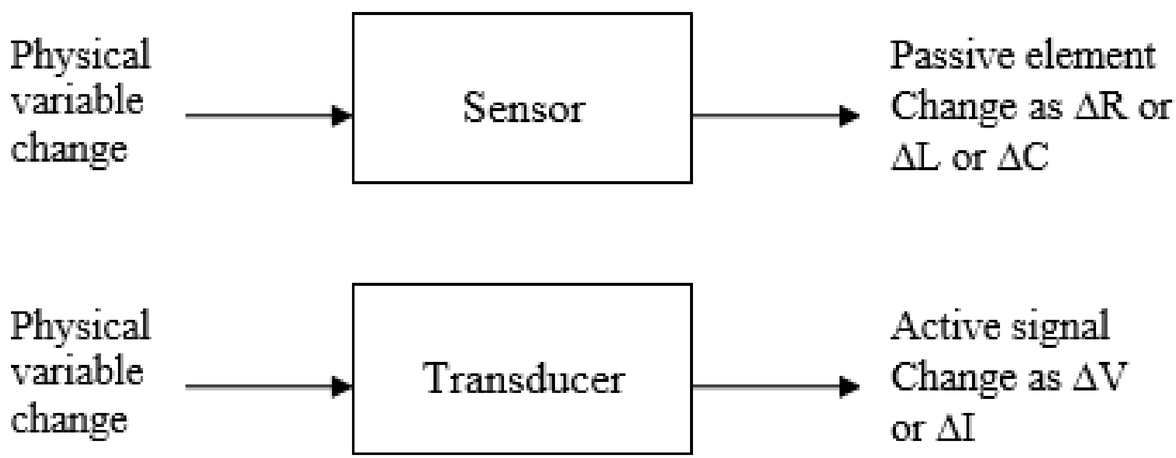
SENSOR v/s TRANSDUCER

The sensor or the sensing element is the first element in a measuring system and takes information about the variable being measured and transforms it into a more suitable form to be measured. The following figure illustrates the difference between sensor and transducer.



In a resistance thermometer, the resistance depends on the temperature value (sensor - primary measuring element). It can be inserted into a bridge circuit (signal conditioning circuit - secondary measuring element) in order to transform the change in the resistance value to a change in the voltage output. Finally, the output voltage from the bridge circuit express about the temperature change value. In general, we can say that:

Transducer = primary measuring element + secondary measuring element
i.e. Transducer = Sensor + Signal conditioning circuit

NEED OF SENSOR IN ROBOTICS

The sensors are one of the useful technologies, which play a vital role in the robotics field. There are four important categories where uses of sensors are highly required in robotics such as:

- ✓ Safety monitoring
- ✓ Interlocking in work cell control
- ✓ Quality control in work part inspection
- ✓ Data collection of objects in the robot work cell

Safety monitoring:

The sensors are extremely used in industrial robotics for monitoring the hazardous and safety conditions in the robot cell layout. This certainly helps in avoiding the physical injuries and other damages caused to the human workers.

Interlocking in work cell control:

In robot work cell, the series of activities of different equipments are controlled by using interlocks. Here, sensors are employed for verifying the conclusion of the current work cycle before progressing to the next cycle.

Quality control in work part inspection:

In olden days, the quality control was performed with a manual inspection system. Nowadays, sensors are employed in the inspection process for determining the quality features of a work part automatically. A major advantage of using sensors in this category provides high accurate results.

Data collection of objects in the robot work cell:

Sensors are used in this category to determine the position or other related data about the fixtures, work parts, equipment, human workers, and so on. Apart from sensing the position, it is also implemented to find out the other information like work part's color, orientation, size, shape, etc. The key reasons for determining the above information while executing a robot program includes:

Recognition of work parts
Random position and orientation of work parts
Improved accuracy of robot position using the feedback data

Detectable Phenomenon

Stimulus	Quantity
Acoustic	Wave (amplitude, phase, polarization), Spectrum, Wave Velocity
Biological & Chemical	Fluid Concentrations (Gas or Liquid)
Electric	Charge, Voltage, Current, Electric Field (amplitude, phase, polarization), Conductivity, Permittivity
Magnetic	Magnetic Field (amplitude, phase, polarization), Flux, Permeability
Optical	Refractive Index, Reflectivity, Absorption
Thermal	Temperature, Flux, Specific Heat, Thermal Conductivity
Mechanical	Position, Velocity, Acceleration, Force, Strain, Stress, Pressure, Torque

Choosing a Sensor

Environmental Factors	Economic Factors	Sensor Characteristics
Temperature range	Cost	Sensitivity
Humidity effects	Availability	Range
Corrosion	Lifetime	Stability
Size		Repeatability
Overrange protection		Linearity
Susceptibility to EM interferences		Error
Ruggedness		Response time
Power consumption		Frequency response
Self-test capability		

POSITION SENSOR

Position sensors are employed to determine the position of an object in relation to some reference point. **Position Sensors** can detect the movement of an object in a straight line using **Linear Sensors** or by its angular movement using **Rotational Sensors**.

- ✓ Contact type
  - Potentiometer
  - LVDT
- ✓ Non contact type
  - Proximity sensors
  - Encoders

POTENTIOMETER

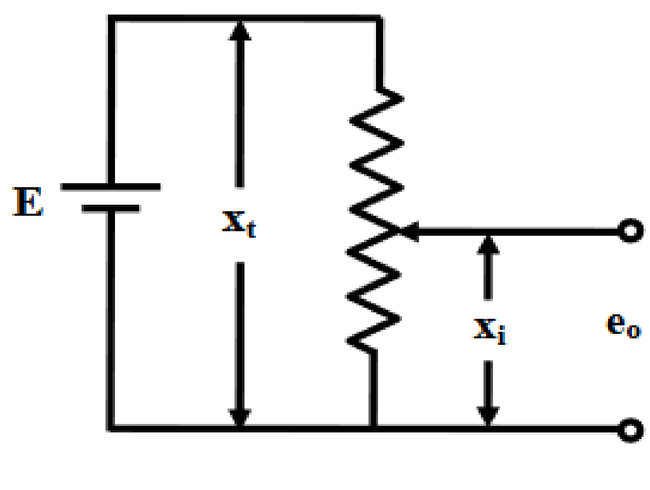
Potentiometers are simplest type of position sensors. They can be used for linear as well as angular position measurement. They are the resistive type of transducers and the output voltage is proportional to the displacement and is given by:

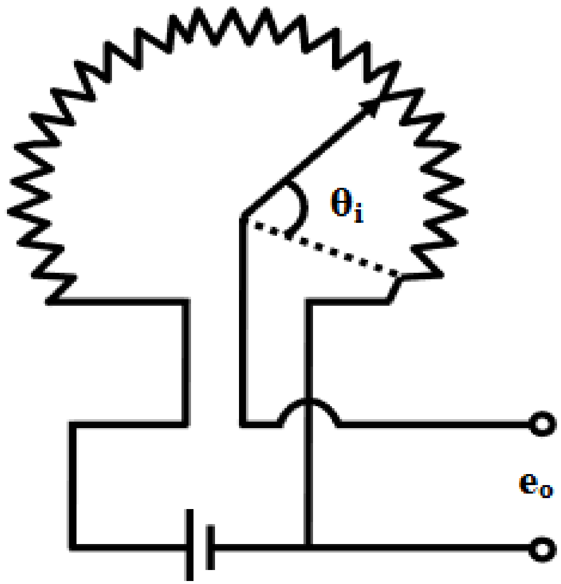
$$e_o = \frac{x_i}{x_t} E \ ,$$

X_i is the input displacement,
X_t is the total displacement
and E is the supply voltage.

These sensors are primarily used in the control systems with a feedback loop to ensure that the moving member or component reaches its commanded position.

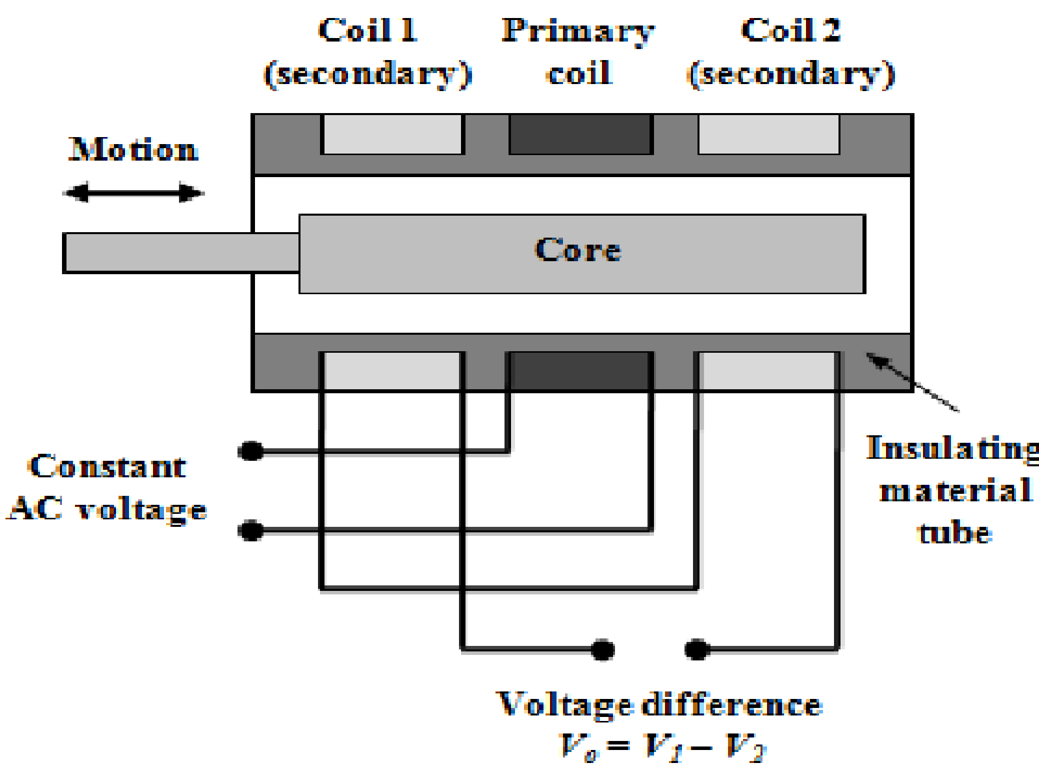
During the sensing operation, a voltage E is applied across the resistive element. A voltage divider circuit is formed when slider comes into contact with the wire. The output voltage (e_o) is measured. The output voltage is proportional to the displacement of the slider over the wire. Then the output parameter displacement is calibrated against the output voltage e_o

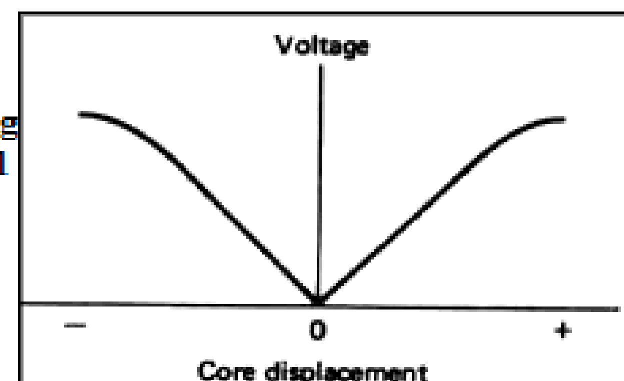




Linear Variable Differential Transformer (LVDT)

The term **LVDT** stands for the **linear variable differential transformer**. It is the most widely used inductive transducer that covert the linear motion into the electrical signals. The output across secondary of this transformer is the differential so it is called so.





Construction

•The transformer consists of a primary winding P and two secondary winding S_1 and S_2 wound on a cylindrical former (which is hollow in nature and will contain core).

•Both the secondary windings have equal number of turns and are identically placed on the either side of primary winding

•The primary winding is connected to an AC source which produces a flux in the air gap and voltages are induced in secondary windings.

•A movable soft iron core is placed inside the former and displacement to be measured is connected to the iron core.

•The iron core is generally of high permeability which helps in reducing harmonics and high sensitivity of LVDT.

•The LVDT is placed inside a stainless steel housing because it will provide electrostatic and electromagnetic shielding.

•The both the secondary windings are connected in such a way that resulted output is the difference of the voltages of two windings.

Working

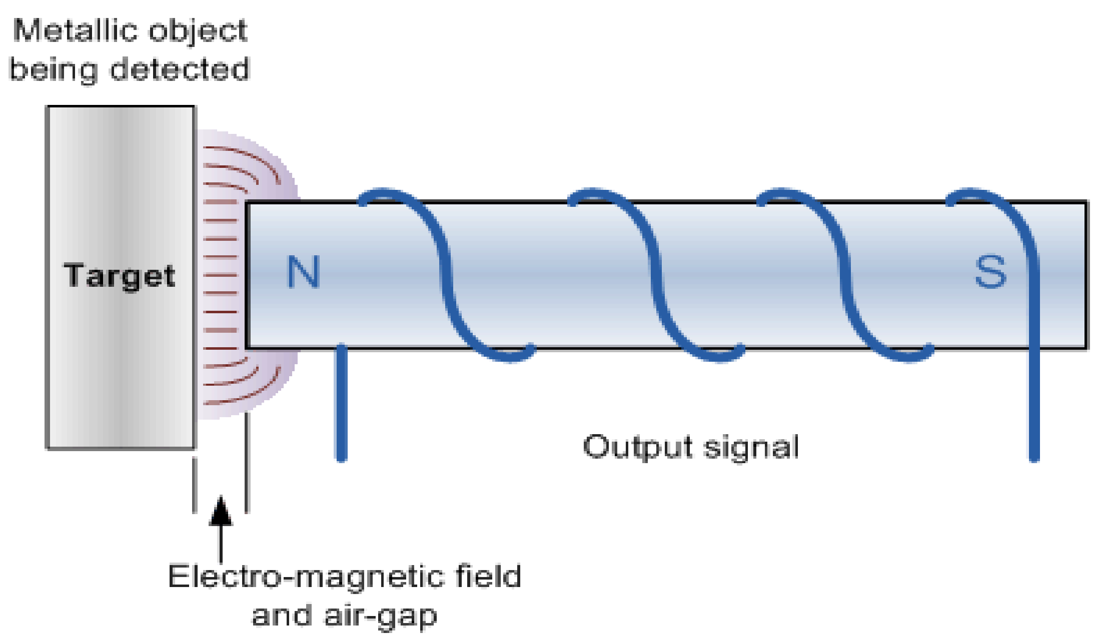
CASE I When the core is at null position (for no displacement) When the core is at null position then the flux linking with both the secondary windings is equal so the induced emf is equal in both the windings. So for no displacement the value of output V_{out} is zero as V_1 and V_2 both are equal. So it shows that no displacement took place.

