A REVIEW ON APPLICATION AND IMPACT OF SENSORS

Prof. (Dr.) Sudhakar Singh
Professor and Head, Department of Physics &
Director, School of Science and Research
Sardar Patel University, Balaghat (M.P.), India

Abstract: A sensor is device that collects environmental data on water or soil in situ without the need to obtain a discrete sample. Sensors collect large amounts of data on a continuous basis over time, with the sensor often placed in one location. Real time data availability, lower analytical cost, ability to evaluate trends, timely response to public concerns and transparency to data presentations. There are a wide variety of sensors depending on the technology (analogue/digital) and applications.

Keywords: Moisture sensors, Pressure sensors, Vibration sensors, Biological sensors, Gas sensor

1. INTRODUCTION

Sensor is an input device which provides an output (signal) with respect to a specific physical quantity (input). The simplest example of a sensor is an LDR or a Light Dependent Resistor. It is a device, whose resistance varies according to intensity of light it is subjected to. When the light falling on an LDR is more, its resistance becomes very less and when the light is less, well, the resistance of the LDR becomes very high. We can connect this LDR in a voltage divider (along with other resistor) and check the voltage drop across the LDR. This voltage can be calibrated to the amount of light falling on the LDR. Hence, LDR is a Light Sensor. Sensors are connected to a computer network for monitoring and control purposes. Using sensors and the Internet, IoT systems have wide applications across industries with their unique flexibility in providing enhanced data collection, automation and operation.

2. VARIOUS TYPES OF SENSOR

There are several classifications of sensors, some are very simple and some are very complex. In the first classification of the sensors, they are divided in to Active and Passive. Active Sensors are those which require an external excitation signal or a power signal. Passive Sensors, on the other hand, do not require any external power signal and directly generates output response. The other type of classification is based on the means of detection used in the sensor. Some of the means of detection are Electric, Biological, Chemical, Radioactive etc. The next classification is based on conversion phenomenon i.e. the input and the output. Some of the common conversion phenomena are Photoelectric, Thermoelectric, Electrochemical, Electromagnetic, Thermo optic, etc.

The final classification of the sensors are Analog and Digital Sensors. Analog Sensors produce an analog output i.e. a continuous output signal with respect to the quantity being measured. Digital Sensors, in contrast to Analog Sensors, work with discrete or digital data. The data in digital sensors, which is used for conversion and transmission, is digital in nature. The following is a list of different types of sensors that are commonly used in various applications. All these sensors are used for measuring one of the physical properties like Temperature, Resistance, Capacitance, Conduction, Heat Transfer etc. Figure 1.1 shows different type of sensor.

