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A REVIEW ON: A HYBRID SMART IOT BASED REAL TIME ENVIRONMENT MONITORING SYSTEM

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Abstract

An IOT-based environment monitoring system is the focus of this paper. The primary goal of the internet-based Environment Monitoring System is to deliver environmental data to remote locations. Environmental and ambient monitoring applications can benefit from the proposed approach. The system uses low-power wireless sensors that link to the Internet and deliver their data to a central server to represent environmental and ambient parameter monitoring. Since fuzzy logic permits the efficient combination and evaluation of various parameters, its application in WSNs is proven to be a promising technique. As its execution needs are simple enough for sensor nodes to handle, fuzzy logic is a viable strategy that can boost the overall performance of the network. Fuzzy logic's potential extends well beyond that of conventional systems, finding applications in many areas of study (statistics, quality control, optimization methods) and enabling both interdisciplinary approaches and gains in efficiency. Fuzzy logic has been utilized in WSNs to enhance decision-making, lower resource consumption, and boost overall performance in areas including efficient deployment, localization, clustering and cluster head election, routing, data aggregation, security, etc.

Keywords: IoT, Environment Monitoring, IoT Sensor Network, Real Time Environment Monitoring.

1. Introduction

As the damage caused by fine dust and ozone pollution continues to rise, interest in the atmospheric environment is on the rise around the world. Toxic fine dust is primarily created by fossil fuel combustion, according to the most current study. This fine dust is known to induce or exacerbate numerous respiratory ailments in the human body, according to the study. Photochemical reactions of NO2 and VOCs produced by automotive exhaust gas and the like owing to bright sunshine produce ozone, which in turn causes respiratory system illnesses. Computer hardware and software, as well as mechanical or other components, may be integrated into an Embedded System to execute a specific task [1]. An embedded system may be marketed into a highly competitive and cost-conscious market because it is a microcontroller-based, software-driven system that can be autonomous or human- or network-interactive and works on a broad variety of physical parameters. It does not fit the mold of a typical embedded system, commercial program, or scientific program, and neither does it run on a personal computer or UNIX. Embedded systems have various levels of complexity. Generally, 32 or 64-bit controllers are used with an operating system, such as a Personal Digital Assistant (PDA) or a mobile phone. [2] System components at the lower end of the price spectrum — typically 8,16-bit controllers combined with a minimum operating system and specialized hardware. Connecting all our devices and providing us with real-time information is becoming increasingly popular as the Internet of Things (IoT) grows. We're learning more and more about the resources at our disposal and how to make the most of them. It is now feasible to manipulate the environment around us because to advances in technology. We can keep a close eye on the world around us with the technology we have today. Families are becoming more and more likely to have one or more members who work full-time, leaving their houses empty for long periods of time. For optimal safety and management, folks should keep an eye on their homes while they're gone. [3] The goal of this work is to build a single solution that can monitor multiple characteristics of a home. Goal is to create one product capable of measuring and monitoring all of these variables at the same time, rather than having separate devices for each. The product can also be configured to notify the user if the fridge door is left open or the trash can is full. People need to be able to keep an eye on their entire home environment using a single product that can display the information they need on their mobile devices [4].

Air pollution is a problem for everyone, whether they reside in a developed or developing country. Air pollution is a substantial health risk in emerging nations due to rising industrialization and vehicle ownership rates [5]. Air pollution has been linked to a wide range of health problems, from mild allergic responses like itchy eyes and a runny nose to more severe ones like bronchitis, heart disease, pneumonia, and worsened asthma. A recent research found that between fifty thousand and one hundred thousand people die each year in the United States as a direct result of air pollution. throughout comparison, there are more than 300,000 members of the EU and more than 3,000,000 throughout the globe. The Air Pollution Monitoring System maintains tabs on the air quality through a web server linked to the Internet and sounds an alert if the quality dips below a preset level, such as when there is not enough carbon monoxide, smoking, alcohol, benzene, nitrous oxide, or natural gas in the air. The air quality, expressed in parts per million (PPM), will be clearly shown on both the LCD and the website. [6]