CASE II When the core is moved to upward of null position (For displacement to the upward of reference point) In the this case the flux linking with secondary winding S_1 is more as compared to flux linking with S_2. Due to this V_1 will be more as that of V_2. Due to this output voltage V_{out} is positive.

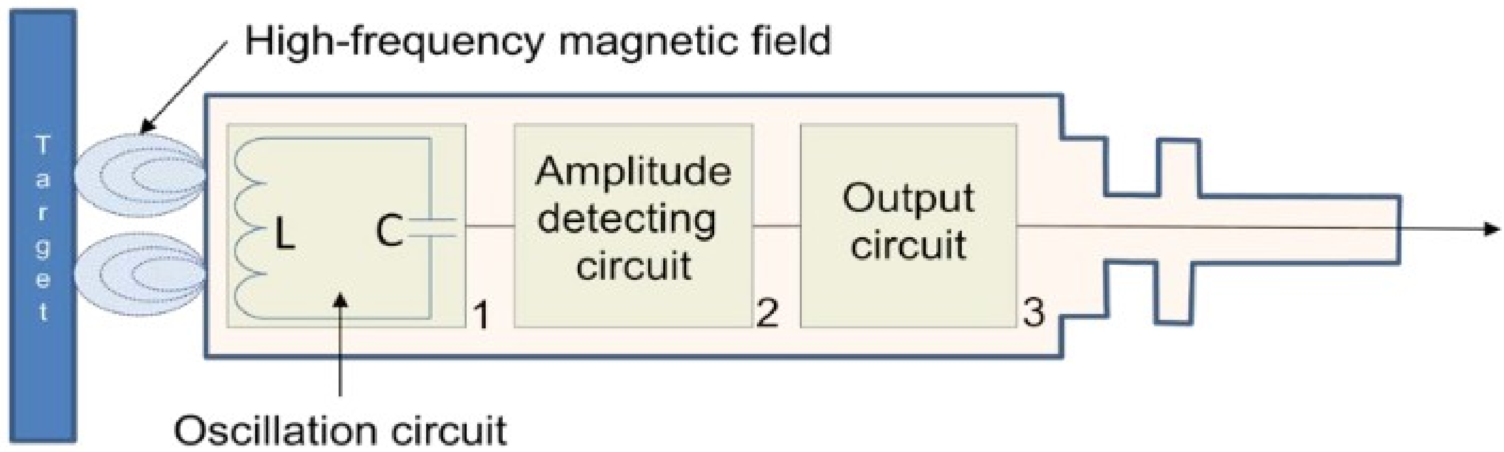
CASE III When the core is moved to downward of Null position (for displacement to the downward of reference point). In this case magnitude of V_2 will be more as that of V_1. Due to this output V_{out}

Proximity sensor

Proximity sensors do not actually measure displacement or angular rotation they are mainly used to detect the presence of an object in front of them or within a close proximity, hence their name "proximity sensor".



Inductive proximity sensor



Inductive proximity switches are basically used for detection of metallic objects. They comprise of a coil, an oscillator, a detector and a triggering circuit. An alternating current is supplied to the coil which generates a magnetic field. When, a metal object comes closer to the end of the coil, inductance of the coil changes. This is continuously monitored by a circuit which triggers a switch when a preset value of inductance change is occurred.

Inductive proximity sensors allow for the detection of metallic objects in front of the sensor head without any physical contact of the object itself being detected. This makes them ideal for use in dirty or wet environments. The "sensing" range of proximity sensors is very small, typically 0.1mm to 12mm.

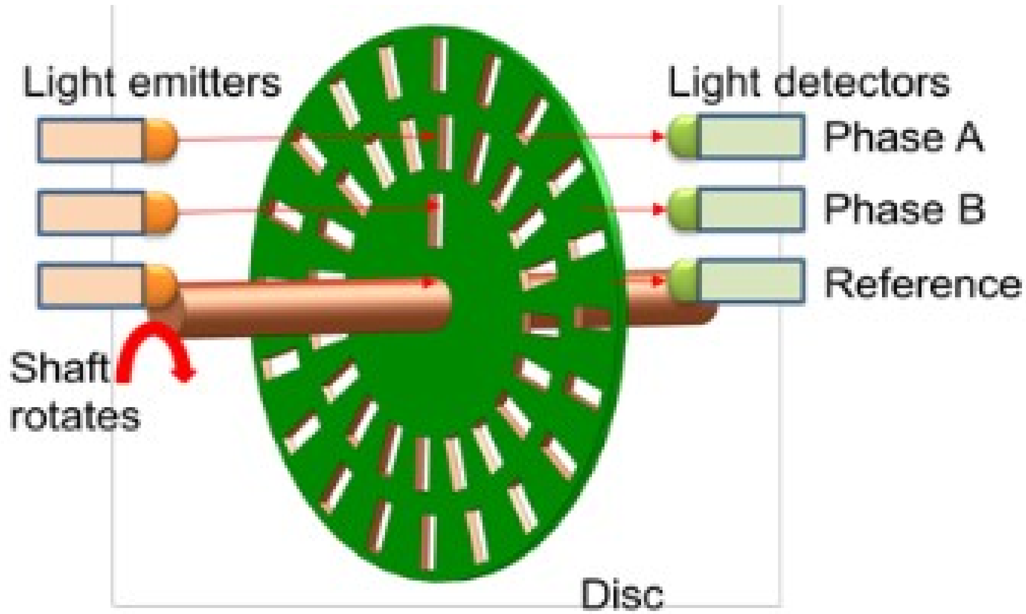
Application

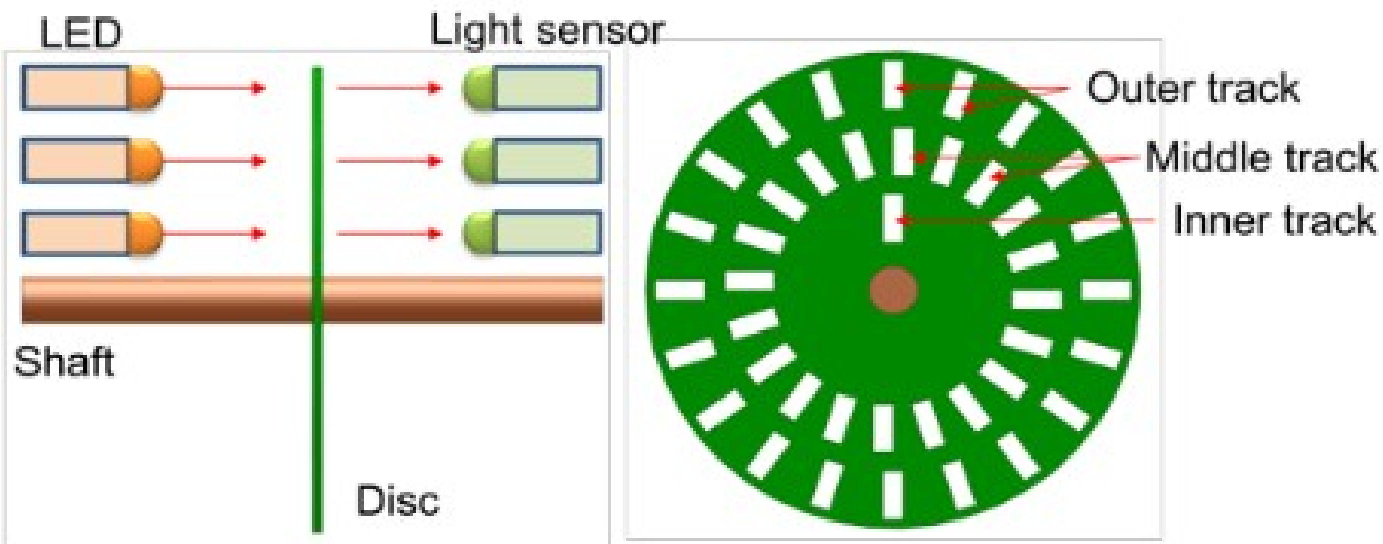
- Industrial automation: counting of products during production or transfer
- Security: detection of metal objects, arms, land mines

Encoders

Encoders are another type of position/displacement non contact sensor where optical devices are used for converting the angular position of a rotating shaft into a digital data code. In other words, they convert mechanical movement into an electrical signal (preferably digital).

All optical encoders work on the same basic principle. Light from an LED or infra-red light source is passed through a rotating high-resolution encoded disk that contains the required code patterns, either binary, grey code or BCD. Photo detectors scan the disk as it rotates and an electronic circuit processes the information into a digital form as a stream of binary output pulses that are fed to counters or controllers which determine the actual angular position of the shaft.

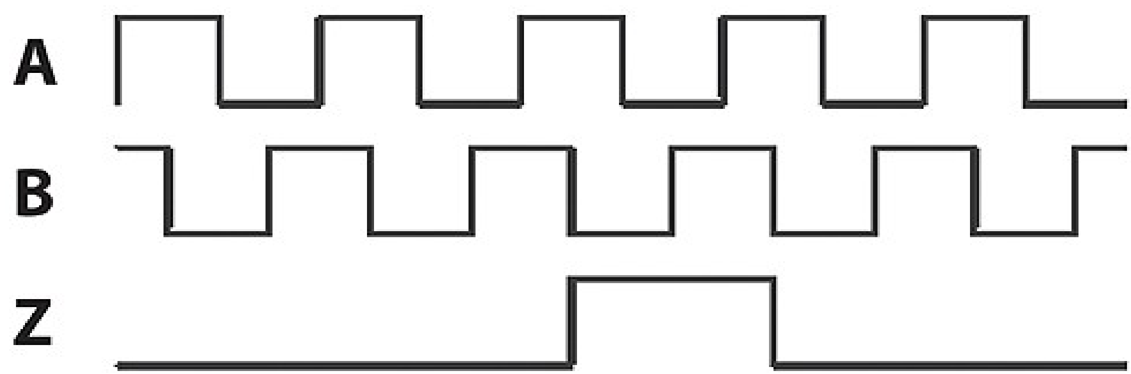

Light emitters
Light detectors
Phase A
Phase B
Reference
Shaft rotates
Disc


LED
Light sensor
Shaft
Disc
Outer track
Middle track
Inner track

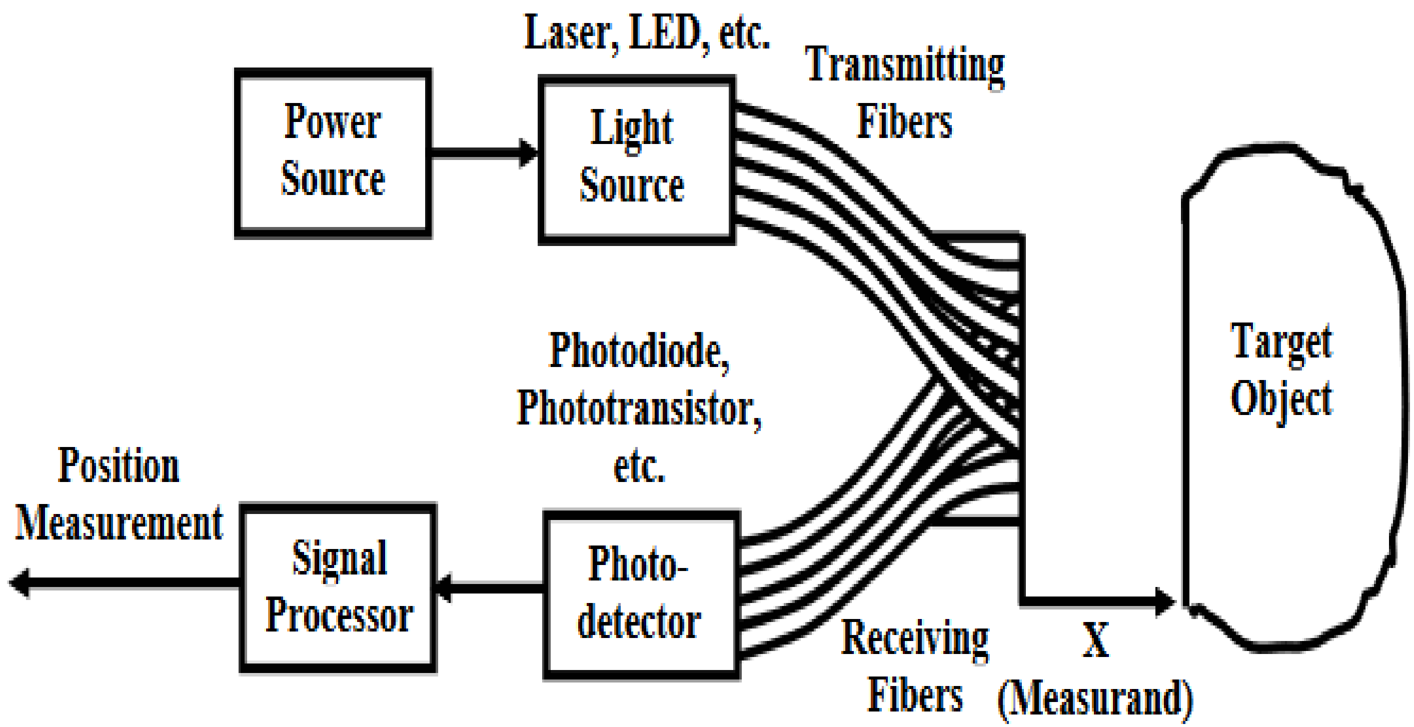
Optical Encoders

Optical encoders provide digital output as a result of linear/angular displacement. These are widely used in the Servo motors to measure the rotation of shafts. Figure shows the construction of an optical encoder. It comprises of a disc with three concentric tracks of equally spaced holes. Three light sensors are employed to detect the light passing through the holes. These sensors produce electric pulses which give the angular displacement of the mechanical element e.g. shaft on which the Optical encoder is mounted. The inner track has just one hole which is used locate the 'home' position of the disc. The holes on the middle track offset from the holes of the outer track by one-half of the width of the hole. This arrangement provides the direction of rotation to be determined.

