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Iot Driven Machine Learning Platform For Real Time Environmental Monitoring

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Abstract: The environment faces real problems due to a number of variables, including radiation, water, and air pollution. Sufficient oversight is required to ensure that a healthy society and sustainable global growth are maintained. Thanks to developments in the internet of things (IoT) and the creation of contemporary sensors, environment monitoring has evolved into a smart environment monitoring (SEM) system in recent years. People are becoming more aware of their surroundings in the last several years. It is because of this awareness that a trustworthy environmental monitoring system has to be created. There are industrial uses for environmental air quality monitoring systems as well. The air in heavy industries like mining may get contaminated by several dangerous gases. An environmental monitoring system may be able to save workers' lives in such dangerous circumstances. There are problems with data collecting, data administration, connections, and power consumption in such large-scale sensor deployments. IoT technology is ideal for this kind of requirement. This article proposes an Internet of Things (IoT) based architecture that uses sensors, microcontrollers, and IoT based technologies to efficiently monitor changes in an environment. The suggested module allows users to keep an eye on temperature, humidity, and the presence of hazardous gases in both indoor and outdoor environments. Through an internet connection, the user may access the data stored on the web server from anywhere in the globe. The suggested work develops a web application to give the user essential information. Additionally, a notification for significant changes in the sensor data may be set up by the user. In contrast to other systems that are closely comparable, the suggested method is accurate, affordable, and easy to use. In addition, it features modules for simple data visualisation and monitoring and is cloud-based. The system has undergone many phases of evaluation. Following extensive testing under various circumstances, it demonstrates a high level of accuracy and dependability.

Keywords: IoT, environmental monitoring, air pollution, water pollution, sensors, machine Learning.

I.INTRODUCTION

The main goal of SEM is to address the challenges resulting from undesirable environmental effects through smart monitoring so that all key indicators of growth, including the health of society, are well regulated. This is because the entire world is working in concert to protect the environment for sustainable agriculture, growth, and a healthy society. Many applications, such as weather forecasting [2], air pollution management, water quality control and monitoring [1], and agricultural damage assessment [2], are among the goals of the environment monitoring techniques. The goal is to create an environment that is conducive to agriculture, human habitation, or any other kind of life on Earth. IoT and wireless network technologies have made environment monitoring easy and AI-controlled. Different kinds of smart sensors [5], wireless sensor networks (WSNs) [6], and Internet of Things (IoT) devices [7] are used by the SEM systems that are reported in the literature. These devices, which communicate via the networks, have aided in environment monitoring as a smart monitoring system that can handle the challenges in variable conditions.

The core components of SEM systems are IoT, WSNs, and appropriate sensors. The connection of the data collected by using sensors and Internet of Things (IoT) devices to record, monitor, and regulate different environmental variables, such temperature, air quality, and water quality, is provided by the WSNs. A cloud-based SEM system example, as seen in Figure 1, makes it simple to understand a smart environment system. This image provides an example of how to monitor and regulate water pollution using a cloud-based system that links Internet of Things devices and several appropriate sensors.

Because AI and machine learning are built into every IoT device, the system may use them to monitor whether the water is polluted or clean. The company, which keeps an eye on the quality of the water in different sources, is able to access the cloud using data gathered from many sensors such as an aqua sensor and performs an IoT-based analysis where the quality check is completed.

Figure 2 provides an additional illustration of a SEM system, showcasing a general-purpose system with an expanded scope. It illustrates how the system is handling several environmental monitoring-related concerns, including humidity, temperature, radiation, dust, UV signal, etc. A WSN serves as the system's backbone, creating the real link between data collected by various kinds of smart sensors and IoT devices. This exemplifies a "smart city" [8], employing a SEM system to guarantee a healthy atmosphere for its populace.

One of the hardest things in the world is effective change management. Government, quasi-government, and public organisations are getting ready to take on this issue on the social and environmental fronts and are working to improve our quality of life in the globe. Many smart systems, such as automated irrigation [8], smart grid [9], traffic and accident monitoring, smart city solutions, wireless sensor network systems, web-based services, and real-world robotic problem solving [10–12], have been developed to meet the dynamic nature of changing reality.