The importance of monitoring indoor environments has been shown by several research in recent years. For the first time in its history, the World Health Organization has acknowledged air pollution as a worldwide health issue. The dangers aren't limited to the great outdoors; in fact, studies of interior air quality have revealed pollution levels to be far greater than those outside. Half of the energy consumed in the EU goes toward heating and cooling buildings and enterprises, and most of this energy is wasted, according to the EU Heating and Cooling Strategy [7]. In the United States, fossil fuels account for 84% of the energy needed for heating and cooling, while renewables account for just 16%. [8] The heating and cooling sector's energy consumption and reliance on fossil fuels must be drastically reduced if the European Union is to meet its climate and energy goals. To reduce energy waste and consumption, the European Union prioritizes automation and environmental control in its Heating and Cooling Strategy. Indoor environmental monitoring systems are growing in popularity for these and other reasons. In this research, we look at a system for monitoring ecosystems that relies on the Internet of Things. The Enviro-monitoring System is a Practical and Low-Cost Method for Applying IoT in the Field of Sensing and Monitoring at Home and in Industry.

2. IoT Architecture

The phrase "Internet of Things architecture" is used to describe the intricate relationship between the many components of an IoT networking system. “It is often organized in levels that facilitate evaluation, monitoring, and maintenance by system administrators”. In a four-step process [9], data collected by sensor-enabled gadgets makes its way to the network, where it is processed, analyzed, and finally stored in the cloud. There is room for growth in the IoT, and that means exciting new opportunities for consumers.

Different Layers of IoT Architecture

IoT technology has become increasingly well-liked in recent years, and it may be put to use in a wide range of contexts. The functionality of IoT apps is determined by the specifics of their design and development for use in a certain domain. However, there is no universally accepted, well-defined architecture of work [9]. The exact business task at hand determines the required complexity and number of architectural levels. The most common and extensively used structure consists of four distinct layers.

1. Sensing Layer

Devices such as sensors and actuators are housed in this Sensing layer. “These sensors and actuators collect data (physical/environmental characteristics), analyze it, and then transmit it across a network”.

2. Network Layer

The Data Acquisition System (DAS) houses useful tools including Internet and network access points. DAS manages data collection, data aggregation, and data formatting (e.g., converting analog sensor data to digital data). Advanced gateways do more than just link sensor networks to the Internet; they also conduct a wide range of standard gateway tasks including filtering out malicious software, making judgments based on incoming data, managing data, etc.

3. Data processing Layer

We can call it the central nervous system of an Internet of Things ecosystem. Here, data is analyzed and prepared for transfer to a data center, where it will be used by business applications to perform tasks like tracking and management. Here is where the use of analytics and information technology at the edge becomes important.

4. Application Layer

“This level is the fourth and last one in the IoT architecture”. End-user applications in sectors including agriculture, health care, aerospace, farming, defense, etc. rely on data handled in data centers or the cloud.

3. Common Modules Used for Environment Monitoring System

3.1 Dust Sensor:

Principles and characteristics the sensor used in this module is the GP2Y1010AU0F. This device incorporates an inbuilt infrared emitting diode (IRED) to measure the amount of dust and smoke in the air by detecting the reflected light. The output voltage is proportional to the density of the dust.

3.2 DHT SENSOR

Accurate digital readings are produced by the Temperature & Humidity Sensor's array of temperature and humidity sensors. High reliability and durability are ensured using cutting-edge digital signal collection methods and cutting-edge temperature and humidity sensing technology. With its high-quality 8-bit microprocessor, quick response time, and immunity to interference, this sensor combines a reactive humidity sensor with a non-thermistor temperature sensor (NTC). [10] Each and every DHT11 sensor's humidity calibration is thoroughly tested in a lab setting. OTP memory stores the calibration coefficients used by the sensor's internal signal detecting system [11]. System integration is sped up when a serial interface is used. Its small form factor and low power consumption make it an excellent choice for a wide range of applications, even those with particularly severe needs. This component is housed in a 4-pin, single-row-pin box. It's simple to sign up, and bespoke plans can be provided on demand.