When the disc rotates in clockwise direction, the pulses in the outer track lead those in the inner; in counter clockwise direction they lag behind. The resolution can be determined by the number of holes on disc. With 100 holes in one revolution, the resolution
would be, $360^{o}/100 = 3.6^{o}$

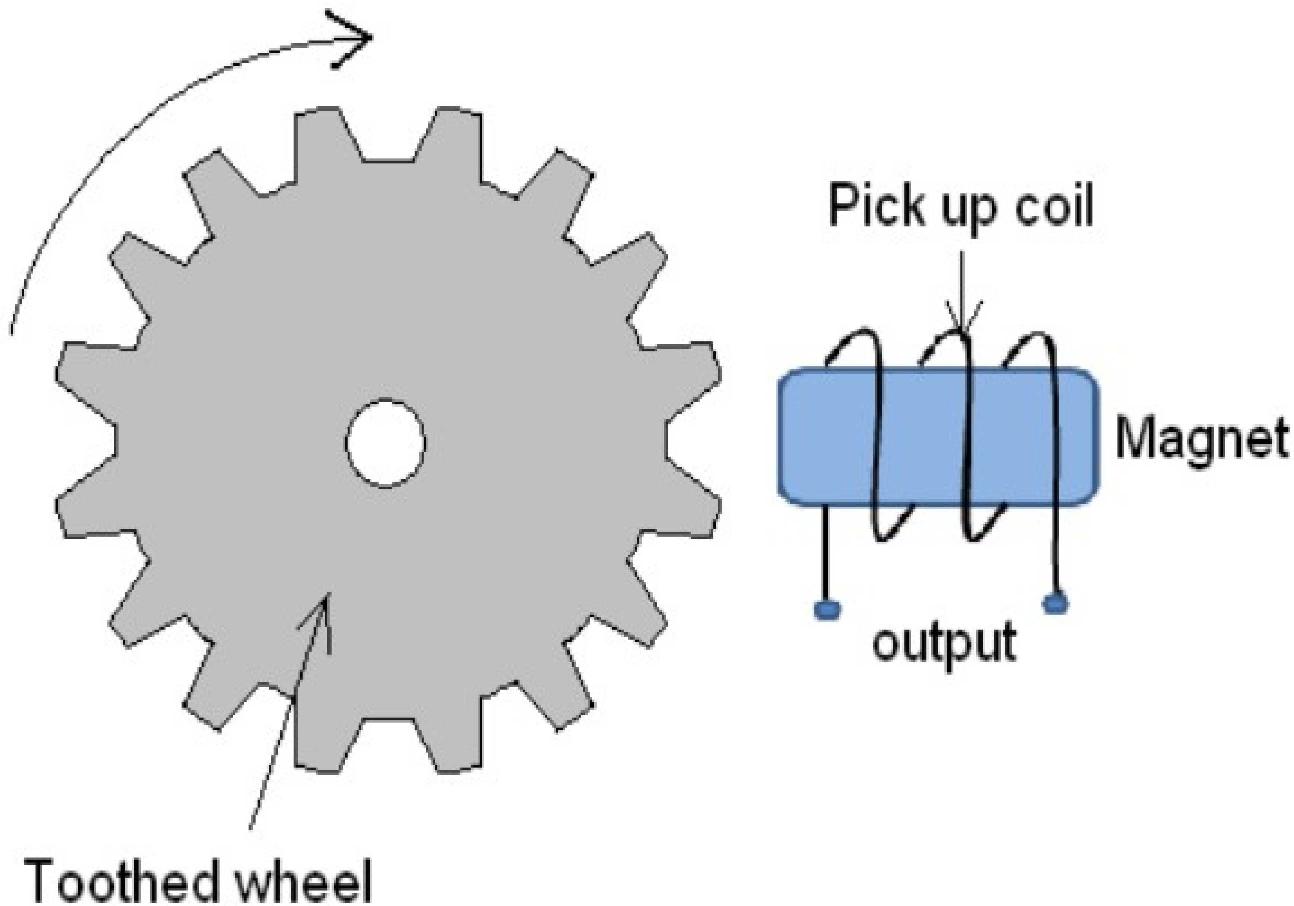


Fiber optic position sensor (non contact)



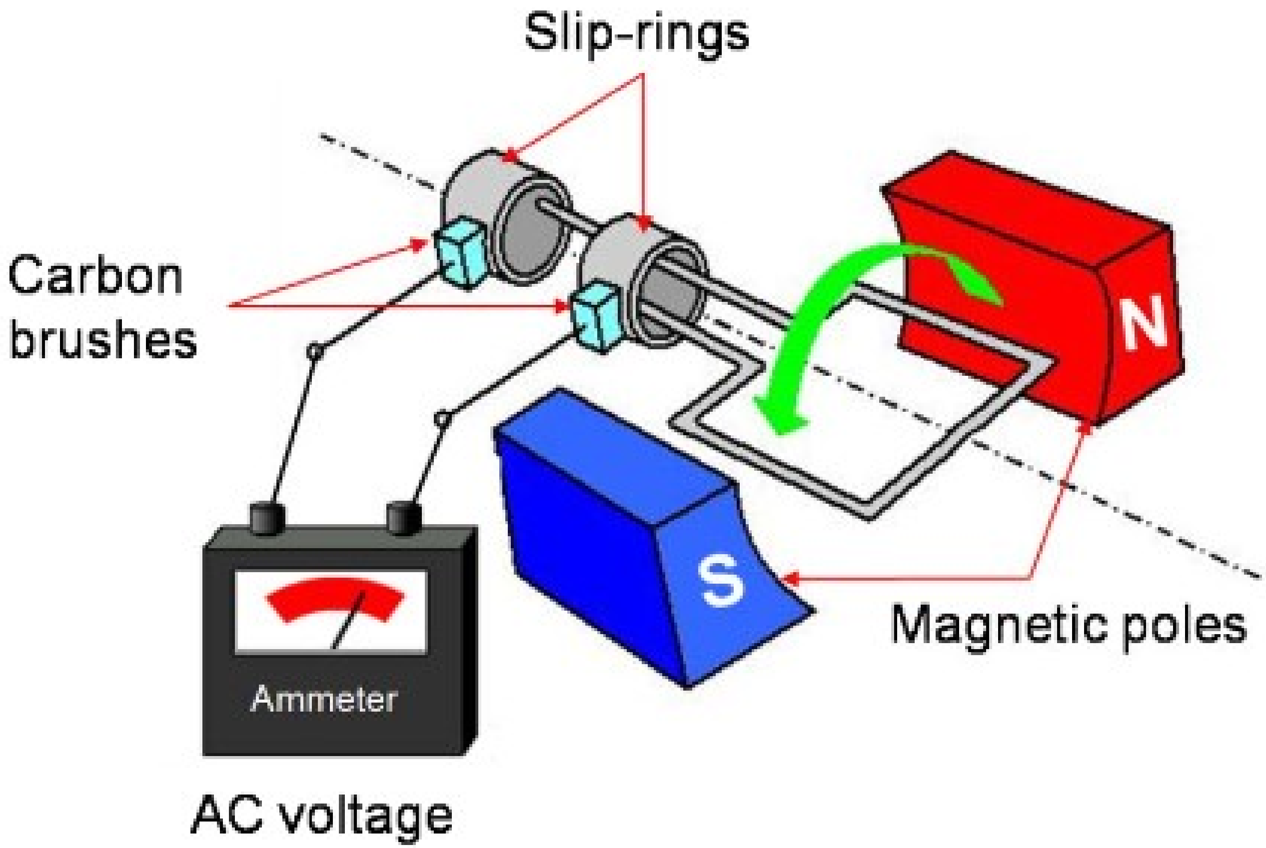
Optical displacement sensors work on the basic principle that the intensity of light decreases with distance. So if the source and detector are fixed, the amount of light reflected from a moving surface will depend on the distance of the moving surface from the fixed ones. Measurement using this principle requires proper calibration since the amount of light received depends upon the reflectivity of the surface, intensity of the source etc. Yet it can provide a simple method for displacement measurement. Optical fibers are often used to transmit light to and from the measuring zone. Such a scheme with bundle fibers is shown in Fig. It uses two bundle fibers, one for transmitting light from the source and the other to the detector. Light reflected on the receiving fiber bundle by the surface of the target object is carried to a photo detector. The light source could be Laser or LED; photodiodes or phototransistors are used for detection.

Velocity sensors



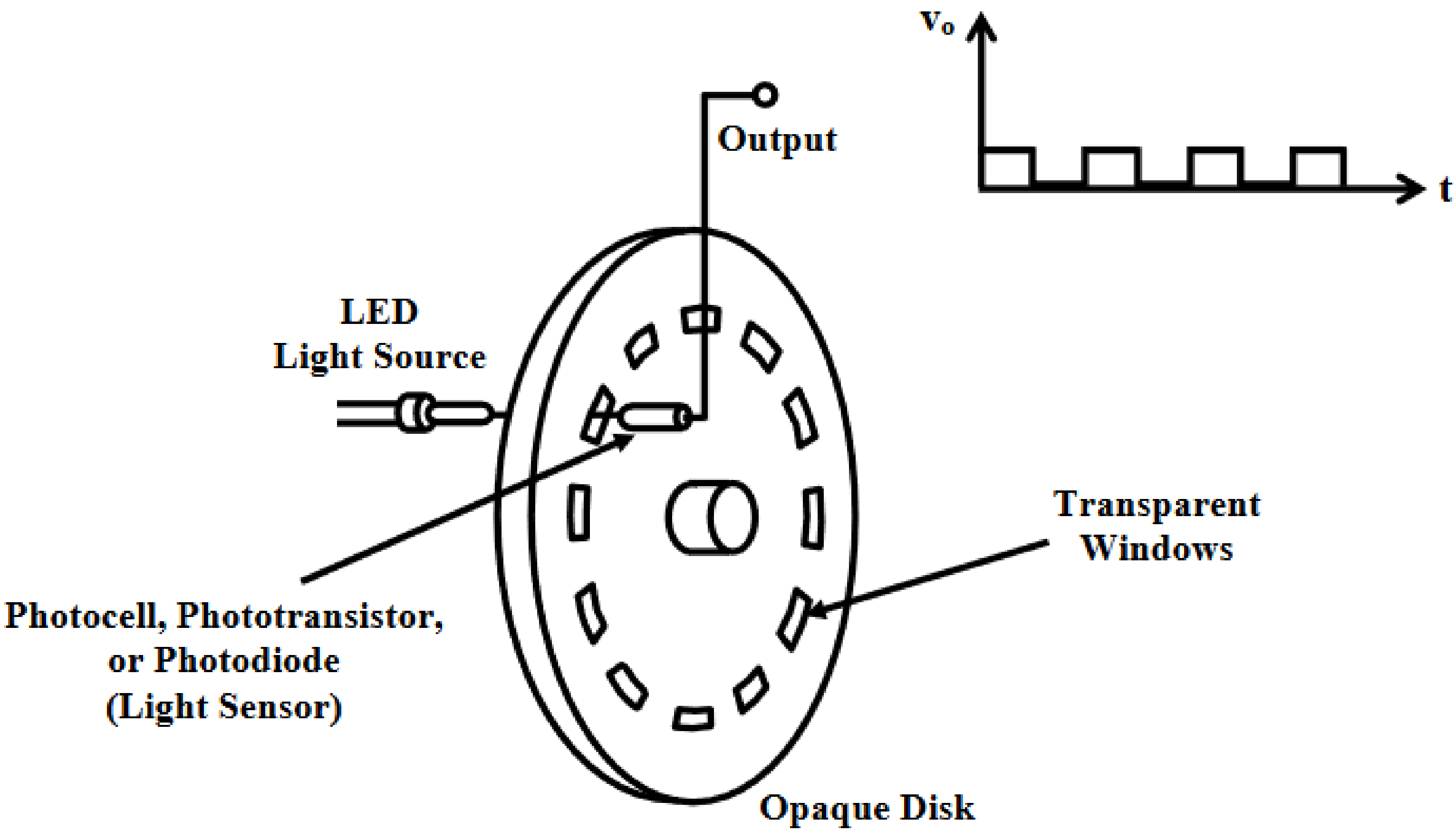
Working

Tachogenerator works on the principle of variable reluctance. It consists of an assembly of a toothed wheel and a magnetic circuit as shown in figure. Toothed wheel is mounted on the shaft or the element of which angular motion is to be measured. Magnetic circuit comprising of a coil wound on a ferromagnetic material core. As the wheel rotates, the air gap between wheel tooth and magnetic core changes which results in cyclic change in flux linked with the coil. The alternating emf generated is the measure of angular motion. A pulse shaping signal conditioner is used to transform the output into a number of pulses which can be counted by a counter.


Slip-rings
Carbon
brushes
N
S
Ammeter
Magnetic poles
AC voltage

An alternating current (AC) generator can also be used as a techognerator. It comprises of rotor coil which rotates with the shaft. Figure shows the schematic of AC generator. The rotor rotates in the magnetic field produced by a stationary permanent magnet or electromagnet. During this process, an alternating emf is produced which is the measure of the angular velocity of the rotor. In general, these sensors exhibit nonlinearity error of about $\pm$ 0.15% and are employed for the rotations up to about 10000 rev/min.

Speed sensors



The simplest way for speed measurement of a rotating body is to mount a tachogenerator on the shaft and measure the voltage generated by it that is proportional to the speed. However this is a contact type measurement. There are other methods also for noncontact type measurements. An opaque disc transparent windows at regular interval is mounted on the shaft whose speed is to be measured. A LED source is aligned on one side of the disc in such a way that its light can pass through the transparent windows of the disc. As the disc rotates the light will alternately passed through the transparent windows and blocked by the opaque sections. A photo detector fixed on the other side of the disc detects the variation of light and the output of the detector after signal conditioning would be a square wave (as shown) whose frequency is decided by the speed and the number of holes (transparent windows) on the disc.

Accelerometer

Consistent with Newton's second law of motion ($\mathbf{F} = \mathbf{ma}$), as an acceleration is applied to the device, a force develops which displaces the mass. The support beams act as a spring, and the fluid (usually air) trapped inside the cylinder acts as a damper, resulting in a second order lumped physical system. This is the source of the limited operational bandwidth and non-uniform frequency response of accelerometers.

