## 3.1 Introduction to Sensors

Sensors are devices that are used to measure physical variables like temperature, pH, velocity, rotational rate, flow rate, pressure and many others. Today, most sensors do notindicate a reading on an analog scale (like a thermometer), but, rather, they produce a voltage ora digital signal that is indicative of the physical variable they measure. Those signals are often imported into computer programs, stored in files, plotted on computers and analyzed to death.

Sensors come in many kinds and shapes to measure all kinds of physical variables. However, many sensors have some sort of voltage output. There are a number of implications to that.

- If a sensor has a voltage output, then it is a voltage source that is controlled by the physical variable it measures.
- If the sensor is a voltage source, you need to remember that no physical voltage sources are ideal, and non-ideal voltage sources are usually best described with a Thevenin Equivalent Circuit that contains the voltage source and an internal resistance.
- If a source has an internal resistance, there is a possibility of loading the source. If a significant load is attached to the source, the terminal voltage will drop. At that point, the terminal voltage is not what you expect it to be (from calibrations, spec sheets, etc.)

### 3.1.1 Need of Sensors:

Seismic monitors provide an early warning system for earthquakes

The latest sensor equipment includes heart rate, electrical voltage, gas, light, sound, temperature, and distance sensors. Data is collected via the sensors and then transmitted to the computer. Up to date software is used to collect, display and store the experimental data. The computer software can then display this data in different formats - such as graphs, tables or meter readings, which make it easy for students to understand the process and bring science to life.

The significance of sensor technology is constantly growing. Sensors allow us to monitor our surroundings in ways we could barely imagine a few years ago. New sensor applications are being identified everyday which broadens the scope of the technology and expands its impact on everyday life.

**In Industry**

On the factory floor, networked vibration sensors warn that a bearing is beginning to fail. Mechanics schedule overnight maintenance, preventing an expensive unplanned shutdown. Inside a refrigerated grocery truck, temperature and humidity sensors monitor individual containers, reducing spoilage in fragile fish or produce.

**In the Environment**

Networks of wireless humidity sensors monitor fire danger in remote forests. Nitrate sensors detect industrial and agricultural runoff in rivers, streams and wells, while distributed seismic monitors provide an early warning system for earthquakes. Meanwhile built-in stress sensors report on the structural integrity of bridges, buildings and roadways, and other man-made structures.

**For Safety and Security**

Fire fighters scatter wireless sensors throughout a burning building to map hot spots and flare-ups. Simultaneously, the sensors provide an emergency communications network. Miniature chemical and biological sensors in hospitals, post offices, and transportation centres raise an alarm at the first sign of anthrax, smallpox or other terror agents.

## 3.2 Position Sensors

In this tutorial we will look at a variety of devices which are classed as Input Devices and are therefore called "Sensors" and in particular those sensors which are Positional in nature. As their name implies, Position Sensors detect the position of something which means that they are referenced either to or from some fixed point or position. These types of sensors provide a "positional" feedback.

One method of determining a position, is to use either "distance", which could be the distance between two points such as the distance travelled or moved away from some fixed point, or by "rotation" (angular movement). For example, the rotation of a robots wheel to determine its distance travelled along the ground. Either way, Position Sensors can detect the movement of an object in a straight line using Linear Sensors or by its angular movementusing Rotational Sensors.

**Sensors used in Robotics**


A robot with visual and force sensors

The use of *sensors* in robots has taken them into the next level of creativity. Most importantly, the sensors have increased the performance of robots to a large extent. It also allows the robots to perform several functions like a human being. The robots are even made *intelligent* with the help of Visual Sensors (generally called as machine vision or computer vision), which helps them to respond according to the situation. The Machine Vision system is classified into six sub-divisions such as Pre-processing, Sensing, Recognition, Description, Interpretation, and Segmentation.

Different types of sensors:

There are plenty of sensors used in the robots, and some of the important types are listed below:

- Proximity Sensor,
- Range Sensor, and
- Tactile Sensor.

### 3.3 Proximity Sensor:

This type of sensor is capable of pointing out the availability of a component. Generally, the*proximity sensor* will be placed in the robot moving part such as end effector. This sensor will be turned ON at a specified distance, which will be measured by means of feet or millimeters. It is also used to find the presence of a human being in the work volume so that the accidents can be reduced.

### Range Sensor:

Range Sensor is implemented in the end effector of a robot to calculate the distance between the sensor and a work part. The values for the distance can be given by the workers on visual data. It can evaluate the size of images and analysis of common objects. The range is measured using the Sonar receivers & transmitters or two TV cameras.

### Tactile Sensors:

A sensing device that specifies the contact between an object, and sensor is considered as the*Tactile Sensor*. This sensor can be sorted into two key types namely:

- Touch Sensor, and
- Force Sensor.