These days, there is a lot of worry about air quality, which calls for the monitoring of several indicators. A workable technical solution to track environmental conditions and changes is crucial, according to the methods listed in [7]. The Internet of Things (IoT) provides a very efficient means of keeping an eye on air quality-related indicators. A system can be an effective tool for monitoring both indoor and outdoor environments if it is able to combine different IoT aspects to track and gather data utilising IoT-based sensors. To have a thorough understanding of the surrounding environment, it is necessary to monitor and examine the following indices: smoke, methane, liquid natural gas (LNG), carbon-based and nitrogen-based gases, air temperature, and humidity. The user experience is made considerably more versatile and engaging by utilising the IoT idea.

II.RELATED WORKS

These days, a crucial concern is climate change and the requirement for environmental monitoring, especially air quality monitoring. There are several actual initiatives being created with "air quality" as their goal. IoT is being used by these systems as the foundation for their connectivity.

An Internet of Things-based weather monitoring system was created for agricultural use in [2]. Therefore, the indicators that were constantly observed were temperature, air pressure, humidity, light intensity, and dew point. Only temperature and humidity are tracked in [4] in order to forecast the weather. An environmental monitoring system that records temperature, humidity, and precipitation was introduced in [5]. For farming in a greenhouse, information on temperature, humidity, air pressure, and light intensity is tracked and recorded in [8]. Only temperature and sound data are gathered and examined in [9] in order to provide monitoring. The aforementioned studies in [9] only include a small number of indicators, making it impossible to undertake a thorough monitoring and study of the climate. While carbon-based gases are monitored in [3], nitrogen-based gases are tracked using IoT-based climate monitoring in [3].

Purpose	Findings and Challenges	Method/Device Used
Oceanic environment monitoring	Light weight; costly and invasive sensory networks	Wireless Sensors
Soil monitoring for farming	Efficient vegetable crop monitoring; Greenhouse gases pose challenges on health of vegetables like tomato	Wireless sensors
Marine environment acoustic monitoring	Lower latency; low power consumption; installation and coverage issues	WSN and IoT
Air pollution monitoring system	Mobile kit "IoT-Mobair" for prediction; inferior precision; low sensitivity; computationally complex	Gas sensor and IoT
Air quality monitoring	Scalable and high-density air quality monitoring with interconnection of heterogeneous sensors; computational complexity due to huge data captured and processed	Mobile sensor network and WSN
Environmental monitoring	W3C standard for interoperability; interoperability issues of heterogeneous sensors	Heterogeneous sensors
Air quality monitoring	Large area monitoring; noisy data; accuracy and cost issues	Geomatics sensors and IoT
Air pollution monitoring System	Real time monitoring; accuracy issues	Sensors with MQ3 Model, Raspberry Pi and IoT
Air pollution monitoring system	Efficient for low coverage area; low cost; easy to install; less number of pollutants are covered	Gas sensor and LASER sensor
Dust and humidity monitoring	Wide coverage and efficiency; low cost and small size	IoT
Radiation monitoring	High cost and low stability against temperature variation	HPXe chamber
Aqua Farming	Water quality and quantity control; higher carbon emission and energy requirement	Odor, pH, conductance and temperature sensor

Table 1. Research studies based on purpose and applications of environment monitoring.

To get a thorough understanding of the air quality level, it is necessary to monitor a few more harmful gases. In [2], a weather monitoring system was created. Nevertheless, it only considers four indices, making environmental monitoring incomplete. When comparing the work done in [2] to that done in [3], more indices are taken into consideration. Temperature, relative humidity, carbon dioxide, air pressure, and light intensity are the indices. However, using the indices given in [3], a comprehensive analogy of the surrounding environment is still not achievable.