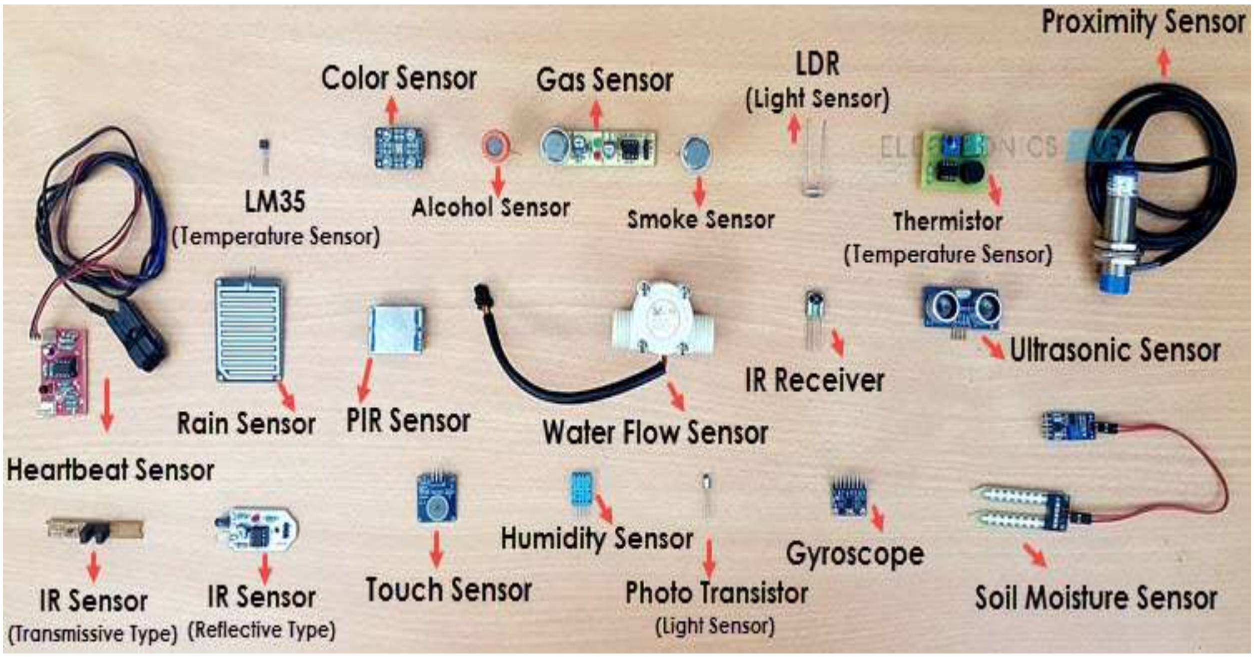

Figure 1.1: Different type of Sensor

2.1TEMPERATURE SENSOR

One of the most common and most popular sensor is the Temperature Sensor. A TemperatureSensor, as the name suggests, senses the temperature i.e. it measures the changes in the temperature. In a Temperature Sensor, the changes in the Temperature correspond to change inits physical property like resistance or voltage. There are different types of Temperature Sensorslike Temperature Sensor ICs (like LM35), Thermistors, Thermocouples, RTD (Resistive Temperature Devices), etc. Temperature Sensors are used everywhere like computers, mobile phones, automobiles, air conditioning systems, industries etc. Figure 1.2 shows temperature Sensor.

Figure 1.2: Temperature Sensor

2.2 PROXIMITY SENSORS

A Proximity Sensor is a non-contact type sensor that detects the presence of an object. Proximity Sensors can be implemented using different techniques like Optical (like Infrared or Laser), Ultrasonic, Hall Effect, Capacitive, etc. Some of the applications of Proximity Sensors are Mobile Phones, Cars (Parking Sensors), industries (object alignment), Ground Proximity in Aircrafts, etc.

2.3 ULTRASONIC SENSOR

An Ultrasonic Sensor is a non-contact type device that can be used to measure distance as well as velocity of an object. An Ultrasonic Sensor works based on the properties of the sound waves with frequency greater than that of the human audible range.

2.4 INFRARED SENSOR

IR Sensors or Infrared Sensor are light based sensor that are used in various applications like Proximity and Object Detection. IR Sensors are used as proximity sensors in almost all mobile phones. There are two types of Infrared or IR Sensors: Transmissive type and Reflective type. In Transmissive type IR sensor, the IR Transmitter (usually an IR LED) and the IR Detector (usually a Photo Diode) are positioned facing each other so that when an object passes between them, the sensor detects the object. The other type of IR Sensor is a Reflective Type IR Sensor. In this, the transmitter and the detector are positioned adjacent to each other facing the object. When an object comes in front of the sensor, the sensor detects the object. Different applications where IR Sensor is implemented are Mobile Phones, Robots, Industrial assembly, automobiles etc.

2.5 RFID SENSORS

RFID chips as small as the size of rice grains can be inserted directly under the skin for use as ID cards. There is a trend to use RFID chips in many products including contactless banks cards and Oyster cards. There are also cases where chips are implanted in pets and cattle for monitoring.

2.6 WEARABLE SENSORS

These latest sensors include medical sensors, GPS, inertial measurement unit (IMU) and optical sensors. With modern techniques and miniature circuits, wearable sensors can now be deployed in digital health monitoring systems. Sensors are also integrated into various accessories such as cloths, wrist bands, eyeglasses, headphones and smartphones.

