and efficient way. These situations demanda complete freedom of flexibility for the developing team through which a high percentage of productivity is achieved. Agile methodologies are the best option for the present situation where you need a developer to have an environment to develop the product with minimum time and cost that accepts changes. Many different Agile methodologies are practiced in industries which follow a common philosophy. The difference

among them comes on the mix that they follow on the practices and the tactics of Agile methodologies[1]. An organization can become Agile by following any of the development methodologies like scrum, XP, Kanban, Lean etc. Actually, it can be said that the Agile is an umbrella term that has many frameworks beneath it[2.]
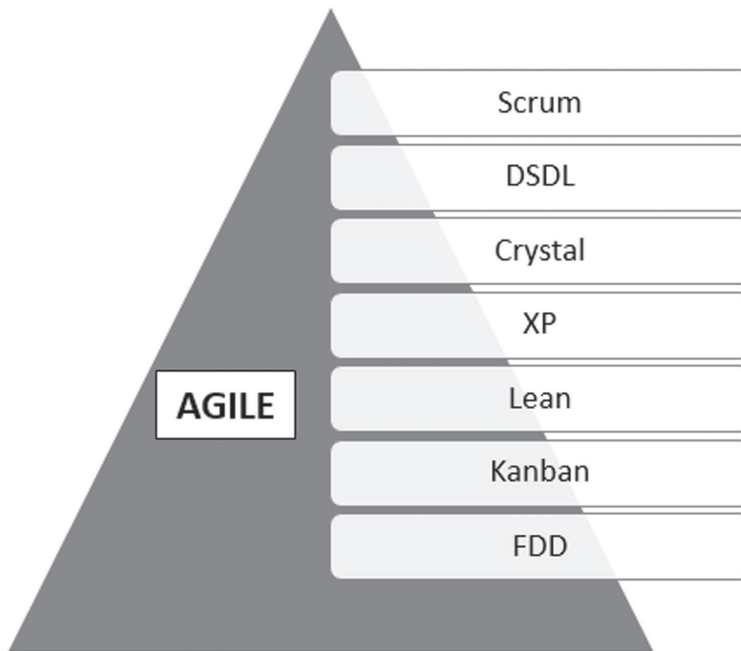


**Fig. 1 :** Agile Methodologies

## History of Kanban

It has passed only a few years that the software industry has started using Kanban in software developmentas an important Lean practice in software industry[3]. The word Kanban was taken from two Japanese words "Kan" and "Ban". The meaning of "Kan" in Japanese is sign and the word "Ban" means board[4]. Kanban was first introduced by Taiichi Ohnoin the earlies of 1940. Kanban system was introduced for Toyota automotive with a main purpose of planning, controlling and managing their work at different stages. The benefit that they achieved through this system was just in time production and the company was able to increase their productivity with less expense[5]. After introducing it in the manufacturing industry later by 2014 David J. Anderson applied it in the IT and software development. David J. Anderson along with some others defined the Kanban system with pull systems, queuing theory and flow. It was found to be very effective in software development industry as it used to be in manufacturing and inventory control[6].

## Kanban

Kanban can be explained as the simplest framework that helps to easily manage and control the tasks by the project managers[7]. It is a workflow management method that has gained high popularity among the Lean teams. Among the Lean teams the prime focus of using it is to visualize and thereby managing the creation of products. It is a method that gives importance to the continual delivery of the product. Its prime focus is on the team performance and unity in order to have high performance along with productivity. It provides a good transparency and flexibility over the workflow so that the stress reduces and the productivity increases. For software development Kanban follow the different stages of Software development Life cycle. It is mostly appreciated at situation where the work arrives unpredictably and can be delivered as soon as it is completed.

## Core Practices of Kanban

Kanban started with three basic principles which were visualize, Limit work in progress, and manage flow. Later the David J. Anderson and others have added two more principles to this basic threeto form five properties which later became six practices. These practices are now referred to as the core practices[8].

The core practices of Kanban are listed below[9]:

### Visualize Workflow

A proper visualization of the whole project related task is required by the organization while using Kanban methodology. For this to be possible the Kanban boards are used which provide a proper knowledge regarding the task and the stages. In order to depict the work item, it uses the Kanban cards and to represent the stages it uses the columns.

### Limit Work in Progress (WIP)[10]

It is the process of limiting the number of tasks in each stage which would help the team to focus on a single task at a time and completing it faster. This limit would help the team to locate the bottleneck in whole work progress and also to provide value to a customer as early as possible. This method would accept only as many as it could be completed. Hence the burden of in completed task could be reduced. It would give a proper idea on the number of people to be assigned for each task based on its complexity.

## Measure and Manage Flow

It gives a clear picture of impact that the above two principles are having on the organization and what can be done to improve it. It helps the team to understand weather they are moving towards a service which can gain customer satisfaction. It has a great role in managing the activities and thereby taking proper actions and practices for the organization. Different Kanban metrics, diagrams etc are presently available in the industry that can be used to measure them[11].

## Make Process Policies Explicit[11]

In order to have this proper flow in Kanban methodology, it requires the use of well-defined policies. These policies help in taking decisions on task that it assigns to a particular team and also regarding when a task item must be pulled from one stage to another. Its responsibility is in providing the conditions that helps the pull system to work.

## Implement Feedback Loops[8]

The feedback loop explains that the Kanban should have a practice to getting feedback from its processwhich give a clear idea on what goes wrong, what should be rectified and what should be followed next in order to avoid it.

## Use (Theoretical) Models to Recognize Improvement Opportunities[11]

Teams should thoroughly focus on their activities. They should understand what goes wrong and where. It should analyse their present scenarios of the project development and should make a clear picture of the areas which could be improved. The work flow should be in such a way that it should be able to find out the constrains to sort it and to avoid wasteful activities. This process should repeat for the search of other constraints.

## Values of Kanban

Kanban has nine values which has to be followed in an organization while using Kanban methodology. Kanban believe to respect all those who contribute to the success and hence are these values[12]. The values are as follows:

1. **Transparency:** The team should be aware of every steps and action being performed while development. It can be the transparency regarding work visibility, updates of status, understanding related to process, actions taken for decision making and its results and also to provide a clear picture work status

to the customer. The transparency hence would help in developing a system which is adaptable and very much flexible.

2. **Balance:** In order to develop a system with much effectiveness it requires a proper balance between different aspects, viewpoints, and capabilities.

3. **Collaboration:** Kanban focused on improving the way people work together for the organization growth.

4. **Customer Focus:** Kanban systems aims to work and develop a product which achieves a complete customer satisfaction. A work should not be done only because it has to be completed in time and delivered to the customer. But the actual motto should be to develop something that reduces waste work and is delivered just in time with maximum satisfaction to the customer.

5. **Flow:** Work flows in a systematic and predictable way so that any ongoing changes and issues are tolerable.

6. **Leadership:** Leadership is a quality which increases the productivity by inspiring the team members to work in a more fruitful way.

7. **Understanding:** Both the individuals and organization should have a thorough knowledge regarding the starting point in order to have a universal approach towards work and changes.

8. **Agreement:** People working in a Kanban environment are supposed to have commitment and mutual respect for working as a team. The opinions from each and every one is respected and if possible accommodated. The prime focus is to move together to achieve the final goal.

9. **Respect:** It better understanding and consideration is provided for people and are valued.

## Roles in Kanban

For teams practicing Kanban two primary roles can be implemented. They are:

1. Service Delivery Manager (SDM)
2. Service Request Manager (SRM)

### Service Delivery Manager in Kanban (SDM)

The Service Delivery Manager is also known as flow manager. As per the title flow manager, this role is for improving the productivity of the workflow. This role is similar as that of Scrum master but not equivalent to it. The primary functions of SDM are to ensure the flow of work items and to promote change and continuous improvement activities[13].

SDM must check the Kanban board regularly and must ensure that no work items have been in the blocked list. Execution of regular Kanban meetings is also the responsibility of SDM. The other duty is to address the owner and offer help, if any task is delayed and then it must be checked to know if any sort of risk lies with this. It must be ensured that the team members are following the policies.

SDM is responsible for incorporating continuous improvement tasks and should be involved in a meeting called Service Delivery Review. This is a channel for enhancing quality in specific activities. The information related to work on the Kanban board must be collected and should make discussions with the team. SDM is authorised to ask questions towards the team until it is possible to identify the underlying driver of the given problem. It should also be ensured that errors are not repetitive.

SDM role can be given to a person who is having a great knowledge in the service delivery processes ought to be dependent on ceaseless improvement. The individual in the SDM job should always be dedicated enough to work with a desire to live and inhale with a powerful urge to execute greatness[14].

### Service Request Manager in Kanban (SRM)

The Service Request Manager role can be assigned to a team member who have profound knowledge of the team or company's value stream. This role is similar as that of product owner in Scrum, as both are answerable for understanding the customers' necessities and assumptions.

The essential objective of SRM ought to be to fill in as a risk manager and facilitator. SRM must create an order for the various work items and must prioritise it. Another responsibility is to claim the approaches for the framework which outline choices together. It is the duty of SRM to work for improving corporate administration, consistency of cycle, and decreasing individual risk related with a single person[14]. SRM role can be given to a person who is having a mind to know the customer as well as an understanding about customer needs and expectations.

The Service Delivery Manager and the Service Request Manager are two popular roles in Kanban, and these are some additional duty that is assigned to the team members for managing the risks and enhancing the quality of the project[13].

### Workflow of Kanban

The project is completely transformed in to prioritised set of tasks by the manager and is presented to the developers[15]. The manager can change the priority of the items, add more items and thereby control the amount of work. This is the only

control to be performed by the manager over the teams[15]. Now it's the responsibility of the team to select the items from the set and complete it as many as possible.

## Kanban Board

Kanban Board is the tool which provides visualization of the task. The figure shown below gives a pictorial representation of Kanban Board.



**Fig. 2:** Kanban Board Representation

Using Kanban board, a list of tasks is grouped together as a single card. The cards are categorised into three: To-do, In-progress and Done[16].

1) **To-do:** This category represents the work for a particular team/developer of a team.
2) **In-Progress:** Work-In-Progress (WIP) by team members are represented by this category.
3) **Done:** This is the column which shows the completion of each task mention in cards. When all the tasks listed in a card is completed by the card holder, the card is moved to this category.

## Kanban Workflow[16,17]

Kanban takes items from backlog, prioritizes it, creates three categories called to-do list, in-progress list and done list. Each work item is represented as a card on Kanban board. This board is visible to everyone in the organization. These work items are pulled into the 'To-do' list based on the team's capacity. According to WIP (Work-In-Progress) limit, the work is assigned to each developer. Each member of development team can pull a card from the 'To-do' list. Only one card
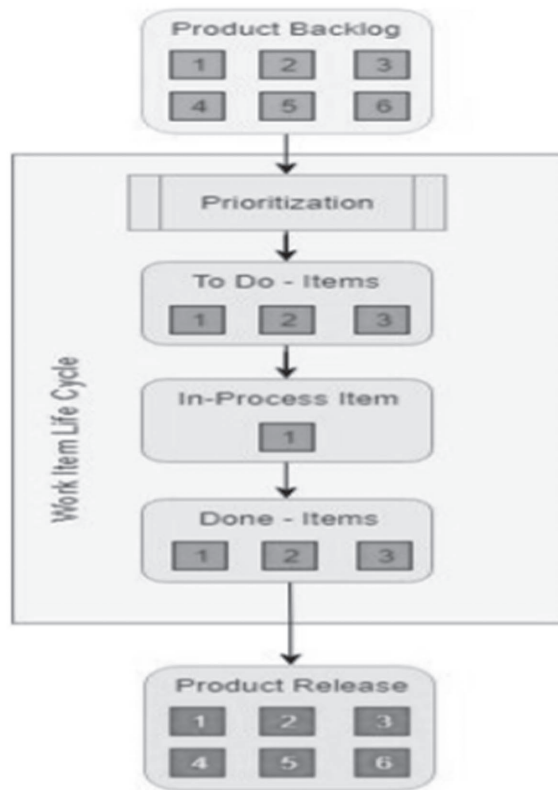
**Fig. 3:** Kanban workflow

of this category as per WIP limit can be taken by a team member. 'Done- list 'contains completed items. New work is added to the "to-do" column in the form of cards or written through makers. once the task is ready to work, at that time, it will be moved to the second column which indicate "in – progress" which means that now that task is in progress. Once the work of that task is completed, it needs to be tested. At last the task will be moved to last column," Done" which denote the completion of the task. Thus, each time every task in a system will be moved from one column to next according to the progress of work.

## Conclusion

Kanban is a simple and effective tool which will help to optimize task management. The advantage of Kanban is that it will increase the transparency. Kanban board will help to break down large, complex projects into tractable discrete actions. Kanban board will act as a product roadmap. The team can check the status of project by checking the Kanban board. Kanban will boost motivation because the

team members gain the flexibility, which will influence in the working process. Kanban gain popularity in the field of Software industry and production because of it has few rules and demands a certain level of self -organization as a project team. It is possible to facilitate the integration of Kanban in existing workflows and also works well when working with location independent projects. The above mentioned Kanban strategies, values, principles and the approach towards handling a project has concluded how it provides proper visualization to all the team members in the organization in order to track the whole process from start to end.

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# 16

# Hydrogen Fuel Cells as Clean Energy Source

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**ABSTRACT**

The impact of pollution is a global issue, which most of the countries are facing a major threat. Pollution to the environment is received from various sources. One such source is pollution from the automotive. One-fourth of global pollution is contributed by automobiles, by burning fossil fuels. By combustion of fossil fuels in automobiles emissions such as hydrocarbons, oxides of nitrogen, carbon monoxide, smoke, and soot are experienced, which are a major threat to the environment. To reduce the emissions from the automobiles, we are in a position to use clean energy for automobiles to reduce emissions. One such clean energy technology is using of energy cells. By using energy cells we can provide clean energy to propel the vehicles which are safe to the environment.

**Keywords:** Clean energy, energy cells, environment, combustion, emissions.

## Introduction

Since the emissions levels lead out by automobiles pose a greater threat to the environment, there is a need to switch to clean energy. To reduce the emission levels from automobiles government adopted various policies to promote electric vehicles. But due to addiction to the usage of fossil fuels and their versatility people refuse to switch to electric vehicles. But the government came forward to subsidize the customers, there is less response from the customers. Even though if we switch to electric vehicles we need to power the batteries for propelling the vehicle. Again for powering the batteries we need to depend on conventional energy sources such as fossil fuels for power. Again we are contributing emissions from power generation since mostly we are using thermal power stations.

