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Overview on Sensors used in Agriculture

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Abstract: According to the FAO changing climate is affecting directly and indirectly to the farming Practices and crop yield. changing climate demanding technological solutions with the aim of increasing production or accurate inventories for sustainably increase the productivity and resilience to environmental pressure. Sensors-based technologies provide appropriate tools to achieve the objectives of climate smart agriculture to achieve precise farming. The dramatic growth in technological advances and development in recent years enormously facilitates the fulfilment of these objectives removing many barriers for their implementation. Precision Agriculture is an emerging area where sensor-based technologies play an important role. Farmers, researchers and technical manufacturers, all together are joining their efforts to find efficient solutions, improvements in production and reductions in costs.

Keywords: Sensor Characteristics, Anatomy Of Sensors, Solar Radiation, Soil Moisture

I. INTRODUCTION

History has shown that advancements in fabrication technique and large scale integration in integrated circuits have been important drivers in the development of sensor technologies. By the development of large-scale silicon processing, permitting the capitalization of silicon to create new methods for transducing physical phenomena into electrical output that can be readily processed by a computer. Ongoing developments in materials technology will offer advanced features, such as greater fidelity, lower cost, and increased reliability. The American National Standards Institute (ANSI) standard MC6.1 defines the terms "sensor" and "transducer" as synonyms. It defines the transducer as "a device which provides a usable output in response to a specific measurand”. An output is defined in terms as an "electrical quantity," and a measurand is "a physical quantity, property, or condition which is measured". In 1975, the ANSI standard stated that "transducer" was preferred to "sensor". However, the scientific literature has not generally adopted the ANSI definitions, and thus currently "sensor" is the most commonly used term.

A. Definition

sensor definition varies with literature. sensor is define on the basis of information in the current technical literature as:

Sensor element: The fundamental transduction mechanism that converts one form of energy into another. Some sensors may incorporate more than one sensor element.

Sensor: A sensor element including its physical packaging and external connections.

Sensor system: A sensor and its assorted analog or digital signal processing hardware with the processing either in or on the same package or discrete from the sensor itself.

The composition of a complete sensor system is shown as follows

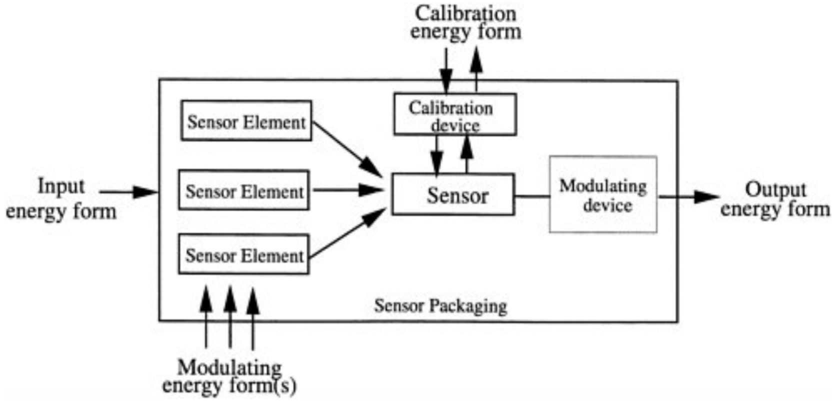

Fig. 1 Anatomy of sensor system

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1) Technological components in current sensor systems include
a) sensor element(s) and transduction material(s);
b) interconnection between sensor elements (electrical and/or mechanical) input "gate" and output "gate;
c) packaging;
d) modulating input interconnects;
e) calibration device;
f) calibration input/outputs;
g) output signal modifying device (amplifier);
h) output signal processing
i) actuators for calibration

One of the most important advances in sensor technology has been the focused as development of smart sensors. The definition of "smart" and "intelligent" sensing can be debate. Smart sensors are sensors with integrated electronics that can perform one or more of the following function as;

j) logic functions,
k) two-way communication,
l) make decisions

schematic representation of smart sensors is that employs "on chip" signal processing within a sensor package.