3.3 Power supply

Electricity is supplied by generators to consumers. Power supplies are more correctly referred to as electric power converters due to their principal role of transforming one kind of electrical energy into another. There is a wide range of uses for diverse energy sources. The gadgets may function as standalones or as parts of more complex setups.

4. Basic Home Environment Monitoring System

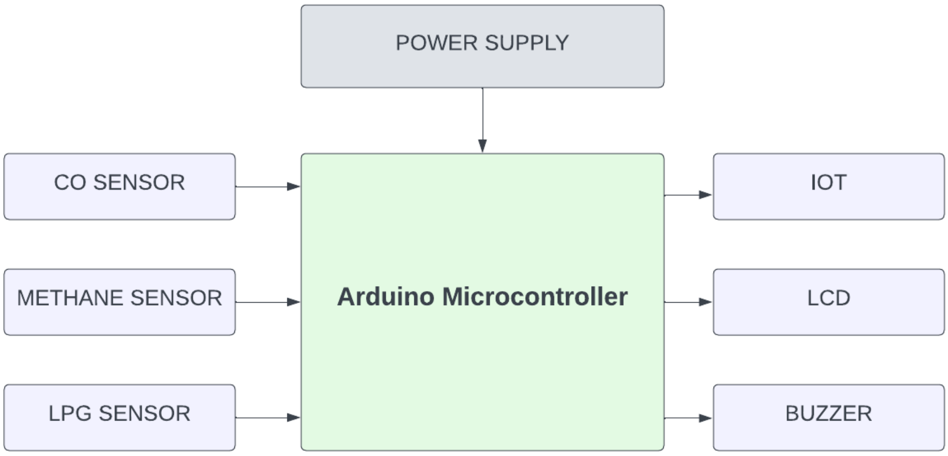


Figure: 1 Basic Home Environment Monitoring System

The IoT architecture is used to build the home environment monitoring system, which consists of three primary parts: the device, the server, and the client. The user will be able to monitor his home environment from a mobile device as a result of the integration of the three components. The system's design process is based on an incremental model [12]. The various parts of the work will be worked on separately and then brought together to form a cohesive whole. Deliverables from this work can be released in stages by adding sensors to each release. All components of the home environment are monitored by a variety of various sensors, and this system can be expanded when new technology develops sensors for other functions.

4.1 THINGSPEAK

When obtaining sensor data and sending it to the server, software implementation is critical. The "Thingspeak" website is used to visualize the sensor data. To cut down on implementation costs, this data logger is available as open-source software. It allows users to create their own data channels in an unrestricted environment. [13] Each channel will have eight fields where the various data can be entered, and the data is automatically plotted in a graphical form. It is possible to communicate with the Thingspeak server by means of the IP address it has been assigned. A single API key will be assigned to a single channel for data entry into the website. So before we write any data, we need to enter the API key. Then the data will be stored and shown in the desired channel.

4.2 Environment Sensing

"Sensors like the DHT11 Temperature and Humidity Sensor, MQ-7 Carbon-Monoxide Gas Sensor, and MQ135 Air Quality Sensor are used by the robotic system". The technology can also detect CO2 and smoke levels in the atmosphere. A digital thermometer and humidity sensor, the DHT11 measures both temperature and humidity. Data is sent out on the data pin through capacitive humidity sensor and thermistor. Detecting harmful chemicals in the air, the MQ-135 sensor is used by the air quality sensor [14]. Having a high toxicity level Detection of carbon monoxide (CO) is challenging since it is odorless, colorless, and tasteless. Carbon Monoxide (CO) gas sensor MQ7 is capable of measuring CO concentrations from 20 to 2000ppm and displaying the reading as an analogue voltage. Fast response time and great sensitivity make this sensor ideal. The sensor's output gain can be manually adjusted using a potentiometer. Using the ADS1015, both sensors' analogue data is converted to a digital format [15].

