UNIT I FOUNDATION FOR BEGINNERS

INTRODUCTION

The field of robotics has its origins in science fiction. The term robot was derived from the English translation of a fantasy play written in Czechoslovakia around 1920. It took another 40 years before the modern technology of industrial robotics began. Today Robots are highly automated mechanical manipulators controlled by computers. We survey some of the science fiction stories about robots, and we trace the historical development of robotics technology. Let us begin our chapter by defining the term robotics and establishing its place in relation to other types of industrial automation.

Robotics: -

Robotics is an applied engineering science that has been referred to as a combination of machine tool technology and computer science. It includes machine design, production theory, micro electronics, computer programming & artificial intelligence.

"Robotics" is defined as the science of designing and building Robots which are suitable for real life application in automated manufacturing and other non-manufacturing environments

1.1 History of Robotics

- Robotics was first introduced into our vocabulary by Czech playwright Karel Capek in his 1920's play Rossum's Universal Robots.
- 1954 – George Devol replaced the slave manipulator in a tele operator with the programmability of the CNC controller, thus creating the first "industrial robot", called the "Programmable Article Transfer Device".
- 1956 - Joseph Engleberger, a Columbia physics student buys the rights to Devol's robot and founds the Unimation Company.
- 1956 -George Devol applied for a patent for the first programmable robot, later named 'Unimate'.
- 1966 – 1968 'Shakey', a mobile robot is developed by SRI (Stanford Research Institute). 'Shakey' was capable of planning, route-finding and moving objects.
- 1977 – 1992 Development of mobile robot Hilaire at Laboratoise d'Automatique et d'Analyse des Systemes (LAAS) in Toulouse, France. This mobile robot had three wheels and it is still in use
- 1978- Puma (Programmable Universal Machine for Assembly), by Unimation.

- 1979 - SCARA (Selective Compliant Articulated Robot for Assembly) introduced in Japan and the US (by Adept Technologies).
- 1980's – Legged and hopping robots (BIPER – Shimoyama) and Raibert 1986.
- 1984 -1991 –Hogg, Martin and Resnick at MIT create mobile robots using LEGO blocks (precursor to LEGO Mindstorms). Rodney Brooks at MIT creates first insect robots at MIT AI Lab – birth of behavioral robotics.
- 1986 - Honda starts work on its first humanoid, robot named 'E0' (later to become ASIMO).
- 1988 - SCAMP designed as the first robot pet with emotions.
- 1991 - First HelpMate mobile autonomous robot used in hospitals
- 1999 - Sony introduces AIBO, an autonomous robotic dog capable of seeing, walking and interacting with its environment.
- 2002 - iRobot introduces Roomba, a personal robotic vacuum cleaner.
- 2003 - Osaka University unveils their first 'Actroid', the term given for a humanoid robot with strong visual human characteristics.
- 2010 - NASA and General Motors join forces to develop Robonaut-2, the new version of NASA's humanoid robot astronaut.

1.2 Common Types of Industrial Robots

- **Articulated** - This robot design features rotary joints and can range from simple two joint structures to 10 or more joints. The arm is connected to the base with a twisting joint. The links in the arm are connected by rotary joints. Each joint is called an axis and provides an additional degree of freedom, or range of motion. Industrial robots commonly have four or six axes.
- **Cartesian** - These are also called rectilinear or gantry robots. Cartesian robots have three linear joints that use the Cartesian coordinate system (X, Y, and Z). They also may have an attached wrist to allow for rotational movement. The three prismatic joints deliver a linear motion along the axis.
- **Cylindrical** - The robot has at least one rotary joint at the base and at least one prismatic joint to connect the links. The rotary joint uses a rotational motion along the joint axis,

while the prismatic joint moves in a linear motion. Cylindrical robots operate within a cylindrical-shaped work envelope.

- **Polar** - Also called spherical robots, in this configuration the arm is connected to the base with a twisting joint and a combination of two rotary joints and one linear joint. The axes form a polar coordinate system and create a spherical-shaped work envelope.
- **SCARA** - Commonly used in assembly applications, this selectively compliant arm for robotic assembly is primarily cylindrical in design. It features two parallel joints that provide compliance in one selected plane.
- **Delta** - These spider-like robots are built from jointed parallelograms connected to a common base. The parallelograms move a single EOAT in a dome-shaped work area. Heavily used in the food, pharmaceutical, and electronic industries, this robot configuration is capable of delicate, precise movement.

1.3 Robot Components (Anatomy)

A Robot is a system, consists of the following elements, which are integrated to form a whole:

Manipulator / Rover: This is the main body of the Robot and consists of links, joints and structural elements of the Robot.

End Effector : This is the part that generally handles objects, makes connection to other machines, or performs the required tasks. It can vary in size and complexity from a end effector on the space shuttle to a small gripper.

Actuators: Actuators are the muscles of the manipulators. Common types of actuators are servomotors, stepper motors, pneumatic cylinders etc.