While studying the existing literature on SEM methods, especially on advancements in IoT and sensor technologies for SEM systems, we found that an extensive review on this topic has not been much reported. We found some interesting literature on specific areas of research addressing some challenges of environmental factors such as water pollution, air quality, radiation, and smart agriculture. We aimed at bringing out major advances in IoT and sensor technologies used for addressing the challenges in SEM and thus we included some significant research studies and contributions of various sources highlighting specific classic work on SEM methods. The current study on advances in IoT and sensor technologies used for SEM provides insight to the scientists, policymakers, and researchers in developing a framework of appropriate methods for monitoring the environment that faces challenges mainly due to poor air quality, water pollution and radiation. These factors also affect agriculture which is backbone of any developed and developing economy and thus smart agriculture monitoring (SAM) has also been studied in this section.

By focusing on agriculture, as a relevant issue for the growth of any nation, it is easy to underline how SEM can play a significant role by providing a “smart or green agriculture”, that can deal with major challenges and factors involved in sustainable growth and enhancing productivity within the agriculture sector. One such smart agriculture scenario can be seen in Figure 3, where a SEM system is actually a smart agriculture monitoring system. In this case, the health of soil, moisture analysis, water contamination level, water quantity level and several other factors are very important in obtaining sustainable productivity in the agriculture sector.

III. ENVIRONMENTAL MONITORING

An environmental monitoring system monitors the environment's quality using several parameters, including relative humidity, temperature, dew point, and frost point. Rotronic offers solutions for these parameters and differential pressure, pressure, and flow. It also monitors CO2 levels.

Perception layer: The perception layer is the physical layer of the Internet of Things (IoT), which uses sensors to gather information about the environment. The Sensing layer includes sensors and actuators that collect data from the environment and emit transmission over the network respectively. The network layer connects to other intelligent objects to exchange data [8].

Network layer: Internet/network gateways, data acquisition systems (DASs), and sensor networks are present in this layer. DAS performs essential gateway functions such as data aggregation and conversion (collecting data from sensors and then converting it to digital format). Advanced gateways can also open up connections between sensor networks and the Internet, allowing them to communicate with each other. The network layer connects to other smart things, devices, and servers. It also handles data transmission and processing.

Preprocessing layer: It is important to perform preprocessing on sensor data. This removes unnecessary data from the sensor data using filtering, processing, and analytics. Temporary storage provides functionalities such as replication, distribution, and storage. Finally, security performs encryption and ensures data integrity as well as privacy.

Application layer: The business layer manages the entire IoT system, including applications, business models, and privacy concerns. The application layer is the interface between the IoT device and the network with which it needs to communicate. It manages data formatting and presentation and, is responsible for ensuring handoffs that occur when moving data from one network to another.

The main objective of the Smart Environment Monitoring (SEM) project is to discourse the provocation due to unacceptable effects on the environment through intelligent monitoring so that all primary indicators of growth, including a healthy society, are assorted. Various applications of this technology are proposed for multiple purposes, aiming to serve particular occasions, which may comprise weather reports, acid precipitation control, contaminated water control & monitoring, and crop damage assessment. A cloud-based system that connects IoT devices and various suitable sensors is one example of an intelligent environment system. This system can monitor water quality, air quality, waste management, and control. Such systems can be shown in Figure 3, which depicts contaminated water, Pollution of air, waste management (waste collection and disposal), and its control. The organization involved in such monitoring gets to the cloud through accumulation from various sensors connected to it via the internet. The existing literature on SEM methods does not contain many surveys or reviews. A poll published in a peer-reviewed journal on quick-witted agricultural systems, intelligent home technologies, innovative health monitoring systems, an Internet of Things (IoT)-based ecological system, an IoT-enabled marine environment monitoring system, and a survey on pollution monitoring system design and implementation details are just a few of the articles highlighting different aspects of SEM sensor networks.

It is difficult to find surveys or reviews on this topic in the existing literature, so we conducted a critical study of AEM techniques. Many factors affect the environment, including water pollution, waste management, and industrial air pollution. Diffraction & noise pollution are also severe problems. This review will examine the most common methods used to mitigate these challenges. From this, we have been motivated to write an extensive study about Sensor and SEM systems, which includes beneficial components harming the environment, such as IoT and sensory technologies.

