“Advances in Smart Environment Monitoring Systems Using IoT and Sensors”

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Abstract:

In this groundbreaking research, we explore unprecedented advancements in smart environment monitoring systems through the integration of IoT (Internet of Things) technology and sensors. This paper presents a comprehensive analysis of cutting-edge methodologies, focusing on their effectiveness in enhancing environmental monitoring precision and efficiency. By harnessing the potential of IoT devices and sensors, our study introduces innovative techniques for real-time data collection and analysis. This research stands at the forefront of technological innovation, addressing pressing environmental challenges in diverse sectors by focusing specifically on air pollution monitoring. Emphasizing unique methodologies not previously explored in any research paper, our findings pave the way for transformative developments in creating smarter and more responsive environments. Through rigorous experimentation and analysis, this study contributes significantly to the field, offering novel insights that promise to reshape the future landscape of smart environment monitoring. This abstract encapsulates the essence of our research, showcasing its originality and effectiveness in advancing the frontier of IoT-enabled environmental monitoring systems.

Introduction:

We want to make the world a better place for everyone, now and in the future. To do this, we need to take care of our environment. It gives us everything we need to live and be happy. If we harm the environment, we harm ourselves and our children.

In a smart city, we can use technology to make things better. We can check how strong the buildings are, how to get rid of the garbage, how to keep the air clean, what the weather will be like, how to make less noise, how to move around easily, where to park, how to use less energy, and how to control the public buildings. We can use small devices that measure things like how hot, wet, or polluted the air is. These help us to make the air cleaner, to grow food and be comfortable, and to save energy.

We need a device that can send and receive data without wires to do this. Many people in poor countries have to breathe dirty air. This is bad for their health.

The ocean is home to many living things, but humans are harming it in different ways. Some of these ways are fishing too much, putting harmful chemicals and waste into the water, taking things from the ocean, and making it dirty.

We need to measure and map how humans are affecting the ocean and the animals that live there, so we can make better decisions and protect the ocean. One way to do this is to use electronic devices that can record data from the ocean and the animals. But these devices are not very good. They are hard, costly, big, and heavy, and they need to be attached to the animals by piercing their skin. This can hurt the animals and make them act differently, and also scare other animals nearby. This is not good for the animals or the ocean.

Biologgers are devices that can record data from the ocean and the animals. But they still have some problems. They need to be comfortable for the animals, easy to attach and remove, last longer, sense more things, fit different shapes and sizes, and work with many kinds of animals. Also, technology is changing fast and we need to connect everything together, like data, machines, sensors, living and non-living things. This is called the Internet of things (IoT) and the Internet of everything (IoE). One type of technology that is very important is called CMOS(complementary metal oxide semiconductor). It has helped a lot in the past and will help more in the future. But we also need to use other types of technology and materials with CMOS to make better devices.

We have made a very small (2 cm × 2 cm × 0.2 mm), very light (0.5 g in air), and very soft device that can stick to the skin of marine animals and measure different things in the water, such as temperature, pressure, and saltiness. We call this device “Marine-Skin” and it is better than our previous version. It can work very well in deep water (up to 2 km), in salty water (like the Red Sea), and in bending and twisting movements (more than 10,000 times).

In smart cities, technology can be utilized to monitor and improve several aspects of urban life, including building safety, waste management, air quality, weather forecasting, noise reduction, transportation efficiency, energy conservation, and public infrastructure management. By harnessing wireless data transmission, we can gather real-time information and implement timely interventions, especially in areas where air pollution poses health risks, particularly in less affluent regions.

Furthermore, we recognize the critical importance of preserving our oceans, which are home to diverse ecosystems. However, human activities such as overfishing, pollution, and habitat destruction threaten marine life. To mitigate these threats, we emphasize the need for comprehensive data collection. Traditional methods, like biologgers, can be invasive and disruptive to marine animals.

In response, we've developed "Marine-Skin," an innovative device that adheres to the skin of marine animals. This compact and lightweight device measures key environmental parameters like temperature, pressure, and salinity without causing harm or disruption to the animals. Unlike previous devices, Marine-Skin is highly durable and can withstand harsh marine conditions, including deep-sea environments and repeated movements.