3. ENVIRONMENTAL MONITORING SENSORS

Many potentially harmful chemicals, released by industries and human activities, can contaminate water, soil, or air and further impact the environment and public health. Real-time and in situ monitoring of various contaminants such as pathogens, metals, radioisotopes, volatile organic compounds, crude oil and agricultural chemicals at low levels is mandatory in the fields of industrial plants, automotive technologies, health and medicine, air and water quality control, natural soil/land/sea, and so forth. Reliable sensing technologies with high performance are highly desirable to address these issues. Sensitivity, selectivity and limit of detection are several key parameters to evaluate the performance of sensors. The aim of this special issue is to present original research articles on all kinds of sensors for monitoring environment. The paper cover various aspects including design and fabrication of sensor platforms for environmental monitoring, theoretical studies in sensing mechanisms and principles for environmental monitoring, sensors for real-time and in situ monitoring environments, detection of pathogen in water, monitoring pollutant gases, inspection and monitoring of contaminated soil/land/sea, development of portable sensors for environmental monitoring and multitarget detection in environmental monitoring. The papers in this special issue provide significant scientific contribution to the development and applications of sensing technologies in environmental monitoring. With respect to the above, this collection of articles is expected to be of interest for environmental engineering practitioners and researchers. Figure 1.3: shows Environment Monitoring Sensor

Figure 1.3: Environment Monitoring Sensor

Environmental monitoring is needed to be able protect the public and the environment from toxic contaminants and pathogens. It is used to prepare environmental impact assessments, as well establish the circumstances in which human activities carry a risk of harmful effects on the natural environment.

Types of monitoring carried out includes that of air, water and soil. All monitoring strategies and programmes have reasons and justifications which help them to establish the current status of an environment or to establish trends in environmental parameters.

3.1 TYPES OF CONTAMINATION

Toxic contaminants and pathogens that can be released into a variety of media including air, soil, and water. Air pollutants originate from sources such as vehicle emissions, refineries, power plants and industrial and laboratory processes. Pollutants include sulfur dioxide, nitrogen dioxide, carbon monoxide and volatile organic compounds.

Soil and water contaminants can be split into microbiological, radioactive, inorganic, synthetic organic and volatile organic compounds. Pesticides and herbicides are applied directly to plants and soils and spills, leaking pipes, underground storage tanks, waste dumps and waste repositories can cause incidental releases of other contaminants. Heavy metals and organic contaminants are increasing in parts of the environment as a result of anthropogenic activity. Metal contaminants concentrate in aquatic matrices such as suspended matter, sediment and biota, which results in an increased presence in the aquatic food chain. Some contaminants persist for years and can migrate through large regions of soil, until they eventually reach water resources and present ecological and human-health threats.

3.2 TYPES OF MONITORING

The three main types of environmental monitoring are air, soil and water. Air pollution is a constantly growing problem worldwide. Air monitoring is done via air sampling. The sampling can be passive, diffusive or done by biomonitoring with organisms that bioaccumulate air pollutants. As air pollution concentration is heavily influenced by the wind, anemometer data is also taken into account, as well as topography as landscape features can hinder the process of lateral atmospheric mixing.

Soil monitoring is done through soil sampling, which includes looking at soil erosion, salinity and contamination. Farming key to the world's food production while the regeneration of forests and jungles is central to keeping the air clean and free of CO2, so a large number of environmental monitoring projects focus on soil quality.

Water monitoring has a wide range of sampling methods depending on the environment and the type of material being analysed. The types of water sampling include judgmental, simple random, stratified, grid, systematic, adaptive cluster, biomonitoring, remote sensors, passive, semi and continuous and grab sampling. The chemical condition of water is of high importance, so the presence of oxygen, nutrients, oils, pesticides and metals are all monitored.

3.3 TYPES OF ENVIRONMENTAL SENSORS

There are numerous types of environmental sensors depending on the specifications needed for monitoring. Sensitivity, size and speed are all factors to consider when choosing an environmental sensor. Sensors can be divided into categories depending on the type of sensor being used and the environmental factors that an analyst is looking at.The main types of sensors include:

(i) Trace metal sensors - Laser-induced breakdown spectroscopy (LIBS), nanoelectrode array and miniature chemical flow-probe sensor
(ii) Radioisotopic sensors - RadFET (Radiation field-effect transistor), cadmium zinc telluride (CZT) detectors, low-energy pin diodes beta spectrometer, thermo luminescent dosimeter (TLD), isotope identification gamma detector, neutron generator for nuclear material detection, non-sandia radiation detectors
(iii) Volatile organic compound sensors - Evanescent fiber-optic chemical sensor, grating light reflection spectroscopy (GLRS), miniature chemical flow probe sensor, chemical sensor arrays, MicroChemLab (gas phase), gold nanoparticle chemiresistors, electrical impedance of tethered lipid bilayers on planar electrodes, MicroHound, hyperspectral imaging, chemiresistor array
(iv) Biological sensors - Fatty acid methyl esters (FAME) analyser, insulator-based dielectrophoresis, biological sensor arrays, µProLab, MicroChemLab (Liquid)

Sensors can also be split into types depending on environmental factors. These types of sensors include:

(i) Moisture sensors – Moisture sensors are essential for the measurement of volumetric water content in the soil towards the chimerical environment by several orders of magnitude
(ii) Pressure sensors/transducers – Pressure sensors operate on the basis of pressure applied. They are used in fields such as aviation, manufacturing biomedical measurements, auto mobile and hydraulic measurements.
(iii) Tilt sensors – The tilt sensor relates the two different axes indicating a reference plane which may be in two different axes. This plays an important role in measuring tilt angles with reference to the Earth's ground plane. Tilt sensors are common in industry and in game controllers.

(iv) Rain sensors – Rain sensors are a type of switching device which gets activated in the presence of rainfall. Rain sensors are used in areas such as water conservation devices in irrigation systems and in automobiles with windscreen wipers

(v) Vibration sensors – Vibration sensors are important for displacement and acceleration with respect to the enduring impact on the environment. Displacement, linear velocity and acceleration are different factors which vibration sensors are measured according to.

4. SENSORS UTILIZATION

Study on sensor utilization involving a total of 285 interested users in terms of sensors preferences. The users include researchers and practioners (developers). The results are classified in the next 5 main fields:

4.1 USES OF ENVIRONMENTAL SENSORS

Sensors: Temperature, Humidity (soil,leaf,ambient), Soil moisture, Wind (speed and direction), Pressure, Leaf, Ph, Redox. Application of these sensors include. Precision agricultural applications are one of the most required in the terms of temperature, humidity (soil, leaf, ambient) and wind (speed and direction). Ph and Redox sensors being demanded for water quality. Figure 1.4: shows Uses of Environment Sensor

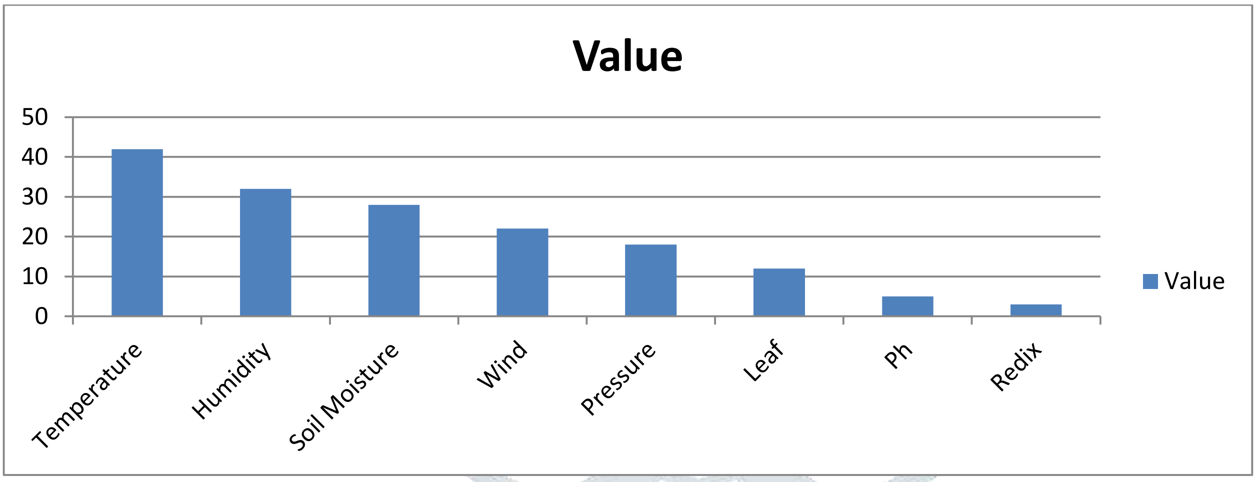

Figure 1.4: Uses of Environment Sensor

4.2 USE OF PHYSICAL SENSORS

Sensors: accelerometer, presence, vibration, power, hall, ultrasound, water, sound, bend, flex, strain, stress. Application of these sensors include. Motion of any kind using accelerometers, vibration, and presence sensors .security applications are waiting to be deployed. Bend, flex, strain and stress sensors let know how each object is interacting with the world and monitorize its state. Figure 1.5: shows Uses of Physical Sensor.