IV. DESIGN METHODOLOGY

To store and analyze data continuously on various environmental indices, the design methodology of the proposed environment monitoring system is presented in the following sub-sections:

System Model: The diagram in Fig. 1 illustrates the overall architecture of the network system in this project. User can deploy the nodes randomly in an environment. To maintain the simplicity of the network architecture, star topology is selected. In a star topology, one failed device will not affect the other devices in the network, and there will be no data collision in the network. Between the internet and the nodes, a gateway is used. This gateway can be wired or wireless, giving us the flexibility to use it anywhere. The gateway also does the heavy lifting of internet communication and keeps the power consumption in the node low.

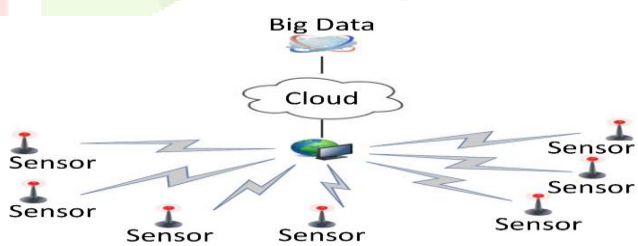

Fig. 2. Sensor node system model.

Logical data model: Logical data flow model of the proposed system is presented in Fig. 2. The ThingSpeak service provides channels for each node. Each of the channels has its API Key. This key helps to organize data in the channels and to maintain the database. This individual databased then can be visualized in the ThingSpeak service or can be transferred to other services to analyze the data.

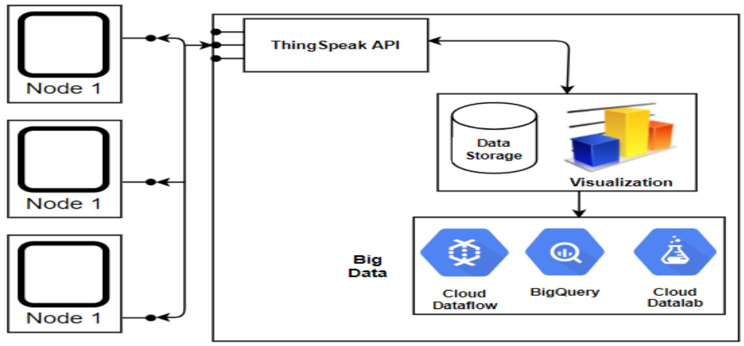

Fig. 2. Logical Data Model for data visualization.

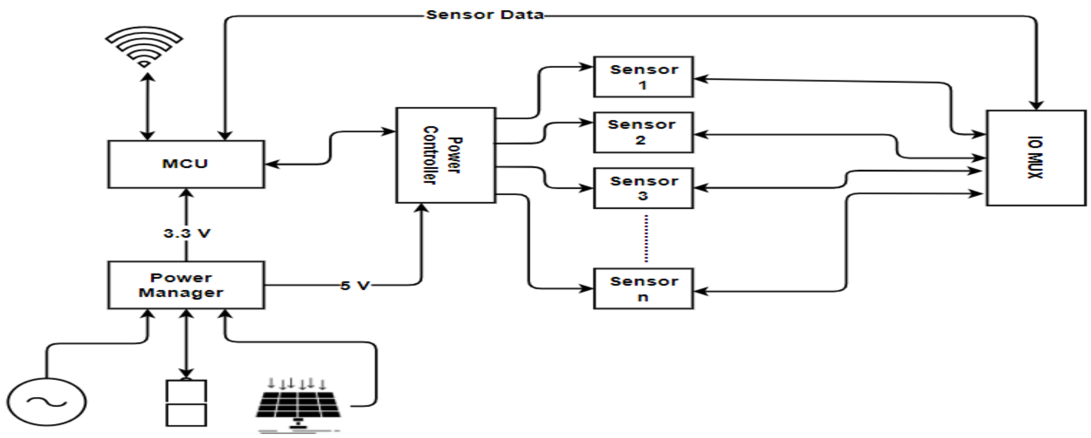

Fig. 3. Device block diagram.