Seismic Accelerometer

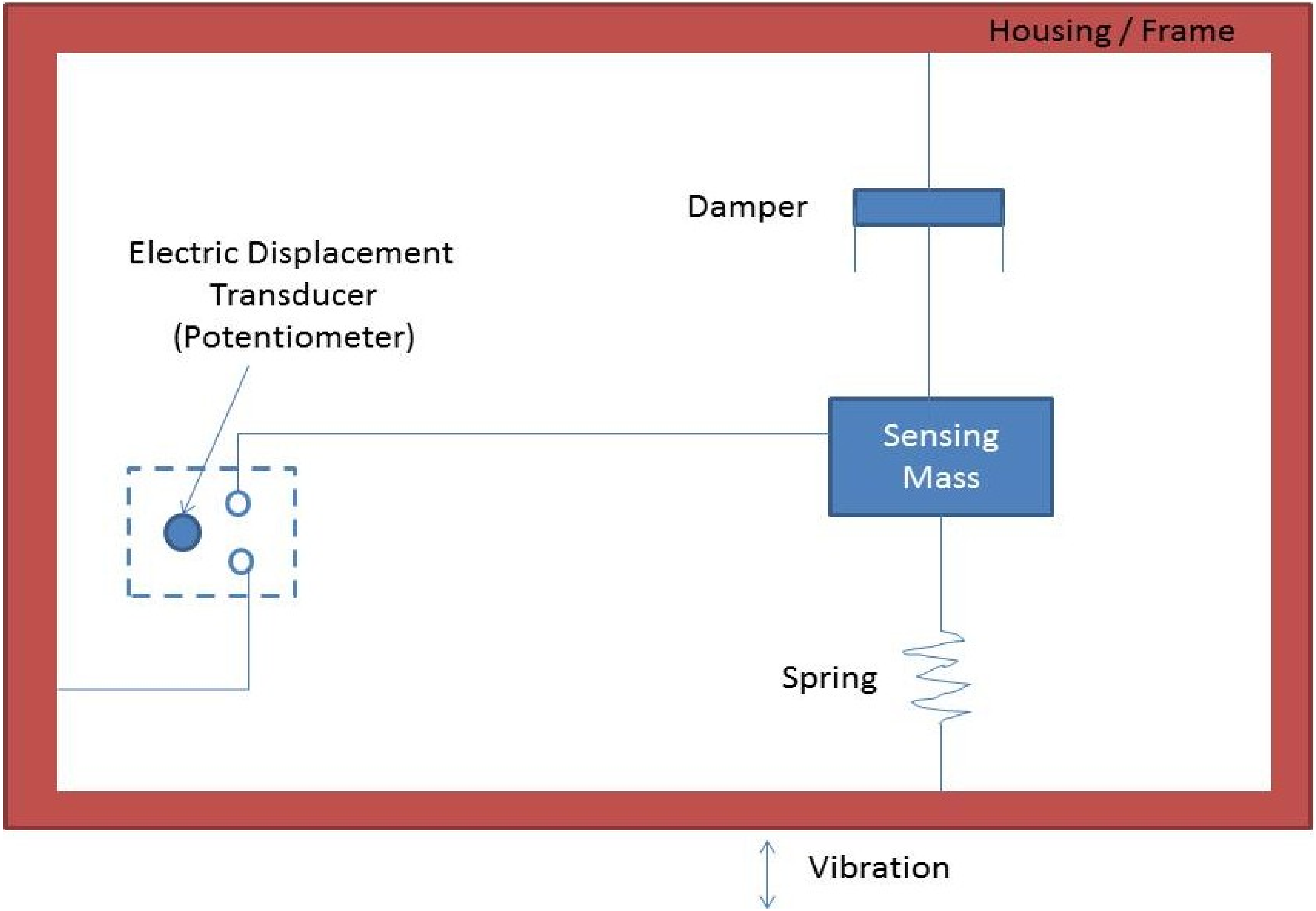
When a spring mass damper system is subjected to acceleration, the mass is displaced, and this displacement of the mass is proportional to the acceleration. Hence a measure of displacement of the mass becomes a measure of acceleration (rate of change of velocity).

$$a = \frac{\partial v}{\partial t} = \frac{\partial^2 x}{\partial t^2}$$

a – acceleration, m/s2
v – velocity, m/s
x – displacement, m

The main parts of a seismic accelerometer are as follows:

1. A seismic mass is suspended from the housing of the accelerometer through a spring.
2. A damper is connected between the seismic mass and the housing of the accelerometer.
3. The seismic mass is connected to an electric displacement transducer.



$$F = m\frac{d^2x}{d^2t} + c\frac{dx}{dt} + kx$$

Operation

- ✓The accelerometer is fitted on to the structure whose acceleration is to be measured.
- ✓Due the acceleration, the seismic mass experience a displacement and this displacement of the mass is proportional to the acceleration.
- ✓As the mass is connected to an electric displacement transducer, the output of the transducer depends on the extent to which the mass is displaced.
- ✓Hence the output of the transducer is calibrated to give a direct indication of the acceleration characteristics of the structure.

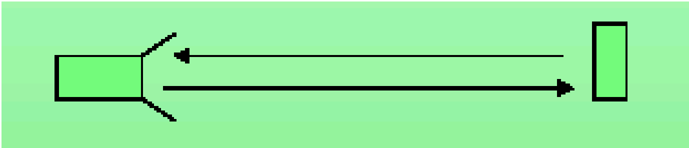
Common Types of Accelerometers

- **Capacitive**-Metal beam or micro machined feature produces capacitance; change in capacitance related to acceleration
- **Piezoelectric**-Piezoelectric crystal mounted to mass –voltage output converted to acceleration
- **Piezo resistive**-Beam or micro machined feature whose resistance changes with acceleration
- **Hall Effect**-Motion converted to electrical signal by sensing of changing magnetic fields
- **Magneto resistive**-Material resistivity changes in presence of magnetic field

Range Finder

(Ultrasonic, Laser)

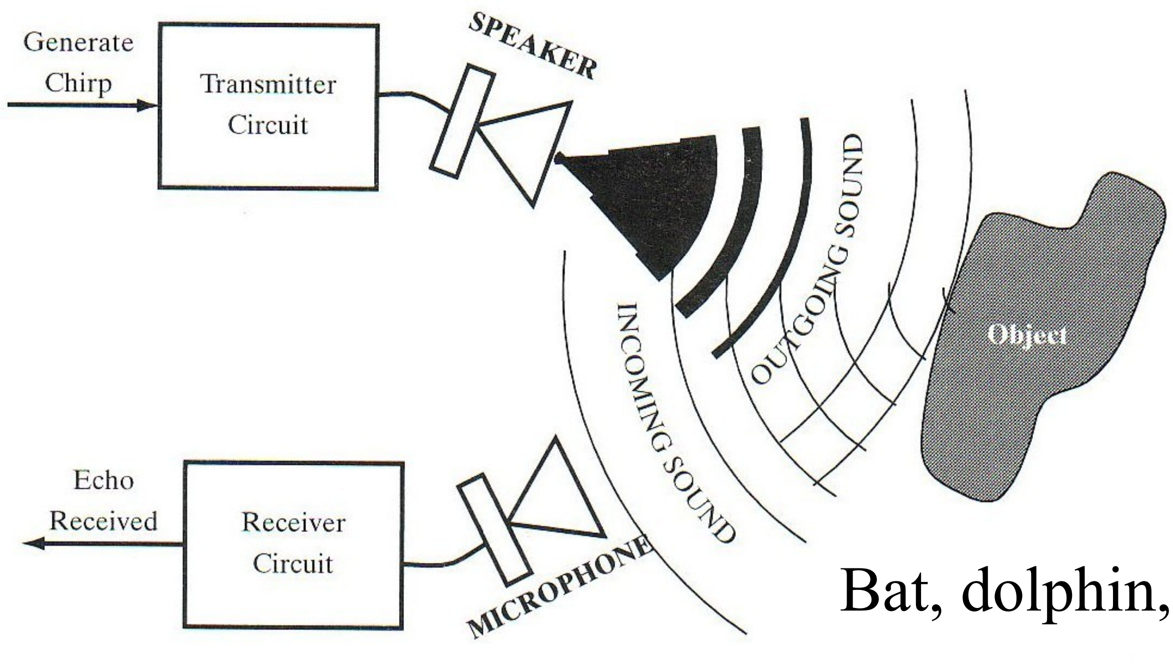
Range Finder



- Time of Flight
- The measured pulses typically come form ultrasonic, RF and optical energy sources.
  - **D = v * t**
  - D = round-trip distance
  - v = speed of wave propagation
  - t = elapsed time
- Sound = 0.3 meters/sec

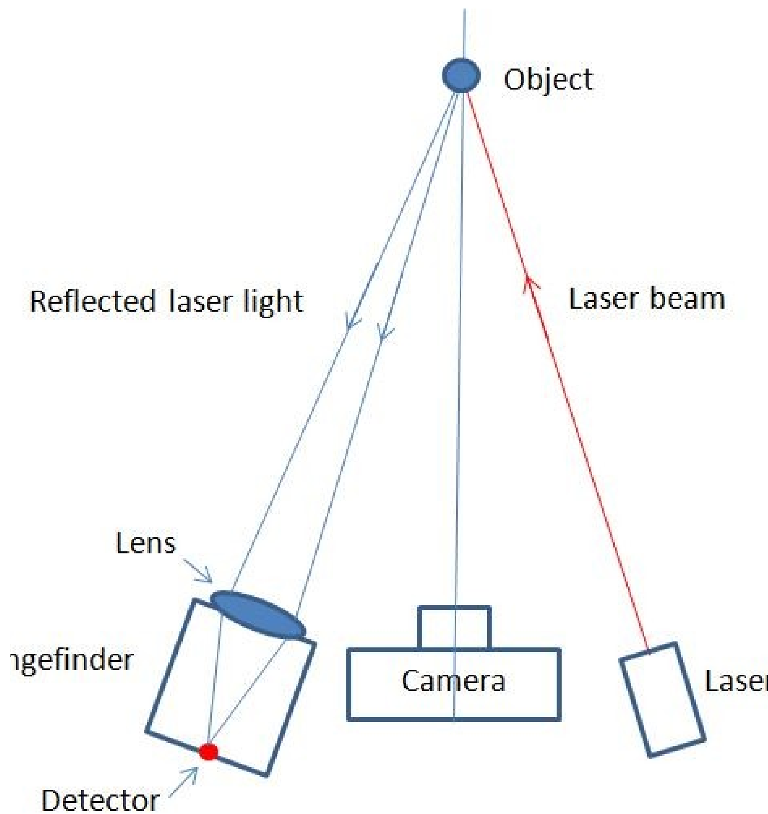
Ultrasonic Range Sensors

- Basic principle of operation:
  - Emit a quick burst of ultrasound (50kHz), (human hearing: 20Hz to 20kHz)
  - Measure the elapsed time until the receiver indicates that an echo is detected.
  - Determine how far away the nearest object is from the sensor



Bat, dolphin, …

Laser Range Sensors



Laser rangefinders work by emitting laser beams at the push of a button. The beams bounce off distant objects and the rangefinder's high-speed clock measures the total time it took from when the beam left the unit until it returned. Using that time measurement, the rangefinder calculates the distance and displays it to the user.

Applications:

1.robot navigation,

2.obstacle avoidance

3.to recover the third dimension for monocular vision.

Comparison

Contact Type

1) The tachometer has to be in physical contact with the rotating shaft.
2) Preferred where the tachometer is generally fixed to the machine.
3) Generally, optical encoder / magnetic sensor is attached to shaft of tachometer.

Non Contact Type

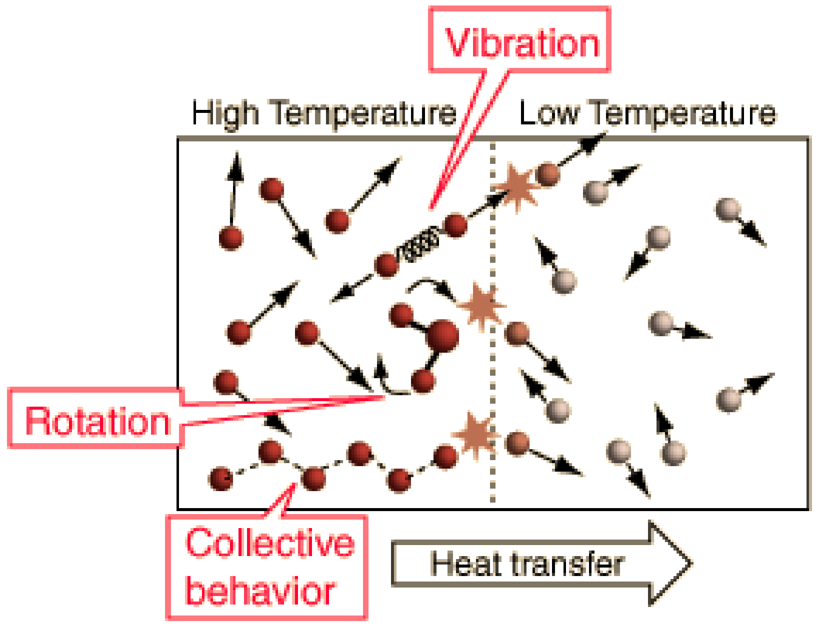
1) The tachometer does not need to be in physical contact with the rotating shaft.
2) Preferred where the tachometer needs to be mobile.
3) Generally, laser is used or an optical disk id attached to rotating shaft and read by a IR beam or laser.

Different sensing variables

- Heat/temperature
- Touch
- Smell
- Humidity
- Light
- Speech/voice recognition system

Heat/temperature sensors

A SIMPLIFIED DESCRIPTION OF TEMPERATURE



"Temperature is a measure of the tendency of an object to spontaneously give up energy to its surroundings. When two objects are in thermal contact, the one that tends to spontaneously lose energy is at the higher temperature.“

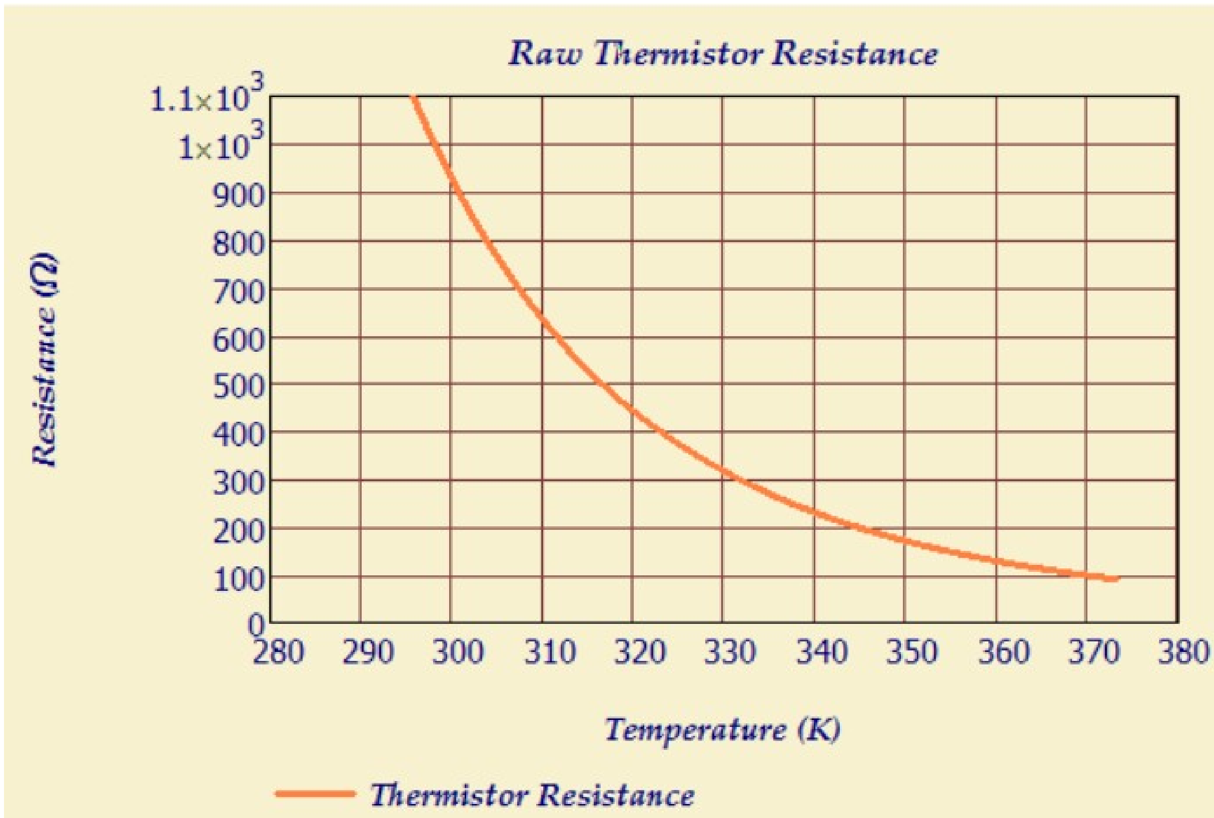
Thermistor

<u>Thermistor</u> – a resistor whose resistance changes with temperature

- Resistive element is generally a metal-oxide ceramic containing Mn, Co, Cu, or Ni
- Packaged in a thermally conductive glass bead or disk with two metal leads
- Suppose we have a "1 kΩ thermistor"
  - What does this mean?
  - At room temperature, the resistance of the thermistor is 1 kΩ
  - What happens to resistance as we increase temperature?