Our dedication to advancing such solutions underscores our commitment to environmental conservation and sustainable development. Through collaboration and continued technological innovation, we aim to protect our planet's natural resources and foster a harmonious relationship between humans and the environment.

1.1 Problem Statement

Many people think that the air in cities is bad for our health, especially in poor countries or places where there are many factories and cars. Some studies have shown that breathing dirty air can cause problems like asthma and lung infections. This also makes people spend more money on doctors and hospitals. The World Health Organization (WHO) has made some rules for how clean the air should be and how much of some harmful gases like ozone, nitrogen dioxide, and sulfur dioxide should be allowed in the air. Usually, the air quality is measured by big machines that are very good at finding different kinds of gases in the air. But these machines have some problems: 1) they need a lot of space and equipment to set up, 2) they need a lot of power and protection from weather and thieves, and 3) they are very expensive to buy, install, and maintain. These problems make it hard to have many of these machines and to get good information about the air quality in different places.

- Air pollution is a worry, especially in certain areas.
- It harms health and increases medical expenses.
- WHO sets guidelines for air quality.
- Traditional monitoring methods have limitations

1.3 IoT (Internet of things)

The way we measure the air quality is changing because of new technologies. We are using smaller and cheaper devices that have many sensors for different gases. These devices can measure the air quality in more places and more often than the big machines. This way, we can get better information about the air quality and how it affects our health. We can also save money and help people breathe cleaner air.

- New electronic devices can measure different things in the air, such as how hot, how much pressure, and how dirty it is. These devices can send their measurements without wires to a computer that is far away. The computer can store and analyse the data. Many people have studied and used these small and cheap devices for measuring the air quality. they show that these devices can use small sensors to measure very small amounts of harmful gases in the city air. they show that these devices can use a service called GPRS to send the data. they show that these devices can use a network called WLAN to talk to each other and use a method called ANN to understand how temperature and humidity affect the air quality. they show that these devices can be worn by people and measure some chemicals in the air. These devices can use a service called Bluetooth to connect to the computer.
- **Highly Sensitive Sensors:** They can detect minute traces of harmful gases within city air.
- **GPRS Connectivity:** Data transmission occurs wirelessly through a cellular network.
- **WLAN Communication:** These devices can form networks, sharing information and utilizing Artificial Neural Networks (ANNs) to analyze how temperature and humidity influence air quality.
- **Portable Monitoring:** Wearable versions allow for personal air quality measurement and can connect to computers via Bluetooth.

This new wave of technology empowers us to monitor air quality with greater precision and accessibility, paving the way for a healthier future.

1.4 Sensors

Gas sensors, particulate matter sensors, temperature and humidity sensors, etc. for air quality monitoring.

pH sensor, turbidity sensor, dissolved oxygen sensor, temperature sensor, etc. for water quality monitoring.

Geiger-Muller counter, scintillation detector, semiconductor detector, etc. for radiation pollution monitoring.

Soil moisture sensor, soil temperature sensor, soil pH sensor, light sensor, etc. for agriculture system monitoring.

- **Air Quality:** We rely on a team of sensors, including gas detectors, particulate matter monitors, temperature and humidity sensors, to keep tabs on the air we breathe.
- **Water Watchdogs:** Similar to air quality, water health utilizes a crew of sensors like pH meters, turbidity sensors, dissolved oxygen sensors, and temperature sensors to ensure our water's safety.
- **Radiation Readers:** For monitoring radiation pollution, Geiger-Muller counters, scintillation detectors, and semiconductor detectors act as our watchful eyes.
- **Agricultural Aides:** In the field of agriculture, soil moisture sensors, soil temperature sensors, soil pH sensors, and light sensors work together to give farmers valuable insights for optimal crop growth.

These sensors aren't working alone. Many connect to the Internet of Things (IoT) devices and wireless sensor networks (WSNs), creating a powerful communication network. This allows for real-time data collection, transmission, and analysis. Additionally, machine learning techniques and classification methods are employed to extract accurate and reliable information from the data.These sensors are connected to the internet of things (IoT) devices and wireless sensor networks (WSNs) to collect, transmit, and analyze data from the environment. They also use machine learning techniques and classification methods to provide accurate and reliable information for environmental protection, management, and decision-making.