A. Device design

Fig. 3 shows the connections between the different parts of the device. To make the power supply flexible, several input options are available. If multiple power sources are connected simultaneously, the power manager will switch between them to provide a consistent supply. The solar cell or the main AC supply will charge the battery and provide the power to the other parts of the hardware. If the mains AC supply fails or during the night when there is no power in the solar cell, the power manager will switch to the battery for uninterrupted operation. There is a buck-boost converter in the power management system with the solar cell connection. As the solar cell does not produce constant voltage, the buck-boost converter takes any voltage between 3V to 18V and converts it to a constant 15V. This 15V is feed to the battery charging system.

The power unit consists of a rechargeable 1500 mAh 12.5-volt lithium-ion battery. To save the battery from completely discharging or overcharging, battery charge protection circuit has been integrated into the system. To efficiently stepdown the voltage two buck modules are used. The ESP8266 and the nodeMCU board requires 3.3v and the sensors required 5v and 12v. The ESP8266 is the brain of the whole device. It is responsible for sensor data collection, formatting the data and sending to the sensor gateway. To make the device flexible in terms of how many sensors it can connect, IO mux is used in the design. The IO mux can be chained to add more sensors if necessary. There is a separate power controller for sensor power supply as different sensors require different voltage levels. The power controller can also cut off the power of the unused sensors, maximizing power savings.

B. Controlling sensors

There are a power control MOSFET array and a 12v boost converter in the power controller unit. Upon receiving the request from the MCU, the power control unit powers on a particular sensor. The power controller unit also ensures that the appropriate current and voltages are set. After that, the MCU reads the data from the sensor. The MCU then turns off the power of that sensor ensuring a low current consumption.

Sensors used

The device is designed in such a way that a number of environmental and gas sensors can be added here. For the proposed model experiment, MQ2, MQ4, MQ135 and DTH22 sensors are used. MQ2 gas sensor can detect LPG, Smoke, Alcohol, Propane, Hydrogen, Methane and Carbon Monoxide
concentrations anywhere from 200 to 10000ppm. MQ4 gas sensor has a high sensitivity to Methane, also has anti interference to alcohol and other gases. MQ135 gas sensor has high sensitivity NH_3, NO_x, alcohol, benzene, smoke and CO_2. Ideal for use in the factory environment. The DHT22 is a digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air temperature.

Data collection procedure

The device sends data to the gateway with the along with the API key. The gateway then posts the data to the Thingspeak server. The device has a quick boot time. There is a scheduler that periodically fetches information from the sensor and stores it on the RAM. It stores the sensor value and as well as the time stamp. All the sensor values are sent to the server at once to reduces current consumption. The schedular is configurable and for this example, it is configured to read data from the sensor every five minutes. The user can configure the schedular to meet their exact
need. When not working, the schedular puts the device into sleep mode to conserve power.

The data can be visualized in thingspeak site with various graphs and charts. The graph shows the time stamp and sensor value. A trigger can be set in the thingspeak server for a particular sensor when it crosses a threshold value. Moreover, it is possible to download the data to CSV or JSON format from thingspeak server for further processing. To stop data collection, it is essential to turn off the system's power.

V. IMPLEMENTATION

The device is housed in an FDM box. The connections are made between all sensors, microcontrollers, and project board with removable connectors. Microcontrollers these days used in all sorts of applications ranging different appliances, embedded systems to implantable medical
devices [3]. The FDM box has various compartments for the sensor, the circuit board and the battery. The battery is in the lower compartment and the circuit and the sensor board are in the upper compartment. The battery is in the bottom section which can easily slid in and out. The gas sensors are mounted on the side.

Fig. 4 (a). Implementation Requirements Design

Fig. 4 (b). Implementation Requirements Design.

The battery powers the 5v and 3.3v buck converter unit. The 5v rail powers the sensor array and the 3.3v powers the NodeMCU module. The NodeMCU then reads the sensor data of each sensor, formats them and sends data to the cloud database. The power unit consists of 1500 mah 12.5-volt battery. The cloud database stores different data such as the presence of Carbon dioxide, Carbon monoxide, smoke, Methane, natural gas, particle in the air. So, a database is important for further studying the data.