5. Android App Development Tools for Real Time Monitoring and Power Unit

In order to use the MIT App Inventor visual development environment, you don't need to have any prior programming experience. We decided to use MIT App Inventor to develop Android apps. App Inventor, developed in partnership by MIT and Google, has grown in popularity as a teaching tool and a platform for students to put their innovative ideas into practise.

5.1 Power Module

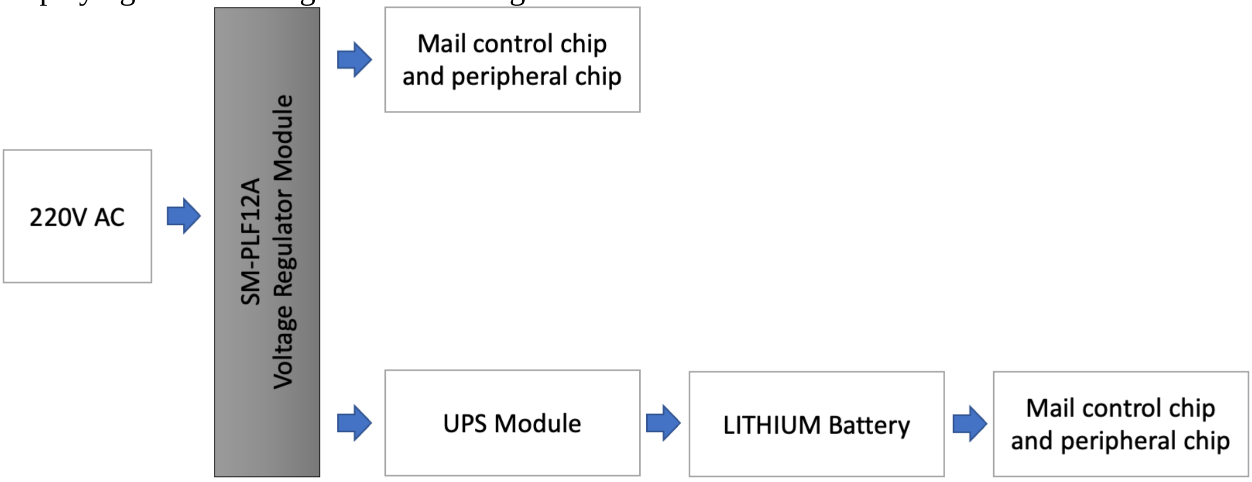


Figure: 2 Power Control Unit

The system can be powered by either an external commercial power source or a set of batteries. The SM-PLF12A module can be powered by 220V AC when a voltage regulator is used. The central processing unit (CPU) and other chips will get electricity after the voltage has been lowered. The battery is connected to the battery UPS module that is in turn connected to the SM-PLF12A module. The lithium battery supplies energy for the central processing unit (CPU) and other chips. You can see the power components laid out in a block diagram here.