So for clean energy, we need to adopt different technology that gives zero-emission. Since electric vehicles are zero-emission vehicles but for powering the batteries we need to depend on conventional power sources. But we need technology of zero-emission without depending on conventional power sources. One such clean energy technology for propelling the vehicle as well as for power generation is Fuel cells. The fuel cells are a clean form of energy since their by-product is water. In this book chapter, the detailing of fuel cells will be discussed.

## Hydrogen Fuel Cell

A fuel cell is where electric current is generated by combining hydrogen and oxygen in the presence of an electrolyte. With the help of hydrogen and oxygen, the fuel cell produces power in the form of electricity. The chemical energy present with hydrogen when it combines with oxygen is converted into electrical energy. The fuel has two electrodes namely an anode and cathode and is dipped in a suitable electrolyte. Hydrogen and oxygen are fed to the electrodes without any interruption separately.

The energy conversion in a fuel cell is of the order where

Chemical energy→ Heat→ Mechanical energy→ Electrical energy

The conversion rate of heat to mechanical energy is small with a fuel cell. In the case of the fuel cell, all the chemical energy is transformed into electrical energy with one hundred percent efficiency. The state of fuel may be gas or liquid which is to be used in a fuel cell. Liquid fuels like methanol, ethanol, hydrazine, formaldehyde can be used. In the same way gaseous fuels like hydrogen, alkane, CO is used. There are different types of oxidants that can be used in a fuel cell such as air, $O_2$, $H_2O_2$, $HNO_3$, etc.
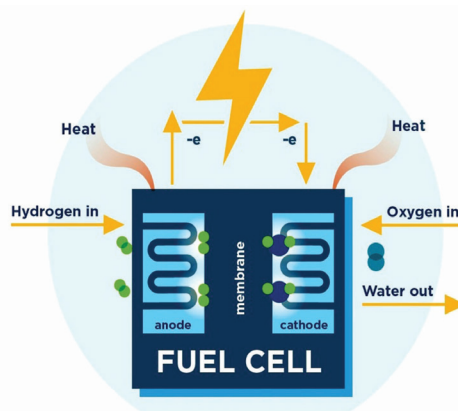


**Fig. 1:** Fuel cell (*Courtesy:* fchea.org)

According to operating temperature electrodes such as platinum, porous PVC, nickel boride, Raney nickel, Teflon coated with silver are used. Fuel cells can be classified according to the range of temperature they operate.

1.  Low-temperature cells (<100°C)
2.  Medium temperature cells (100°C-250°C)
3.  High-temperature cells (<500°C)

In the case of biochemical cells, organic compounds are broken by microorganisms. In a hydrogen-oxygen fuel cell, carbon electrodes are dipped in a solution of concentrated NaOH. Hydrogen and oxygen are the surface of the electrodes. Electrodes are integrated with suitable catalysts. The electrode reactions are

> **In cathode:** $O_{2(g)} + 2H_2O_{(I)} \rightarrow 4OH^-$
> **In anode:** $2H_{2(g)} + 4OH^-_{(aq)} \rightarrow 4H_2O_{(I)} + 4e^-$
> **Overall reaction:** $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(I)}$
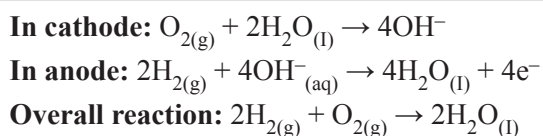
The fuel cell continuously works as long as reacting gases are supplied. Heat generated due to combustion is directly converted into electrical energy.

## Hydrogen as a Fuel

Hydrogen is a neat fuel that produces only water when consumed in a fuel cell. Hydrogen can be harnessed from a variety of domestic resources, such as natural gas, nuclear power, biomass, and renewable sources such as solar and wind power. These qualities make it a promising fuel resource for applications for transport and electricity generation. It can be used for portable power in cars, in houses, and many more applications.

Hydrogen is a power pack that can be used for energy from other sources to store, delivers, and produce. Hydrogen fuel can today be produced by adopting several methods. Natural gas reforming (a thermal process), and electrolysis are the most common methods today. Alternative methods are solar-driven and biological processes.

### Thermal Process

It is a high-temperature process where steam reacts with a hydrocarbon-based fuel to yield hydrogen. Almost all hydrocarbon fuels can be redeemed to generate hydrogen. This includes natural gas, diesel, gasified coal, or gasified biomass. In recent years about 90% of hydrogen is redeemed from natural gas.
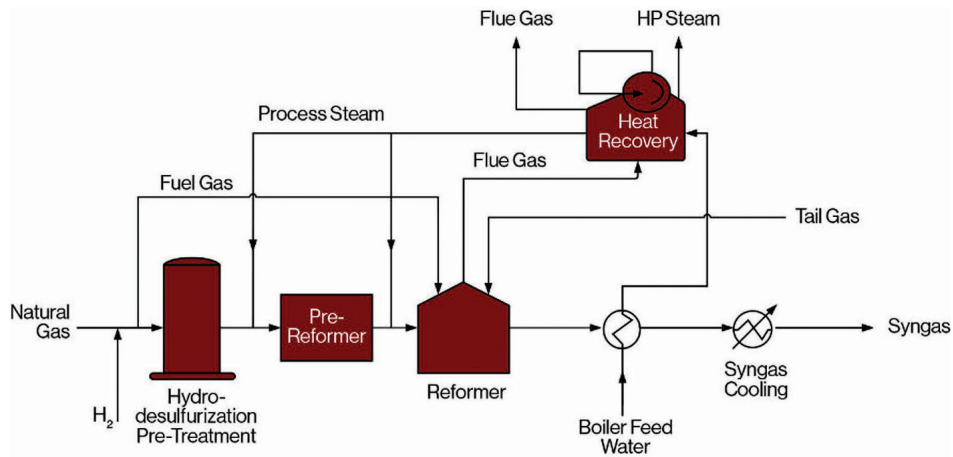
**Fig. 2:** Steam Methane Reforming—Hydrogen Production (*Courtesy:* Air liquid)

## Electrolytic Process

It is a familiar process in which water can be break up into oxygen and hydrogen by a process called electrolysis. The process takes place in an electrolyzer much like a reverse of a fuel cell. Thus electrolyzer generates hydrogen from water molecules.
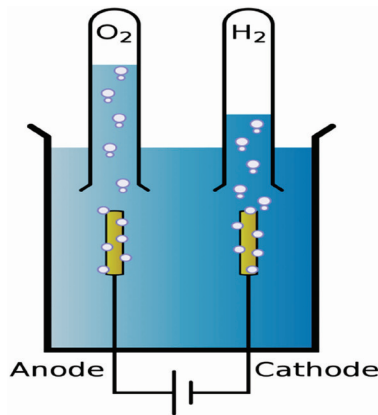


**Fig. 3:** Electrolysis (*Courtesy:* Wikipedia)

## Solar-Driven Process

This process uses light as the primary source for hydrogen production. The types of processes involved in the production of hydrogen are photo-biological, photo-electrochemical, and solar thermochemical. The photo-biological process uses the well known photosynthetic activity of green algae and bacteria for the production of hydrogen. The photo-electrochemical process uses unique semiconductors for

the production of hydrogen. Solar thermochemical processes utilize focused solar energy to activate water separating reactions in the presence of metal oxides.
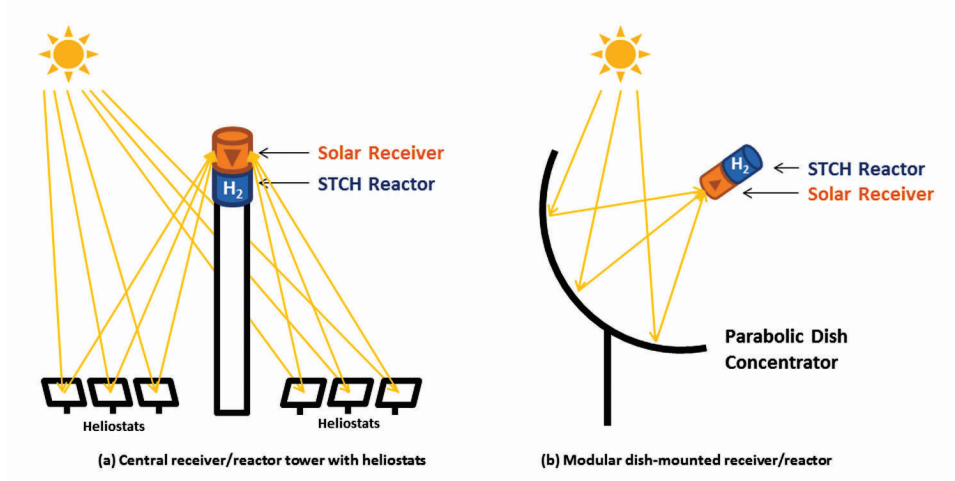


**Fig. 4:** Solar Thermo chemical Process (*Courtesy:* U.S. Department of Energy)

## Biological Process

This process utilizes microbes such as bacteria and microalgae for the production of hydrogen through biological reactions. Microbes split into organic matter or water for the production of hydrogen. In the case of the photo-biological process, microbes use sunlight as a primary energy source for the production of hydrogen.

The above mentioned are the various process by which hydrogen can be successfully derived for the use in hydrogen fuel cells for vehicle propulsion and power generation without any pollutant source.

## Hydrogen Fuel Cells and Its Types

A fuel cell integrates hydrogen and oxygen to produce electricity, heat, and water. They are similar to batteries as they discharge power. In both batteries and fuel cells, the energy obtained from a chemical reaction is converted into usable electric energy. The fuel cell continuously produces electricity as long as there is a continuous supply of hydrogen and it also never loses its charge.

In near future, hydrogen could become an energy hub for electricity because of its cleanliness. An energy carrier is a source that transits and provides energy most regularly for the end-users. Renewable sources may not able to deliver energy at all times but fuel cells energy can be produced and stored and can be utilized whenever we want to. Hydrogen can be easily moved to the desired location according to its need.

The various types of hydrogen fuel cells are

1. Solid Oxide Fuel Cells (SOFC)
2. Proton Exchange Membrane Fuel Cells (PEMFC)
3. Alkaline Fuel Cells
4. Direct Methanol Fuel Cells (DMFC)
5. Phosphoric Acid Fuel Cells (PAFC)
6. Molten Carbonate Fuel Cells (MCFC)

## Solid Oxide Fuel Cells (SOFC)

In SOFC the electrolyte used is a hard non-porous ceramic compound. In this type, the cells are need not be in the shape of a plate because of a solid electrolyte. These types are 50% to 60% efficient in converting the fuel into usable electricity.

These types operate at elevated temperatures range between 500°C to 1000°C. At these elevated temperatures they do not require expensive catalyst material such as platinum which are required for low-temperature fuel cells such as PEMFCs. They also go soft on carbon monoxide catalyst poisoning. But they are vulnerable to sulfur and sulfur should be ejected before it enters the fuel cell with the assist of adsorbent beds or by any other effective means.

SOFC has a wide range of applications from supplementary power units for vehicle propulsion to stationary power generation units with capacities ranging from 100 Watts to 2 Mega Watts. Its elevated temperature operations are most suitable for recovering heat energies or for integrated power and heat, since it is used in an integrated system the overall fuel efficiency can be increased.
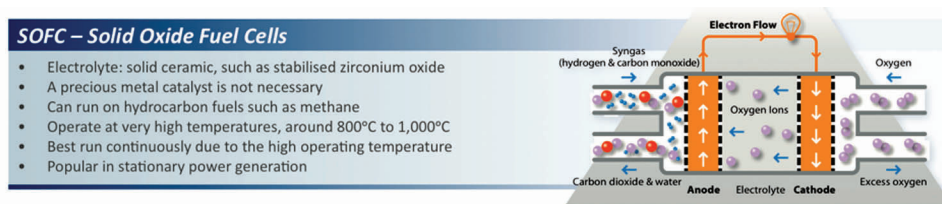


**Fig. 5:** Solid Oxide Fuel Cell (*Courtesy:* Fuel Cell Today)

## Proton Exchange Membrane Fuel Cells (PEMFC)

It is represented by Polymer Electrolyte Fuel Cells or PEMFC. It is high power density and it has many advantages in its weight and volume when compared to other variants of fuel cells. Here polymeric membrane is used as an electrolyte with porous carbon electrodes and catalysts as platinum. To operate they need hydrogen, oxygen from the air, and water. During operation, they do not involve in

the production of corrosive fluids like other types of fuel cells. They are supplied with neat hydrogen which is stored in a separate tank. These types the operating temperature maintained at lower values as 80°C and it is widely suitable for mobile applications.

Their operation at lower temperatures has some advantages and drawbacks. The primary advantage is that it can quickly reach the operating temperature from the ambient temperature. The main drawback is that they should be operated in the presence of a platinum catalyst at any cost. Since the catalyst is vulnerable to CO poisoning there is a condition for using a reactor to reduce CO in fuel gas if hydrogen derived from alcohol or HC-based fuel. These make the fuel cell cost much.

In recent days PEM fuel cells are the best choice for transit applications and well suited for stationary applications.



**PEMFC – Proton Exchange Membrane Fuel Cells**

- Electrolyte: water-based, acidic polymer membrane
- Also called polymer electrolyte membrane fuel cells
- Use a platinum-based catalyst on both electrodes
- Generally hydrogen fuelled
- Operate at relatively low temperatures (below 100°C)
- High-temperature variants use a mineral acid-based electrolyte and can operate up to 200°C.
- Electrical output can be varied, ideal for vehicles

**Fig. 6:** Proton Exchange Membrane Fuel Cell (*Courtesy:* Fuel Cell Today)

## Alkaline Fuel Cells

This type is the first-ever developed fuel cell technology, and the U.S. space program mostly uses it for generating electric power and water for the usage onboard. Potassium hydroxide in water is used as an electrolyte in these types of fuel cells. In these types of fuel cells, a wide range of low-cost metals can be adopted as catalysts at anode and cathode. These alkaline fuel cells are operated between temperature ranges from 100°C to 250°C. But in the case of newly developed alkaline fuel cells typically operate at a lower temperature range that lies between 23°C to 70°C. The range of efficiency of an alkaline fuel cell while using pure hydrogen is achieved by 60%.

The main attractive feature of these types of fuel cells is that the water produced during the reaction can be used for drinking and the cost to manufacture this type of fuel cell is low. In alkaline fuel cells, cheaper materials can be adopted for catalyst that's why it is cost-effective when compared to types of fuel cells.