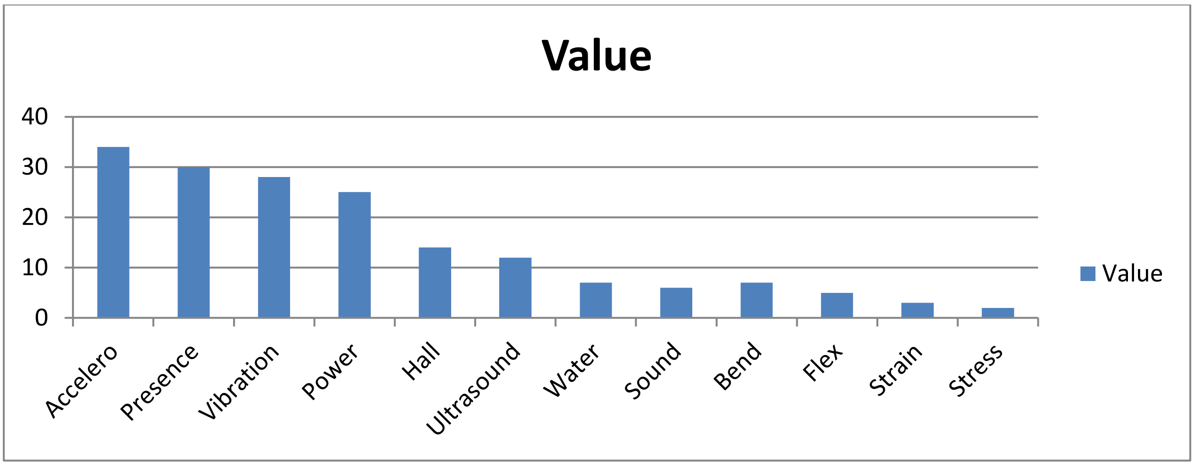

Figure 1.5: Uses of Physical Sensor

4.3 USE OF GAS SENSORS

Sensors: Co2, Co, CH4, O2, NH3, SH2, NO2, Pollution. Application of these sensors includes. Organic gases (carbone) derived from the "live system" such as respiration in humans (CO2), animals (CH4) and combustion (CO) of vegetable elements (fire forest) are the most required sensors. Other toxic gases which can be found in animal farms (NH3, SH2) and the fabric and cars pollution gases (NO2) complete the list. Figure 1.6: shows Uses of Gas Sensor