6. Wireless Sensor Network (WSN) and Development Process

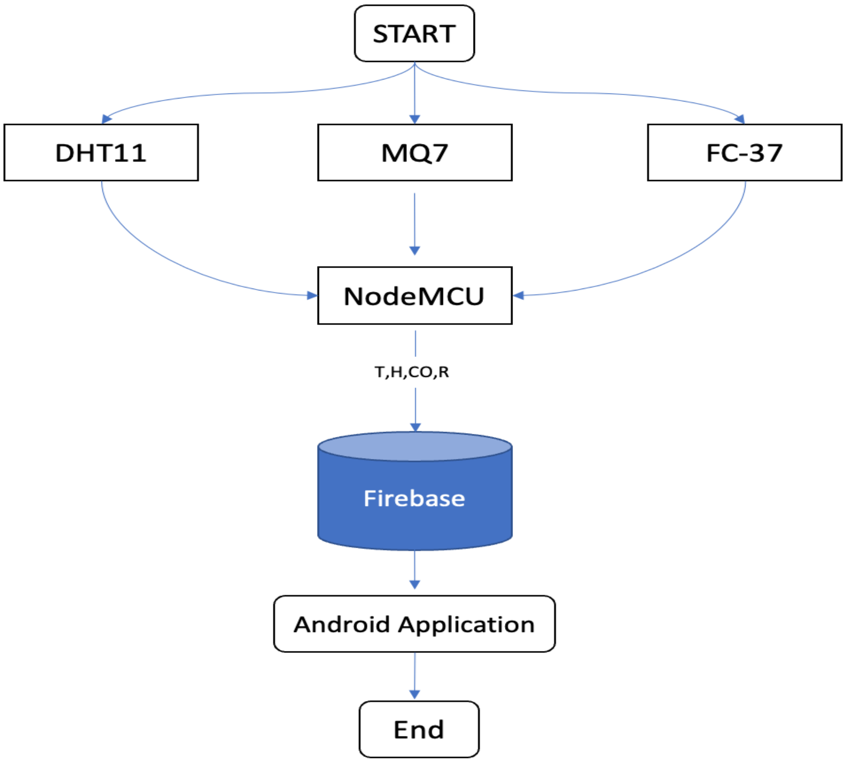
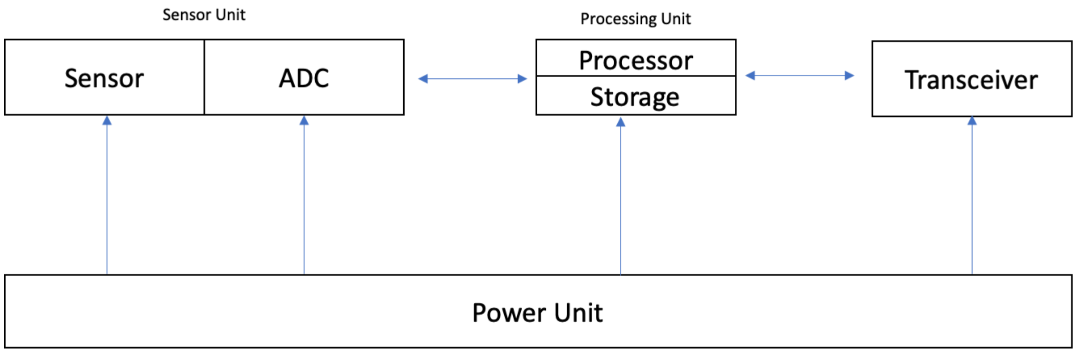


Figure: 3 Wireless Sensor Network Workflow

Wireless sensor network efficiency has raised to the top of the research agenda in recent years. Physical or environmental conditions, such as pressure, heat, light, and so on, can all be used as inputs to a sensor. If the sensor generates an electrical signal, the controller can use it as input for processing. In the context of sensor networks, "a wireless sensor network is a collection" of devices that may exchange data about a monitored area using short-range wireless connections. A gateway connects the data to other networks, such as wireless Ethernet, across many nodes. Base stations and nodes make up a wireless sensor network (WSN) (wireless sensors). They are used to monitor physical or environmental factors like sound pressure and temperature in order to send data through the network as depicted in the image to a central point.