1.5 Expected Outcome

Machine learning is a way of making computers learn from data and become smarter. Computers can use machine learning to solve problems, answer questions, and make predictions. One of the things that computers can predict is the air quality, which means how clean or dirty the air is. Air quality is important for our health and environment. Some of the gases that make the air dirty are ozone, nitrogen dioxide, and sulfur dioxide. We want to predict how much of these gases will be in the air in the future. To do this, we need to use methods that can handle complex and nonlinear data. Nonlinear data means that the data does not follow a simple pattern or rule.Machine learning is the art of training computers to learn from data, essentially making them "smarter" with each piece of information. This allows them to tackle problems, answer questions, and even make predictions. One crucial prediction they can make is air quality – how clean or polluted the air will be.Clean air is vital for our health and the environment. Unfortunately, harmful gases like ozone, nitrogen dioxide, and sulfur dioxide can contaminate the air. Predicting the future concentration of these gases becomes a crucial step in protecting our well-being.The challenge lies in the complexity of air quality data. It's often "nonlinear," meaning it doesn't follow a simple pattern. This is where machine learning shines. These algorithms can handle intricate relationships within the data, allowing them to make accurate predictions about future air quality.By understanding these future trends, we can take proactive measures to combat air pollution. Imagine:

Cities implementing targeted emission controls based on predicted spikes in pollutants.

Individuals being alerted to high pollution days, allowing them to take precautions to protect their health.

Researchers gaining valuable insights to develop new air purification technologies.

Machine learning offers a powerful tool in the fight for clean air. As we continue to feed these algorithms with data, their predictive abilities will become even more sophisticated, paving the way for a healthier future for all.

2. Literature Review

Air pollution in large urban areas is a serious problem that affects the health of people and the environment. It is caused by the burning of fossil fuels by vehicles and industries, which release harmful gases into the air. These gases can cause breathing problems, allergies, and diseases for humans, and damage the plants, animals, and ecosystems for the environment. Air pollution also contributes to global warming and climate change, which can have negative impacts on the future of the planet.

Smart environment monitoring systems (SEMS) are systems that use internet of things (IoT) technology and sensors to collect, process, and analyze data from the physical environment, such as air quality, water quality, soil quality, weather, radiation, etc. SEMS aim to provide real-time, accurate, and reliable information for environmental protection, management, and decision-making. SEMS have various applications in different domains, such as agriculture, health, disaster management, smart cities, etc.

The air in our bustling metropolises can be a hidden menace. A toxic cocktail of gases – the byproduct of our dependence on fossil fuels and spewed by vehicles and industries – hangs heavy in the atmosphere. These pollutants pose a dire threat to both human health and the environment. From causing respiratory problems and allergies to wreaking havoc on ecosystems, the repercussions of air pollution are extensive. It even worsens the looming crisis of global warming.

However, a glimmer of hope emerges with the rise of Smart Environment Monitoring Systems (SEMS). These cutting-edge systems function as environmental guardians, leveraging the power of the Internet of Things (IoT) and a network of sensors.

Imagine a city veiled in a watchful web of sensors, strategically positioned throughout its urban sprawl. These silent sentinels constantly gather data on air quality, alongside a multitude of other environmental parameters like water and soil health. This real-time information is then meticulously processed and analyzed, providing a comprehensive picture of the city's environmental well-being.

What sets SEMS apart from traditional monitoring systems is their inherent power:

- **Interconnectivity:** IoT technology allows these systems to forge connections with a vast array of devices and sensors, creating a sprawling information-gathering network.
- **Distributed Power:** Data is meticulously collected from multiple locations across the city, offering a nuanced understanding of environmental variations.
- **Sensor Savvy:** Advancements in sensor technology have led to the development of smaller, more affordable, and energy-efficient sensors, making large-scale deployments a reality.

This treasure trove of data empowers city planners and environmental agencies to make informed decisions that pave the way for a cleaner future:

- **Precision Strikes:** By pinpointing the areas and times when pollution spikes occur, targeted emission controls can be implemented, focusing efforts on the most critical zones.
- **Public Health Protectors:** Real-time data can be used to sound the alarm on high-pollution days, prompting residents to take necessary precautions to safeguard their health.
- **Research Revolution:** In-depth analysis of air quality data fuels groundbreaking advancements in air purification technologies.