The main drawback of alkaline fuel cells is, they are much sensitive to $CO_2$ which is normally present in air or fuel. The conductivity may get decreased when

$CO_2$ gets react with electrolyte to form carbonate. The research was made for this type of fuel cell for non-mobile power applications.
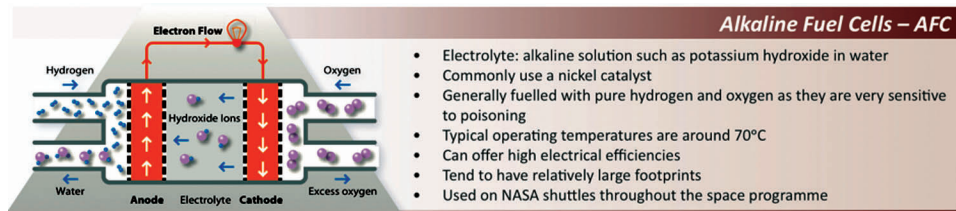


**Fig. 7:** Alkaline Fuel Cell (*Courtesy:* Fuel Cell Today)

## Direct Methanol Fuel Cells (DMFC)

In this type, steam is mixed with neat methanol and directly given to the DMFC anode. Their uniqueness is the type of fuel used. The anode can be given either with liquid methanol or methanol in vapor form where the cathode receives air. The DMFCs belong to fewer operating temperature types. The DMFCs are considered as an upgrade version of PEMFCs since both types use electrolytes as polymer membranes. In DMFCs there is no need for a fuel converter because the anode with platinum-ruthenium catalyst is capable of separating hydrogen from methanol which is in liquid form.

The typical operating temperature range of DMFCs lies between 60°C to 130°C, and it can be used for applications where modest power requirements are needed. Typically its applications are viewed in mobile chargers and portable power packs. With hydrogen onboard in tanks, these types can be used in small electric city vehicles.
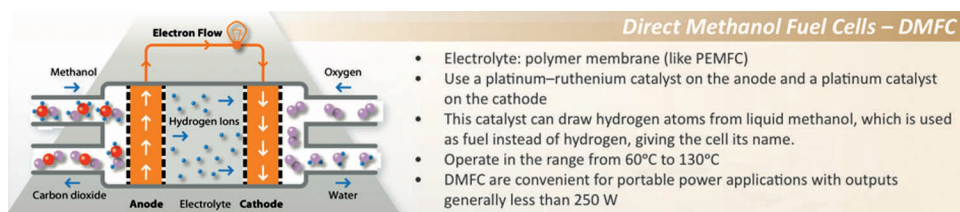


**Fig. 8:** Direct Methanol Fuel Cells (*Courtesy:* Fuel Cell Today)

## Phosphoric Acid Fuel Cells (PAFC)

As the name implies it uses phosphoric acid as an electrolyte and the electrodes are porous carbon with platinum as a catalyst. Cell development took place in the middle of 1960 and extensively used until the 1970s. The features like instability, performance, and cost are magnified. These features promise the PAFCs for non-

mobile applications. The operating temperature range of such fuel cells lies between 150°C to 200°C. The water that results from the reaction can be utilized for steam generation which is used to heat air and water typically as combined heat and power. Due to combined heat and power effects, the efficiency may be increased by up to 70%. At lower temperatures, it becomes vulnerable to CO poisoning of the platinum catalyst at the anode. But when compared to PEMFCs and AFCs, PAFCs are less vulnerable to CO. PAFCs can withstand up to 1.5% concentration levels in the fuel.

**Note:** Sulfur must be drained if gasoline used as fuel.
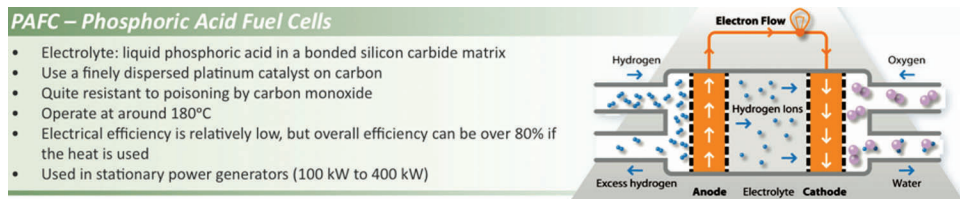


**Fig. 9:** Phosphoric Acid Fuel Cells (*Courtesy:* Fuel Cell Today)

## Molten Carbonate Fuel Cells (MCFC)

The MCFCs are developed for specified applications, such as for Natural gas and coal-based thermal power plants, industrial, military for electrical utilities. The electrolyte used is a molten carbonate mixture suspended in a porous, chemically inert lithium aluminum oxide ($LiAlO_2$). MCFCs operate at very elevated temperatures of 650°C and above, so no need for costly metals such as platinum for the catalyst. The efficiency of such fuel cell systems is about 60% and the same efficiency can be varied up to 85% when it is used as a combined system. (Cogeneration).

The main advantage of a high-temperature fuel cell system is that its efficiency can be increased and well cheaper catalyst materials can be adopted. The drawback of high-temperature fuel cells is that it is prone to corrosion and has less life. MCFCs can operate with a wide range of fuels such as natural gas, biogas, syngas, methane, and propane. Drawbacks are low power density and aggressive electrolyte.
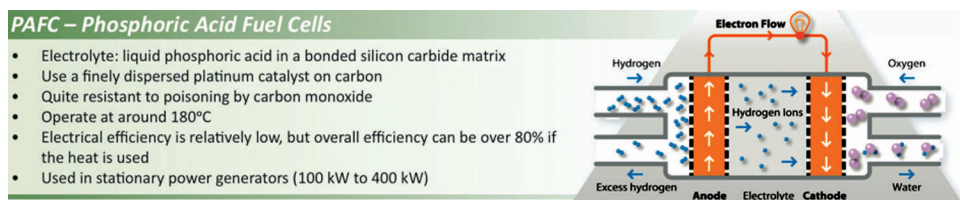


**Fig. 10:** Molten Carbonate Fuel Cells (*Courtesy:* Fuel Cell Today)

## Hydrogen Fuel Cell Electric Vehicles

HFCEV gets power from a battery pack which is powered by the fuel cell. Since fuel cells are 100% efficient ultimately HFCEVs are more efficient than I.C engines. HFCEVs emissions are water and heat, so they are called zero-emission vehicles. The vehicles with Hydrogen fuel cells are in the earlier stage. The department of energy of the United States has undertaken an effort to make the HFCEVs at an affordable rate to the customers. Hydrogen is a known qualified alternate fuel.

### How Does Vehicles Propel Using Hydrogen in Fuel Cell?

Like electric vehicles, the fuel cell vehicle uses a battery to run an electric motor. The fuel cell vehicle produces its electricity with the assistance of fuel cell-powered by hydrogen. The power of the vehicle is defined by its size of an electric motor by the vehicle manufacturer at the earlier design process. The amount of energy for HFCEVs depends on the capacity of the hydrogen tank. The hydrogen stored in the tank is used to power the fuel cell for the production of electricity. This electricity is used to power the battery packs. The power from the battery packs is used to power the electric motor which is connected to the wheels of the vehicle. Thus a hydrogen fuel cell electric vehicle is propelled.
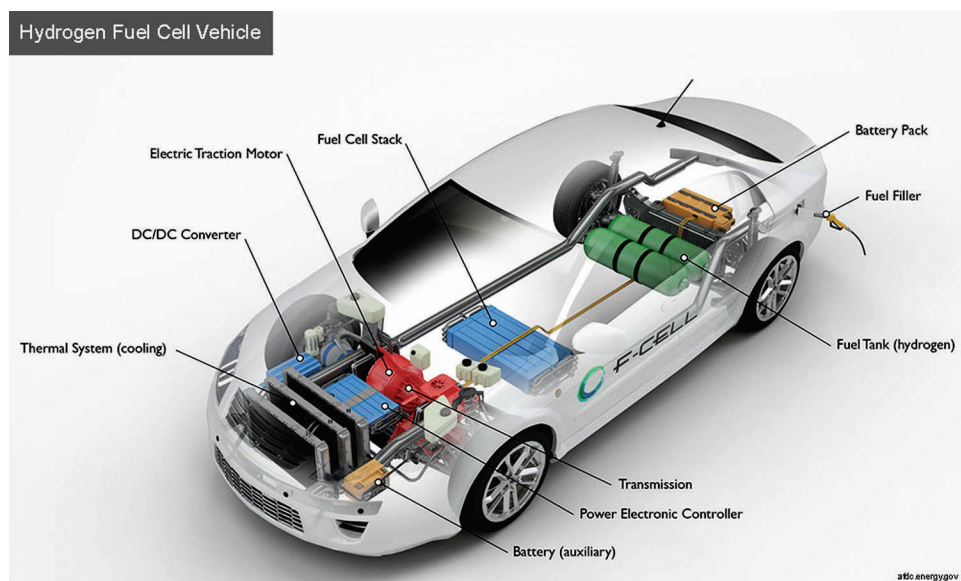


**Fig. 11:** Hydrogen Fuel Cell Electric Vehicle (*Courtesy:* U.S. Department of Energy)

## The Primary Functional Parts of a Hydrogen Fuel Cell Electric Car

### Battery (Auxiliary)

In an electric vehicle, the primary power source is the battery. The battery is used to start the vehicle before traction and the battery powers all vehicle accessories.

### Battery Pack

This battery pack stores energy from the regenerative braking system and provides supplementary power for the traction motor which is fitted with the wheel.
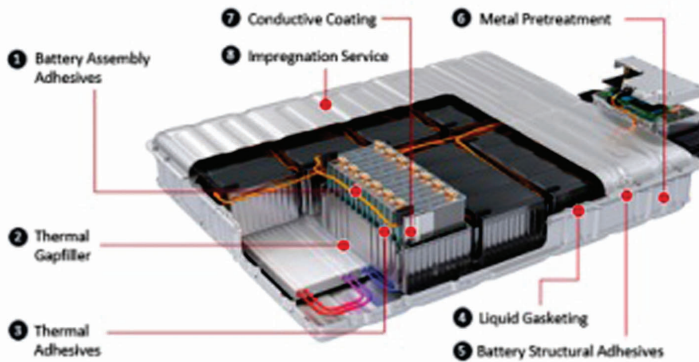


**Fig. 12:** Battery Pack (*Courtesy:* Henkel-EV-battery-pack)

### DC/DC Converter

It is used to convert high DC power to lower voltage DC power which is used to run the accessories of a vehicle and it is also used to charge the auxiliary battery.

### Electric Traction Motor (FCEV)

The electric traction motor receives power from the battery pack which is fitted to the wheels. Some FCEVs use motor-generator both for driving and regenerating.

### Fuel Cell Stack

It is a pack of single electrode membranes that uses hydrogen and oxygen to generate electricity.

## Fuel Filler

A nozzle from a high-pressure dispenser attached to the socket which is used to fill the hydrogen tank.

## Fuel Tank (Hydrogen)

It is used for the storage of hydrogen on board which is used by the fuel cell when needed.

## Power Electronics Controller (FCEV)

It is used to control the flow of electric energy given by the fuel cell for controlling the torque produced by the traction motor.

## Thermal System (Cooling) - (FCEV)

The cooling system is to dissipate heat from the battery packs as they generate heat while discharging current, so it is viable to maintain the optimum operating temperature of the fuel cell, electric motor, power electronics, and other accessories.

## Transmission (Electric)

It is used to transmit the mechanical power available with an electric motor to the driving wheels.

## Difference between Electric Vehicle and Hydrogen Fuel Cell Vehicle

In electric vehicles, we use battery packs for propelling vehicles. In electric vehicles, the power depends upon the size of the battery pack we use for propulsion. The more power we need the more cells we need in the pack. So the battery packs need to be charged regularly. For charging we need electricity, for that we need to depend on power generation units, obviously, it's from power plants. Again we pollute the environment by depending on power generation units. Even though electric vehicles are clean but for powering up it has to depend on polluting sources.

The developers developed two types of electric vehicles:
1. Plug-in system
2. Battery swap system

But in the case of hydrogen fuel cell vehicles, it has its own power generation unit, obviously the fuel cell. The power produce by the fuel cell is used to charge

the battery pack used for propulsion. By compact design, we can successfully propel with clean and safe. So hydrogen fuel cell vehicles need not depend on other power generation units for charging the battery. As conventional fossil fuel vehicles, it is enough to fill the tank with hydrogen to produce electricity with fuel cells. So it can also be treated as a mobile power generation unit. Apart from all its a clean form of energy.

## Hydrogen Fuel Cell as Stationary Power

The hydrogen fuel cell also can be used for power generation same as a power plant only thing is that we need a larger fuel cell and battery packs for discharging. We can continuously generate power with the help of hydrogen fuel cells without any interruption. When compared to other types of electric power generation modes such as thermal power plants, nuclear HFC power plants produce zero-emission and it is a clean form of energy. As per the census, there are over 550 MW stationary fuel cells installed in the U.S. as of January 2020.



**Fig. 13:** A stationary hydrogen fuel cell
(*Courtesy:* Fchea Fuel Cell and Hydrogen Energy Association)

## Conclusion

So hydrogen fuel cells will provide clean energy with zero-emission which is safe to the environment. Hydrogen is abundant so that we can involve in continuous power generation without abruption. Hydrogen fuel cells have a wide range of applications from propelling vehicles to stationary power generation for domestic and industrial uses. In near future, this may become the primary source of power due to its availability and pollution-free characteristics. Since the emissions are water and heat, the heat can be used for cogeneration.

## Acknowledgement

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# 17

# Optimization of Mix Design—Taguchi Method of Multivariate Analysis

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## ABSTRACT

The main aim of this work is to optimize the mix ratios of concrete as the number of trials are more and with various variations. Through using multi variant analysis, the Taguchi approach clearly clarifies the optimization. It is possible to scrutinize the various parameters considered in mix ratios together with the various variables and obtain maximum performance. Saving time and money for any project.

**Keywords:** Taguchi Method, Optimization, Mix design.

## Introduction

The Taguchi technique was built by Dr Genichi Taguchi of Japan, who demonstrated how little can make a huge difference. The Taguchi method minimize the variation in a certain operation. The key aim of this approach is to deliver high-quality goods at a cheap price to the producer. Taguchi also built a method to ascertain the influence of factors on process efficiencies, as a way to establish targets for design of process structures. Taguchi's experimental design utilizes for coordinating independent variables the critical parameters in the device and the thresholds under which they may be changed. Instead of checking all combinations, Taguchi will measure several pairs of combinations at a time. Data is rendered simpler to be gathered to determine which component influences the quality of product. Where an intermediate number of variables is present, (eg) 3 to 50, few connections between variables, and where there is a large input of just a few variables, Taguchi approach is bestused.

It is necessary to derive or look up the Taguchi arrays. Limited arrays may be manually drawn out; deterministic algorithms can derive huge arrays. Arrays can usually be searched electronically. The number of parameters (variables) and number of levels are chosen for the arrays (states). Later on, in this post, this is further clarified. Variance analysis of the collected data from the Taguchi experiment architecture may be used to choose Latest Values of Parameters in order to improve the output function. Through mapping Data and visual analysis, ANOVA, bin yield and the exact measure of Fisher, or Chi-squared test to test significance, the data from the arrays may be analysed. The basic Steps that are involved in implementing the Taguchi method will be outlined in this article and examples will be provided Usage of the Taguchi approach to design studies.