6.2 WSN architecture



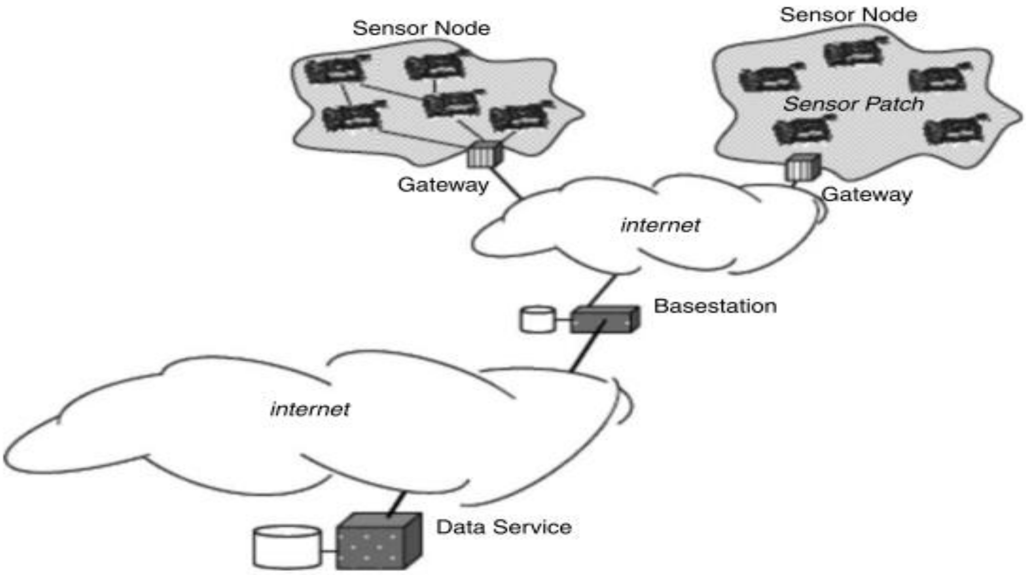


Figure: 4 WSN architecture and Sensor Node

The majority of the current WSNs literature uses precise, or "crisp," values to specify the important parameters. Hard numbers aren't always the ideal choice for defining WSN settings [16]. Integrating SC technologies (such as fuzzy logic, neural networks, fuzzy rule-based systems, and data mining methods) into sensor nodes is one example of a WSNs application that works effectively. Since fuzzy logic can cope with imperfect information, it is particularly useful for wireless sensor networks. [17] "Fuzzy logic is significantly more in line with how people think than crisp logic, and it is also far more intuitive and easy to use than other classification algorithms based on probability theory" [18]. This very advanced modeling language can accommodate a broad range of real-world uncertainty. It may be used to many different situations because to its malleability and versatility. "With n variables, each of which may take m values, the number of rules in the rule-base is mn", which might lead to a memory overhead proportional to the number of variables.

6.3 Overview of fuzzy logic

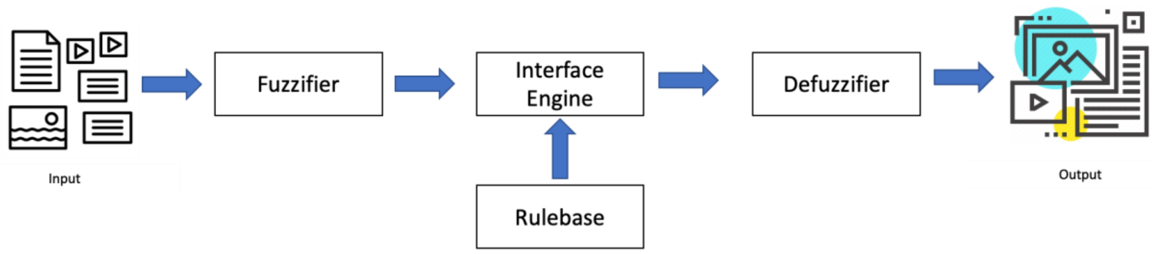


Figure: 5 The structure of a fuzzy logic

Fuzzy sets and logic were initially defined by L. Zadeh in 1965. Their unique characteristics are currently being put to use in several applications. As the name implies, a system that uses fuzzy rules to describe its knowledge does so by using IF-THEN statements whose input and output variables are also fuzzy rules. One distinguishing feature of these systems is their ability to learn from human expertise despite the limitations of that expertise. More than just "true" and "false," "high" and "low," "small" and "large," "short" and "long," etc., are part of this kind of reasoning. The mathematical and computational analysis of concepts like "moderately lengthy," "extremely long," and "little," "very small," is possible. Making a number less clear or accurate is called "fuzzifying" it. This can be achieved simply by admitting that many apparently deterministic values are, in fact, unpredictable in important ways despite appearances to the contrary. If the uncertainty is due to imprecision, ambiguity, or vagueness, then a membership function, a crucial component of a fuzzy set, can be utilized to express the fuzzy variables in question. Whether the elements of a particular fuzzy set are discrete or continuous, membership functions can be used in the mathematical formalisms of fuzzy set theory to offer a graphical representation of the fuzziness existing in that set. However, the forms that are utilized to define the fuzziness might have essentially no restrictions imposed on them. There is no finite number of methods to characterize fuzzy sets, and the same holds true for the graphical representations of their membership functions.