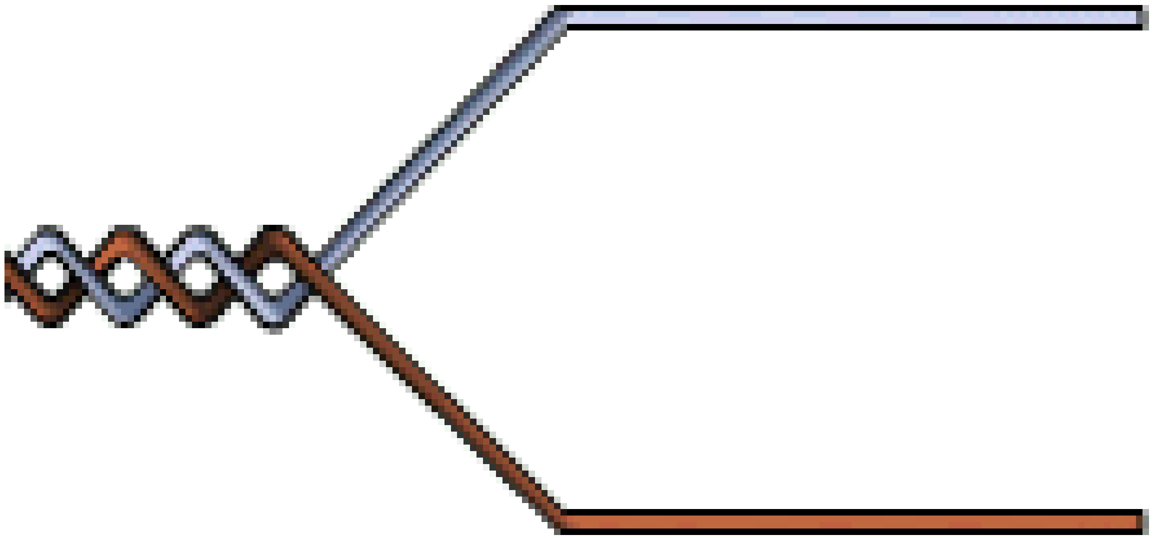
Negative Temperature Coefficient

- Most materials exhibit a **negative temperature coefficient (NTC)**
  - Resistance **drops** with temperature!



Thermocouple

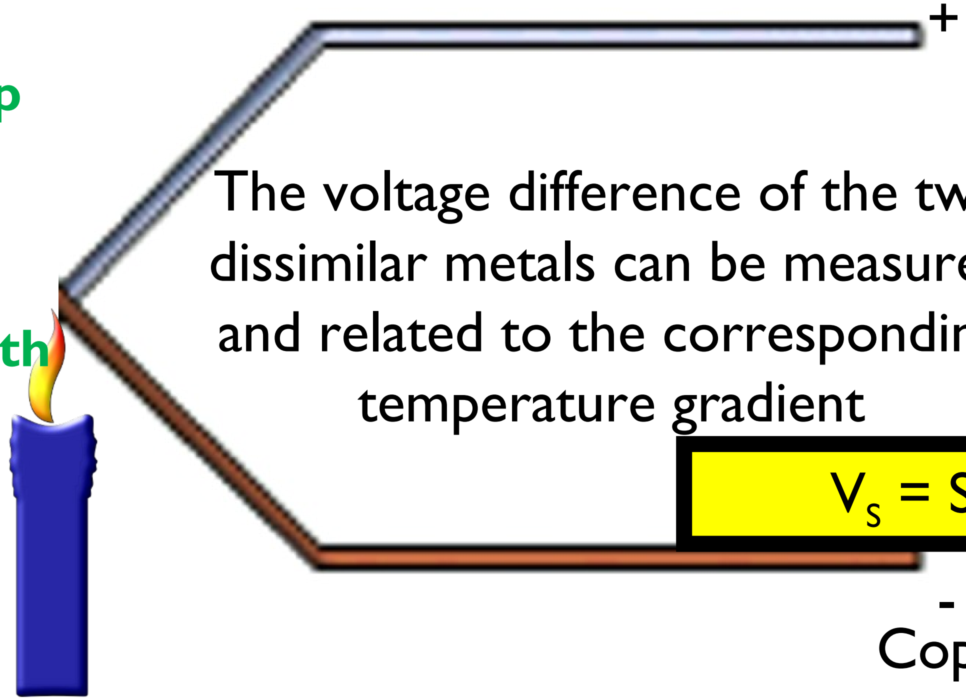
- **Thermocouple** – a two-terminal element consisting of two dissimilar metal wires joined at the end



The Seebeck Effect

- **Seebeck Effect** – A conductor generates a voltage when it is subjected to a temperature gradient
  - Measuring this voltage requires the use of a second conductor material
  - The other material needs to be composed of a different material

Nickel-Chromium Alloy



Copper-Nickel Alloy

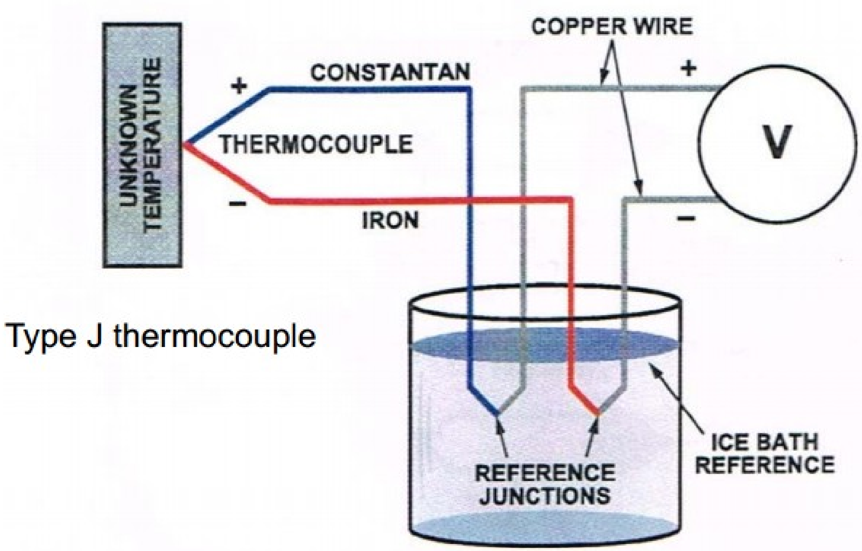
The relationship between temperature difference and voltage varies with materials

The voltage difference of the two dissimilar metals can be measured and related to the corresponding temperature gradient

$$V_S = S\Delta T$$

Ice Bath Method (Forcing a Temperature)

- Thermocouples measure the voltage difference between two points
- To know the absolute temperature at the hot junction, one must know the temperature at the Ref junction



Type J thermocouple

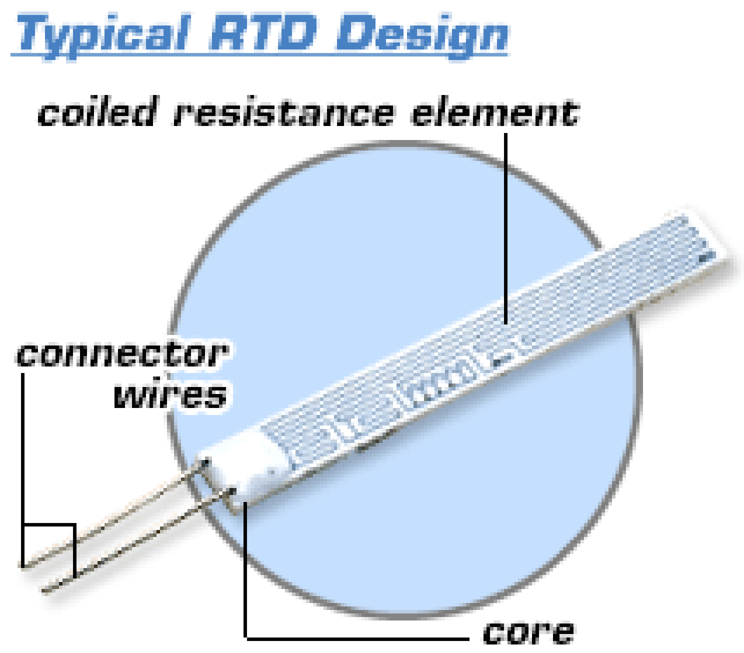
- NIST thermocouple reference tables are generated with T_{ref} = 0 °C

$$V_{meas} = V(T_{hot}) - V(T_{ref})$$

$$V(V_{hot}) = V_{meas} + V(T_{ref})$$

If we know the voltage-temperature relationship of our thermocouple, we could determine the temperature at the hot junction

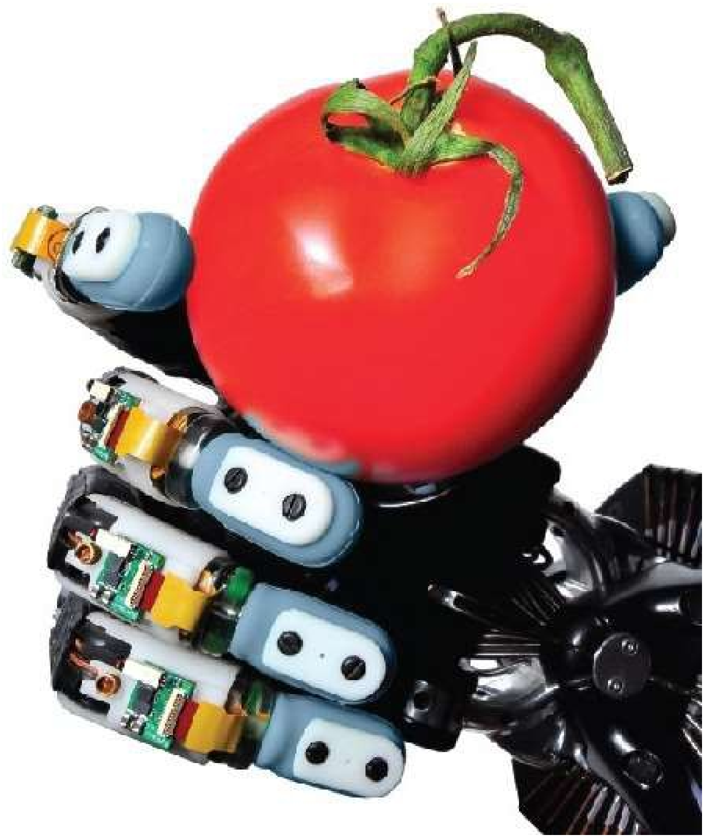
Resistive Temperature Detector (RTD)

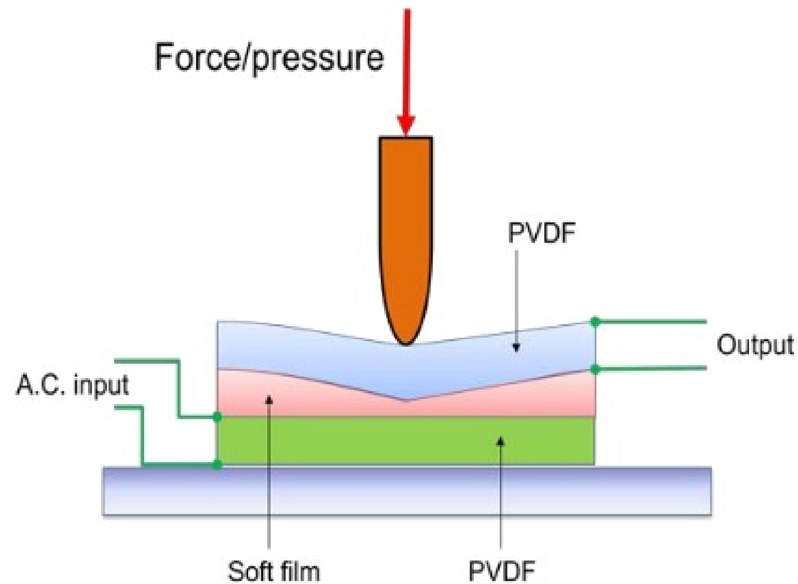


- Two terminal device
- Usually made out of platinum
- Positive temperature coefficient
- Tends to be linear
- $R = R_0(1+\alpha)(T-T_0)$ where $T_0 = 0°C$

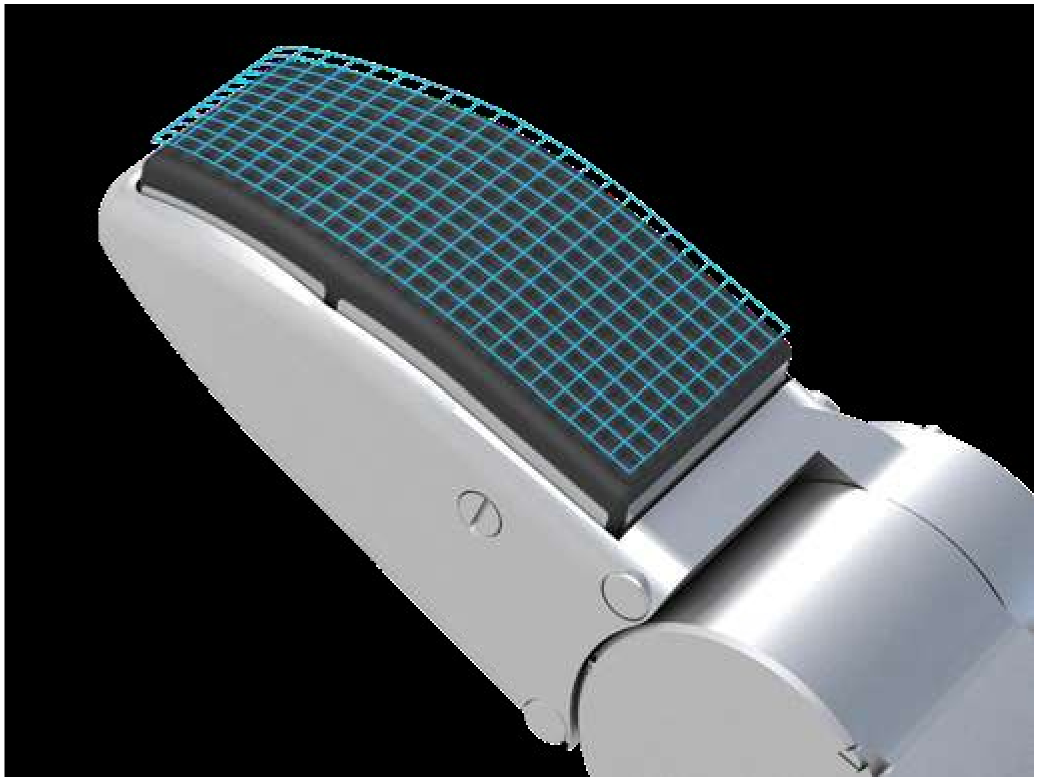
  $R_0 = 100\ \Omega$, $\alpha = 0.03385\ \Omega/\ \Omega\ °C$
- At 10°C, $R = 100(1+0.385)(10) = 103.85\ \Omega$
- Accuracy of 0.01 °C
- EXPENSIVE!