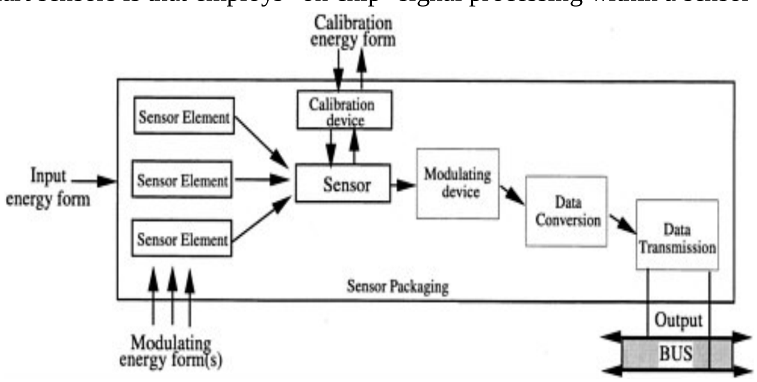

Fig. 2 Anatomy of Smart Sensor

2) The subsystems of a smart sensor include
a) a primary sensing element;
b) excitation control;
c) amplification (possibly variable gain);
d) analog filtering;
e) data conversion;
f) compensation;
g) digital information processing;
h) digital communications processing; and
i) power supply.

II. SENSOR CHARACTERISTICS

Sensors must have the significant properties to define quality of sensor . After receiving signals from a sensor these signals need to be processed to get acceptable and accurate process information. These signal requires:

1) Full knowledge regarding nature of signals and operation of the sensors
2) Succeeding knowledge regarding the received signals
3) Particulars about the dynamic and static characteristics of the sensing systems.

Static characteristics are those that can be measured after all transient effects have been stabilized to their final or steady state values. Static characteristics relate to issues such as how a sensor’s output change in response to an input change, how selective the sensor is, how external or internal interferences can affect its response, and how stable the operation of a sensing system can be. The most important static characteristics of sensors are as follows:

A. Accuracy
B. precision
C. linearity
D. sensitivity
E. repeatability
F. Reproducibility
G. stability
H. error
I. noise
J. drift
K. Minimum Detectable Signal
L. Calibration Curve

A sensing system response to a dynamically changing measurand can be quite different from when it is exposed to time invariable measurand. In the presence of a changing measurand, sensing system's transient properties can be describe by the dynamic characteristics. They can be used for defining how accurately the output signal is apply for the description of a time varying measurand. These characteristics deal with issues such as the rate at which the output changes in response to a measurand variation and how these changes occur.

1) zero order system
2) first order system
3) second order system

III. CLASSIFICATION OF SENSOR

There are many ways to categorize sensors. sensors are categories on following parameters as:

1) Based on physical property
2) Based on physical contact
3) Based on physical law
4) Based on signal type
5) Based on application or field area
6) Based on specification

Following are the classification of sensors based on signal type and physical law:

Input (Primary) Signal	Output (Secondary) Signals					
	Mechanical	Thermal	Electrical	Magnetic	Radiant	Chemical
Mechanical	(Fluid) Mechanical effects; e.g., diaphragm, gravity balance. Acoustic effects; e.g., echo sounder.	Friction effects; e.g., friction calorimeter. Cooling effects; e.g., thermal flow meter.	Piezoelectricity. Piezoresistivity. Resistive. Capacitive. Induced effect.	Magneto-mechanical effects; e.g., piezomagnetic effect.	Photoelastic systems (stress-induced birefringence). Interferometer. Sagnac effect. Doppler effect.	
Thermal	Thermal expansion; e.g., bimetallic strip, liquid-in-glass and gas thermometers. Resonant frequency. Radiometer effect; e.g., light mill.		Seebeck effect. Thermo-resistance. Pyroelectricity. Thermal (Johnson) noise.		Thermo-optical effects; e.g., liquid crystals. Radiant emission.	Reaction activation; e.g., thermal dissociation.
Electrical	Electrokinetic and electro-mechanical effects; e.g., piezoelectricity, electrometer, and Ampere's Law.	Joule (resistive) heating. Peltier effect.	Charge collectors. Langmuir probe.	Biot-Savart's Law.	Electro-optical effects; e.g., Kerr effect, Pockels effect. Electro-luminescence.	Electrolysis. Electro-migration.
Magnetic	Magneto-mechanical effects; e.g., magnetostriction, and magnetometer.	Thermo-magnetic effects; e.g., Righi-Leduc effect. Galvano-magnetic effects; e.g., Ettingshausen effect.	Thermo-magnetic effects; e.g., Ettingshausen-Nernst effect. Galvano-magnetic effects; e.g., Hall effect, and magneto-resistance.	Magneto-optical effects; e.g., Faraday effect, and Cotton-Mouton effect.		

