

Review: IoT Sensors, Classification and Applications in Weather Monitoring

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Abstract: In today's world of 'Data at Finger Tips', sensors have become ubiquitous, their applications have become numerous and this data is required round the clock and on-the-go. The data picked up by the sensors is delivered to end-user in real time by IoT and further utilised for real time reports, off-line analysis and data aggregation. This review paper focuses on the different types of IoT sensors used for monitoring of atmospheric parameters. Sensors aided by wireless networking are the backbone of nowcasting and prevailing trends at any given area. IoT sensors data combined with satellite data and operational models enhance accuracy and expedite weather predictions. IoT data enable validation and updating of atmospheric depression models. Comprehensive study of sensors has been carried out and consolidated in this paper for ready reference by all stakeholders- Meteorological department, pollution control board, Non-destructive testing and evaluation of corrosive elements in atmosphere, farmers and horticulturists, to name a few.

Keywords: IoT, Weather Sensors, Data Transmission, Wms, Wireless, Nowcasting

I. INTRODUCTION

With rapid advancements in technology, various electronics gadgets have marked their importance in each and every aspect of human life. These devices used along with networking, computing and communication with other devices marked the advent of Internet of Things (IoT). It utilises the connected internet connectivity to provide inter-connection and inter-communication among these devices continuously. IoT encompasses sensors, actuators, interactive devices and many more, which are connected with each other through well defined communication interfaces and message formats allowing them to exchange information among themselves and the internet. The information collected through sensors is processed and the suitable control mechanism is implemented with the help of actuators. [1, 2, 3]

This paper provides classification of these sensors, followed by nowcasting sensors. Various sensors are mounted at multiple points of a particular geographical area for collecting the data. The data collected is then processed and analysed there by summarizing the behaviour or pattern prevalent in that particular area.

II. SENSOR CLASSIFICATION

Sensors are the devices that respond to the changes occurring in the surroundings and collect information from varied sources. A Wide range Sensor Network includes multiple sensors called sensor nodes, which aid in data collection for the application under various situations. Distinct sensors are used to provide relevant and accurate information regarding a particular application. The collected data is shared with the other connected devices and management systems for developing application specific analysis and insights into crucial trends in the information.

A primary classification of sensors is into analog and digital sensors.

- i. **Analog Sensors:** Sensors producing continuous or analog output are classified as analog sensors. These depend on the parameter being measured by the sensor.
- ii. **Digital sensor:** These include digital data conversion and transmission. The measured signal is converted to digital signal and is then transmitted.

Based on input power source, sensors are classified as Active and passive sensors.

- i. **Active sensors:** These sensors require external power supply for functioning.
- ii. **Passive sensors:** These sensors are independent of external power supply. They self generate the power required for their functioning from the quantity being measured.

Sensors are classified based on the mode of detection used.

- i. **Electric sensor:** It is converts the sensed parameter into electric signal which is then used for measurement or triggering an action.
- ii. **Chemical sensor:** These poses ability to detect chemical level changes and chemical substances in air and liquid mediums.
- iii. **Biosensor:** It is an analytical device used for detecting a chemical substance in biological samples (analyte). [4]
- iv. **Electrochemical Sensor:** They are used for determining different gases, water quality analysis - Nitrogen compounds, alkali and heavy metals to name a few, medical and bio-technical applications. [5] These facilitate the information by coupling the chemically selective layer or the recognition element to an electrochemical transducer.[6]
- v. **Optical Sensor:** The target object interrupts the light beam emitted by the source and this interruption is suitably evaluated for its characteristics.