Touch or tactile sensor





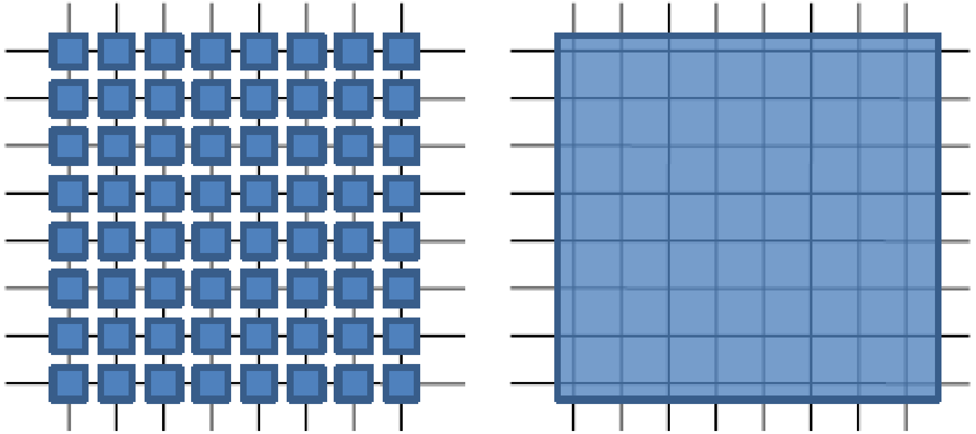
A **tactile sensor is a device that measures** information arising from physical interaction with its environment



A grid of tactile

Usually an array of discrete sensing elements.
Sensing elements can be many types:

- Resistive: strain gauge, piezo-resistive.
- Capacitive
- Piezoelectric
- & others like (magnetic, optical, conductive rubber, ultrasonic)



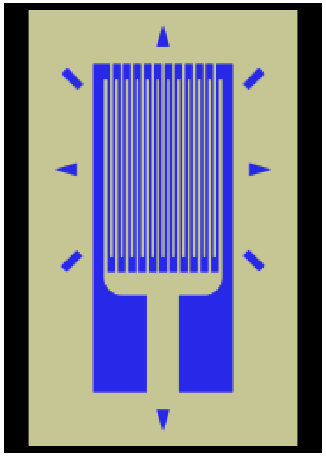
Resistive Sensing Elements

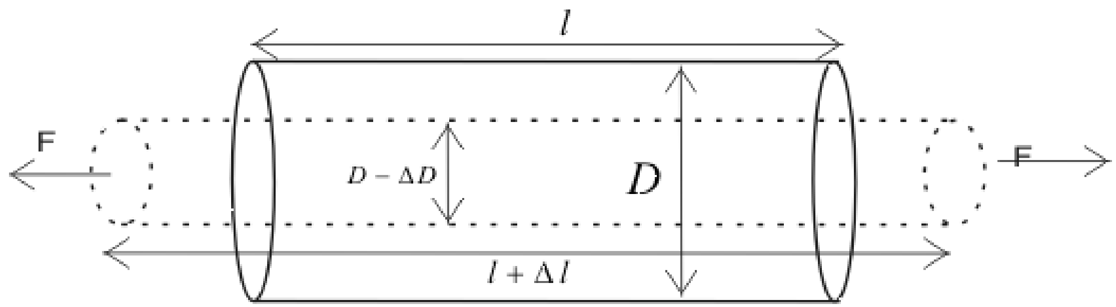
Strain gauge: a thin film having a metal pattern that changes resistance when strained.

•Piezoresistive element : Pressure on the element causes the material to compress, changing it's resistance

☐ Advantages: very simple construction, durable, good dynamic range, easy readout

☐ Disadvantages: non-linearity, hysteresis, low sensitivity





We know that,

$$R=\rho * L/A$$

Where, R= Resistance of the conducting material

ρ =Resistivity

L= Length

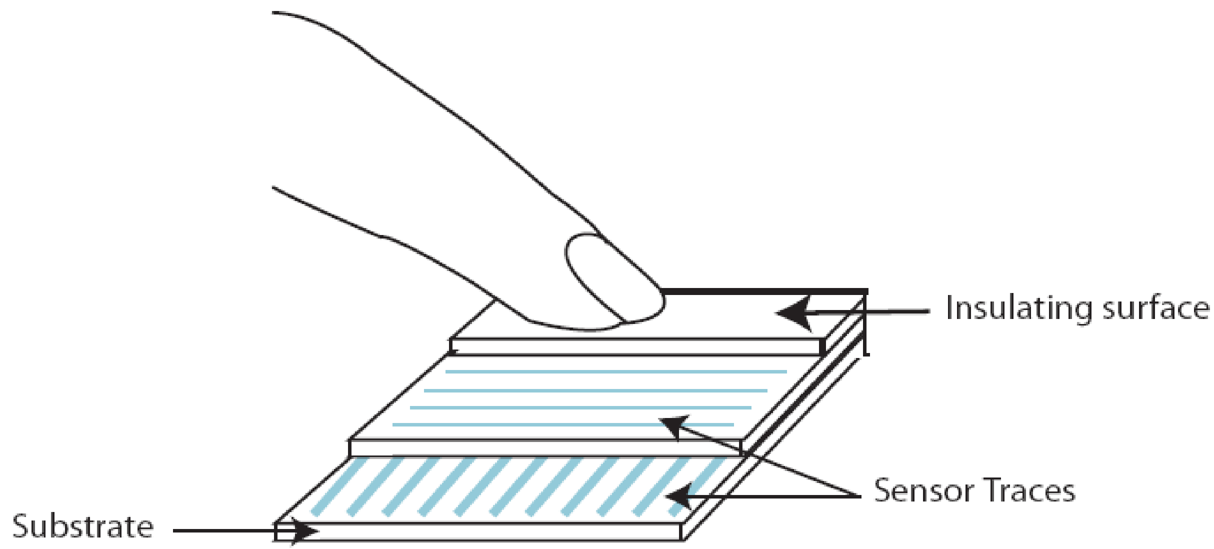
A= Cross sectional area

From the above formula we can deduce that resistance of an object is directly proportional to its length.

ie $R \propto L$

Capacitive Sensing Elements

Mechanical deformation changes the capacitance of parallel conducting plates



$$C = \frac{\varepsilon A}{d}$$

Where,

- C = Capacitance in Farads
- ε = Permittivity of dielectric (absolute, not relative)
- A = Area of plate overlap in square meters
- d = Distance between plates in meters

$$C = \frac{Q}{V}$$

$$\text{Unit} = \frac{\text{coulomb}}{\text{volt}} = \text{Farad}$$

In general, tactile sensors are used to sense the contact of fingertips of a robot with an object. They are also used in manufacturing of ‘touch display’ screens of visual display units (VDUs) of CNC machine tools. Figure shows the construction of piezo-electric polyvinylidene fluoride (PVDF)based tactile sensor. It has two PVDF layers separated by a soft film which transmits the vibrations. An alternating current is applied to lower PVDF layer which generates vibrations due to reverse piezoelectric effect. These vibrations are transmitted to the upper PVDF layer via soft film. These vibrations cause alternating voltage across the upper PVDF layer. When some pressure is applied on the upper PVDF layer the vibrations gets affected and the output voltage changes. This triggers a switch or an action in robots or touch displays.

Smell sensors

Electronic nose

- An **electronic nose** is a device intended to detect odors or flavors.

- Over the last decade, “electronic sensing” or “e-sensing” technologies have undergone important developments from a technical and commercial point of view. The expression “electronic sensing” refers to the capability of reproducing human senses using sensor arrays and pattern recognition systems

Human smell system and molecules

- The olfactory system has mucus membrane which contains small segments, nerve cells, the actual sensory organs .
- The dendrites, some type of fiber, are covered from the nerve cells to nasal cavity with a thin layer of moisture.
- The smell particles are the source of what we smell.
- The moisture dissolves microscopic particles that are carried in by air from the odor-emitting substance to the nose The dissolved particles in the mucus stimulate the olfactory nerve cells through chemical reactions.

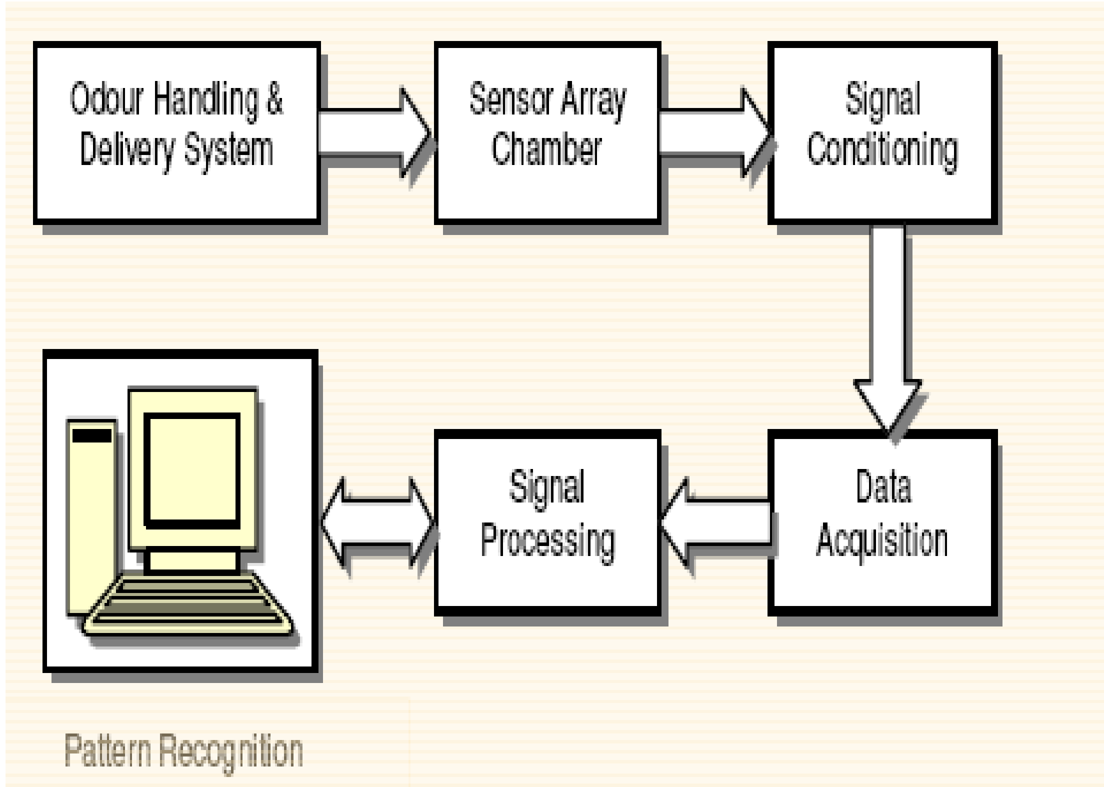
Electronic nose working principle

- **A sample delivery system:** enables the generation of the headspace (volatile compounds) of a sample, which is the fraction analyzed.
- **A detection system:** which consists of a sensor set, is the “reactive” part of the instrument. When in contact with volatile compounds, the sensors react.
- **A computing system:** works to combine the responses of all of the sensors, which represents the input for the data treatment

Performing analysis

- As a first step, an electronic nose need to be trained with qualified samples so as to build a database of reference. Then the instrument can recognize new samples by comparing volatile compounds fingerprint to those contained in its databaseto perform analysis.
- Odour handling system
- Sensor array chamber
- Signal conditioning
- Data aquistion
- Signal processing

Block diagram



Applications :

1.Using dogs to detect to sniff out bombs, drugs, or fugitives.

2.Measuring environmental contamination and detect hazardous chemicals

3. Identifying chemical spills, diagnose strep infection, hunt for truffles, keep toast from burning, or detecting bad batches of food or drink .

Humidity sensors

Humidity measurement finds wide applications in different process industries. Moisture in the atmosphere must be controlled below a certain level in many manufacturing processes, e.g., semiconductor devices, optical fibres etc. Humidity inside an incubator must be controlled at a very precision level. Textiles, papers and cereals must be dried to a standard storage condition in order to prevent the quality deterioration.

The humidity can be expressed in different ways: (a) absolute humidity, (b) relative humidity and (c) dew point.

<u>Absolute humidity</u>

Mass of water vapor per unit volume

<u>Relative humidity</u>

ratio of the actual vapor pressure and the saturation vapor pressure at a certain temperature

<u>Dewpoint temperature</u>

is the temperature to which a gas must be cooled, at constant pressure, to achieve saturation

Humidity sensors work by detecting changes that alter electrical currents or temperature in the air. There are three basic types of humidity sensors: capacitive, resistive and thermal. All three types of sensors monitor minute changes in the atmosphere in order to calculate the humidity in the air.

Capacitive: A capacitive humidity sensor measures relative humidity by placing a thin strip of metal oxide between two electrodes. The metal oxide's electrical capacity changes with the atmosphere's relative humidity. Weather, commercial and industries are the major application areas.

Resistive: Resistive humidity sensors utilize ions in salts to measure the electrical impedance of atoms. As humidity changes, so does the resistance of the electrodes on either side of the salt medium.

Thermal: Two thermal sensors conduct electricity based upon the humidity of the surrounding air. One sensor is encased in dry nitrogen while the other measures ambient air. The difference between the two measures the humidity.