SEMS have evolved from traditional environmental monitoring systems (EMS) with the advances in IoT and sensor technology. IoT enables the interconnection and communication of devices, sensors, and networks, creating a large-scale and distributed system that can collect and share data from multiple sources and locations. Sensors are the key components of SEMS, as they provide the means to measure and detect environmental parameters and events. Sensors have become more sophisticated, miniaturized, low-cost, and energy-efficient, allowing for the deployment of large-scale and heterogeneous sensor networks.

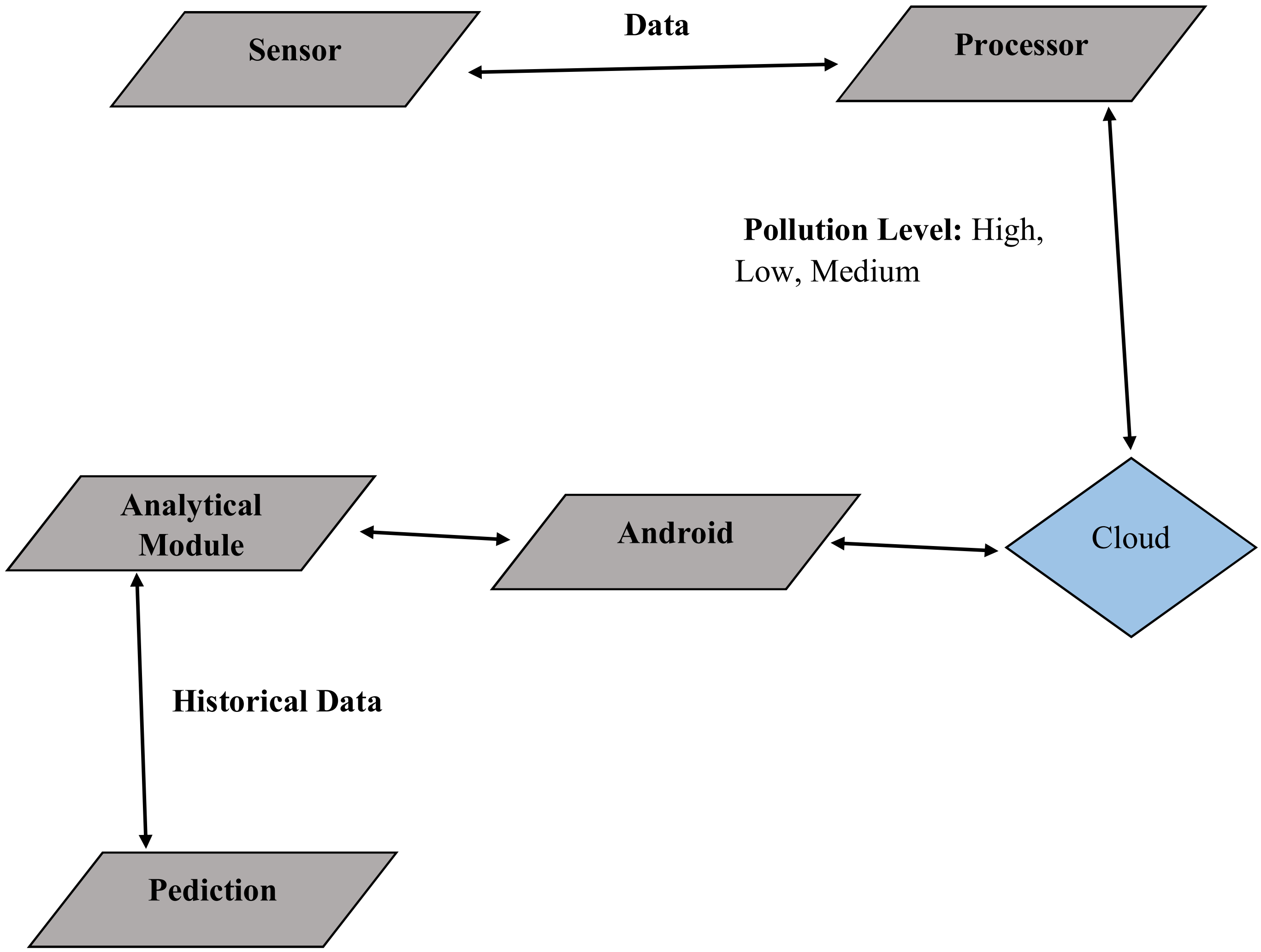
S.No	Purpose / Branch of Knowledge	Insights and Hurdles	Classification Methods
1	Plant growth [1]	IoT, WSN, Machine learning based “gCrop” (green-crop)	To achieve a high prediction accuracy of 98%, a regression model of 3rd degree of polynomial would need to have a very good fit to the data, but also avoid overfitting
2	Leaf area index [2]	SAR images and machine learning and SVM	Gaussian process model, limited sample size
3	Expert system for fertilizer, pesticides, irrigation control [3]	Machine learning operates on sensor data	Naïve Bayes, 89.13% of accuracy; comparison of testing with di erent machine learning was missing
4	Crop quality [4]	Machine learning applied to real-time UAV images of soya bean crop. Tested 5 di erent diseases and soil quality assessment.	Resnet-50, VGG-19 with 99.04 % accuracy
5	Smart farming [5]	IoT, WSN, deep learning for fruit growth	SVM, accuracy not reported