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These measure quantities like temperature, Pressure, vibrations, Strain, pH-value, Electric field, particle size, type of object material and others. Photoconductive devices, photovoltaic cell (solar cell), photodiodes are the common optical sensors. These in combination with biosensors are widely used for analytical applications like monitoring of environment and human health. [7]

- vi. **Object Information Sensor:** These are object specific and application specific in nature, as in CPU temperature monitoring and Hydraulic oil temperature monitoring where in temperature sensor is internal to the system.
- vii. **Machine Vision Sensors:** These possess the ability to capture the images and also process them to render the suitable information.[8]

Sensor Data Transmission, Reception, Post-Processing: The data acquired by various sensors is integrated and transmitted using low power transmitters. The received signal is converted into desired format for post processing. [9] Data aggregation, data fusion, data compression play a vital role in eliminating data redundancy, effective bandwidth utilisation, reducing network traffic and energy conservation thereby increasing the efficiency and life span of Wireless Sensor Network. [10]

III. SENSORS FOR WEATHER MONITORING SYSTEM (WMS)

Weather Monitoring System (WMS) is used for real time information for weather. Multiple parameters like temperature, humidity, atmospheric pressure, rainfall, and other parameters.

- i. **Air temperature and Humidity sensors:** Temperatures sensors are used to measure the temperature and heat of a particular medium. The measured value is then converted to electric signal usually in terms of voltages. Humidity sensors detect the relative humidity of air. It is the ratio of moisture in the air to the highest amount of moisture at a particular temperature. These could be capacitive, resistive or thermal in nature. Hence a sensor measuring both temperature and humidity is more accurate and relevant because of their interdependency. DHT11 is a widely used temperature and humidity sensor generating a digital output. It uses capacitive humidity sensor and a thermistor. DHT22 is another such sensor which is similar to DHT11, but has better resolution and a wider measurement ranges. The responsiveness and accuracy are outstandingly high.
- ii. **Barometric pressure:** It measures the changes in pressure or force applied per unit area exerted by the atmosphere and converts the data into electrical signal. BMP180 is one of the BMP XXX series sensors, which is a widely used barometric pressure sensor with I2C interface. BMP varies with both the weather and altitude. Pressure is affected by the temperature changes and hence these BMP sensors have temperature sensor present in them.

- iii. **Rain Drop Sensor:** Rain drop sensor is used for sensing the rain. Rain board module detects the rain and the control module compares the analog values and then converts into digital values for further processing. These two modules are responsible for functioning of the sensor. The control module consists of a potentiometer which decides the sensitivity and LN393 comparator for comparing analog values. The rain board module has variable resistors in the form of copper tracks. The rain board wetness determines the resistance. [11]

- iv. **Anemometer for Wind speed and direction:** Anemometer determines the wind speed. A wind vane is used to determine the wind direction. A potentiometer is used for measuring the wind direction. The resistance varies in accordance to the direction of wind. The analog output values are to be converted into degrees notation. Usually the direction up to 540degrees might be received which are to be carefully calibrated into 0-360 degree range of values. Anemometer is a 3 cup, 3 wire device. The opening and closing of reed switch by the device's cups determine the wind speed. The cups have a small magnet which enables this operation when passed over the reed switch once per revolution. Reed switch produces a digital output. The number of revolutions during a period of time, usually 2.5 seconds, is converted to get wind speed. [12]

- v. **Pyranometer for Solar Radiation:** Broadband solar radiation called the global irradiance is an electromagnetic wave with 300-3000nm wavelength range. Pyranometer is used to measure the solar radiation flux density from the hemisphere above within the wavelength range. Pyranometer converts the received solar radiation into electrical signals in the form of voltages. The voltages are converted into the global irradiance parameter using the sensitivity of the sensor. Solar spectrum lies in the wavelength range from 0.15 to 4.0 μm of which a part of it is measured using pyranometer. The angle of solar radiation called the cosine response is also measured by the pyranometer.

These use solid-state/thermopile sensors or silicon photocells for light detection purpose which yield high accuracy. LDR, photodiodes or phototransistor may also be used for detection purposes, but the accuracy is comparatively less. [13]

CMP11 is a popularly used sensor for measuring solar radiation using a thermopile pyranometer. It has spectral range of 280-2800nm making it widely implemented in green houses, under plant canopies applications.