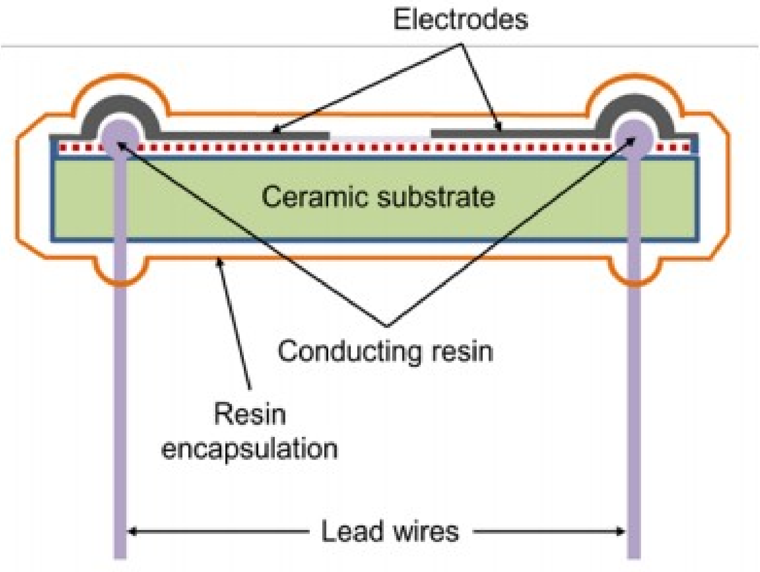
Light sensors

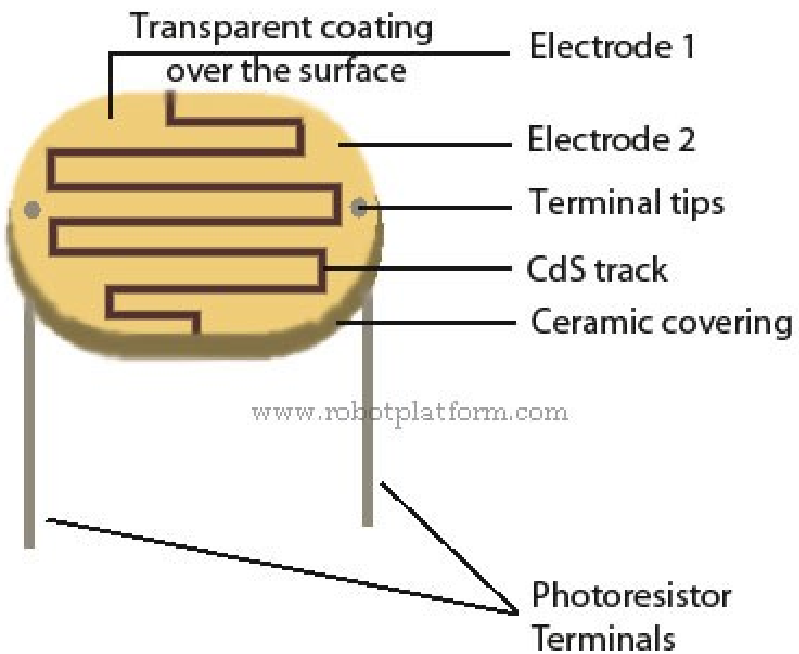
A light sensor is a device that is used to detect light. Two different types of light sensors such as
1.photocell/photoresistor
2.photo diodes

Photoresistor is also called as light dependent resistor (LDR). It has a resistor whose resistance decreases with increasing incident light intensity. It is made of a high resistance semiconductor material, cadmium sulfide (CdS). Photoresistor follows the principle of photoconductivity which results from the generation of mobile carriers when photons are absorbed by the semiconductor material.

Photo resister

Figure shows the construction of a photo resistor. The CdS resistor coil (electrodes) is mounted on a ceramic substrate. This assembly is encapsulated by a resin material. The sensitive coil electrodes are connected to the control system though lead wires. On incidence of high intensity light on the electrodes, the resistance of resistor coil decreases which will be used further to generate the appropriate signal by the microprocessor via lead wires. Photoresistors are used in science and in almost any branch of industry for control, safety, amusement, sound reproduction, inspection and measurement.





Transparent coating
over the surface
Electrode 1
Electrode 2
Terminal tips
CdS track
Ceramic covering
www.robotplatform.com
Photoresistor
Terminals

Photo diode

Photodiode is a solid-state device made of Silicon which converts incident light into an electric current during reverse biased condition. It consists of a shallow diffused p-n junction. When photons of energy greater than 1.1eV (the bandgap of silicon) fall on the device, this light energy is absorbed and the electron-hole pairs drift apart. The generated minority carriers reach the junction, they are swept across by the electric field and an electric current establishes. Photodiodes are one of the types of photodetector, which convert light into either current or voltage.

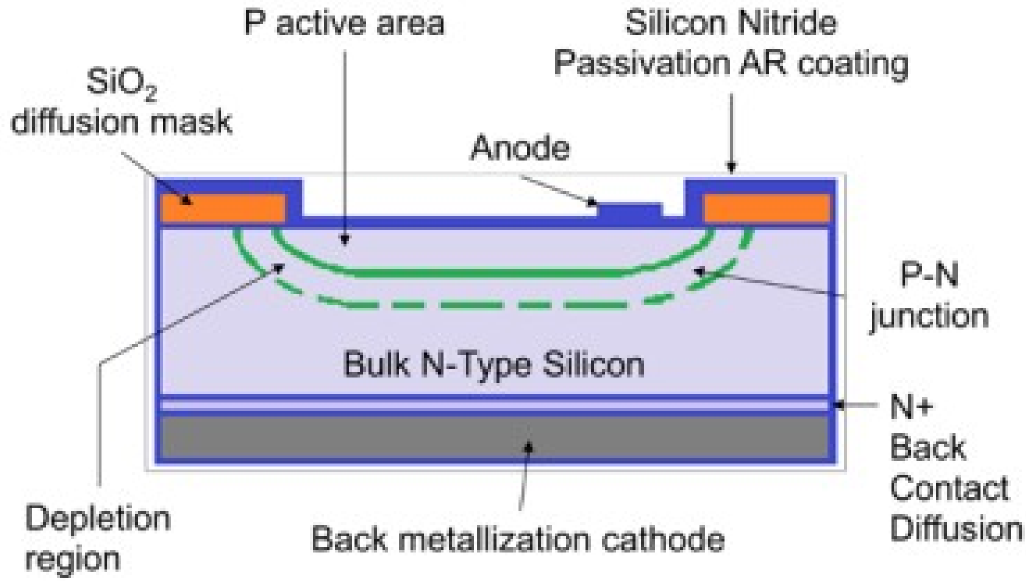
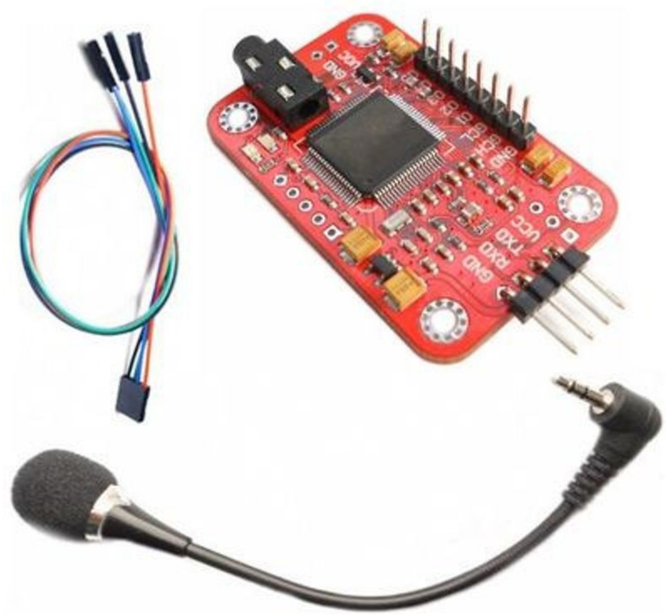


Figure shows the construction of Photo diode detector. It is constructed from single crystal silicon wafers. The upper layer is p layer. It is very thin and formed by thermal diffusion or ion implantation of doping material such as boron. Depletion region is narrow and is sandwiched between p layer and bulk n type layer of silicon. Light irradiates at front surface, anode, while the back surface is cathode. The incidence of light on anode generates a flow of electron across the p-n junction causes current to flow which is the measure of light intensity.

Applications of photodiode

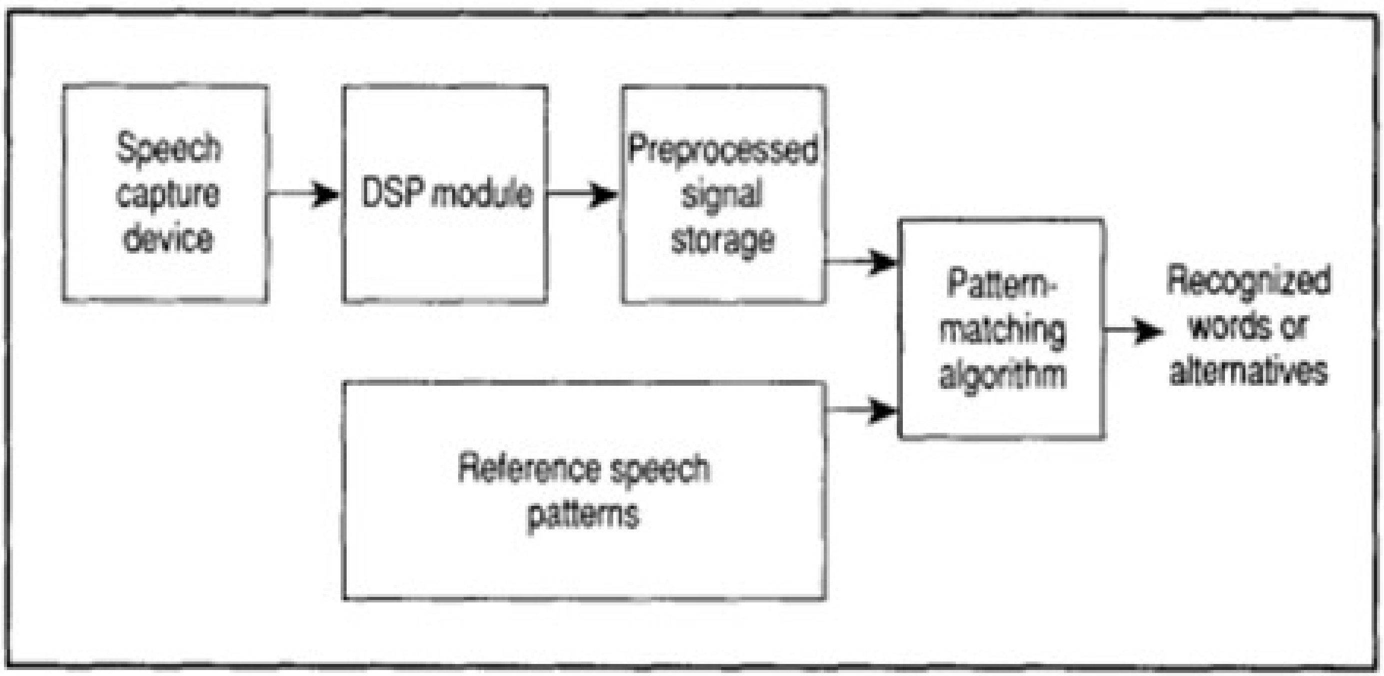
- ✓Camera
- ✓Medical
- ✓Industry
- ✓Safety Equipment
- ✓Automotive
- ✓Communications

Speech/voice recognition sensors



The basic principle of voice recognition involves the fact that speech or words spoken by any human being cause vibrations in air, known as sound waves. These continuous or analog waves are digitized and processed and then decoded to appropriate words and then appropriate sentences.

Components of a Speech Recognition System



A speech capturing Device: It consists of a microphone, which converts the sound wave signals to electrical signals and an Analog to Digital Converter which samples and digitizes the analog signals to obtain the discrete data that the computer can understand.

A Digital Signal Module or a Processor: It performs processing on the raw speech signal like frequency domain conversion, restoring only the required information etc.

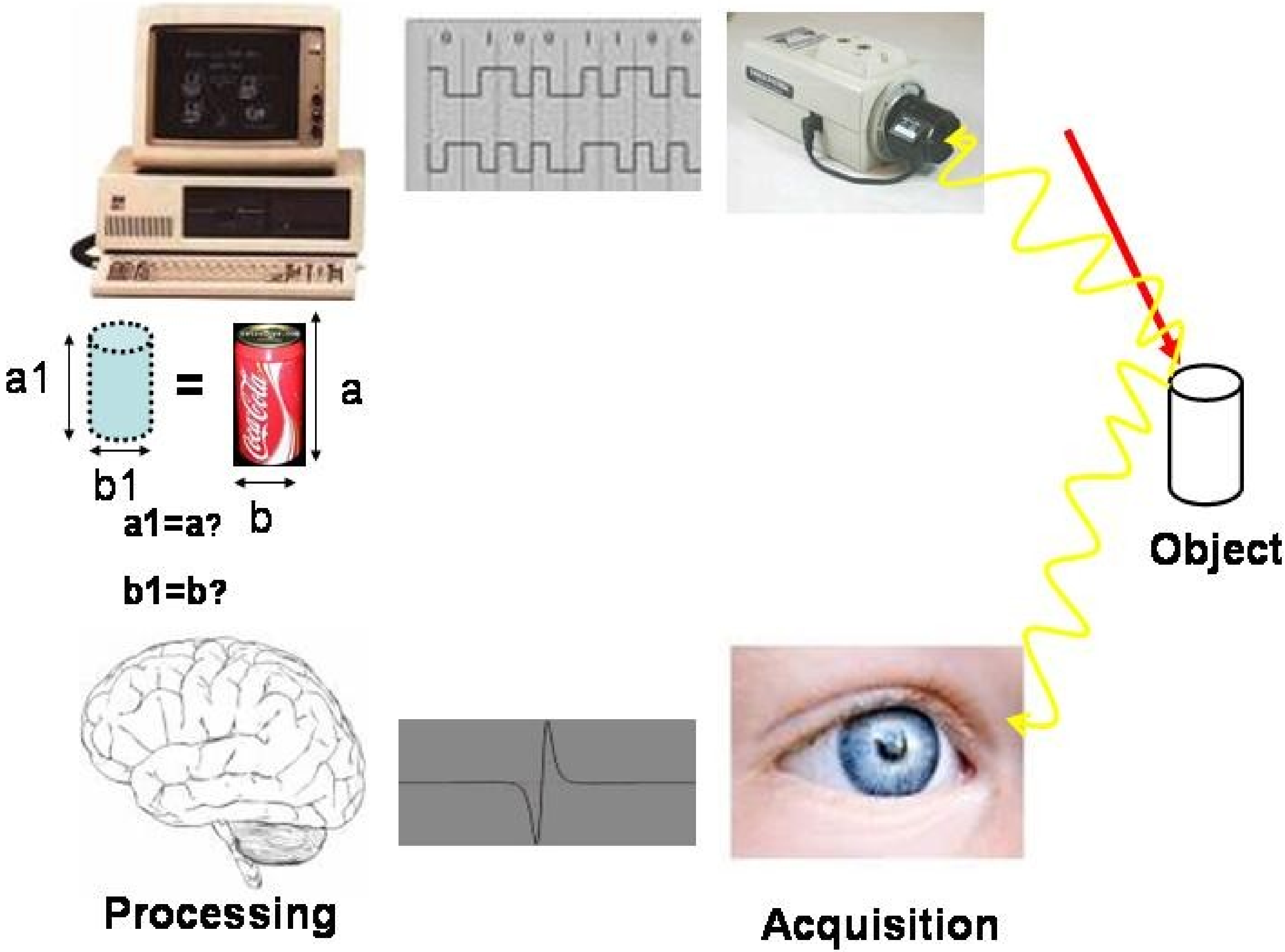
Preprocessed signal storage: The preprocessed speech is stored in the memory to carry out further task of speech recognition.