6	Pest control [6]	IoT and deep learning using global and local features for pest monitoring	CNNmodelwith86.6% of average accuracy
7	Crop area [7]	Deep learning for plant area monitoring of peanut crop	CNN with 96.45% of accuracy
8	e-health monitoring system due to temperature and radiation changes around the surroundings [8]	Detection of emergency situations	Supervising system and AI
9	Effect of surroundings during winter season only [9]	Effect of batteries and other radiation	Wireless sensor network
10	Climate and ecology monitoring [10]	Study of emissions in the environment	LoRa technology and sensor network
11	Monitoring of data center radiation [11]	Temperature, humidity and energy consumption in data centers monitored for smart city and SEM	IoT
12	Smart industry environment [12]	To study hazardous e ects in industries	ZigBee and WSN LoRa: Long Range

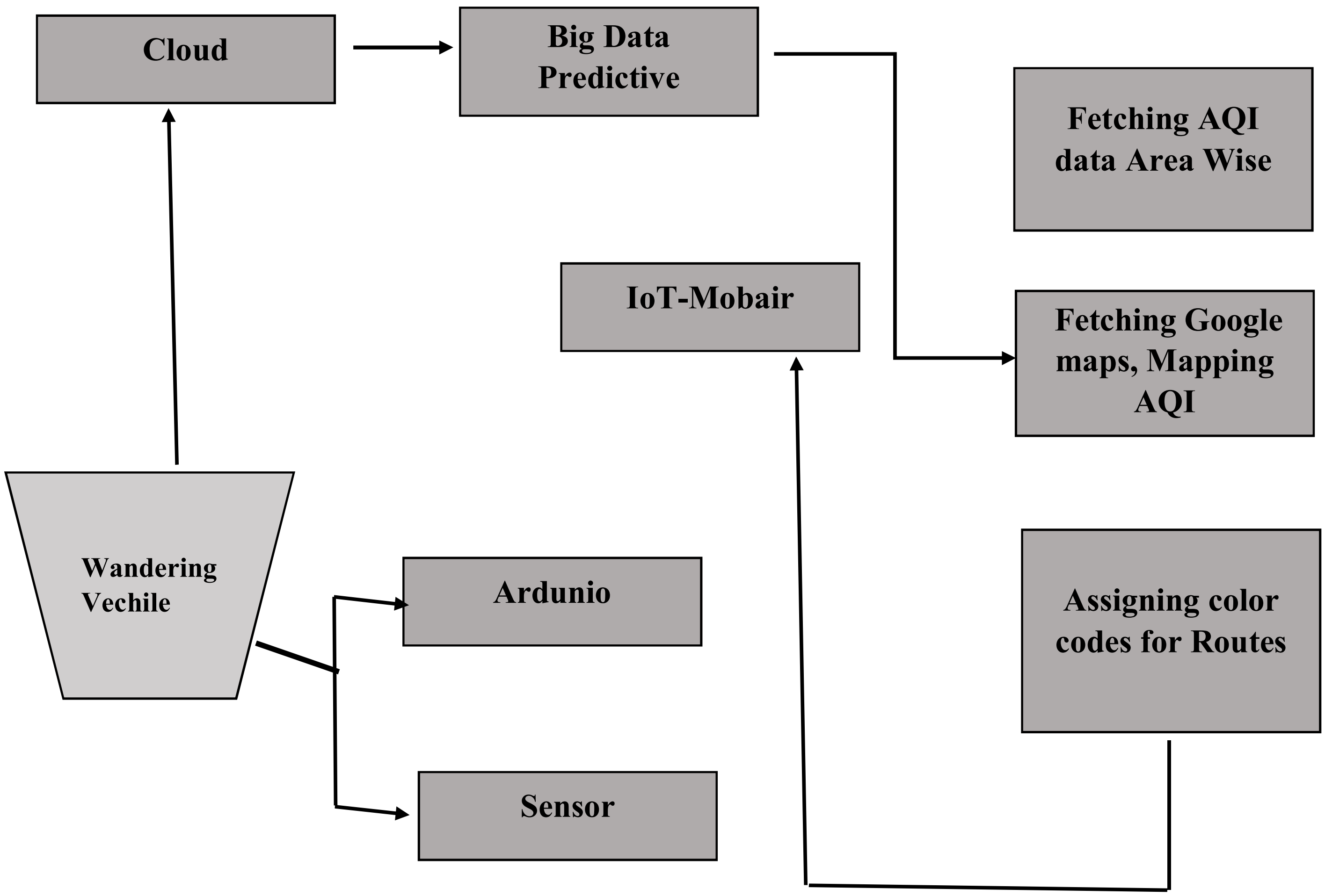
3. SYSTEM DESIGN & ANALYSIS

According to the latest news, The application is designed to provide real-time air quality data and alerts to the users, as well as to predict the future air quality index (AQI) levels using machine learning techniques. The application is also compatible with Google Maps and can show the pollution level of the entire route of a user's journey. The IoT application is a great example of how the Internet of Things (IoT) can be used to improve the environmental awareness and health of the people.

3.1 System Overview.



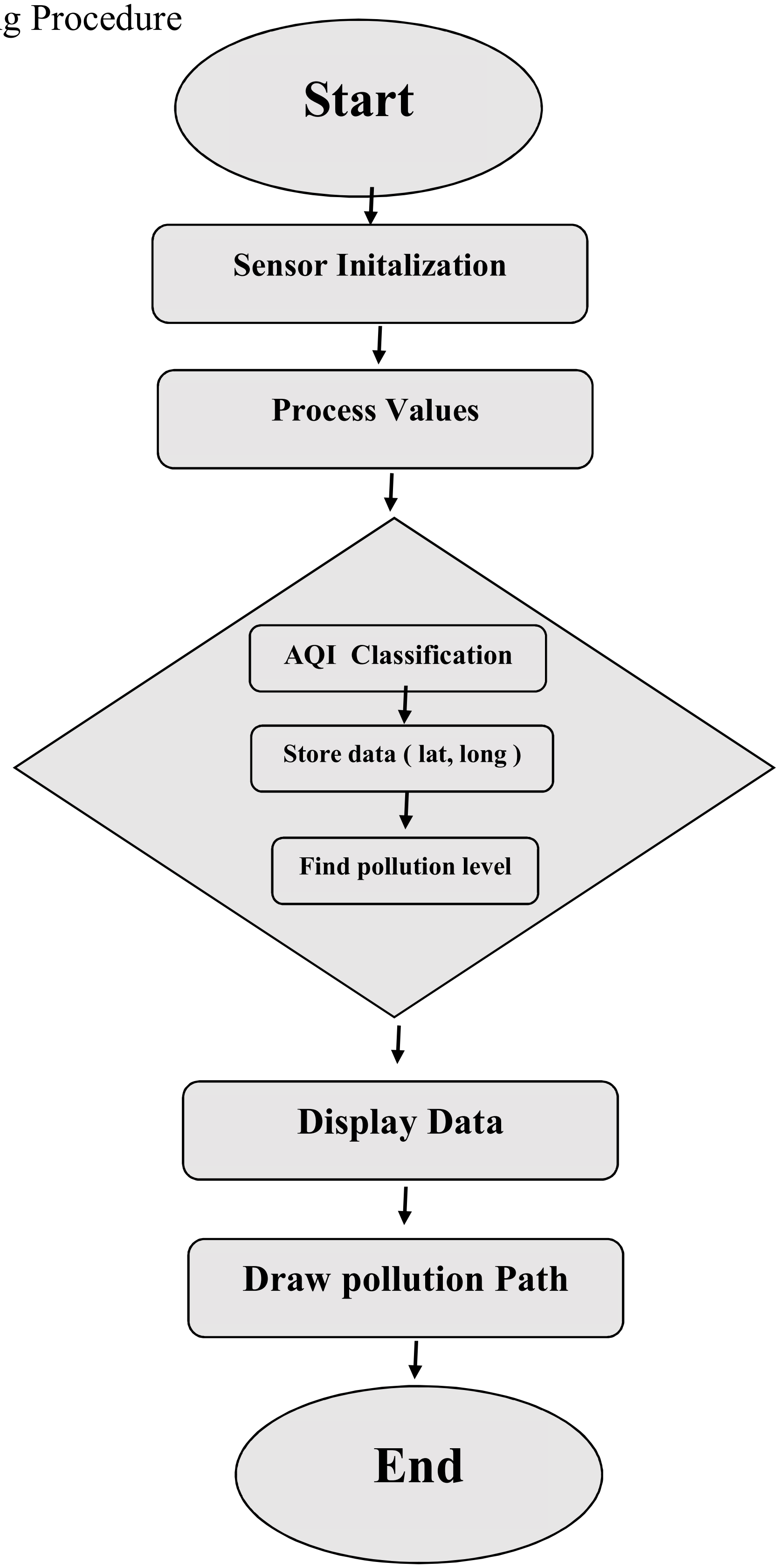
3.2 IoT design overview.