## The Taguchi Method's Theory

1. Quality can be built into, not tested into, a component. Via system design, design of parameters, and design of tolerances, consistency is built into a procedure. The design of parameters, which can be the subject of this report, is carried out by deciding which process parameters influence the product and then designing them to provide a defined target product quality. The "inspected into" standard of a commodity indicates the product is manufactured by the arbitrary levels of quality and any so far below the average are automatically tossedout.

2. By minimizing the variance from a goal, consistency is better accomplished. The product should be engineered such that it is resistant to environmental conditions which are uncontrollable. In other terms, the ratio of product quality to uncontrollable variables should be high. As a function of variance from the norm, the quality cost should be estimated and the losses should be measured system-wide.

3. This is the principle of the loss function, or the complete loss caused by a low performing product to the consumer and community. Because the retailer is still a part of community and because consumer disappointment would deter potential loyalty, the manufacturer will revert to this price for consumers and society.

## Taguchi Process of Experiments

The following are the general measures involved in the Taguchi Method:

1. Establish the purpose of the method, or more precisely, a target value for a process success metric. This will reflect other parameters, for example flow rate, etc. A system may target at minimizing output flow or growing it. The

deviation from the target meaning of the characteristic is used to calculate the success of the operation.

2. Determine the process-affecting architecture parameters. Parameters are factors that can be readily monitored throughout the method that influence the measure of efficiency, such as temperatures, pressures, etc. It is important to determine the number of levels at which the parameters can differ.

3. Build orthogonal arrays showing the amount and conditions of each experiment for the parameter configuration. The collection of orthogonal arrays for each parameter is dependent regarding the number of parameters and the variance levels and will be discussed below.

4. Perform the tests Indicated in the final one series to gather data on the results on the performance metric.

5. To assess the influence of the various parameters on the results metric, full data review.

The next move would be to discuss a thorough overview of the application of these measures. The following flow chart shows the complete process followed in TAGUCHI Method.



DETERMINE THE MATERIAL FACTORS AND THEIR REACTIONS

DETERMINE THE RATIO OF EACH MATERIAL

CHOOSE AN APPROPRIATE ARRAY

ASSIGN THE MIX PROPORTIONS OF EACH TRIAL MIXES TO THE COLUMN OF ARRAY

CONDUCT THE EXPERIMENTS

ANALYZE THE EXPERIMENTAL DATA

DETERMINE THE OPTIMAL LEVEL OF FACTORS

CONDUCT THE CONFIRMATION EXPERIMENT
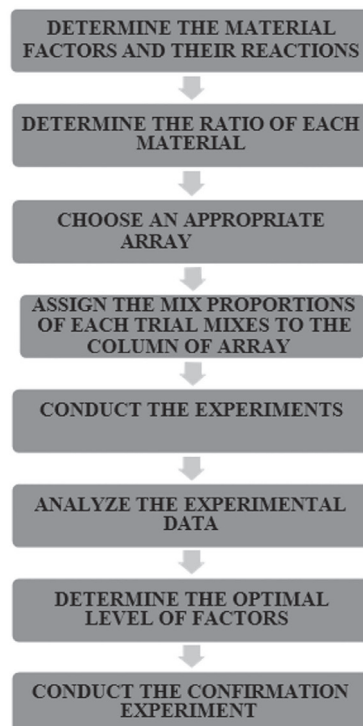
**Fig. 1:** Flow Chart shows Process of TAGUCHI Method

## Taguchi Loss Function

The aim of the Taguchi approach is to minimize costs due to uncertainty in development methods for the producer and society. Taguchi describes the discrepancy as a loss function between the goal value of the output attribute of a process, x, and the calculated value, y, as seen below.

$$l(y) = k_c(y - \tau)^2$$

The constant kcmay be determined in the loss function by considering the limits of definitions or the necessary intervaldelta.

$$k_c = \frac{C}{\Delta^2}$$

The challenge in evaluating kc is that it is often challenging to identify Ì and C.

If the objective is to minimize the output characteristic benefit, the loss function is described as,

$$l(y) = k_c y^2$$

where $\tau = 0$

If the objective is to optimize the output characteristic benefit, the loss function is described as follows:

$$l(y) = \frac{k_c}{y^2}$$

The loss function described here is the loss to a customer of one item. It is also possible to compute the overall cost to humanity by calculating these failure functions.

## Determining the Orthogonal Array Parameter Design

The influence of several distinct Quality parameters component in a compact collective experimentation may be performed and investigated using the orthogonal array experimental architecture suggested by Taguchi. As once parameters are often used, which influencing a mechanism that can be monitored have been determined, the thresholds to which these parameters can be modified must be Stated. To decide what proportions of a component to evaluate, it takes in-depth perception of the mechanism, inclusive of the minimum, limit, and present value of the parameter. If there is a significant gap between a parameter's minimum and maximum value, it is necessary to further isolate the values being measured or to measure further values. If a parameter's range is limited, least values can be measured or checked values can be taken closer to each other.

Knowing the number of parameters and phase figures, the proper orthogonal set can be chosen. By observing the column and row referring to the number of parameters and the number of ranks, define the name of the appropriate array using the array selector table shown below. These arrays can be created using an algorithm built by Taguchi, which enables each variable and environment to be verified in the same way. For example, the correct array may be seen to be L4 if we have three parameters (required target power, cement form, workability) and two strengths (high, low). You can see that there are four distinct experiments in the collection by loading on the L4 link to display the L4 collection. The levels specified as 1, 2, 3 etc. should be substituted in an assortment of the exact degree values, should vary and the real parameters should be replaced with P1, P2, P3. (Required target strength, Type of cement, Workability).

## Important Notes Concerning the Choice and Use of Orthogonal Arrays

**Note 1**

Selector of array implies that there are same number of levels for and parameter. The higher value would typically be chosen or it will split the variance. In an orthogonal array, the following examples include guidance on doing and doing it properly. The following example will demonstrate in both of these cases how to choose an orthogonal array.

**Example:** An attempt was made to quantify the effect on concrete mixes with respect to water/cement ratio, fine aggregate specific gravity, coarse aggregate specific gravity, slump, aggregate size and cement grade, and cost of concrete mix. An excel program was created where the input parameters can vary to design different concrete mix ratios.

In this example, Parameters A, B, C, D, E are given as inputs and variable X, Y.

Using the designed excel spread sheet, the appropriate mix ratio (Variable) that will hold the appropriate strength with the defined input parameters can be set up in compliance with IS 10262: 2009. The appropriate mix can be taken into consideration and parameters may vary to determine the necessary control factors to produce the desired results in order to attain different results. A 16*16 matrix can be framed prepared using the Taguchi approach where two variables vary in four levels and five variables differ in two levels. Each combination's tests can be done and the results can be assessed using statistical analysis. The parameters considered and the values allocated at different levels are shown in **Table 1**.

| Table 1: Provided the details of the L 16 matrix, constructed according to the Taguchi process | | | | | |
|---|---|---|---|---|---|
| *Variables* | *Parameter "A"* | *Parameter "B"* | *Parameter "C"* | *Parameter "D"* | *Parameter "E"* |
| | A1 | B1 | | | |
| X | A2 | B2 | C1 | D1 | E1 |
| Y | A3 | B3 | C2 | D2 | E2 |
| | A4 | B4 | | | |

The parameters considered for different trials are tabulated in **Table 2**.

| Table 2: Values of Parameter considered | | | | | | |
|---|---|---|---|---|---|---|
| *S.No.* | *Variables* | *Parameter "A"* | *Parameter "B"* | *Parameter "C"* | *Parameter "D"* | *Parameter "E"* |
| 1. | X | A1 | B1 | C1 | D1 | E1 |
| 2. | Y | A2 | B2 | C1 | D2 | E2 |
| 3. | X | A3 | B3 | C2 | D1 | E1 |
| 4. | Y | A4 | B4 | C2 | D2 | E2 |
| 5. | Y | A1 | B2 | C2 | D1 | E2 |
| 6. | X | A2 | B1 | C2 | D2 | E1 |
| 7. | Y | A3 | B4 | C1 | D1 | E2 |
| 8. | Y | A4 | B3 | C1 | D2 | E1 |
| 9. | Y | A1 | B3 | C2 | D2 | E2 |
| 10. | X | A2 | B4 | C2 | D1 | E1 |
| 11. | Y | A3 | B1 | C1 | D2 | E2 |
| 12. | X | A4 | B2 | C1 | D1 | E1 |
| 13. | X | A1 | B4 | C1 | D2 | E1 |
| 14. | Y | A2 | B3 | C1 | D1 | E2 |
| 15. | X | A3 | B2 | C2 | D2 | E1 |
| 16. | Y | A4 | B1 | C2 | D1 | E2 |

## Analyzing Research Findings

When the study design has been established and the experiments have been carried out, it is important to use the calculated output function of each test to evaluate the relative influence of the numerous parameters. The following L16 array will be used to illustrate the data analysis process, but the rules can be transferred to any array form.

It can be shown in this collection that any number of replicated experiments (trials) could be included. The multiple trials with I = experiment number and j = study number are described by Ti, j. It should be remembered that the Taguchi approach requires, rather than repetitive experiments, the usage of a noise matrix

including external variables influencing the result of the process, the allocation of degree for each parameter are shown below.

| Table 3: Allocations of degrees | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Trial* | *P1* | *P2* | *P3* | *P4* | *P5* | *P6* | *P7* |
| 1. | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2. | 2 | 2 | 2 | 1 | 1 | 2 | 2 |
| 3. | 1 | 3 | 3 | 2 | 2 | 1 | 1 |
| 4. | 2 | 4 | 4 | 2 | 2 | 2 | 2 |
| 5. | 2 | 1 | 2 | 2 | 2 | 1 | 2 |
| 6. | 1 | 2 | 1 | 2 | 2 | 2 | 1 |
| 7. | 2 | 3 | 4 | 1 | 1 | 1 | 2 |
| 8. | 2 | 4 | 3 | 1 | 1 | 2 | 1 |
| 9. | 2 | 1 | 3 | 1 | 2 | 2 | 2 |
| 10. | 1 | 2 | 4 | 1 | 2 | 1 | 1 |
| 11. | 2 | 3 | 1 | 2 | 1 | 2 | 2 |
| 12. | 1 | 4 | 2 | 2 | 1 | 1 | 1 |
| 13. | 1 | 1 | 4 | 2 | 1 | 2 | 1 |
| 14. | 2 | 2 | 3 | 2 | 1 | 1 | 2 |
| 15. | 1 | 3 | 2 | 1 | 2 | 2 | 1 |
| 16. | 2 | 4 | 1 | 1 | 2 | 1 | 2 |

The optimized mix ratio (SN) amount must be determined for each experiment performed to evaluate the influence of each variable on the output. For the particular target value of an output characteristic, the estimation of the SN for the first experiment in the array above as shown below. Yi is the mean value in the equations below and si is the variance. Yi for a particular experiment is the importance of the output characteristic.

$$SN_i = 10\log\frac{\bar{y}_i^2}{s_i^2}$$

$$\bar{y}_i = \frac{1}{N_i}\sum_{u=1}^{N_i} y_{i,u}$$

$$s_i^2 = \frac{1}{N_i - 1}\sum_{u=1}^{N_i} (y_{i,u} - \bar{y}_i)$$

Where
- i is the experimental number,
- u is the trial number, and
- Ni is the number of trials for experiment.

In order to minimize output characteristics, the following Optimized Mix Ratio (SN) description should be calculated:

$$SN_i = -10 \log \left( \sum_{u=1}^{N_i} \frac{y_u^2}{N_i} \right)$$

If output characteristics are to be maximized, the following description of the SN ratio should be calculated:

$$SN_i = -10 \log \left[ \frac{1}{N_i} \sum_{u=1}^{N_i} \frac{1}{y_u^2} \right]$$

For each factor and degree, the total SN value is calculated after calculating the SN ratio for each experiment. As can be shown below for Parameter 3 (P3), this is done in the list. Table 4 shows the details of allocating the degrees with respect to parameters to analyse the optimised mix ratio.

| Table 4: Allocation of Degrees with respect to parameters | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Trial* | *P1* | *P2* | *P3* | *P4* | *P5* | *P6* | *P7* | *SN* |
| 1. | 1 | 1 | 1 | 1 | 1 | 1 | 1 | SN1 |
| 2. | 2 | 2 | 2 | 1 | 1 | 2 | 2 | SN2 |
| 3. | 1 | 3 | 3 | 2 | 2 | 1 | 1 | SN3 |
| 4. | 2 | 4 | 4 | 2 | 2 | 2 | 2 | SN4 |
| 5. | 2 | 1 | 2 | 2 | 2 | 1 | 2 | SN5 |
| 6. | 1 | 2 | 1 | 2 | 2 | 2 | 1 | SN6 |
| 7. | 2 | 3 | 4 | 1 | 1 | 1 | 2 | SN7 |
| 8. | 2 | 4 | 3 | 1 | 1 | 2 | 1 | SN8 |
| 9. | 2 | 1 | 3 | 1 | 2 | 2 | 2 | SN9 |
| 10. | 1 | 2 | 4 | 1 | 2 | 1 | 1 | SN10 |
| 11. | 2 | 3 | 1 | 2 | 1 | 2 | 2 | SN11 |
| 12. | 1 | 4 | 2 | 2 | 1 | 1 | 1 | SN12 |
| 13. | 1 | 1 | 4 | 2 | 1 | 2 | 1 | SN13 |
| 14. | 2 | 2 | 3 | 2 | 1 | 1 | 2 | SN14 |
| 15. | 1 | 3 | 2 | 1 | 2 | 2 | 1 | SN15 |
| 16. | 2 | 4 | 1 | 1 | 2 | 1 | 2 | SN16 |

$$SN_{P3,1} = \frac{(S_{N1} + S_{N6} + S_{N8})}{3}$$

$$SN_{P3,2} = \frac{(S_{N2} + S_{N4} + S_{N9})}{3}$$

$$SN_{P3,3} = \frac{(S_{N3} + S_{N5} + S_{N7})}{3}$$

If the SN ratio values for each component and is defined, they can be tabulated as seen below, and for each parameter, the SN range R (R = high SN - low SN) is measured and incorporated into the chart. The bigger the R values for a function, the larger the effect on the component's operation.