Reference Speech patterns: The computer or the system consists of predefined speech patterns or templates already stored in the memory, to be used as the reference for matching.

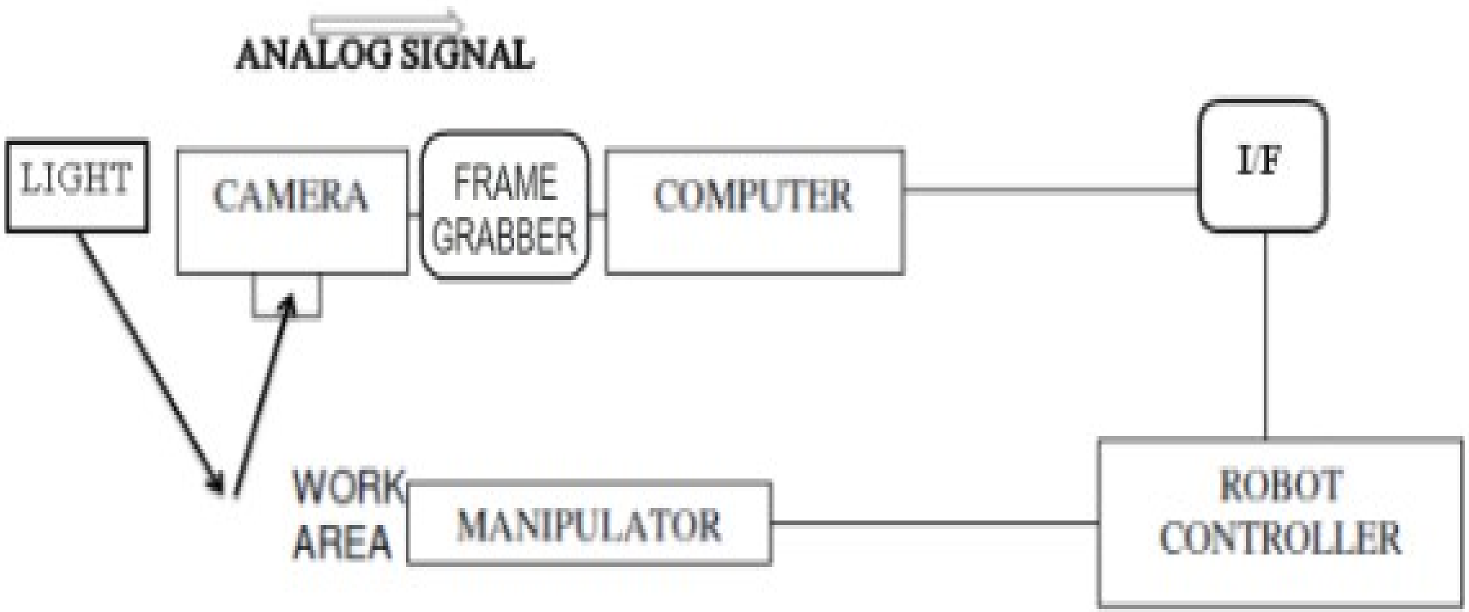
Pattern matching algorithm: The unknown speech signal is compared with the reference speech pattern to determine the actual words or the pattern of words.

ROBOT VISION SENSORS

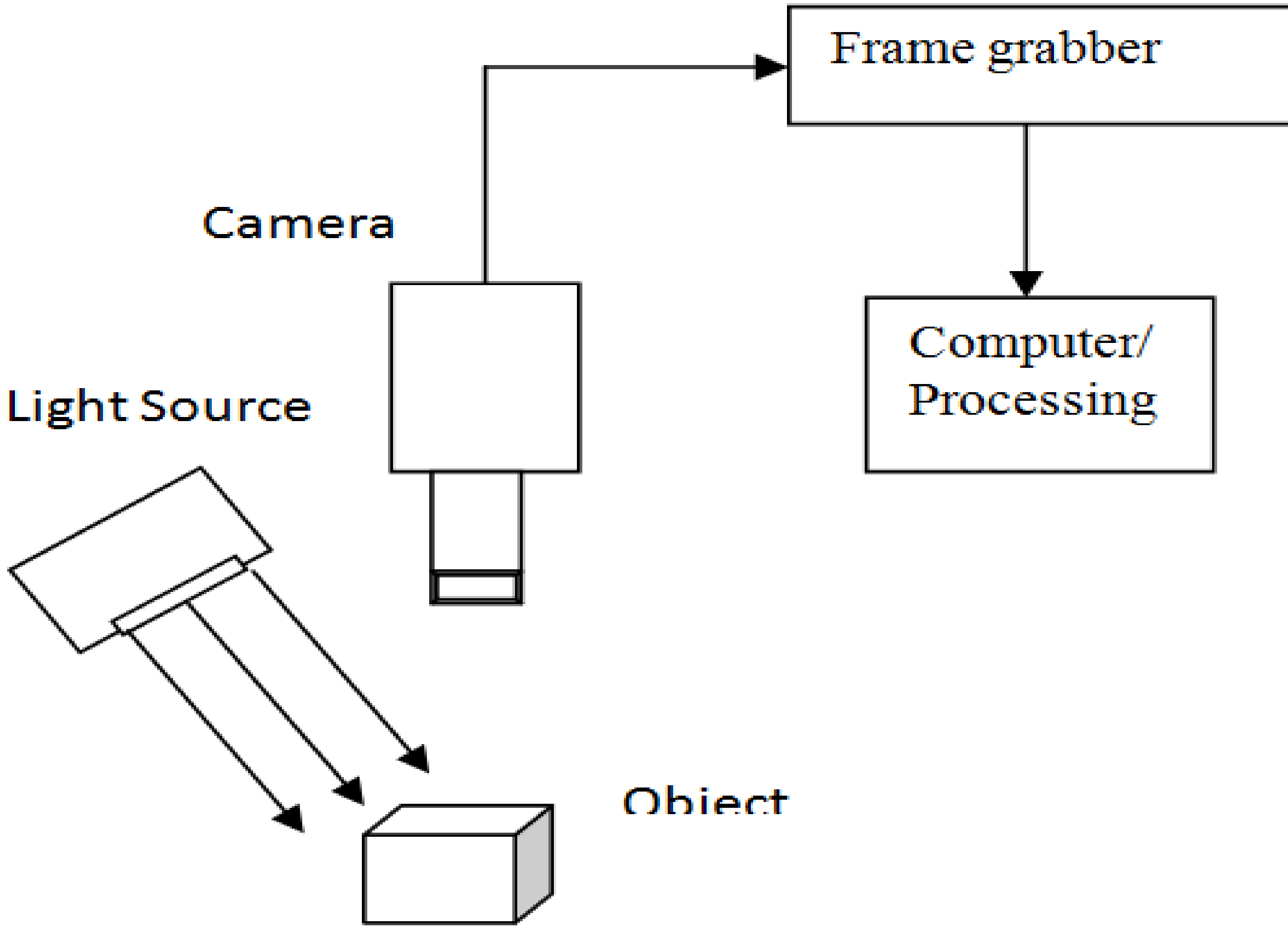
CAPABILITIES	HUMAN VISION	MACHINE VISION
1. Distance	Good qualitative capabilities	Limited capabilities
2. Orientation	Good qualitative capabilities	Good for 2D
3. Motion	Good qualitative capabilities	Limited, sensitive to image blurring
4. Recollection	100% is not possible	Its possible
5. Distinguish b/w colors	Difficult	Easy
6. Minute details	Difficult to detect	Easy
7. Time delay	Negligible	Considerable
8. Intelligence	More	Less
9. Worst environment	Not comfortable	Comfortable
10. Continuous process	More problems	Less problems
11. Automation	Cannot automate	Can automate


a1
=
a
b1
b
a1=a?
b1=b?
Object
Processing
Acquisition

Block Diagram Of Vision System



MACHINE VISION SYSTEM



- The sensing and digitizing functions involve the input of vision data by means of camera focused on the scene of interest
- Special lighting techniques – to obtain sufficient contrast for processing
- Image viewed by Camera stored in computer memory
- The digital image is called a frame of vision data – it is captured by hardware device called frame grabber.
- Digitization images at the rate of 30 frames per second
- A frame consist of a matrix of data representing – scene sensed by camera

- The elements of matrix are called picture elements or pixels
- A single pixel is the projection of a small portion of the scene- which reduces that portion to single value.
- The value is a measure of the light intensity for that element of the scene.
- Each pixel intensity is converted into a digital value.
- The digital image matrix for each frame is stored and then subjected to image processing and analysis function for data reduction and interpretation of image

- An image frame will be threshold to produce a binary image – various feature measurements – reduce the data representation – hundred thousand bytes to hundred bytes.
- The resultant feature data can be analyzed in the available time for action by robot system.
- Various techniques to compute the feature values can be programmed into the computer to obtain feature descriptors of the image – which are matched against previously computed values stored in the computer.

DISADVANTAGES OF HUMAN VISION

1. The eye has limited size and therefore limited light-gathering power.
2. The eye has limited frequency response, since it can only see electromagnetic radiation in the visible wavelengths.
3. The eye cannot store an image for future reference like a photographic plate can.
4. Slower process
5. Continuous long time work is not possible.
6. Cant operate in hazardous environment
7. Variation in accuracy and precision
8. Wages, salaries etc

ADVANTAGES OF MACHINE VISION

1. Can use a verity of different lenses from wide angles to telephoto lengths.
2. Can create a bigger picture with less light than an eye can.
3. 100% recollection is possible
4. Faster process
5. Continuous long time work is possible.
6. Can operate in hazardous environment
7. NO Variation in accuracy and precision
8. Can automate

APPLICATIONS OF MACHINE VISION SYSTEM

Quality Assurance
- Metrology
- Flaw detection

Defect Detection
- Foreign particles
- Contamination

Test & Calibration
- Sensor calibration

Real time process control
- Optical fiber drawing
- Hot steel strip rolling

Machine Monitoring
- Operation monitoring

Material Handling
- Storage, Retrieval, Routing

Gauging/Metrology
- Non contact measurement

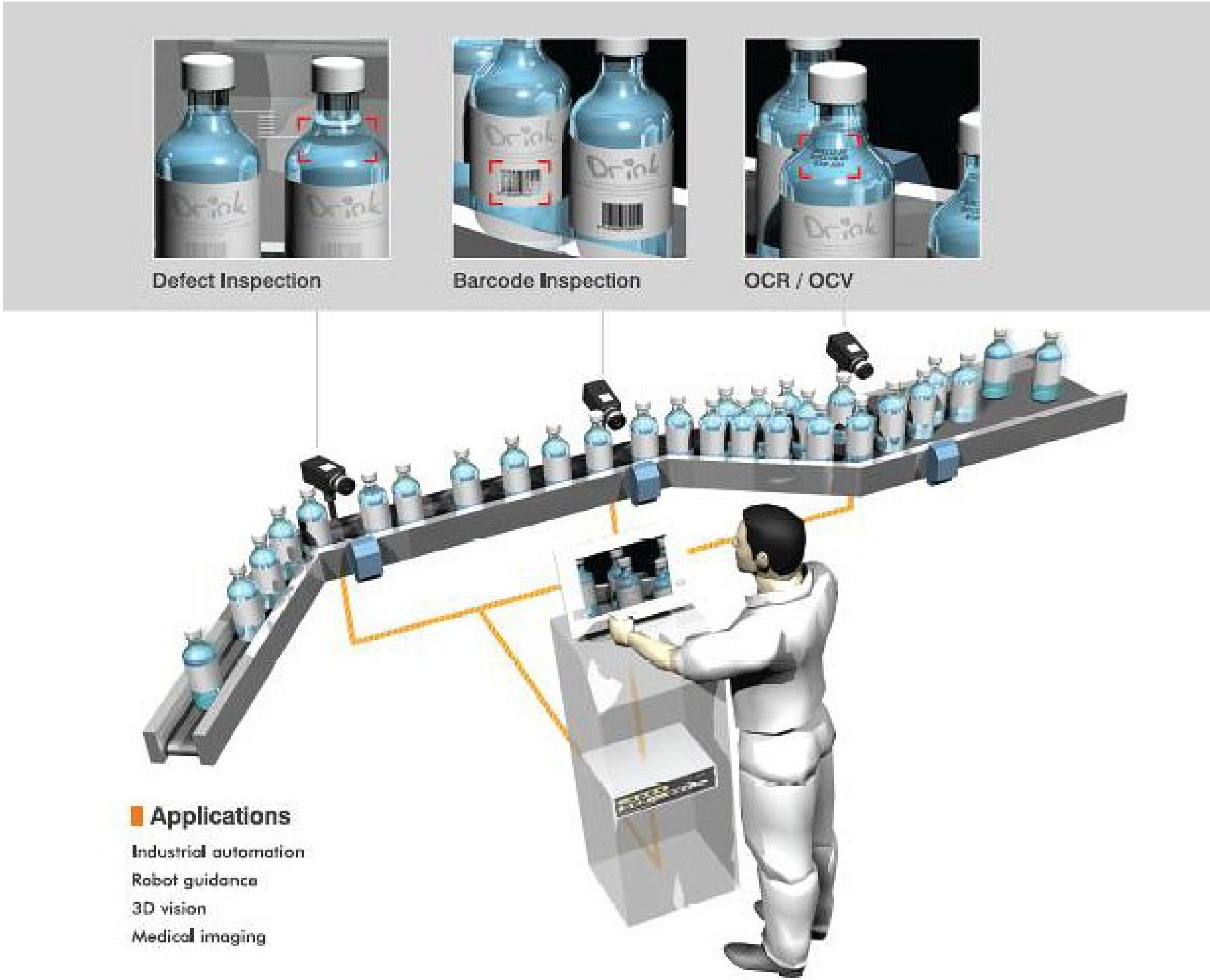
Robotic/Machine guidance
- Recognize, Locate, Guide

ID Tracking
- OCR, 1D & 2D barcode

Counting
- Counting bottles or canes in a conveyer

Safety
- Detect obstacles and alarm or stop

Law enforcement
- Vehicle tracking
- Electric road pricing


Defect Inspection
Barcode Inspection
OCR / OCV
Applications
Industrial automation
Robot guidance
3D vision
Medical imaging