Table 1: Classification Of Sensors

A. Mechanical Sensors

Mechanical sensors detect mechanical properties and actions. This includes pressure, velocity, vibration sensors and accelerometers.

1) *Pressure sensors:* Pressure is one of the most important physical properties. pressure is defined by the force applied on object to the area of an object. It measured in Nm^{-2} hence it is the first micro-sensors developed and used by the industry. A wide variety of applications calls for a wide variety of pressure sensors, but most belong in one of three major categories.

a) *Piezorezistive Pressure Sensors:* Piezorezistive pressure sensors have a piezo-resistor integrated in a membrane. Pressure is applied to the membrane, causing it to deform. piezo-resistive sensors causes a change in resistance, proportionate to the applied force.

b) *Capacitive Pressure Sensors*: In capacitive pressure sensors pressure is applied on the sensor surface, causing a membrane to deflect and the vary the capacitance . These sensors generally have greater sensitivity and linearity, while exhibiting very little or no hysteresis. However, these sensors also have higher production costs when compared to Piezorezistive pressure sensors.

c) *Optical Pressure Sensors*: Optical pressure sensors operate on the principal of the Mach-Zehnder interferometer. Laser light is brought into the sensor via an optical fiber. This light is split into two beams. One of the two beams crosses through one of the beams which is deformed by the pressure. This deformation changes the light's properties. The two beams are combined and brought to a photodiode. Different propagation speeds create a phase shift between these beams which is detected at the diode.

2) *Position and Motion Sensors:* Position sensors is the device which permits measurement of position as it play an important role in a wide variety of applications. There are diverse ways of detecting position are available, ranging from simple contact sensors to more complex contact-free ones. Position measurement can either be relative or absolute, linear or angular.

3) *Accelerometers:* Accelerometers are sensors that measure acceleration they are subjected to by change in velocity to the time taken. Most are based on resistive or capacitive and piezoelectric methods.

i) *Resistive And Capacitive Accelerometers*: Micro-sensors with an elastic cantilever with an attached mass is usually used in accelerometer. When the sensor is subjected to acceleration, cantilever deforms proportionate to the force to this acceleration . With piezo-resistive sensors, a piezo-resistor is integrated into the cantilever, whose deformation causes a change in its' resistance. With capacitive sensors the cantilever acts as one electrode, with a electrode strip acting as the other. As the cantilever is deformed it is brought closer to the electrode strip, which in turn effects the capacitance between the two electrodes. Resistive and capacitive accelerometers can be used to measure constant acceleration, such as that of earth’s gravity. They are generally used for measuring low frequency vibrations.

ii) *Piezoelectric Accelerometers:* Piezoelectric accelerometers are based on the piezoelectric effect. This means that an electric charge is created when the sensing material is compressed or strained. Several methods of straining of the material can be used, three of the basic being: compression, flexural, and shear. Shear is the most common one. These accelerometers are generally durable, protected from contamination, impervious to extraneous noise influences.