## Advantages and Disadvantages

A benefit of the Taguchi approach is that it stresses a characteristic value of mean output comparable to the target value rather than a value beyond such design limits, thereby improving the accuracy of the part. Furthermore, the experimental design method of Taguchi is transparent in certain engineering contexts, it is clear and quick to implement. Making it an important yet basic method. It may be used to easily narrow down the scope of a research project or to identify problems in a supply chain from data already in nature. The Taguchi method also allows for the analysis of many various criteria without a prohibitively high amount of exploration. For example, a method of 8 variables, each with 3 states, would require 6561 (38) experiments to test all variables. Of this manner, it helps to specify important parameters that have the greatest impact on the feature of the performance characteristic, such that further experiments may be carried out on those parameters and it is easy to miss parameters that have little influence.

The major downside the Taguchi strategy is that the results produced are only relative and do not explicitly illustrate which parameter has the greater impact on the output value of characteristics. Also, since all variable configurations are not evaluated by orthogonal arrays, this approach cannot be used on all the relationships of all acceptable variables. The Taguchi approach has been questioned difficulty accounting for criteria in the literature for associations. Another downside is that the strategies of Taguchi are offline and so insufficient for a continuously varying mechanism, Simulation including research. Furthermore, since Taguchi approaches deal with quality design instead of adjusting for low-quality, at the early stages of the growth of processes they are most effectively applied. Once design variables are established, the usage of experimental design may be less cost effective.

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# 18

# Sensorless BLDC Motor with Reduced Commutation Torque Ripples using DTC Technique

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## ABSTRACT

In the field of industrial design and electronic drives, energy conservation plays a critical role. Recently, the method in the industry using a brushless DC motor (BLDC) has improved overall system performance. The process can therefore perform excellent operation by using BLDC, which is operated by the z-source network and the VSI (VSI) source inverter. BLDC has more features such as low inertia and friction, low radio interference, high reliability and high performance. Due to the lack of brushes, virtually no maintenance is needed. Since it has some disadvantages are high cost, low starting torque compared to traditional DC motor and has no versatility control due to lack of field winding. The above downside Direct Torque Control (DTC) is implemented with BLDC to increase its performance compared to other conventional control techniques. Using the DTC technique, torque-produced ripples can be reduced. Owing to this decrease in ripple torque, the engine has improved the power and the speed torque curve. The system is therefore configured by using a z-source network and a sensor-less technique to energise the BLDC generator. The simulation of the DTC-based z-source network for BLDC is performed using MATLAB/Simulink and the results are checked on the basis of a theoretical analysis.

## Introduction

A drive is an electronic device that harnesses and controls the electrical energy sent to the motor. The drive feeds electricity into the motor in varying amounts and at varying frequencies, thereby indirectly controlling the motor's speed and torque. The speed of rotation of an electrical machine can be controlled precisely by implementing the concept of drive. The main advantage of this concept is, the motion control is easily optimized with the help of drive. In very simple words, the systems which control the motion of the electrical machines are known as

electrical drives. This drive system is widely used in large number of industrial and domestic applications like factories, transportation systems, textile mills, fans, pumps, motors, robots etc. Drives are employed as prime movers for diesel or petrol engines, gas or steam turbines, hydraulic motors and electric motors. In this thesis the drive system is used to control the speed of the brushless DC motor.

Brushless motors fulfil many functions originally performed by brushed DC motors, but cost and control complexity prevents brushless motors from replacing brushed motors completely in the lowest-cost areas. Nevertheless, brushless motors have come to dominate many applications, particularly devices such as computer hard drives and CD/DVD players. Small cooling fans in electronic equipment are powered exclusively by brushless motors. They can be found in cordless power tools where the increased efficiency of the motor leads to longer periods of use before the battery needs to be charged. Low speed, low power brushless motors are used in direct-drive turn tables for gramophone records.

## Overview

The main objective of this research-work is to improve the performance of the BLDC drive by attending more precise speed tracking and smooth torque response by implementing a direct torque scheme. The overall objectives are to be achieved, to design the Z source network model for BLDC drive and its direct torque analysis and closed loop operation of drive system. Analysis and implementation of direct torque control, direct torque space vector modulation control in steady state and transient condition (step change in load and speed) in MATLAB/Simulink environment. Comparing the speed response by using PI and fuzzy logic controller and also to compare the reduction in torque ripples due to the addition of the Z source network.

## Proposed System

This project proposes z source network based Direct torque controlled Permanent magnet Brushless DC Motor. Compared with the most recent and highly performed DTC strategy, the proposed one offers improved reliability. Furthermore, the torque ripple is significantly damped during sector-to-sector commutations using a three-level hysteresis torque controller. Closed loop speed control algorithm is achieved by using Fuzzy logic controller and it is implemented in DSPIC30F2010 Controller. Implementing Z source network based Direct torque control strategy in BLDC Motor. Hence this will reduce the commutation torque ripples in the BLDC motor with low starting current. So that proposed system achieve the closed loop control using Fuzzy logic controller.
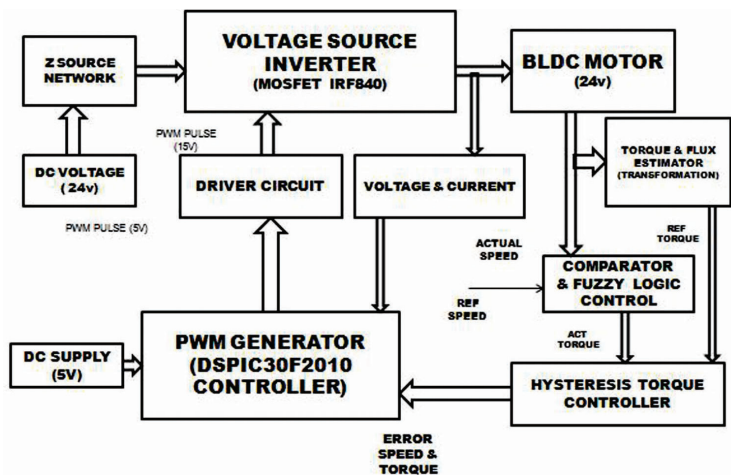
**Fig. 1:** Z source fed DTC-BLDC block diagram

## Block Diagram Description

The inverter is fed with the dc supply through the Z-source impedance network. The output of the voltage source inverter is given to the BLDC motor. The three phase to two phase conversions are carried out in the transformation block. The torque estimator utilizes the necessary dq axis current, voltage and the necessary parameters to estimate the actual torque value. The speed error is given as the input to the fuzzy controller to generate the reference torque value. The rotor position is obtained through the back emf sensing method. The direct axis current reference and actual value are compared to obtain the flux error. The flux error, torque error and the rotor position are given as the control signals to the PWM generate to generate the gating pulses for the inverter. The figure showsthe block diagram of the fuzzy logic controlled Z- source fed DTC-PMBLDC motor.

## Circuit Diagram
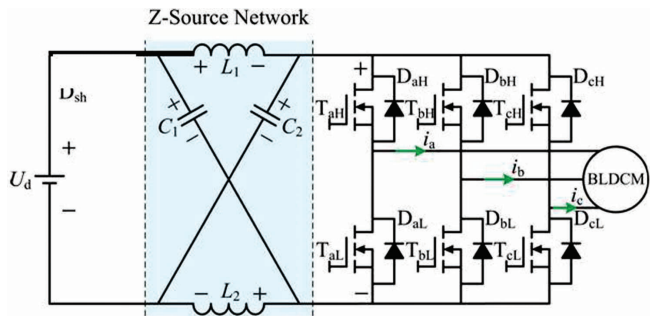


**Fig. 2:** FLC Z source fed DTC-BLDC circuit diagram

## Components Explanation

### DC Supply

It may be a DC battery or the rectified output from the rectifier. Fuel cell can also act as the DC power source.

### Z-Source Network

It is an impedance network coupled between the inverter and the power source. Its unique feature is to boost up the voltage from the battery without the need of boost converter or the step-up transformer. This impedance source network includes a combination of two inductors and two capacitors.
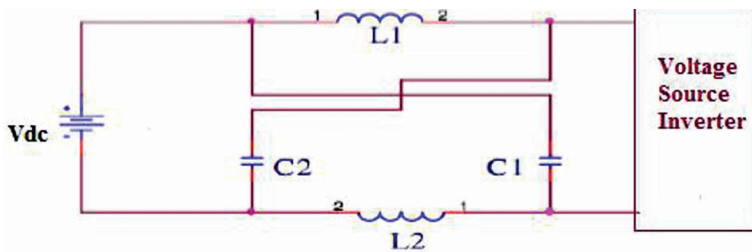


**Fig. 3:** Z-source network connection

This combined circuit network works as the energy storage element. Two inductors of same values and two capacitors of same values are used.

### Voltage Source Inverter

The voltage source inverter acts as an electronic commutator. It consists of six switches and operates in 120 degree conduction mode. The output of the Z-source network is given as the input to this inverter. The speed of the PMBLDC motor is controlled by varying the switching frequency of the switches. The inverter's output is given to the stator windings of the motor. The space vector modulation technique is used to vary the switching of the inverter switches.

### PWM Generator

The PWM pulses to the inverter switches are generated by means of space vector modulation technique. Embedded MATLAB coding is used to generate the gate pulses to inverter switches having torque error, flux error and rotor position as the control signals. The six states in the space vector modulation are used. The gate pulses to the upper arm switches are inverted then given to the lower arm switches.

## BLDC Motor

The permanent magnet brushless dc motor with trapezoidal back EMF is used. Because of the concentrated stator winding arrangement the air gap flux is trapezoidal and so the back EMF is the trapezoidal. Permanent magnet is used as the rotor. The three phase stator winding of the motor is connected to the inverter output. The rotor position is sensed by means of the EMF sensing method. Separate coding is used to change the sequence of phase excitation using the rotor position. This back EMF sensing eliminates the need of the hall sensors thereby reducing the cost of the low power drives.

## Three Phase to Two Phase Transformations

This block converts the three phase stator voltages and currents in the stationary reference frame to the synchronously rotating reference frame using the park transform. The Clarke transformation is used to estimate the flux linkage vector in alpha and beta co-ordinates and this is used to find out the sector of the stator flux linkage vector. The exact angular position of the rotor flux vector can be find out using it, which replaces the separate rotor positioning sensors.

## Torque Estimator

This block calculates the actual torque by using the equation,

$$\text{Torque} = (3P/4\omega)*(ed*id + eq*iq)$$

The current and the voltage parameters are obtained from the transformation block. "P" represents the number of poles and "$\omega$" represents the angular velocity.

It gives the actual torque value produced by the motor. This actual value is compared with the reference value to generate the torque error. The comparator compares the respective actual and reference values and generates the error values.

## Fuzzy Speed Controller

The fuzzy logic controller processes the speed error and the change in error speed and produces the output. That output is maintained in the limits between 0 and 1. Then it is given as the reference torque value to the comparator to generate the torque error.

The flux error is produced by comparing the actual and the reference direct axis current. Both the errors are limited between the threshold value in the hysteresis comparator. Along with the rotor position angle they fed as the controlling signal to the PWM generator.

## Working

The permanent magnet brushless DC motor is fed by the AC source through the electronic commutator. A Z-source network is coupled between the DC supply and the inverter to boost up the supply thereby increasing the torque magnitude by reducing the ripples.

The direct torque control method is used to control the speed of the motor. The torque error, flux error and the rotor position are the three controlling signals used to generate the gating signals for the inverter. The motor three phase voltages and currents are transformed to the two phase quantities in the synchronously rotating frame using the park and Clarke transformations.

The transformed voltage and current values are used to find out the flux and rotor position values. These values are used to calculate the actual torque value. The reference torque value is obtained from the speed controller and its value is limited in the hysteresis comparator.

The flux error is calculated by comparing the reference and the actual value of the direct axis current. The theta (i. e rotor angle) is calculated and acts as the controlling signal for the inverter.

The Fuzzy logic controller is used to control the speed of the PM-BLDC motor. The speed error and the change in speed error are given as the input to the fuzzy logic block. Based on the fuzzy rules the reference torque value is generated.

The torque, flux errors and the theta values are used to select the frequency and voltage magnitude of the motor supply and hence controlling the speed of the motor.
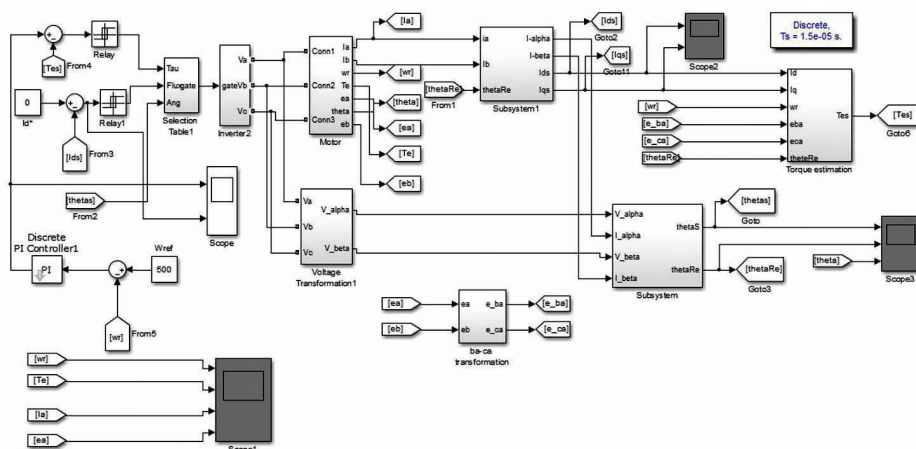


**Fig. 4:** Z source network based DTC BLDC with PI controller MATLAB simulation

### Matlab Simulink

The **figure 4** shows the simulation diagram of the DTC –BLDC motor with the PI speed controller. The PI controller has some drawbacks.

1) It requires manual tuning parameter estimation for various speeds.
2) The speed response using PI controller has a drop in the speed after the step time.

These drawbacks can be overcome by using fuzzy logic speed controller whose simulation diagram is shown in figure. Since it provides the automatic speed control over a range and does not requires manual parameter estimation for various speed, it makes the overall control loop as the easy one.

### Z Source Network Based DTC BLDC Using Fuzzy Logic Controller - Matlab Simulation



**Fig. 5:** Z source network based DTC BLDC with fuzzy logic controller MATLAB Simulation

### Conclusion

A fuzzy logic controller (FLC) has been employed for the DTC speed control of PMBLDC motor drive and analysis of results of the performance of a fuzzy controller and SV-PWM is presented. The simulation of the complete drive system is described in this project. Effectiveness of the system is established by performance prediction over a wide range of operating conditions.

A performance comparison between the fuzzy logic controller and the conventional PI controller has been carried out by simulation runs, confirming the validity and superiority of the fuzzy logic controller. The fuzzy logic controller

implementation significantly reduces the manual tuning time of the classical controller. The Z source network has damped the torque ripples in the BLDC motor.

