Martina: Slides -> 8/9/12/13

Giordano: Slides -> 4/5/6/7/11

Michele: Slides -> 1/2/3/10

**DISCOURSE**

**Slides 1:**

Suitable monitoring for air quality, water pollution, and radiation pollution is necessary so that the world can achieve sustainable growth, by maintaining a healthy society. In recent years, environment monitoring has turned into a smart environment monitoring (SEM) system, with the advances on the internet of things (IoT) and the development of modern sensors.

**Slides 2:**

Environmental monitoring becomes essential to ensure that the citizens of any nation can lead a healthy life. Environment monitoring (EM) consists of properly planning and managing disasters, controlling different pollutions, and effectively addressing the challenges arising from unhealthy external conditions. EM deals with water pollution, air pollution, weather changes, earthquake and so on.

**Slides 3:**

With the more recent advances in science and technology, especially artificial intelligence (AI) and machine learning, EM has become a smart environment monitoring (SEM), because the technology has enabled EM methods to monitor the factors impacting the environment more precisely.

It is important to monitor the quality of the environment, the bad quality environment consequences that impact our life can be destruction of biodiversity, scarcity of drinking water, Diseases and so on.

**Slides 4:**

The following Figure highlights the research trends of intelligent monitoring systems in two main categories, first one is IoT and wireless sensor networks while second one is IoT and machine learning. Trends suggest that smart monitoring systems have yet to be implemented and studied extensively on machine learning-based training and subsequent classification or prediction. Research is said to have increased every year, but a greater impact of the IoT and WSN can be clearly seen in the Figure.

**Slides 5:**

In general, the monitoring system consists of various sensors such as pH sensors, turbidity sensors, temperature sensors, and many others. There will be a core controller that forms the heart of the system. All sensors are connected to a main controller and this controller checks the operation, obtains the data from the sensors, compares them with those of the standard values ​​and sends the values ​​to the end user or to the authorities concerned via wireless modules.

The sensor values ​​will be processed, and the primary controller reads the values ​​and uploaded to the cloud. The values ​​will be monitored continuously verifying if the sensor values ​​are greater than the established threshold or not. If the sensor values ​​are greater than the threshold, they will be communicated to the end use.

With advances in IoT technology, monitoring systems are becoming smarter with reduced power consumption and ease of use.

**Slides 6:**

The environment monitoring system is mainly composed of three levels: the perception layer, the network communication layer, and the application layer. This system conforms to the basic architecture of the IoT.

The network layer mainly uses the 4G or General Packet Radio Service (GPRS) to transmit data to the server. The user can query the measurement data through the terminal computer or their phone. The main function of the application layer is to analyse the received data and displays the data more intuitively through the form of a graph. Combine the database and obtain the analysis result.

**Slides 7:**

Since data collection using IoT technology was the main goal, several additional requirements must be met to make the solution applicable in different contexts.

This goal can be achieved by inserting 3 layers:

- Measurement nodes: Microcontrollers with sensors.

- Message broker: MQTT.

- Data storage and visualization.

As shown in the Figure, a measurement node consists of a microcontroller and several sensors. Microcontrollers allow the use of a wide variety of low-cost sensors. Furthermore, the micro controllers require low power and can be easily implemented in different places. The addition of a Wi-Fi module allows for simple integration of measurement nodes into existing networks. Using Wi-Fi, the measurement nodes can also be placed in any point of the production plant without the need for additional network cabling.

The measurement node uses the MQTT protocol to publish the sensor data. Message Queuing Telemetry Transport (MQTT) is a lightweight protocol that uses a model of publication / subscription. Therefore, MQTT is often used for data transmission in IoT applications. The MQTT broker broadcasts messages to all clients who subscribe. The MQTT protocol allows for a very scalable solution since multiple measurement nodes can be added as clients. This allows for simultaneous measurement and monitoring at different locations within the facility. The next step includes analysing this information, while proper visualization is essential when performed by human operators.