4) *Humidity Sensors:* Humidity is the amount of water vapour in the given substance (usually a gas). It is an important parameter in a variety of fields, including room air humidity in patient monitoring and exhibit perseveration in museums, meteorological observations, soil humidity in agriculture, and process control in the industrial applications.. Humidity is the amount of water vapour in the given substance (usually a gas). It is an important parameter in a variety of fields, including room air humidity in patient monitoring and exhibit perseveration in museums, meteorological observations, soil humidity in agriculture, and process control in the industrial applications.

a) *Absolute Humidity*: Humidity can be measured as the absolute humidity as ratio of water vapour to the volume of substance, relative (compared to the saturated moisture level) or dew point is called as temperature and pressure at which the observed gas starts to turn into liquid.

b) *Relative humidity (RH):* is the ratio of the partial pressure of water vapour to the equilibrium vapour pressure of water at a given temperature. Relative humidity depends on temperature and the pressure of the system of interest. The same amount of water vapour results in higher relative humidity in cool air than warm air. A related parameter is that of dew point. Most common humidity sensors are based on capacitive, resistive, and thermal conductivity measurement techniques.

i) *Capacitive RH Sensors:* In a capacitive RH sensor, change in dielectric constant is almost directly proportional to relative humidity in the environment. Relative humidity sensors have three-layer capacitance construction and consists of thermoset polymer, platinum electrodes, and a silicon chip with integrated voltage output signal conditioning. These sensors have low temperature coefficient, and response times that range from 30 to 60 seconds. They offer near-linear voltage outputs, wide RH ranges and condensation tolerance, and are stable over long-term use. However, the capacitive effect of the cable connecting the sensor to the signal conditioning circuitry is large compared to the small capacitance changes of the sensor. This limits the distance from sensing element to signal conditioning circuitry.

ii) *Resistive Humidity Sensors:* Resistive humidity sensors measure the resistance change in a medium such as a conductive polymer or a salt. Resistance usually has an inverse exponential relationship to humidity. Response times of these sensors is 10-30 seconds. Resistive humidity sensors are small size, low cost, and are usable from remote locations.

B. Thermal Sensors

Thermal sensors are used to detect thermal properties of an object. it convert thermal energy into equivalent electrical quantity. Temperature sensors detect a change in a physical parameter (resistance or output voltage) that corresponds to a temperature change. Three basic types of temperature sensors are electro-mechanical, electronic, and thermo-resistive.

1) *Electromechanical Temperature Sensors:* These sensors are based on expanding or contracting properties of materials when subjected to a temperature change. Bi-metal thermostats are created by bonding two metals into a single strip of material. Different expansion rates of the metals create electromechanical motion when the material is subjected to a temperature change. In capillary thermostats the capillary motion of expanding or contracting fluid is used to make or break a number of electrical contacts.

2) *Resistive Temperature Sensors:* Resistive temperature sensors are devices whose resistance changes with the temperature.

a) *Thermistors:* A thermistor is a type of resistor with resistance changes according to its temperature. They are typically consist of a combination of two or three metal oxides that are sintered in a ceramic base material. Thermistors can be classified into two types:

i) Positive temperature coefficient (PTC)

ii) Negative temperature coefficient (NTC).

PTC devices shows an increase in resistance as temperature rises, while NTC devices shows a decrease in resistance when temperature increases. The main disadvantage of the thermistor is its strong non-linearity. advantage is that it is Cheap and thermistors have large spread of parameters and calibration is usually necessary.

b) *Resistive temperature detectors (RTDs):* Unlike thermistors that use a combination of metal oxides and ceramics resistive temperature detectors are made from pure metal usually used copper, nickel or platinum ar. RTDs are useful over larger temperature ranges, while thermistors typically achieve a higher precision within a limited temperature range. As a RTD is a resistance device and it needs measuring current to generate a useful signal. Because this current heats the element above the ambient temperature (P = I2.R), errors can occur, unless the extra heat is scattered. This forces us to choose a small-sized resistance device with a quick response or a larger resistance device and better heat release. A second solution is to keep the measuring current low usually between 1 mA and 5 mA.

IV. CONCLUSION

Sensor research and development lends itself to dual use and commercialization efforts. Sensors are an enabling technology, applicable to a wide spectrum of uses. To be effective, it requires identification of potential uses and assessment of the degree of suitability. The greater flexibility and lower production cost associated with advanced, integrated electronic technology allows computer processing that once required large and sophisticated signal processing systems to be reduced to a microelectronic chip; for example, smart sensors have transduction, signal amplification, filtering, and other processing on a single substrate. However, from the perspective of the end user, the sensor system now appears simpler even with its increased functionality and internal complexity.