The performance of the PMBLDC Motor drive with reference to PI controller, FLC controller and experimental verified with conventional PI controller Fuzzy logic speed controller improved the performance of PMBLDC Drive of the fuzzy logic speed controller.

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# 19

# Emission Characteristics of Plastic Oil Fuelled IC Engines

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**ABSTRACT**

Although there is a great improvement in fuel economy over these years, the demand for fuel is rising due to increase in number of automobiles. It is believed that petroleum products and crude oil will soon become very rare and their production will be costly in nearing future. Also, the emissions from gasoline engines along with other polluting systems, contributes to air pollution. Hence, many countries have started using alternate fuels in IC engines. This paper focuses on one such alternate fuel called plastic oil. A complete review on emission characteristics of WPO (Waste Plastic Oil) are discussed when it is used in CI engines along with diesel fuel and some additives.

## Introduction

As the population increases, the demand for fuels is more and hence the fossil fuel reserves get depleted at a faster rate. Also, the number of vehicles plying on road, vehicular and harmful emissions from the conventional fuels has been accelerated. The price of petrol and crude oil has been increased drastically over the past 70 years, leading to an uneconomical situation. Hence many countries have switched to alternate fuels. For example, cars in Brazil run on either pure ethanol or ethanol+gasoline blends whereas Sweden is reported to use the highest biofuel in all over Europe due to which the greenhouse gas emissions in the country has been decreased by 25%. Adverse effect on engine equipment and its performance, high production and distribution cost and lack of fuelling stations are some of the reasons that hinders the implementation of alternate fuels. India manages 82% of its oil needs by importing from other countries like Saudi Arabia, UAE, Iraq, Venezuela, Kuwait and Nigeria. So, there is a need to imply the concept of alternate fuels in India. One such alternative is Waste plastic oil

(WPO). It is produced from non-biodegradable polymers that contains hydrogen and also chlorine, nitrogen etc. There are many types of plastics but only some can be recycled such as 2HDPE (High Density Polyethylene), 4LDPE (Low Density Polyethylene), 5PP (Polypropylene) and 6PS (Polystyrene) whereas, PVC (Poly Vinyl Chloride), PETE (Polyethylene Terephthalate) etc. cannot be recycled. The advantages of using WPO as an alternate fuel are low emissions due to absence of sulphur, coke and LPG by-products, 100% value added product, reduced carbon print (greenhouse gases) and economical than conventional fuels. The emission characteristics of WPO blended with diesel in different ratios are reviewed and discussed in detail in the coming sections.

## Emission Characteristics

### $NO_x$ Emissions

The major constituents of oxides of nitrogen are nitric oxide (NO) and nitrogen dioxide ($NO_2$). The oxidation of nitrogen present in the air leads to the formation of NO and $NO_2$ in the combustion chamber which is given by Zeldovich mechanism[1]. In cylinder temperature, oxygen concentration and residue time determines the formation of $NO_x$. Mani et al.[2] and Güngör et al.[3] conducted experiments with waste plastic oil in a diesel engine by varying the brake power and observed that $NO_x$ emissions increased in WPO when compared with diesel fuel operation. It was due to higher heat release and higher combustion temperature whereas at high load conditions, higher temperature and peak pressure promoted to high $NO_x$ emissions in case of WPO. It was noticed that higher ignition delay of WPO leads to accumulation of more fuel before ignition, thus rising $NO_x$ emissions. Mani et al.[4] conducted experiments with diesel fuel and WPO blended with diesel fuel (WPO10, 30, 50, 70) in a CI engine. They observed that the $NO_x$ emissions of WPO are always greater than Diesel Fuel (DF) over the full load range. $NO_x$ emissions were high at no load conditions and lower at full load. The decreasing order of the $NO_x$ emissions of their fuels was WPO, WPO70, WPO50, WPO30, WPO10, DF. They justified this trend with the help of ring structure of WPO. Due to its structure and its aromatic nature, higher adiabatic temperatures was observed which increased the in cylinder temperature. Mani and Nagarajan[5] conducted the experiments with WPO in a DI diesel engine by varying the brake power and injection timing and found that at standard injection timing they observed decrease in $NO_x$ emissions when retarding the injection timing at all load conditions. This was due to delay in cylinder peak pressure due to late combustion. They concluded that lower peak pressure led to lower peak temperature and thus less $NO_x$ emissions. Ayodhya et al.[6] used DF, P30 with varying ammonia concentration,

selective catalytic reduction (SCR) and exhaust gas recirculation (EGR). They used EGR and SCR for reducing oxides of nitrogen emissions. They observed maximum $NO_x$ reduction at 60% load condition for ammonia flow rate of 0.5 kg/hr and observed a drop in $NO_x$ conversion efficiency at 80% load. This may be due to the decreased residence time and increased temperature. Sachin et al.[7] observed the similar trends of increase in $NO_x$ emission.

Ayodhya et al.[8] concluded from their experiments that Oxides of nitrogen reduced with increase in the amount of EGR over all load range due to rise in the peak temperature inside the combustion chamber. Mukherjee and Thamotharan[9] used WPO, diesel fuel and ethanol blends to perform the experiments. They varied load and noticed that $NO_x$ emissions increases with increase in load due to higher heat release. Authors Devaraj et al.[10] and Kaimal and Vijayabalan[11] conducted experiments using DEE-Diethyl ether additive with WPO in different blend ratio in a DI diesel engine. They varied brake power and found that neat plastic oil had more $NO_x$ emissions compared to diesel due to high temperature inside the engine cylinder. They also observed that increase in DEE levels reduced $NO_x$ emission due to less auto ignition temperature of DEE. The DEE has high latent heat of vaporisation which reduces the temperature inside the cylinder during combustion and can be verified from the low peak pressure inside the engine cylinder. Among the WPO-DEE blends PD5 recorded the highest $NO_x$ emission.

Senthilkumar and Sankaranarayanan[12] used Jatropha methyl ester (JME) on WPO in a DI diesel engine. They varied the load and observed that the $NO_x$ emission increased as the load increased. The decreasing order of the $NO_x$ emission were PJ10, PJ20, WPO and diesel. The reason for more $NO_x$ in WPO-JME is the presence of more oxygen content in combustion chamber that causes $NO_x$ formation. Damodharan et al.[13] discussed about the combined effect of injection timing and EGR in a CI engine with WPO. They varied EGR% and noticed that increase in EGR rate reduced $NO_x$ emissions. Damodharan et al.[14] conducted the experiment using Ultra Low Sulphur Diesel (ULSD), WPO, diesel and WPO-DF-n-butanol blends. They varied bmep and noticed that neat WPO gave out less $NO_x$ emissions compared to ULSD but on addition of n-butanol, they observed raise in $NO_x$ emissions due to more oxygen in the blends. At high loads least $NO_x$ emissions was observed in D50-WPO40-B10. Panda et al.[15] conducted experiments by varying the blend ratio and found that among the new blend ratio, B WPO 50% gave out maximum $NO_x$ emissions.

Kalargaris et al.[16] used WPO-DF blends and by varying the blend ratio they found increase in $NO_x$ emissions due to high combustion temperature. Among the new blends WPO90 recorded the maximum $NO_x$ emissions. Bridjesh et al.[17] used

2-methoxy ethyl acetate (MEA) and diethyl ether (DEE) as additives with WPO and conducted their experiments. They noticed that $NO_x$ emission is very high with WPO than DF, WPO-DEE-MEA blends. Improvements are found when DF and WPO are premixed with MEA and DEE. For 50D40W10DEE, the $NO_x$ emission is found to be lower by 5.5%. Kaimal and Vijayabalan[18] conducted the experiments by differing the blend ratio and concluded that the $NO_x$ emission will be greater for WPO followed by WPO-DF blends and finally DF and the $NO_x$ emission increases as WPO% increases in the blend.

Kumar and team[19-21] run tests on petrol engine unlike other authors using WPO-petrol blends. They noticed that at higher loads there was increase in $NO_x$ emissions. The increase in blend proportion increased the amount of nitrogen in the engine cylinder in terms of intake air. Although nitrogen doesn't have a role to play in combustion process, it react with oxygen and form $NO_x$ emissions and concluded that as blend increases, $NO_x$ emissions increases. They conducted the same tests with different fuels such as WPO-petrol-ethanol blends. They observed that $NO_x$ emissions decreased with addition of ethanol to WPO. The addition of ethanol lowers the heating value of ethanol compared to gasoline that caused a reduction in combustion heat energy and combustion temperatures and hence $NO_x$ emissions were lesser. Sukjit et al.[22] conducted experiments with oxygenated fuels (butanol, DEE) and WPO. They varied load and observed that $NO_x$ emissions increased with addition of butanol to WPO. This was due to presence of oxygen molecule in butanol that caused NO formation. Rao et al.[23] conducted experiments using WPO, DF and ethanol. They found that $NO_x$ emissions increased with retarded injection timing and increase in injection pressure. The reason for increase in $NO_x$ was attributed to the high in-cylinder temperatures due to retarded injection and there was better atomisation with increase in injection pressure.

Santaweesuk and Janyalertadun[24] conducted experiments using distilled WPO. They varied nozzle pressure and engine load and observed that $NO_x$ emissions were less when operated with distilled WPO at a standard nozzle pressure. Chintala et al.[25] conducted experiments using derivatives of WPO (stage 1 and 2- PO1 and PO2). They varied BMEP and observed that at moderate and higher loads the $NO_x$ emissions decreased in case of plastic oil derivatives than neat WPO. Many authors reported that increase in combustion temperature as reason for increase $NO_x$ emissions in IC Engines.[26-28]

### Unburnt Hydrocarbon Emissions

The emission of unburnt hydrocarbon (UHC) is mainly due to the incomplete combustion inside the engine cylinder. Mani et al.[2] and Güngör et al.[3] conducted

experiments with waste plastic oil in a CI engine by varying brake power and found that the concentration of UHC of WPO is marginally more than the diesel. At lower loads due to more oxygen availability and charge homogeneity UHC levels of WPO is lesser but at higher loads UHC level increases due to more fuel consumption which causes higher fumigation rate and less oxygen availability compared to diesel. Mani and Nagarajan[5] conducted the experiment with in a DI diesel engine using WPO alone by varying the brake power and fuel injection timing. They observed that UHC levels decreased when operated at retarded injection timing due to decreased flame quenching thickness. Mani et al.[4], Senthilkumar et al.[26], Kumar at al.[7], Mohanraj et al.[27] and Kalargaris at al.[28] conducted experiments with diesel fuel and WPO blended with diesel fuel (WPO10,30,50,70) in a CI engine by varying load and observed that the hydrocarbon (HC) emission WPO-diesel fuel blends is greater than neat diesel operation. At lower loads HC ranges of WPO and DF was less due to lean mixture whereas at higher loads it was high because of more fuel consumption. Among the blends WPO70 recorded maximum HC emission. They concluded that as load increases the ignition delay of WPO decreases so unburnt hydrocarbon decreases as load increases.

Ayodhya et al.[6] used diesel fuel, P30 with varying ammonia concentration, EGR and SCR. The HC emissions remained unaltered due to the absence of oxidation process in the SCR. When they used EGR, the levels of HC were increased due to dilution effect. When the Engine was operated with EGR the HC emission was maximum at no load condition. Mani et al.[4] and Ayodhya et al.[6] did experiments with diesel and WPO blends and concluded that as EGR rate increases UHC also increases due to oxygen reduction into cylinder which promotes incomplete combustion and more HC emission. Lee et al.[29] conducted experiments using WPO-DF with different blend ratios and observed that at lower loads HC ranges of WPO and diesel fuel was less due to lean mixture whereas at higher loads it was high because of more fuel consumption. Senthilkumar and Sankaranarayanan[12] used JME-Jatropha methyl ester on WPO in a DI diesel engine. They varied the load and observed that adding JME with WPO reduced hydrocarbon levels compared to WPO due to less fumigation rate of WPO-JME blends. The decreasing order of unburnt hydrocarbons are WPO, PJ10, PJ20 and diesel.

Devaraj et al.[10] and Kaimal and Vijayabalan[11] conducted experiments using DEE-Diethyl ether additive with WPO in different blend ratio in a DI diesel engine. They varied brake power and observed that UHC was higher for WPO-DEE blends when compared to that of WPO and diesel. This was due to the reduction in density upon addition of DEE. Panda et al.[15] varied the blend ratio and load and observed that the new blend ratio, B WPO50% gave out maximum HC emissions. Kareddula and Puli[20] conducted tests with WPO-PF-ethanol blends and observed

that the addition of ethanol to WPO-PF led to increase in hydrocarbon emissions. This was due to lower flame speed of ethanol compared to gasoline, hence more amounts of UHC are left behind in each cycle. Damodharan et al.[13] used the combined effect of injection timing and EGR in a CI engine with WPO. They varied EGR percentage and noticed that HC emissions increased with increase in EGR at all injection timings. They also observed reduction in HC emissions at early injection timing. They also conducted the experiment using Ultra Low Sulphur Diesel (ULSD), WPO, diesel and WPO-DF-n-butanol blends. They varied brake mean effective pressure and noticed that HC emissions were higher for WPO as compared to ULSD because of unsaturated HC in WPO that were resilient during combustion. They also observed that on adding n-butanol, hydrocarbon emission increased due to high heat of evaporation led to formation of flame quenching zone where incomplete combustion occurs. They noticed decrease in HC emissions with increase in WPO-PF concentration.

Sukjit et al.[22] investigated the effect of oxygenated fuels (butanol, DEE) and WPO in a CI Engine. They varied load and observed that upon addition of butanol there was no significant change. They observed the same results while adding DEE. Ayodhya et al.[6] used DF, P30 with varying EGR concentration and noticed that P30 blends emit more hydrocarbons due to high viscosity. Hydrocarbon emission increased with addition of EGR due to the lower combustion temperature which led to incomplete combustion. Kumar and Puli[20] conducted tests on petrol engine unlike other authors using WPO-PF blends. Rao et al.[23] conducted experiments using WPO, DF and ethanol. They varied injection timing, injection pressure and compression ratio and found that the HC emissions of all blends increased during advancing injection timing due to longer ignition delay. They also noticed that on addition of ethanol, HC emissions decreased due to better atomisation of fuel droplets in combustion chamber. Venkatesan et al.[30] conducted experiments similar to Mani et al.[4] by using Waste plastic oil and diesel blends and recorded similar results.