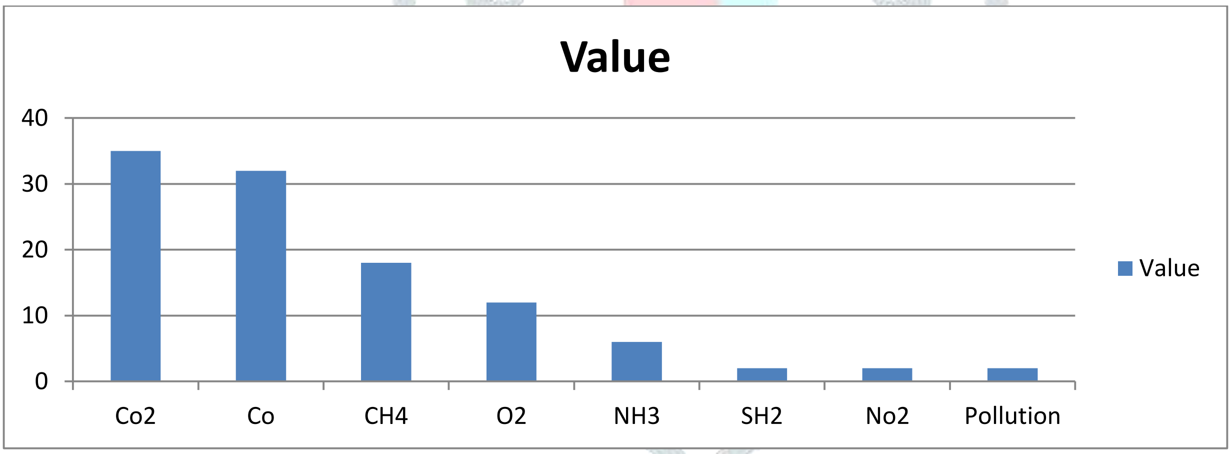

Figure 1.6: Uses of Gas Sensor

4.4 USE OF OPTICAL SENSORS

Sensors: Infrared, Sunlight, Radiation, Ultraviolet, color Application of optical sensor includes. Optical sensors to detect human presence through the IR spectrum are the most voted sensors in this area. Agriculture applications where the sun light, radiation and ultraviolet sensors are required in order to measure the total amount of energy and light which is absorbed by the plants. Figure 1.7: shows Uses of optical Sensor.

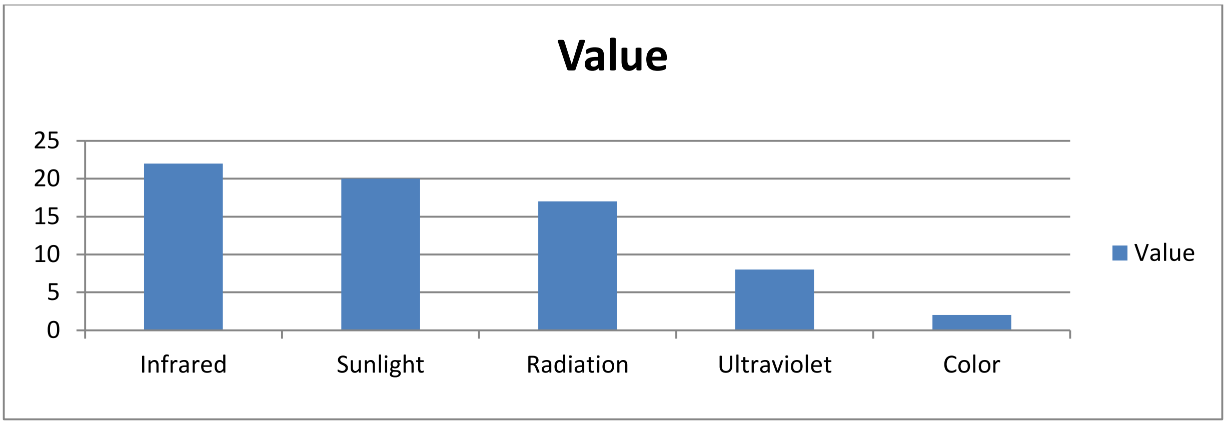

Figure 1.7: Uses of Optical Sensor.

4.5 USE OF BIOMETRIC SENSORS

Sensor types: Electrocardiogram ECG, Oximetry, Pulse, Fall, Sweat. Application of these sensor include. Prevent a possible attack or the fall of a elderly person (using an accelerometer) by monitoring his heart pulse, rate and other heart activities. Used in combination of SMS alarms using the GSM/GPRS module. Requirements a real time and redundant alarm system so that communication can always be established. Figure 1.8: shows Uses of Biometric Sensor.