SQ110 is yet another widely used sensor calibrated for solar radiation measurement. The output voltage produced by the sensor is in response to the light intensity in the visible range of the irradiance spectrum.



vi. UV radiation: It detects the incident ultraviolet radiation. The sensor produces analog output voltages with UV intensity. UV index is the international standard used for measuring UV radiation from sun. Dividing the output analog voltage by 0.1V yields UV index. VEML6075 is one of the most basic UV sensors capable of reading both UVA (tanning rays) and UVB (burning rays) light bands. It uses serial interface for device interaction. ML8511 is another UV light sensor with its applications in weather monitoring systems. It is capable of detecting 280-390nm light effectively. This range includes most of the UVA spectrum and partly UVB spectrum. The output analog voltage is linearly dependent on the UV intensity measured by the sensor. Integrating the exposure to UV over a period of time gives the UV load. [3]

Cloud cover sensor: Cloud cover sensor measures the cloud height and cloud base. Cloud cover is determined using the difference measured between ambient temperature and the sky temperature. It is based on the fact that the heat radiated is less for a cloudless sky than a cloudy sky. MLX90614 is a commonly used sensor for detecting the presence of cloud by measuring IR radiation from the sky. Cloud detectors are often affected by the dew settling on the sensing plates which can be avoided by using a heating element provided this doesn't affect the temperature measurements. [14]