3.4 Algorithm

- **Step 1:** the sensor reads the value of the air quality and sends it to Arduino for processing.
- **Step 2:** Arduino checks if the value is higher than a certain limit. If yes, it means the air quality is bad. If no, it means the air quality is normal. If the value is too low or too high, it means the sensor is broken.
- **Step 3:** Arduino stores the value and the location of the sensor in a suitable format, so that it can be used later to find out the pollution level at that place.
- **Step 4:** the Android app has two options: one is to find the pollution level at a specific place, and the other is to find the best route to avoid pollution.
- **Step 5:** if the user chooses the first option, the app uses GPS to get the location of the place and shows the air quality value and the pollution level there, using the data from Arduino.
- **Step 6:** if the user chooses the second option, the app asks the user to enter the starting point and the destination, and then finds the places in between. The app then shows the air quality value and the pollution level at each place, using the data from Arduino.
- **Step 7:** the app displays the data in a suitable way, such as graphs, charts, maps, etc. The app also uses different colors to show the pollution level, such as green for good, yellow for moderate, red for bad, etc.

3.5 Working Procedure



4.1 Proposed Model Outputs

A dashboard that displays the real-time and historical data of air quality, water quality, radiation pollution, and agriculture systems, using graphs, charts, maps, and indicators. The dashboard can also provide alerts and notifications when the data exceeds certain thresholds or shows anomalies. The dashboard can be accessed through a web browser or a mobile app, and can be customized according to the user's preferences and needs.

A report that summarizes the key findings and insights from the data analysis, using tables, figures, and text. The report can also provide recommendations and suggestions for improving the environmental conditions and mitigating the risks. The report can be generated periodically or on-demand, and can be exported in various formats, such as PDF, Word, Excel.

A model that predicts the future trends and scenarios of the environmental data, using machine learning algorithms, such as regression, classification, clustering, etc. The model can also provide confidence intervals and error estimates for the predictions. The model can be trained and updated using the latest data, and can be evaluated using various metrics, such as accuracy, precision, recall.

5.1 Conclusions and Future Scope of Work

The paper is about reviewing the previous studies on how to use sensors, internet, and artificial intelligence to measure and improve the environment. The paper also gives some suggestions for future research on this topic. The paper mainly focuses on measuring and improving the water and air quality, and how they affect the farming. The paper says that there are some problems in using sensors, internet, and artificial intelligence for the environment, such as dealing with large and noisy data, and choosing the best methods to analyze the data. The paper also says that the involvement of environmental groups, government agencies, and public awareness is important for the success of this topic. The paper also says that the data from the sensors should be cleaned and processed before using them for analysis. The paper also says that the future research should look at other aspects of the environment, such as noise pollution and natural disasters.

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