The sensors begin to work when the machine is turned on. If any gas enters the gas sensor, the sensor heats the filament inside. In the absence of any volatile gases, the hot tin dioxide reacts with oxygen and it prevents current flow. In case of the presence of any volatile gas, the concentration of oxygen decreases. When heated, tin dioxide is a good conductor in the absence of oxygen. This is how the filament resistance changes and depending on the resistance value it can be observed that a certain gas is present. The gas sensors produce analogue values proportional to the gas present. On the other hand, the temperature and humidity sensor is digital. There is resistive thermistor for temperature measurement and a capacitive humidity sensor for humidity measurement. These sensor data will then be sent to the server. Each sensor data is displayed in various charts. These chart show the time and date stamps. It is possible to download the data from thingspeak in CSV or in JSON format. Moreover, it is simple and efficient to obtain information
from minute to minute, or even hours and days. Fig. 4(a) and (b) shows the systems' design.

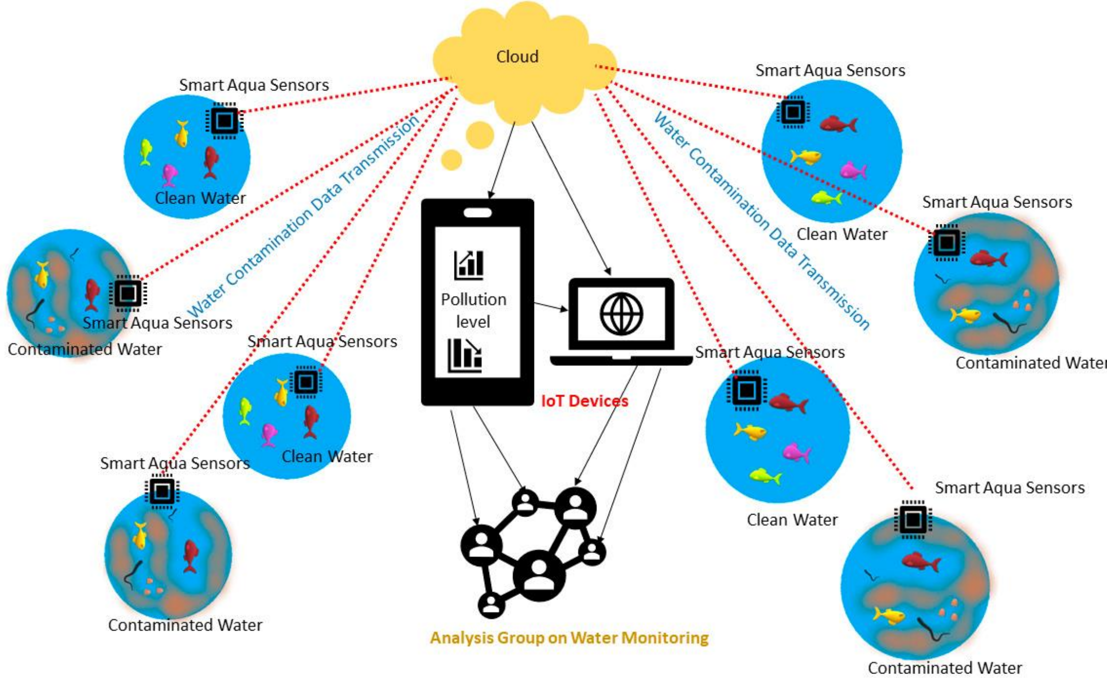

Fig 5. Smart environment monitoring system.

VI. CONCLUSION

In this paper, studies on various environmental monitoring systems used for different purposes. The analysis and discussion of the review suggest vital recommendations for improving these systems. Research on deep learning, handling big data, and using consistent classification approaches has led to a realization of the need for extensive research in these areas. We have focused on water, air quality monitoring and intelligent waste management systems that can deal with environmental challenges. The significant challenges in implementing smart sensors, artificial intelligence (AI), and wireless sensor networks (WSNs) need to be addressed for sustainable growth through Smart Environmental Monitoring (SEM). Participation by environmental organizations, regulatory bodies, and general awareness would strengthen SEM efforts. Pre-processing techniques can be used to improve the quality of sensory data. These techniques include filtering and signal processing, which makes the data more suitable for tasks associated with SEM. All the sensors, microcontrollers, Vero board and everything is linked together in the boxed-shaped unit. It has battery and circuit board compartments and sensors. The battery and the circuit board and sensors are housed in the lower compartment. The battery is in the lower compartment and the boards and controls are right above the compartment which can easily slide in and out. Gas detectors are serially positioned on one side and the other side are the dust and humidity sensors. In this way, a lot of components are put in a standard size box that makes it compact. The most challenging part is this project's complex power supply. Because of 24 processes and information collection. If there are any bugs, the entire system will completely collapse. So it is essential to make sure that there are alternate ways of power. Three types of power supplies are arranged for the proposed design. 12V power supply adapter from AC outlet, battery backup and solar panel to supply power to the device all the time.