Sensors: Sensors are used to collect information about the internal state of the robot or to communicate with the outside environment. Robots are often equipped with external sensory devices such as a vision system, touch and tactile sensors etc which help to communicate with the environment

Controller: The controller receives data from the computer, controls the motions of the actuator and coordinates these motions with the sensory feedback information.

Processor: Brain of Robot- Calculates the motions of Robot's joints, oversees the coordinated actions of the controller and the sensors.

Software:

- **3 groups of software** used in Robot.
- **Operating Systems-** operates the computer
- **Robotic Software-**
- Calculates the necessary motions of each joint and informs the controller
- May be at different levels, from machine Language to Sophisticated languages used by modern robots.
- **Collection of routines and application programs**

Joints and Links:

- Manipulator of an Industrial Robot consists of series of Joints and Links
- Robot anatomy deals with study of different Joints and Links and other aspects of physical construction.
- A robotic Joint provides relative motion between two links of the Robot.
- Each joint provides a certain degrees of freedom of motion.
- Mostly, 1 *dof* is associated with each joint.

1.4 Classification of Robots

The **Japanese Industrial Robot Association (JIRA)** classifies robots into six classes:

Class 1: Manual - Handling Devices actuated by an operator

Class 2: Fixed Sequence Robot

Class 3: Variable-Sequence Robot with easily modified sequence of control

Class 4: Playback Robot, which can record a motion for later playback

Class 5: Numerical Control Robots with a movement program to teach it tasks manually

Class 6: Intelligent robot: that can understand its environment and able to complete the task despite changes in the operation conditions

Robotics Institute of America (**RIA**)- considers only classes 3 -6 as Robots.

Classification according to Association Francaise de Robotique (**AFR**)

Type A: Handling Devices with manual control to telerobotics

Type B: Automatic Handling Devices with predetermined cycles

Type C: Programmable, servo controlled robots with continuous or point-to-point trajectories.

Type D: Same as type C, but with capability to acquire information from its environment.

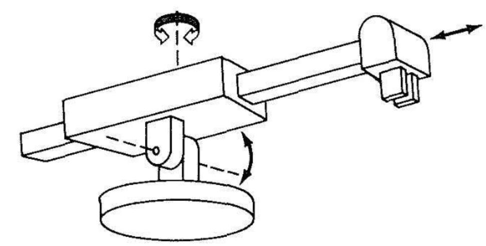
1.5 Classification of Robots (or) Classification by co-ordinate system

Co-ordinate systems:-

Industrial robots are available in a wide variety of sizes, shapes, and physical configurations. The vast majority of today's commercially available robots possess one of the basic configurations:

1. Polar configuration
2. Cylindrical configuration
3. Cartesian coordinate configurable
4. Jointed-arm configuration

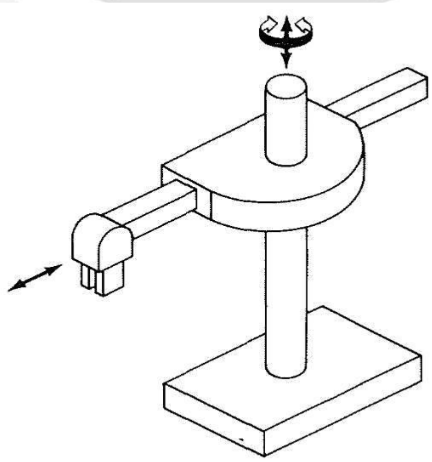
1. **Polar configuration**:-



Spherical

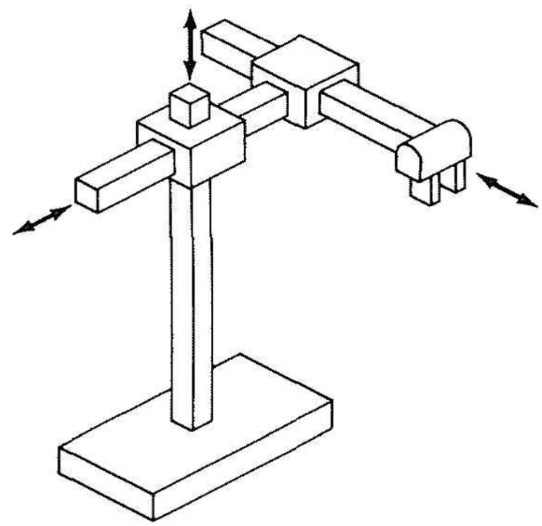
The polar configuration is pictured in the above Fig. It uses a telescoping arm that can be raised or lowered about a horizontal pivot The pivot is mounted on a mta6ng base These various joints provide the robot with the capability to move its arm within a spherical space, and hence the name "spherical coordinate" robot is sometimes applied to this type. A number of commercial robots possess the polar configuration.

2. **Cylindrical configuration**:-



Cylindrical

The cylindrical configurable, as shown in fig, uses a vertical column and a slide that can be moved up or down along the column. The robot arm is attached to the slide so that it can be moved radially with respect to the column. By routing the column, the robot is capable of achieving a work space that approximation a cylinder.