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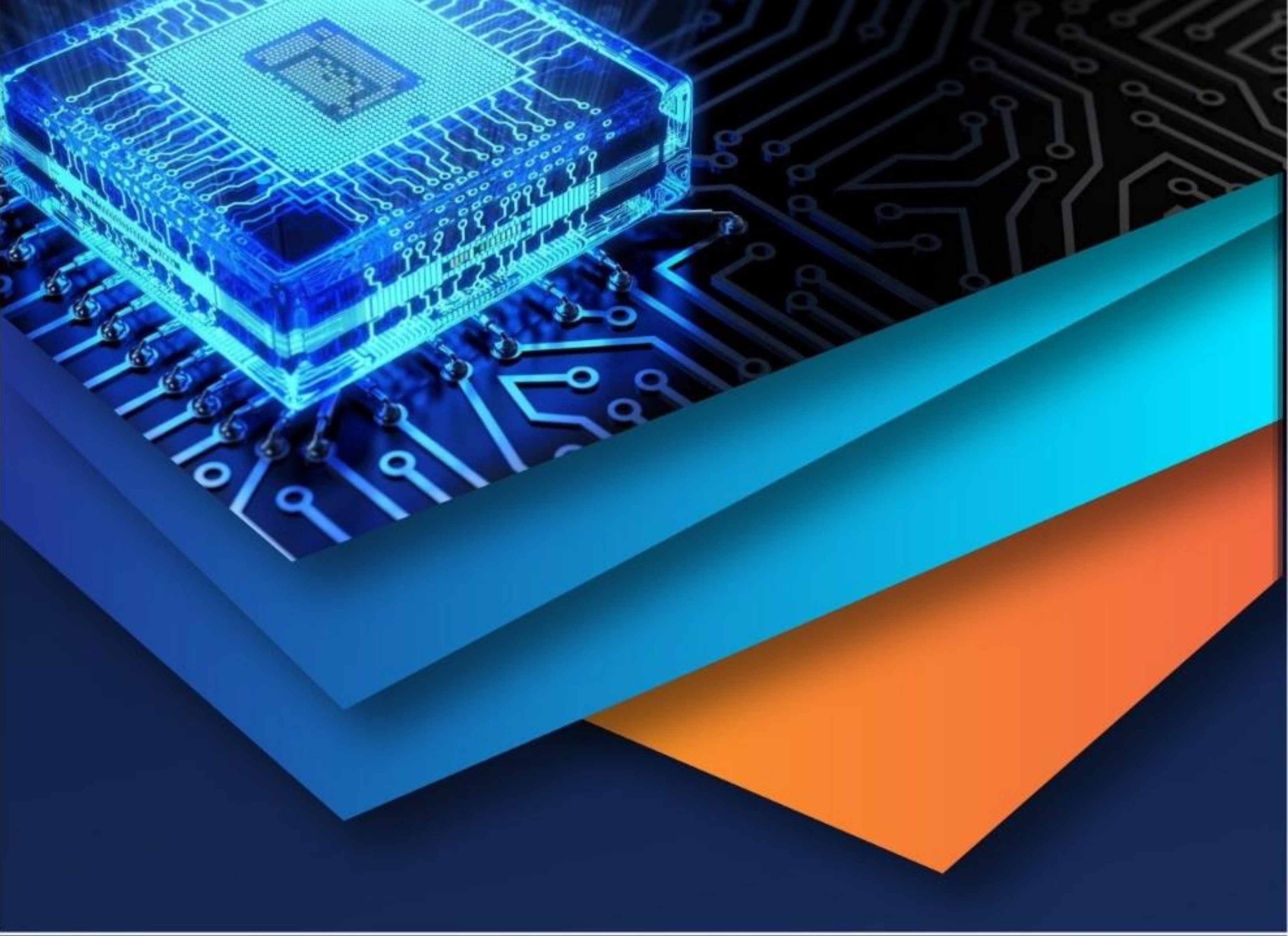

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