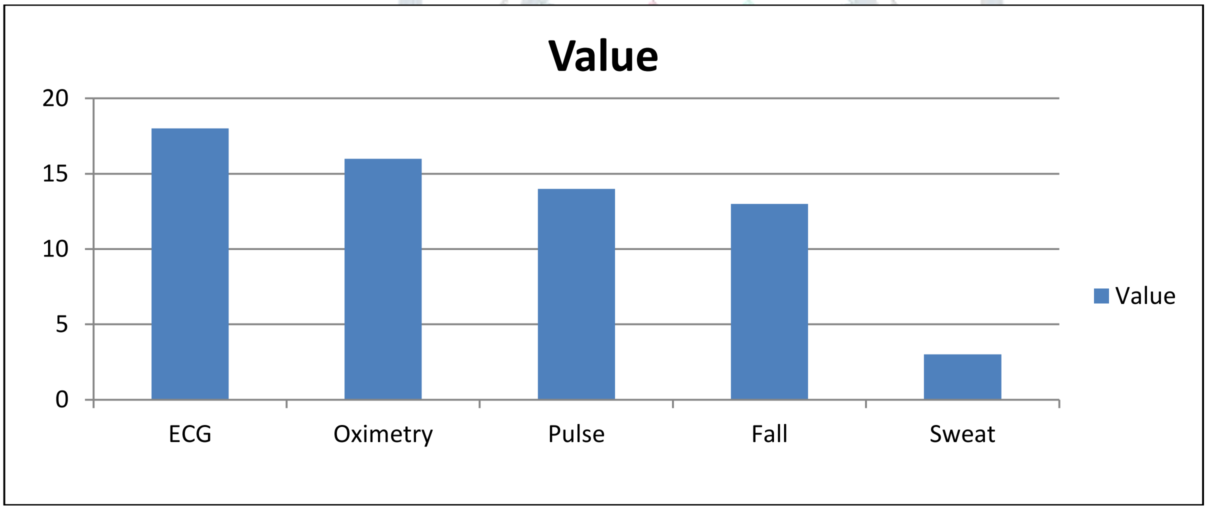

Figure 1.8: Uses of Biometric Sensor

5. CONCLUSION

Sensor come in various type, they used in each together to perform different sophisticated task. Some important task, which maintained by sensors are concluded follows.

5.1 SMART AGRICULTURE

(i) Using a combination of sensors such as humidity, temperature, and light, detect the risk of frost, possible plant diseases and find watering requirements based on soil humidity.

(ii) Manage crop cultivation to know the exact condition in which plants are growing from the comfort of your own home.

(iii) Control conditions in nurseries and closely monitor high performance of delicate crops, such as vines or tropical fruit, where the slightest change in climate can affect the final outcome

(iv) Determine the optimum conditions for each crop by comparing the figures obtained during the best harvests

5.2 NATURAL ENVIRONMENT PROTECTION

(i) Detect and prevent forest fires. Detect flames, heat and gases that help to identify the molecules of chemical compounds generated during combustion (CO and CO2). With GPS, allow the exact geolocation of the nodes.

(ii) Prevention. After installing the WSN, the network can also acquire the daily values for temperature and relative humidity in order to determine the likelihood of a fire in each zone under surveillance.

(iii) Alarm. Send an alarm indicating the status of the fire or the probability level and the area.

5.3 ANIMAL REARING

(i) Instal a wireless sensor network near animals to help optimise their rearing conditions.

(ii) Monitor the temperature of litters to keep it at suitable levels

(iii) Measure levels of gases produced by livestock such as methane (CH4), ammonia (NH3) and Hydrogen Sulphide (SH2);

(iv) Control animals' stress levels by monitoring flock restlessness with vibration and movement sensors.

REFERENCES

[1]. J. Vetelino, A. Reghu," Introduction to Sensors", 1st Ed., CRC Press, 2011.

[2]. J. Fraden, "Handbook of Modern Sensors", Physics, Designs andApplications, 4th Ed., Springer, 2010.

[3]. J. Janata, "Principles of Chemical Sensors", 2nd Ed., Springer US, 2009.

[4]. J. Cooper, T. Cass, "Biosensors", 2nd Ed., Oxford University Press, USA, 2004.

[5]. Mulchandani, K. R. Rogers, "Enzyme and Microbial Biosensors"; Techniques and Protocols, Humana Press, Totowa, New Jersey, 1998.

[6]. F. G. Bănică, "Chemical Sensors and Biosensor"; Fundamentals and Applications, John Wiley & Sons Ltd., 2012.

[7]. P. Gründler, "Chemical Sensors", Springer-Verlag Berlin Heidelberg, 2007.

[8]. G. Meijer," Smart Sensor Systems", Wiley, 2008.

[9]. https://electronicsforu.com/technology-trends/tech-focus/latest-sensors-applications, retrieved on 01 Dec. 2018

****