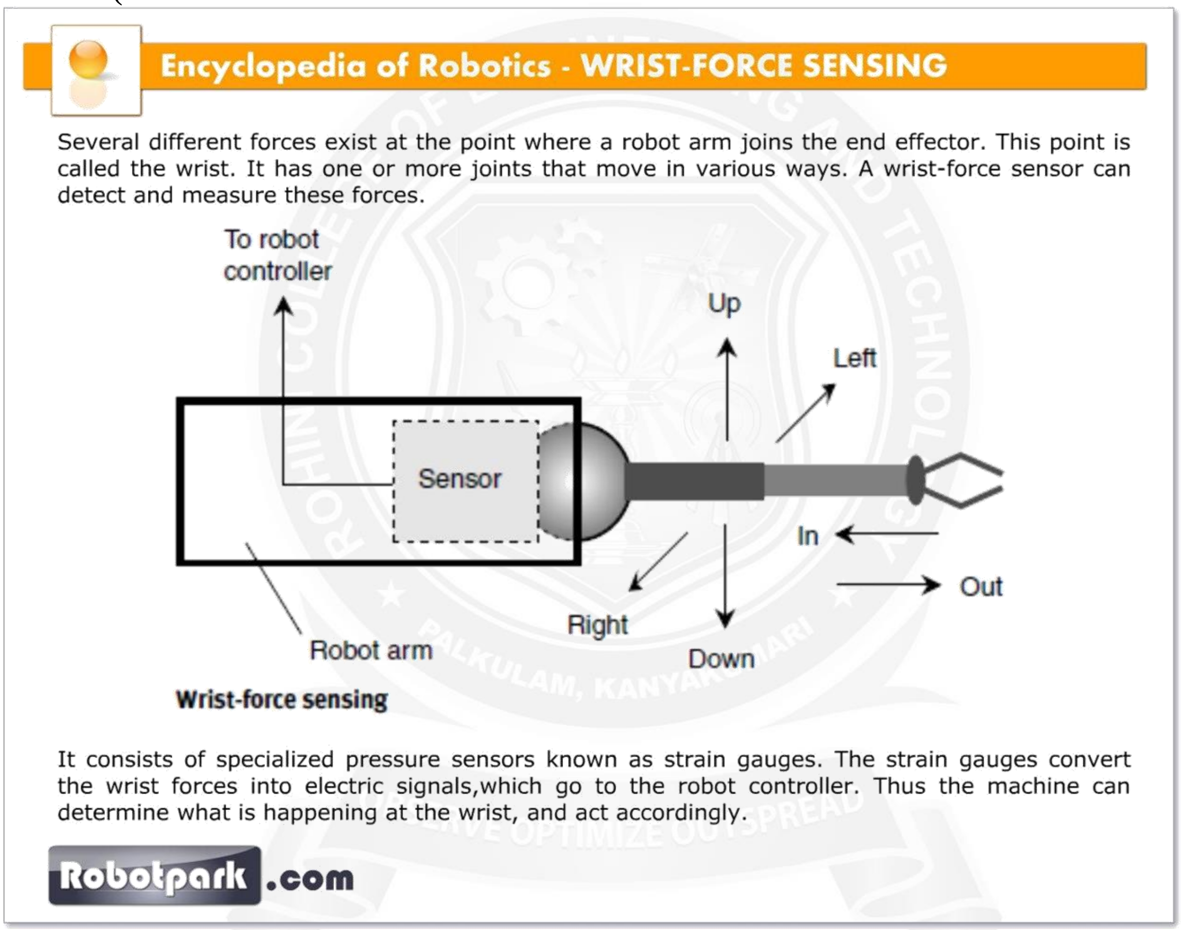

The *touch sensor* has got the ability to sense and detect the touching of a sensor and object. Some of the commonly used simple devices as touch sensors are micro – switches, limit switches, etc. If the end effector gets some contact with any solid part, then this sensor will be handy one to stop the movement of the robot. In addition, it can be used as an inspection device, which has a probe to measure the size of a component.


The *force sensor* is included for calculating the forces of several functions like the machine loading & unloading, material handling, and so on that are performed by a robot. This sensor will also be a better one in the assembly process for checking the problems. There are several techniques used in this sensor like Joint Sensing, Robot – Wrist Force Sensing, and Tactile Array Sensing.

### 3.5 Wrist-Force Sensing

Several different forces exist at the **point where a robot arm joins the end effector**. This point is called the **wrist**. It has one or more joints that move in various ways. **A wrist-force sensor** can detect and measure these forces. **It consists of specialized pressure sensors known as strain gauges**. The strain gauges convert the wrist forces into electric signals,which go to the robot controller. Thus the machine can determine what is happening at the wrist, and actaccordingly.

Wrist force is complex. Several dimensions are required to represent all the possible motions that can take place. The illustration shows a hypothetical robot wrist, and the forces that can occur there. The orientations are right/left, in/out, and up/down. Rotation is possible along all three axes. These forces are called pitch, roll, and yaw. A wrist-force sensor must detect, and translate, each of the forces independently. A change in one vector must cause a change in sensor output for that force, and no others.The compliant geometry of the robot allows the body to deform. The side of the body isto be covered with textile. An impact at any point on its textile cover will deform the textile slightly but also tilt the top of the body away from the impact. A compliant body has many safety advantages in populated environments, such as a party or conference reception. Many robots use a mobile outer shell to detect collisions, e.g. in the Rug Warrior (Jones and




Flynn, 1993). In ButlerBot however, the body itself s the detector. While compliance has been investigated for couplings and joints (see e.g. Trease et al., 2005; Meyer et al., 2004), we are not aware of other work using the whole body as a compliant system. Inside the robot is a light-weight support structure. The tray of ButlerBot is supported by 4 poles which have foam dampers at the end. Additionally 4 strings stretch from the centre of the tray down to the edge of the base like the stays of a boat mast, see figures 1b and 2. Each string incorporates a spring to allow flexibility. The 4 poles are mounted off-centre, which allows the tray effectively to shake in the horizontal X-Y plane. The springs have a sensor attached (potentiometer Pot in figure 2) in order to measure their extension. This allows estimating the position of the tray at the top and the amplitude and direction of the shaking. There is a sensor in the spring aligned with the X-axis and another sensor in the spring aligned with the Y-axis.