REFERENCES

[1] BiswalAK, Singh D, Pattanayak B K, et al. (2021) IoT-based smart alert system for drowsy driver detection. Wireless communications and mobile computing 2021.

[2] Rath M, Swain J, Pati B, et al. (2018) Network security: attacks and control in MANET. InHandbook of Research on Network Forensics and Analysis Techniques 2018: 19–37.

[3] Rath M, Pati B, Pattanayak BK, et al. (2018) Relevance of soft computing techniques in the significant management of wireless sensor networks. In Soft Computing in Wireless Sensor Networks 2018: 75–94.

[4] Hosenkhan MR, Pattanayak BK (2020) Security issues in Internet of things (IoT): a comprehensive review. New Paradigm in Decision Science and Management 2020: 359–369.

[5] Biswal AK, Singh D, Pattanayak BK (2021) IoT-based voice-controlled energy-efficient intelligent traffic and street light monitoring system. In Green Technology for Smart City and Society 2021:43–54.

[6] Biswal AK, Singh D, Pattanayak BK, et al. (2021) Adaptive fault-tolerant system and optimal power allocation for smart vehicles in smart cities using controller area network. Security and Communication Networks 2021.

[7] Ravindra Changala "A Survey1 on Clustering Techniques to Improve Energy Efficient Routing in Wireless Sensor Networks" in International Journal of Applied Engineering Research ,10(58), pp.-1-5,2015.

[8] Rath M, Pati B, Pattanayak BK (2020) Manifold surveillance issues in wireless network and the secured protocol. International Journal of Information Security and Privacy (IJISP) 14: 16–26.

[9] Pattanayak BK, Nohur D, Cowlessur SK, et al. (2021) An IoT-Based System Architecture for Environmental Monitoring. In Progress in Advanced Computing and Intelligent Engineering 2021: 507–514.

[10] Laha SR, Mahapatra SK, Pattnaik S, et al. (2021) U-INS: an android-based navigation system. In Cognitive Informatics and Soft Computing 2021: 125–132

[11] Pattnaik S, Banerjee S, Laha SR, et al. (2022) A Novel Intelligent Street Light Control System Using IoT. In Intelligent and Cloud Computing 2022: 145–156.

[12] Canning J, Guo Y, Chazcko Z (2022) Towards a bionic IoT: environmental monitoring using smartphone interrogated plant sensors. bioRxiv.

[13]. Ravindra Changala, Framework for Virtualized Network Functions (VNFs) in Cloud of Things Based on Network Traffic Services, International Journal on Recent and Innovation Trends in Computing and Communication, ISSN: 2321-8169 Volume 11, Issue 11s, August 2023.

[14] Osman N, Jamlos MF, Dzaharudin F, et al. (2022). Real-time and predictive analytics of air quality with iot system: A review. Recent Trends in Mechatronics Towards Industry 4.0 2022: 107–116.

[15] Ravindra Changala, “Diminution of Deployment Issues in Secure Multicast System with Group Key Management” published in International Journal of Computer Application (IJCA), Impact Factor 2.52, ISSN No: 2250-1797, Volume 2, Issue 3, June 2012.

[16] Kho EP, Chua SND, Lim SF, et al. (2022) Development of young sago palm environmental monitoring system with wireless sensor networks. Computers and Electronics in Agriculture 193.

[17] Pattanayak BK, Amic S (2020) Modified lightweight aes based two-level security model for communication on IoT. TEST Eng Manage 82: 2323–2330.