**Slides 8:**

IoT, WSN and suitable sensors are the most important parts of environmental monitoring systems. WSNs provide the connectivity of data, acquired using IoT sensors and devices, used to record, monitor, and control various environmental conditions, such as water quality, temperature, air quality, and so on. An intelligent environmental system can be easily understood with the help of an example of a cloud-based system, as shown in the Figure. The example shown in this figure illustrates the monitoring of water contamination and its control, using a cloud-based system that connects IoT devices and various suitable sensors.

The system can monitor, with the help of IoT devices, whether the water is contaminated or clean as all IoT devices have incorporated the capability of AI and machine learning. The organization, which is involved in monitoring the water quality of various water sources, has access to the cloud through data collected from various sensors, such as a water sensor, and is subject to IoT-based analytics where quality control is carried out.

**Slides 9:**

There are a lot of existing system in environmental quality monitoring, now we will focus on water quality ones:

The first one is an IoT-based Smart Water Quality Monitoring (SWQM) system which helps in the incessant measurement of the quality of water based on four different parameters of water quality, such as pH, temperature, turbidity, and electric conductivity. Four different sensors are coupled to Arduino Uno to sense the quality parameters. The data collected from all four sensors are communicated to a desktop application.

The second one is again a Smart Water Quality Monitoring (SWQM) system, here we have a reconfigurable sensor interface device using an IoT environment. Sensors, Field Programmable Gate Array (FPGA) board, and a Zigbee-based wireless communication module were used in the proposed model. Six different water quality parameters like turbidity, pH, humidity, water level, water temperature, and carbon dioxide (CO2) on the surface of the water were considered in real-time. The proposed method will help in guarding the safer and balanced environment of water bodies. The system reduces the cost and time in determining the quality of water in water resources as part of managing environmental and ecological balance. In a future work, the WSN network will be developed involving of an additional number of nodes to encompass the coverage area.

**Slides 10:**

The environmental monitoring systems that have been studied have led to the following observations:

• SEM research has several purposes. Studying water pollution, air quality, moisture and soil can help model and design healthy environmental systems that would also aid smart agriculture for sustainable economic growth.

• The methods for each of the purposes are broken down in terms of sensory data used, machine learning methods used, IoT devices used, and types of sensors involved.

• The methods were used for both classification and forecasting; for example, water is classified as polluted or clean water; in the same way it is possible to predict the quality of water and air.

**Slides 11:**

All studies on environmental monitoring systems have major problems such as:

• Wherever heterogeneous sensors are used, there is the problem of interoperability in the analysis of the data acquired through different types of sensors.

• The sample size is limited in many of the contributions.

• Noisy data presents a challenge in analysis. Noise is present in the data acquired through sensors used for various purposes. Noise can be contributed by several internal and external factors.

• Machine learning methods used for data training and classification are mostly traditional machine learning methods.

• No robust machine learning approach has been reported that can be employed to address the challenges of the environment regardless of the purpose of monitoring and control, the types of data and types of sensors used.

**Slides 12:**

Some recommendations for better, robust, and smarter environmental monitoring systems are the following:

• A framework of machine learning methods needs to be developed.

• It is necessary to design a robust set of classification and prediction models capable of operating on any data, regardless of the purpose of using the SEM.

• Adequate denoising methods need to be implemented as pre-processing for the main stages of SEM as most research did not use data denoising and their appropriate pre-processing.

• Data duplication approaches and other methods are needed to address the big data problems involved in some studies.

• SEM aims at the sustainable development of any nation and smart agriculture and smart environment play a very important role in achieving sustainable goals, but in rural areas, the infrastructure required for building IoT, WSN and other sensors is still a challenging task.

• Interoperability problems in the implementation of various types of sensors can be addressed by developing adequate standards and protocols that can make data compatible for all acquisitions and analysis systems.

**Slides 13:**

The need of extensive research on deep learning, handling big data and noisy data issues, and a framework of robust classification approaches are highly needed. The major challenges in implementation of smart sensors, AI and WSN need to be addressed for sustainable growth through SEM. The poor quality of sensory data can be pre-processed using appropriate filters and signal processing methods to make the data more suitable for all subsequent tasks associated in SEM. In this presentation we have focused mainly on water quality since water in one of the most valuable things we have, our next is to develop by our own an IoT water quality monitoring system.