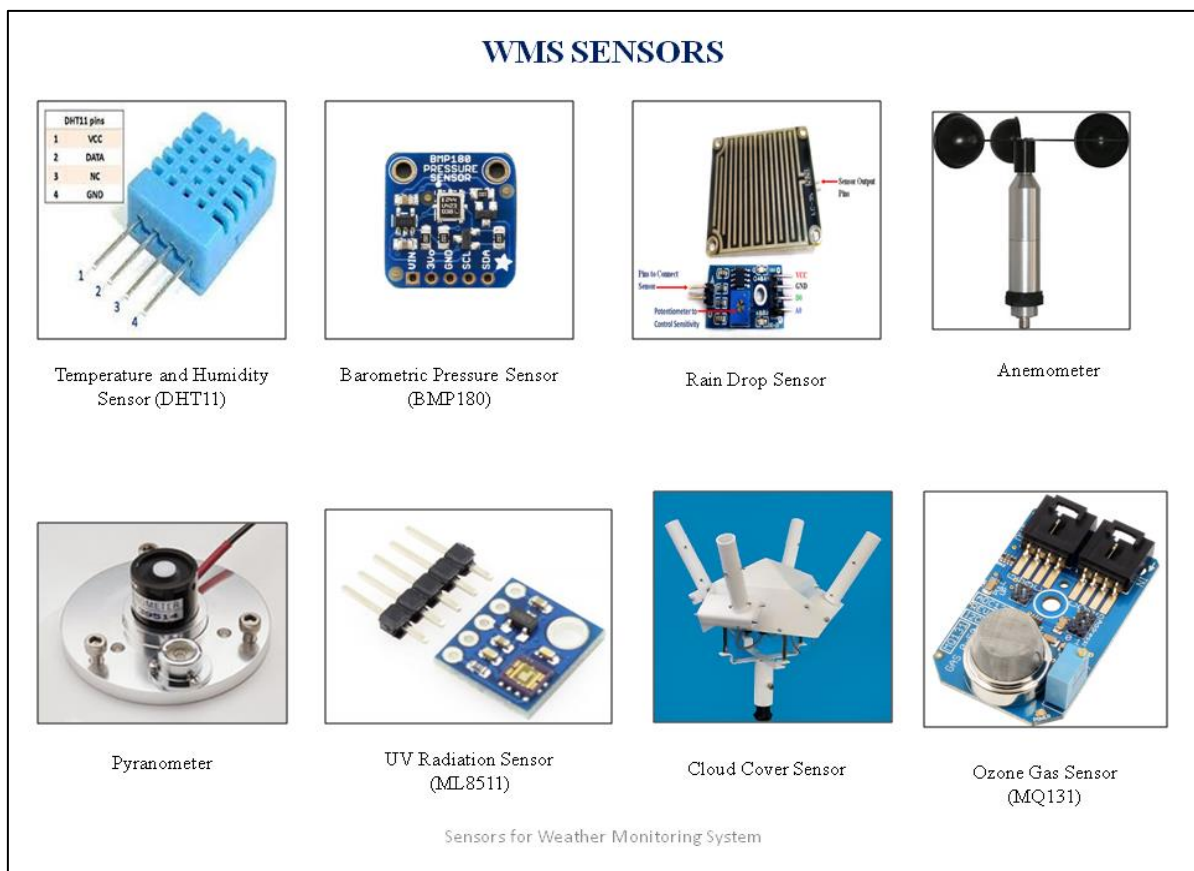


Fig 1: Weather Monitoring System Sensors

vii. Ozone Sensor: MQ131 is a semiconductor gas sensor composing sensor circuit and heater circuit. A metal sensor may be used for high ozone concentration while a blue Bakelite sensor may be used for low ozone concentration levels (using WO3 or SnO2 as sensitive materials). It is capable of sensing concentration range of 10ppm-1000ppm. An internal pre-heater aids in ideal sensing but requires about 24 hours for preheating to achieve optimal accuracy. Peak ozone concentrations occur for high intense sunlight. [15]

The weather monitoring sensors are shown in Figure 1. The stratospheric Ozone absorbs the harmful UV rays from the Sun thereby protecting the life on Earth. On the contrast, the surface Ozone reacts with the materials and poses a threat to the life. But ozone when inhaled causes respiratory issues as it chemically reacts with the biological elements in the tract.

The surface ozone has adverse effects on the plant ecosystems. It oxidizes the plant tissues during respiration and thereafter blocks all the pores, and hence affecting the photosynthesis process. In the presence of intense sunlight, Surface Ozone degrades the polymers, as in rubber, thus reducing their life span.

A monitoring and alerting system may be designed which is capable of monitoring the surface ozone levels and their concentration. When the levels are beyond the threshold levels, an alert would be communicated to the End-User.

Evapotranspiration: is the amount of water accumulating into the atmosphere through evaporation from various surfaces and transpiration from plants. A system designed primarily using relative humidity sensors, pressure sensors and solar radiation sensors can be used for measuring evapotranspiration value.

Off-the-grid WMS: Solar power could be used for powering the system, thus enabling an Off-the-grid WMS. The operation and output efficiency of the solar plant are affected primarily by the module temperature and the soiling of panels.

Module Temperature Sensor: It is an object information sensor. The energy output from a solar panel depends on its temperature. For solar plant performance ratio estimation, the temperature of the panel plates called the module temperature is important. Measuring the module temperature at multiple locations of plant gives a clear temperature distribution over the plant.

Soil Station: The fine dust in the air settles on the panel surface leading to decrease in the efficiency. This is called soiling of panels. The decrease and loss caused by soiling could be measured using soil station.

Data Quality: Before deploying these IoT sensors, there are thoroughly validated using high precision instruments. Periodically, sensors are calibrated against highly precise sensors in the labs to ensure accuracy of the sensor output.

IV. CONCLUSION

It is concluded that the wide range of sensors available for monitoring the weather, combined with the enormous potential of wireless networking is adequate to build a robust WMS.

This can also be configured to measure atmospheric toxins and thereby post an alert to officials and civilians. Green house effect and global warming can be better understood and remedial measures can be undertaken.

Apart from these, sensors find their applications in smart healthcare, smart cities, automobile industries to name a few.

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