## CO Emissions

In IC Engines the emission of carbon monoxide (CO) is attributed to the incomplete combustion in the engine cylinder. The compression ignition engines usually operate on the lean mixture side which reduce the CO emission. So the CO emission from engines depend on the air fuel ratio relative to the stoichiometric proportions. Mani et al.[2] investigated the effects of waste plastic oil in a CI engine by varying brake power and noticed that CO emissions of WPO is greater than that of diesel due to incomplete combustion and less in cylinder temperatures at higher loads CO emission increases due to more fuel consumption. Mani et

al.[4] conducted experiments with neat diesel and WPO blended with diesel fuel (WPO10,30,50,70) in a CI engine and by varying brake power they noticed that CO emission for WPO-DF blends is greater than the DF. The reason for higher emissions were poor mixture preparation, local rich regions inside the cylinder and reduction in in-cylinder temperature. They concluded that at load increases ignition delay decreases so CO emission is low at higher loads. Among the blends WPO70 gave out more CO emissions. The same authors conducted the experiment with in a DI diesel engine using WPO alone by varying the brake power and fuel injection timing and observed that CO emission for retarded injection timing was lower due to high heat release and complete combustion of the fuel. Ayodhya[6] used DF, P30 with varying ammonia concentration, EGR and SCR. P30 recorded the most CO emission. With EGR, the HC emission increased due to dilution effect. Kumar et al.[7] worked on WPO-DF observed the similar trends of CO emission.

Kaimal and Vijayabalan[11] conducted experiments using Diethyl ether (DEE) additive with waste plastic oil in different blend ratio in a DI diesel engine. They varied brake power and observed that the increase in DEE concentration reduced the CO emissions. WPO-DEE blends noted a drastic reduction level of CO compared to WPO due to complete combustion and high volatility. They noted that CO reduced by 9%, 24% and 32% respectively for PD5, PD10 and PD15 blends. Senthilkumar and Sankaranarayanan[12] used Jatropha methyl ester (JME) on WPO in a DI diesel engine. They varied the load and observed that CO levels of WPO-JME was lesser than the WPO due to the presence of excess oxygen in JME which causes complete combustion. Damodharan et al.[13] used the combined effect of injection timing and EGR in a DI diesel engine with WPO. They varied EGR% and noticed the increase in CO emissions as EGR intensified at all injection levels because the use of EGR reduces the percentage of oxygen in the mixture available for combustion which leads to CO emission. Güngör et al.[3] conducted the same experiment as Mani et al.[2] using WPO and recorded the same CO emission trend as them. Devaraj et al.[10] conducted experiments using DEE-Diethyl ether additive with WPO in different blend ratio in a CI engine and they got the same results. Damodharan et al.[31] conducted the experiment using (ULSD) Ultra Low Sulphur Diesel, WPO, diesel and WPO-DF-n-butanol blends. They varied brake mean effective pressure and noticed that the CO emissions were less with the increase in load for all WPO/ULSD blends. The addition of n-butanol to the blends also reduced the emissions due to the availability of additional oxygen that assists CO oxidation.

Panda et al.[15] conducted experiments using WPO and WPO-DF and recorded similar NO$_x$ emissions results. Mukherjee and Thamotharan[9] used WPO, diesel

fuel and ethanol blends to perform the experiments. They varied load and noticed that emission of CO from WPO blends (B20, B40 and B60) and DF are similar and under control. Kalargaris et al.[16] used the WPO-DF blends with different blend ratio and found that the blend PPO75 had more CO emissions. They concluded that the increase in load led to decrease in CO emission due to better combustion at higher loads. Ayodhya et al.[6] used Diesel fuel and P30 with varying EGR concentration and noticed that on application of EGR the CO emissions increased. Lee et al.[29] conducted experiments using WPO-DF blends similar to Mani et al.[4] but with different blend ratio and obtained similar results.

Vijaya Kumar et al.[19] and Kareddula and Puli[32] conducted tests with WPO-PF-ethanol blends and observed that CO emission for ethanol blended fuel gets reduced when compared to gasoline due to the oxygenated nature of ethanol. Sukjit et al.[22] conducted experiments on oxygenated fuels (butanol, DEE) and WPO. They varied the load and observed that butanol addition increases CO emission. This was due to longer ignition delay of butanol and high latent heat of vaporization which lead to incomplete combustion and CO emissions. Rao et al.[23] conducted experiments using WPO, DF and ethanol. They varied injection timing, injection pressure and compression ratio and found that the CO emissions decreased with retarded injection because there was more time available for mixing of air-fuel mixture which led to better combustion. Santaweesuk and Janyalertadun[24] conducted experiments using distilled WPO. They varied nozzle opening pressure and engine load and observed increased CO emissions with increase in nozzle opening pressure. The reasons were unstable combustion and oxygen deficiency. Venkatesan et al.[30] conducted experiments with WPO and found increase in CO emissions. Chintalaa et al.[25] used derivatives of WPO (stage 1 and 2- PO1 and PO2) and run their tests. They varied brake mean effective pressure and observed that CO emissions were higher in case of WPO. The reasons for high CO emeisions were longer ignition delay and presence of aromatic compounds in the WPO.

## Smoke Emissions

Smoke is soot particles suspended in air. It is usually measured in BSU. Mani et al.[2] conducted experiments with waste plastic oil in a diesel engine and by varying brake power they noticed that smoke emission is less in case of WPO compared to diesel. The reason was the availability of premixed homogenous charge inside the engine much before the burning of air fuel mixture inside the cylinder. WPO consists of oxygen which causes complete combustion thereby reducing smoke formation. The other reasons were the higher combustion temperature, increase in combustion duration and high rate of flame propagation. The same authors[2] and

Gungor et al.[3] conducted the experiment with in a DI diesel engine using WPO alone by varying the brake power and fuel injection timing and noticed that smoke levels are more in case of retarded injection timing. This is due to unburnt and partially reacted HC. Mani et al.[4], Senthilkumar et al.[26], Lee et al.[29], Kaimal and Vijayabalan[1], Venkatesan et al.[33], Mohanraj et al.[27], and Kalargaris et al.[28] conducted experiments with diesel fuel and WPO blended with diesel fuel (WPO10,30,50,70) in a CI engine by varying load and they observed that WPO-DF blends gave out more smoke as compared to DF. The reasons were lower combustion temperature, reduced duration of combustion and rapid flame propagation. Among the blends WPO70 recorded maximum smoke intensity.

Ayodhya et al.[6] used DF and P30 with varying ammonia concentration in SCR and with EGR technique. They noticed that SCR had no effect on soot levels. However EGR had an effect on smoke emission. The maximum soot emission was observed at 80% load for EGR. Kumar et al.[7] worked on WPO-DF blends same as Mani et al.[4] and observed the similar trends of smoke. Since the exhaust gas replace the air there was an increase in smoke. They found that 20% EGR was the optimum,which produced lesser smoke when compared to diesel. Kaimal and Vijayabalan[11] conducted experiments using DEE-Diethyl ether additive with WPO in different blend ratio in a DI diesel engine. They varied brake power and observed that WPO has more smoke emission when compared to diesel due to aromatic content in WPO, their lower volatility and higher viscosity. Their experimental results show that there is increase in smoke with increase in DEE levels.

Senthilkumar and Sankaranarayanan[12] used JME-Jatropha methyl ester on WPO in a DI diesel engine. They varied the load and observed that with the increase in fuel injection, air-fuel ratio decreases which led to more smoke emission. They also noticed that addition of Jatropha methyl ester to WPO decreased the smoke levels. Devaraj et al.[10] conducted experiments with DEE-Diethyl ether additive to WPO in different blend ratio in a CI engine and they got the same results. Panda et al.[15] conducted experiments with different blend ratio and load and found that the blend WPO50% gave out maximum smoke intensity. Sukjit et al.[22] conducted experiments on oxygenated fuels (butanol, DEE) and WPO. They varied load and observed that upon addition of butanol blends showed higher smoke emission than DEE blends at higher loads. Rao et al.[23] conducted experiments using WPO,DF and ethanol. They varied injection timing, injection pressure and compression ratio and found that smoke emissions decreased with increase in injection pressure and compression ratio. Chintala et al.[25] used derivatives of WPO and conducted the experiments. They varied the brake mean effective pressure and observed increase in smoke emissions with all the types of fuel.

## Conclusion

Many research studies are going on to find alternatives for conventional fuels on the idea of sustainable development. Numerous experiments and extensive research works were conducted on Waste plastic oil along with diesel and other additives. The results conclude that the $NO_x$ emissions are always greater in WPO than diesel fuel at all loads whereas, it decreased upon retarding the injection timing. The UHC decreased on using WPO with retarded injection but at standard injection, the levels of UHC is more in WPO than in diesel fuel. The smoke level is less in WPO as compared to diesel but on retarded injection timing, WPO emits more smoke than diesel. Also, WPO is environmental friendly and cheaper than conventional fuels. Hence it can be a better alternative for the diesel fuel. Waste plastic oil as CI engine fuel will be a green initiative and play a crucial role in preventing the depletion of fossil fuels and control of greenhouse gases.

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# 20

# Role of Artificial Intelligence in the Battle against COVID-19: A Survey and Future Research Directions

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## ABSTRACT

COVID-19 is a pandemic that has spread all over the world. To date the novel coronavirus SARS-CoV-2 has caused thousands of deaths and infected hundreds of thousands more. The global spread of COVID-19 continues to grow exponentially. Many efforts have been undertaken to accelerate Artificial Intelligence (AI) research in order to combat this pandemic. As requested by the White House Office of Science and Technology Policy, the COVID-19 Open Research Dataset (CORD-19) has recently been released and contains over 29,000 machines.

In this worldwide health crisis, the medical industry is looking for new technologies to monitor and control the spread of COVID-19 (Coronavirus) pandemic. AI is one of such technology which can easily track the spread of this virus, identifies the high-risk patients, and is useful in controlling this infection in real-time. AI has been applied widely in our daily lives in a variety of ways with numerous successful stories. AI has also contributed to dealing with the coronavirus disease (COVID-19) pandemic, which has been happening around the globe.

It can also predict mortality risk by adequately analyzing the previous data of the patients. AI can help us to fight this virus by population screening, medical help, notification, and suggestions about the infection control[1-3]. AI is being used as a tool to support the fight against the viral pandemic that has affected the entire world since the beginning of 2020. The press and the scientific community are echoing the high hopes that data science and AI can be used to confront the coronavirus and "fill in the blanks" still left by science." This technology has the potential to improve the planning, treatment and reported outcomes of the COVID-19 patient, being an evidence-based medical tool.

This article presents a survey of AI methods being used in various applications in the fight against the COVID-19 outbreak and outlines the crucial roles of AI research in this

unprecedented battle. We highlight 13 groups of problems related to the COVID-19 pandemic and point out promising AI methods and tools that can be used to solve those problems. It is envisaged that this study will provide AI researchers and the wider community an overview of the current status of AI applications and motivate researchers in harnessing AI potentials in the fight against COVID-19.

**Index Terms:** Artificial intelligence; AI; machine learning; coronavirus; COVID-19; SARS-CoV-2; pandemic; epidemic; outbreak; survey; review; overview; future research directions.

## Introduction

The novel coronavirus disease (COVID-19) has created tremendous chaos around the world, affecting people's lives and causing a large number of deaths. Since the first cases were detected, the disease has spread to almost every country, over 61.8 million reported cases and 1.4 million deaths globally since the start of the pandemic based on statistics of the World Health Organization in the middle of December 2020.

Governments of many countries have proposed intervention policies to mitigate the impacts of the COVID-19 pandemic. Science and technology have contributed significantly to the implementations of these policies during this unprecedented and chaotic time. For example, robots are used in hospitals to deliver food and medicine to coronavirus patients or drones are used to disinfect streets and public spaces. Many medical researchers are rushing to investigate drugs and medicines to treat infected patients whilst others are attempting to develop vaccines to prevent the virus. Computer science researchers on the other hand have managed to early detect infectious patients using techniques that can process and understand medical imaging data such as X-ray images and computed tomography (CT) scans. These computational techniques are part of artificial intelligence (AI), which has been applied successfully in various fields.

Artificial intelligence (AI) refers to a field of computer science dedicated to the creation of systems performing tasks that usually require human intelligence.[1] AI and its applications have assisted in many areas of COVID-19 and are playing a very crucial role in its management. It is probably for the best that humans have an additional source of intelligence to confront this pandemic. The potential contributions of AI during COVID-19 should be known for a better understanding about this technology.

This article focuses on the roles of AI technologies in the battle against the COVID- 19 pandemic. We provide a comprehensive survey of AI applications that support humans to reduce and suppress the substantial impacts of the outbreak.

Recent advances in AI have contributed significantly to improving humans lives and thus there is a strong belief that proper AI research plans will fully exploit the power of AI in helping humans to defeat this challenging battle. We discuss about these possible plans and highlight AI research areas that could bring great benefits and contributions to overcome the battle. In addition, we present a summary of COVID-19 related data sources to facilitate future studies using AI methods to deal with the pandemic. An overview of common AI methods is presented in **Figure 1** where recent AI development is highlighted.
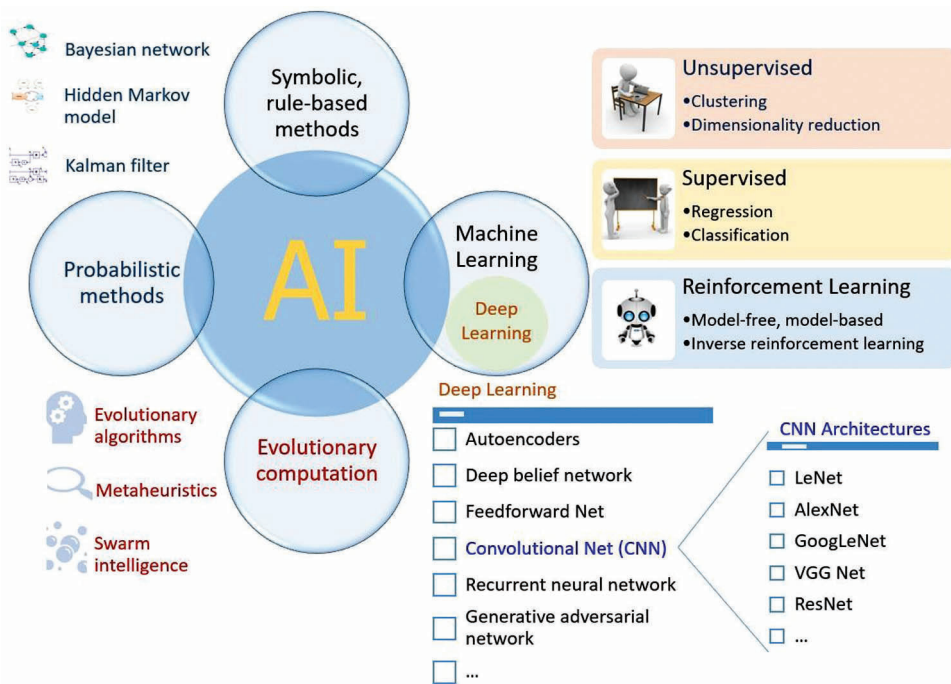


An overview of common AI methods where machine learning constitutes a great proportion.