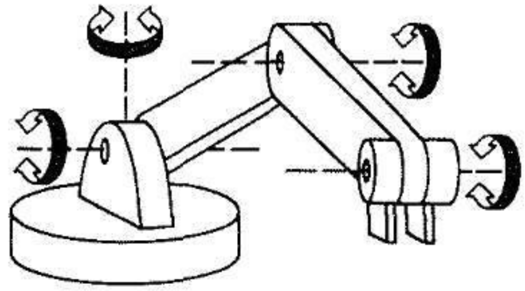


Cartesian or *xyz*

3. **Cartesian coordinate configurable**:-

The cartesian coordinate robot, uses three perpendicular slides to construct the x, y, and z axes. Other names are sometimes applied W this configuration, including xyz robot and rectilinear robot, By moving the three slides relative to one another, the robot is capable of operating within a rectangular work envelope.

4. **Jointed-arm configuration**:-



Revolute

The jointed-arm robot is pictured in Fig. Its configuration is similar to that of the human arm. It consists of two straight components. Corresponding to the human forearm and upper arm, mounted on a vertical pedestal. These components are connected by two rotary joints corresponding to the shoulder and elbow

1.6 Robot Specifications

- **Payload-** weight a robot can carry
- **Reach** -max.distance a robot can reach within its work envelope.
- V-Reach H-Reach
- **Precision (validity)**-how accurately a specified point can be reached.
- **Repeatability (Variability) -** how accurately the same position can be reached, if the motion is repeated many times.

1.7 Need of robots

Industrial robot plays a significant role in automated manufacturing to perform different kinds of applications.

- Robots can be built a performance capability superior to those of human beings. In terms of strength, size, speed, accuracy…etc.
- Robots are better than humans to perform simple and repetitive tasks with better quality and consistence's.
- Robots do not have the limitations and negative attributes of human works .such as fatigue, need for rest, and diversion of attention…..etc.
- Robots are used in industries to save the time compared to human beings.
- Robots are in value poor working conditions
- Improved working conditions and reduced risks.

1.8 Automation and robotics

Automation and robotics are two closely related technologies. In an industrial context, we can dean automation as a technology that is concerned with the use of mechanical, electronic, and computer-based systems in the operation and control of production Examples of this technology include transfer lines. Mechanized assembly machines, feedback control systems (applied to industrial processes), numerically controlled machine tools, and robots. Accordingly, robotics is a form of industrial automation.

Types of Automation:-

Automation is categorized into three types. They are:

1) Fixed Automation

2) Programmable Automation

3) Flexible Automation.

(1) Fixed Automation:-

It is the automation in which the sequence of processing or assembly operations to be carried out is fixed by the equipment configuration. In fixed automation, the sequences of operations (which are simple) are integrated in a piece of equipment. Therefore, it is difficult to automate changes in the design of the product. It is used where high volume of production is required Production rate of fixed automation is high. In this automation, no new products are processed for a given sequence of assembly operations.

Features:-

i) High volume of production rates

ii) Relatively inflexible in product variety (no new products are produced). Ex:- Automobile industries … etc.

(2) Programmable Automation:-

It is the automation in which the equipment is designed to accommodate various product configurations in order to change the sequence of operations or assembly operations by means of control program. Different types of programs can be loaded into the equipment to produce products with new configurations (i.e., new products). It is employed for batch production of low and medium volumes. For each new batch of different configured product, a new control program corresponding to the new product is loaded into the equipment. This automation is relatively economic for small batches of the product.

Features:-

i) High investment in general purpose,

ii) Lower production rates than fixed automation,

iii) Flexibility & Changes in products configuration,

iv) More suitable for batch production.

Ex:- Industrial robot, NC machines tools… etc.

(3) Flexible Automation:-

A computer integrated manufacturing system which is an extension of programmable automation is referred as flexible automation. It is developed to minimize the time loss between the changeover of the batch production from one product to another while reloading. The program to produce new products and changing the physical setup i.e., it 4

produces different products with no loss of time. This automation is more flexible in interconnecting work stations with material handling and storage system

Features:-

i) High investment for a custom engineering system.

ii) Medium Production rates

iii) Flexibility to deal with product design variation,

iv) Continuous production of variable mixtures of products. Ex:- Flexible manufacturing systems (FMS)

1.9 Social and Ethical Issues

The introduction of intelligent machines in our daily life brings up global social and ethical problems, which are summarized as follows:

- Sensitive tasks that should require human supervision could be delegated entirely to robots
- Humans will no longer take responsibility for failures
- Unemployment and de-skilling of the workforce
- AI could erode human freedom
- Using AI in unethical ways

1.10 Applications of robots

- Machine loading
- Pick and Place
- Welding
- Painting
- Assembly operations
- Manufacturing
- Surveillance
- Medical Applications
- Assisting Disabled Individuals
- Hazardous Environment

- Underwater, Space and remote locations