6.4 Decision making

The inference engine, which includes a rule foundation and multiple ways for inferring the rules, then processes the fuzzified data. The Mamdani and Sugeno methods of inferential reasoning are two of the most popular applications of fuzzy logic. “At the Sugeno output, the membership functions are either linear or constant”, and this is the key distinction. Each uses its own own set of fuzzy rules to aggregate and de-fuzzify data in its own unique manner. In both practical and academic contexts, Mamdani is considered definitive. Fuzzy sets are often employed to reflect expert opinion or common sense, and the language variables AND, OR, etc. are frequently put to this use. Fuzzy rules, which are conditional statements in the form of IF-THEN rules, work well for modeling this kind of information. “IF THEN rules are the most suitable mathematical tool for the sorts of WSN issues presented in the study because they demand less processing resources than standard mathematical computational techniques” and merely a small amount of data samples are required to obtain the outcome. The two parts of a fuzzy rule are the antecedent (or predicate) and the result (or component that follows THEN). Implication rules like MIN-MAX and limited arithmetic sums characterize the predicate's combined truth. The rule base's rules are run via parallel processing by the fuzzy inference engine. The ultimate fuzzy solution space is affected by the triggering rule.

7. Programming Environment & Development Process

The microprocessor on the Adruino board establishes a connection to the sensor network, receives the data from the sensors, and sends it over the Wi-Fi after some preliminary processing. The information was saved in a server-side database built on the ThingSpeak platform. ThingSpeak is a free and publicly available IoT application and API (Local Area Network) that communicates over the HTTP protocol. ThingSpeak enables a social network of objects with status updates, sensor recording, and location tracking. The Adruino-based solution utilizes an ESP8266 Wi-Fi module to wirelessly transfer sensor data to ThingSpeak for additional analysis. The system's intelligence, flexibility, and efficiency are all improved when users may access server-based services and data through LAN-connected smart phones, web browsers, and other web browser devices. The ThingSpeak platform now supports the use of MATLAB for data analysis. ThingSpeak is supported by its own set of MATLAB tools.

8. Conclusion

In terms of environmental monitoring, it's a challenge because the environment can change dramatically even over short distances. Even within the same room, temperature, humidity and pollution can vary greatly, especially when closed furniture like cabinets and showcases are employed. Research papers on various environmental monitoring systems have been reviewed critically in this publication. This study aids in the identification of all feasible smart pollution monitoring systems that may be deployed in order to clean up the city. Several studies have shown that human performance is greatly influenced by the ambient conditions in the producing area. These circumstances must be incorporated into production systems to achieve additional improvements, and the current potential given by IoT applications suggest that an IoT-based environmental monitoring is needed. Both indoor and outdoor use of this device is possible with little to no effort on your part. When a threshold level is reached, the gadget will alert the organization through Wi-Fi and the data will be transmitted in real-time. WSNs are a fast growing field for study and business, despite a number of significant limitations, including a lack of readily available energy, diminished computing capacity, and a lack of memory. Military uses, environmental monitoring systems, intelligent agriculture, surveillance, health monitoring, traffic monitoring, industrial management and monitoring, and many more are just some of the many possible uses for WSNs. Fuzzy logic and other forms of soft computing can dramatically enhance network performance measures like throughput, latency, and energy efficiency, which makes them attractive candidates for implementation on sensor nodes.

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