Machine learning, especially deep learning, has made great advances and substantial progress in long-standing fields such as computer vision, natural language processing (NLP), speech recognition, and video games. A significant advantage of deep learning over traditional machine learning techniques is its ability to deal with and make sense of different types of data, especially big and unstructured data, e.g. text, image, video and audio data. A number of industries, e.g. electronics, automotive, security, retail, agriculture, healthcare and medical research, have achieved better outcomes and benefits by using deep learning and AI methods. It is thus expected that AI technologies can contribute to the fight against the COVID-19 pandemic, such as those surveyed in the next section.

## General Procedure of AI and Non-AI Based Applications

The figure shows the general procedure of AI and non-AI based applications that help general physicians to identify the COVID-19 symptoms. The diagram informs and compares the flow of minimal non-AI treatment versus AI-based treatment and explains the involvement of AI in the significant steps of treatment of high accuracy and reduces complexity and time taken. The physician is not only focused on the treatment of the patient, but also the control of disease with the AI application. Major symptoms and test analysis are done with the help of AI with the highest of accuracy. It also shows it reduces the total number of steps taken in the whole process, making more procurable in nature.
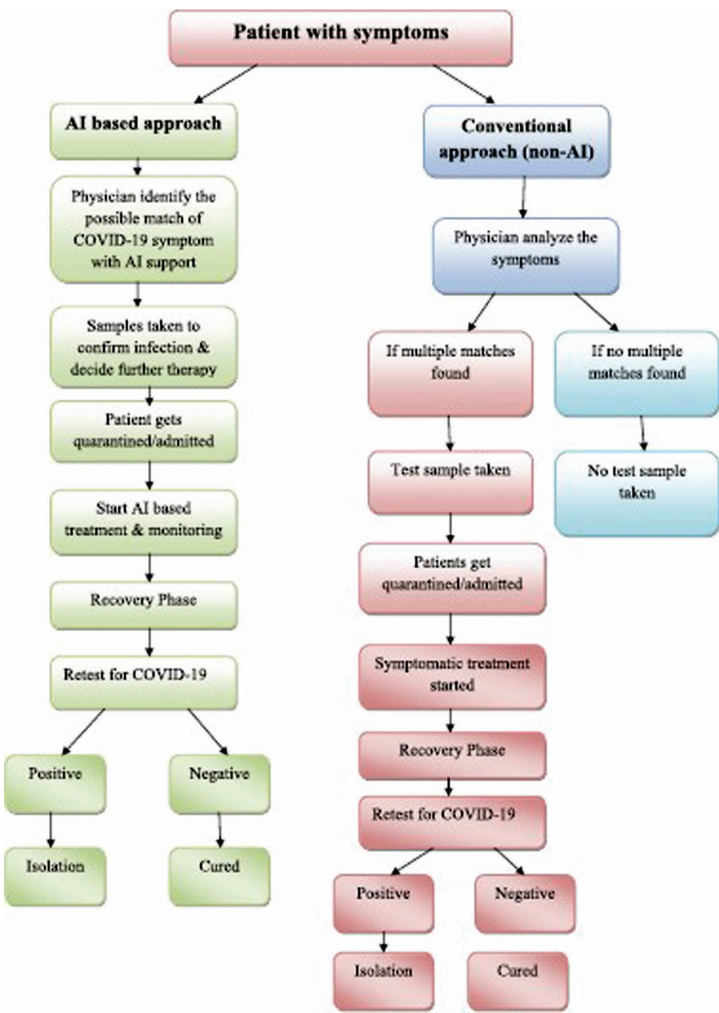


General procedure of AI and non-AI based applications

With the many COVID-19 related datasets that have been collected, AI is helping us fight this virus with applications such as early detection and diagnosis, contact tracing, projection of cases and mortality, development of drugs and vaccines, etc. We invite submission of papers describing timely and innovative research on all aspects of using AI in the fight against COVID.

## Main Applications of AI in COVID-19 Pandemic

I) **Early detection and diagnosis of the infection:** AI can quickly analyse irregular symptom and other „red flags" and thus alarm the patients and the healthcare authorities[4,5]. It helps to provide faster decision making, which is cost-effective. It helps to develop a new diagnosis and management system for the COVID 19 cases, through useful algorithms. AI is helpful in the diagnosis of the infected cases with the help of medical imaging technologies like Computed tomography (CT), Magnetic resonance imaging (MRI) scan of human body parts.

II) **Monitoring the treatment:** AI can build an intelligent platform for automatic monitoring and prediction of the spread of this virus. A neural network can also be developed to extract the visual features of this disease, and this would help in proper monitoring and treatment of the affected individuals[6-8]. It has the capability of providing day-to-day updates of the patients and also to provide solutions to be followed in COVID-19 pandemic.

III) **Contact tracing of the individuals:** AI can help analyze the level of infection by this virus identifying the clusters and „hot spots" and can successfully do the contact tracing of the individuals and also to monitor them. It can predict the future course of this disease and likely reappearance.

IV) **Projection of cases and mortality:** This technology can track and forecast the nature of the virus from the available data, social media and media platforms, about the risks of the infection and its likely spread. Further, it can predict the number of positive cases and death in any region. AI can help identify the most vulnerable regions, people and countries and take measures accordingly.

V) **Development of drugs and vaccines:** AI is used for drug research by analyzing the available data on COVID-19. It is useful for drug delivery design and development. This technology is used in speeding up drug testing in real-time, where standard testing takes plenty of time and hence helps to accelerate this process significantly, which may not be possible by a human[6,7]. It can help to identify useful drugs for the treatment of

COVID-19 patients. It has become a powerful tool for diagnostic test designs and vaccination development[9-11]. AI helps in developing vaccines and treatments at much of faster rate than usual and is also helpful for clinical trials during the development of the vaccine.

## AI-driven Drug Discovery

The COVID-19 is an issue of international concern and threat to public health and there is an urgent need of drug/vaccine design. There is no vaccine or specific drug yet made as of July 23, 2020, for the coronavirus disease (COVID-19). Thus, the patients currently can only be treated symptomatically. A quick identification of the drugs for COVID-19 may act as a potential therapeutic medication which has been used earlier in patients to answer the present pandemic condition before it could get worse. According to our view, an artificial intelligence (AI) based tool that may predict drugs/peptides directly from the sequences of infected patients and thereby, they might have better affinity with the target and contribute towards vaccine design against COVID-19.

Researchers across the world proposed several vaccines/drugs for COVID-19 utilizing AI based approaches; however, testing of these proposed vaccines/drugs will be needed to verify the safety and feasibility for combating COVID-19.

The designing of the drug combination therapy based on AI will prove a crucial approach to identify ideal and effective regimens when a fast intervention is required during pandemics. Presently, AI has been used extensively for drug research against Coronavirus disease (COVID-19) since AI platform can prove to be more useful for the identification of potential existing drugs with inhibitory human coronavirus (HCoV) activities by utilizing various learning datasets

Artificial Intelligence in Computational Drug Designing looks for high quality research related to drug and clinical research on artificial intelligence approaches to exploiting the power of Computational Drug Designing by applying Artificial Intelligence and core chemistry (Chan et al., 2019). Computational Drug Designing is an evolving area of research related with the designing as well as in testing of molecular properties, interactions, and behaviour for assembling better materials, processes, and systems for specific functions.

Computational Artificial Intelligence and molecular chemistry advance in parallel with the rapid progress in drug design methods for COVID-19. This technique is becoming a powerful tool in medicinal chemistry to identify the starting points as hit molecules for COVID-19. The approach reduces time and cost taken for drug research and development. The applications based on utilizing AI-based approach for designing of drugs are involved precisely with

the molecular structure of the drugs. AI based applications crucial retrieve data and information from engines to search novel drug candidates, optimize drug repurposing. Developments in "Artificial Intelligence and Computational Drug Designing" techniques are becoming the benchmark for the COVID-19, opening new avenues for drug discovery.

Race to find cure for COVID-19 already started Now a days, AI is being used by several companies for the identification and screening of existing drugs that could be repurposed for the treatment of COVID-19, aid clinical validation, sift through trial data, and scour through patient electronic medical records (EMRs). Companies like TCS0 Innovation Lab in India, where a team of TCS scientists identified 31 potential hits that might act as inhibitors for COVID-19 (TCS Scientists Hone in On, 2020). Similarly, a startup named Benevolent AI, that has raised $292 million to apply AI-based COVID-19 drug discovery, came up with an already approved drug through AI-based drug discovery approach for COVID-19 as an effective treatment (Potential new treatment, 2020). UK-based company Exscientia already team-up with Diamond Light Source (UK‟s national synchrotron science facility) to utilize its AI drug discovery platform for identifying potential compounds against COVID-19 (AI technology to screen, 2020). The Molecule one, a European AI-centered startup has released its patented syntheses planning platform for free access to the scientific fraternity, in an effort to help researchers rapidly synthesize and test potential candidate molecules against COVID-19. IBM has also utilized its AI generative frameworks to three COVID-19 drug targets and has generated 3000 novel potential hits or molecules (Roy, 2020). The list of companies those are using AI-based drug development against COVID-19 has been mentioned in **Table 1** (How AI is fighting, 2020).

## Reducing the Workload of Healthcare Workers

Due to a sudden and massive increase in the numbers of patients during COVID-19 pandemic, healthcare professionals have a very high workload. Here, AI is used to reduce the workload of healthcare workers[12-17]. It helps in early diagnosis and providing treatment at an early stage using digital approaches and decision science, offers the best training to students and doctors regarding this new disease[18,19]. AI can impact future patient care and address more potential challenges which reduce the workload of the doctors.

## Prevention of the Disease

With the help of real-time data analysis, AI can provide updated information which is helpful in the prevention of this disease. It can be used to predict the probable

sites of infection, the influx of the virus, need for beds and healthcare professionals during this crisis. AI is helpful for the future virus and diseases prevention, with the help of previous mentored data over data prevalent at different time. It identifies traits, causes and reasons for the spread of infection. In future, this will become an important technology to fight against the other epidemics and pandemics. It can provide a preventive measure and fight against many other diseases. AI will play a vital role in providing more predictive and preventive healthcare.

## Tracking the Pandemic

One of the earliest detection of COVID-19 with AI was done with Blue- Dot, a Canadian company. Blue Dot not only detected the spread but also predicted the spread of virus to various cities. The United Nations Educational, Scientific and Cultural Organization (UNESCO), in collaboration with International Research Centre for Artificial intelligence launched "coronavirus watch," which provides live updates related to COVID-19. 3 Similarly, China has used AI to predict and forecast the spread of COVID-19. 4. Pandemic control and detection of cases AI has been used in various countries for checking temperature using AI enabled infrared cameras; tracking cases and their contacts with facial recognition and smartphones; and tracking the GPS location and itinerary of infected person through mobile phones. AI-enabled chat bots are providing information of COVID-19 to millions of people.

## Assisting Healthcare System

The X-rays and computed tomography scans of the COVID-19 patients are being used to train various computational models and neural networks to aid in the diagnosis of COVID-19. In this way, AI can be used to detect severely ill patients as well as predict the prognosis. In addition, AI can help distinguish COVID-19 infection from the community-acquired pulmonary infection. AI-based development of testing kits is helping in rapid production and large scale testing of COVID-19. AI-based robots are helping health care professionals to maintain social distancing by doing temperature screening of the patients and distributing medicines. These robots have been used to disinfect public places and hospital premises.

## Vaccine and Drug Development

The prediction of RNA structure of SARS-CoV-2 through AI was a major achievement. On similar ground, researchers are exploring the utility of AI for

developing vaccine for COVID-19 infection. With AI, the various regions on the viral structure with antibody targets and cell presentation can be identified and used for the development of vaccine. Though in its initial stages, the developments seems interesting.

## Streamlining the Research

Everyday hundreds of papers on COVID-19 appear on Internet carrying variable and valuable information. The COVID-19 Open Research Dataset has come up with a unique idea of utilizing AI and machine learning for harnessing these diverse papers to discover relevant information quickly. The information retrieved is useful for effective treatment and management of COVID-19.

Most of the organizing bodies and institutions are shifting towards virtual meetings; e- conferences and digital learning. AI-powered platforms make these meetings more intelligent and interactive. Facial recognition allows organizers to manage large number of attendees. AI-based chatbots acts as virtual assistants and provides useful information as well as answer to questions of the users. AI-enabled meeting calendar sends automated reminders to the users for a scheduled meeting. AI can personalize learning by mapping each user's individual learning plans, preferences, their weaknesses, and strength.

Constraints in the current application of AI to COVID-19 Most of the AI systems are in their early stages. One of the major factors determining the efficacy of AI is data, which are still low as far as COVID-19 is concerned. Privacy, medico legal, and ethical concerns stemming from AI need to be addressed at the earliest. The key challenges in developing nations includes availability, accessibility, and quality of data; capacity to engage with AI; data ownership and security; governance, accountability, and transparency of AI.

## Conclusion

AI is an upcoming and useful tool to identify early infections due to coronavirus and also helps in monitoring the condition of the infected patients. It can significantly improve treatment consistency and decision making by developing useful algorithms. AI is not only helpful in the treatment of COVID-19 infected patients but also for their proper health monitoring. It can track the crisis of COVID-19 at different scales such as medical, molecular and epidemiological applications. It is also helpful to facilitate the research on this virus using analyzing the available data. AI can help in developing proper treatment regimens, prevention strategies, drug and vaccine development. For COVID- 19, AI has not been proved so impactful

yet. Its potential usage has been hindered due to paucity of available data. To overcome these limitations, a careful balance is required between data privacy and public health, and thorough human-AI interaction. In summary, we can conclude that AI might prove impactful in treatment and cures against COVID-19. These AI-based tools can be used for scanning of peptides/drugs against COVID-19 from their own targets. Nevertheless, when it comes to medicine, AI as of now has a demonstrated reputation for being a rapid and cost-effective method but clinical trials are required for the validation purpose.

Formation of laws, code of ethics, code of conduct, and regulatory bodies to prevent the misuse of AI can help sort out some of these issues. In conclusion, during COVID-19, AI has applications in epidemiology, surveillance, case detection, disease diagnosis, identifying the structure of virus, development of vaccine, and as a research assessment tool. The use of AI for our benefit during COVID-19 implies that it is a tool, which can be utilized for common good. Overcoming the constraints is a laborious job and will require a balance between privacy and health concerns. AI can create innovation in multiple diverse sectors, which may ultimately aid clinicians, patients, and worried citizens alike. Emerging approaches combining integrative medicine with AI could create unique solutions and aid in fight against this deadly pandemic.

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