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IoT-Based Disaster Management Andearly Warning System for Fallen Trees

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Abstract – Natural disasters not only make immense losses and damages to the economy and human lives every year. That is why disaster prediction, timely warning creation, and distribution systems could and shouldbe created and enhanced. In order to offer an effective mechanism to gather information on the environment and produce warnings, technologies, like the Internet of Things, which have been recently introduced to warning systems are being adopted. This work reviews the literature on Internet of Things solutions to early warning systems of the different natural disaster such as flood, earth earthquake, tsunami,and landslides. This paper set out to profile the architectures that have been adopted, articulate the constraints and requirements of early warning systems, and tabulate this step-by-step method of determining the most prolific solutions among the four use cases of the study. Modern technology is being increased at a very high rate in the world in general and the communication technology in forms of the Internet of Things is gaining much demand in large information technology companies. The reason is that the Internet of Things is the net system of the physical connected to the internet, and mutually connected objects.These gadgets have sensor, software and other technologies which can gather and exchange data without any human interaction.The abundance of data implies that analytical decisions can be made in a much shorter timebut more accurately due to the possibility to obtain a wide view of a process. IoT can enhance the humanity.

Keywords: Internet of Thing (IoT), Disaster, Management, Natural, Tree Fall Detection, System, Local Server.

1. INTRODUCTION

When an Early Warning System (EWS) is an integrated architecture of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities, systems, and processes, people, communities, governments and others can be able to take timely action to reduce disaster risks prior to the unsafe event. The key elements of an EWS, knowledge, risk assessment, observation of variables that coul denhance or simplify forecasts and predictions, appropriate warnings, and disaster response preparation arelisted below (Abdalzaheretal.,2023).The United Nations Sendai frame work reachforward its plans on disaster reduction, and it is proposed to increase the range of accessing and availability of multi-hazard early warning systems by 2030 considerably.

The implementation of monitoring, warning and decision support systemis very much important in minimizing the adverse effects of a disaster within the community. An early warning and decision support system provides one with information regarding any impending hazardous event. It also facilitates early intervention so that the risks and loss of life can be avoided early, also so material and economic impacts of disaster can be controlled (Abdalzaher et al., 2023). The modern achievements in the area of communication, information technologies, and risk awareness are of great value to such a system.

The Io Tconsists of the infrastructures that are connected to connected things that make them capable of connecting to data and data mining, management, andaccess.Itaimsat connecting sensors, actuators, or objects to perform a diverse set of functions such as environmental monitoring that can be put to a varietyof specialized applications (Esposito et al., 2022). The purpose of an EWS is not only one. There is a warning system that informs about a future danger, and the reisan EWS that fo recasts the possibility of a disaster and other unwanted occurrences and averts them. Most of the current EWS incorporate algorithms that predict a possible future natural disaster (Suciuetal.,2017) .They are also capable of producing the proper responses to make plant behavior stay within the usual operating limits.

2. MATERIALS AND METHODS

2.1 System Overview

It wasa project aimed at conceptualizing and building anInternet ofThings (IoT) system that was involved in early warning about the stability of trees. The combination ofthe motion and environ mental senses in the system was used to spot early indications of unsteadiness which would cause falls in trees. At the core of this arrangement was the ESP32 microcontroller, which acted as the primary controller, with the role of reading the dataonthe sensors, locally displaying them and relaying them to the cloud, where it could then be monitored remotely. This system allowed visualizing real-time data ona small OLED screen and create alerts in a mobile application with the Blynk IoT platform.

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2.2 Objective 1: to design and develop an electronic circuit for fallen tree detection.

Hardware Components

The main modules employed in this project were ESP32 microcontroller, MPU6050 sensor, DHT22 sensor, 0.96-inch OLED display, and jumper wires, as well as breadboard to test the project. The ESP 32 was selected because it had the built inWi-Fi network and communicated with an extensive varietyof sensors. Since the MPU6050 sensor had information on accelerationand gyroscopic movement,it was appropriate in identifying the tilt and vibration of the trees. In the meantime, to monitor the environ mental conditions environment i.e. temperature and humidity were monitored using DHT22 sensor, this factor plays animportant role to determine the state of soil moisture, as well as the risk of root-related issues. OLED screen presented real time sensor data in the field, which local monitoring was convenient.

Installation and Circuit Design

The subsystems were get together in a simple circuit design. The MPU6050 and OLED display were also connected using the I2C communication standard to the ESP32 and all of them shared the SDA and SCL. The DHT22 sensor was also attached to either one of the digital GPIO pins of the ESP32. The ESP32 had 3.3V and GND pins which were used to power all the components.

The earlycircuit was set on a breadboard so that it could be simple to adjust, test, debug the project andreadjust thecircuit componentsbeforetheywouldbedecideduponthehardware.

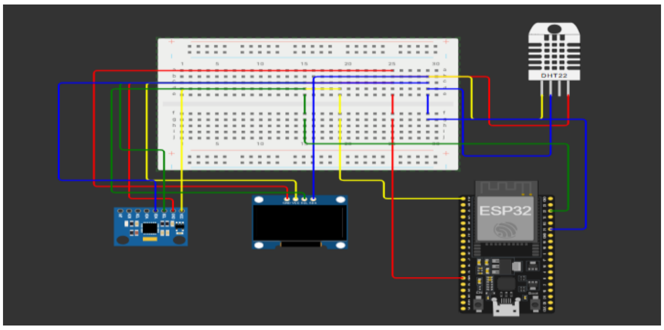

Figure 1. Circuit Diagram of IoT-based disaster management and early warning system

2.3 Objective2: tobuild and program anIoT-based system for monitoring of tree stability.

Software Implementation

The Arduino IDE wasrelieduponso asto writeanduploadthecodetothe ESP32.Anumber of libraries have been incorporated to communicate with sensors and allow communication with cloud. The libraries that were crucial in the connection of the ESP32 to aWi-Fi and the connection to the Blynk platform with it was the WiFi.h and BlynkSimpleEsp32.h libraries. Wire.h was used to allow communication via I2C which both the MPU6050 and OLED display needed. The libraries Adafruit_SSD1306.h and Adafruit_MPU6050.h enabled communication with the OLED display and the motion sensor and the DHT.hlibrary allowed me to read out the temperature and the humidity values of the DHT22.

Program Flow and Functionality

There were two functions used to control the workings of the system; setup () and loop (). When the device wasturned on , it was possible to run the setup () function.It configured the sensors and tried to connect to Wi-Fiand to Blynk cloud. To ensure connectivity, status messages would be displayed in the OLED screen. When the Wi-Fi or Blynk have not connected, error messages were shown in the system.

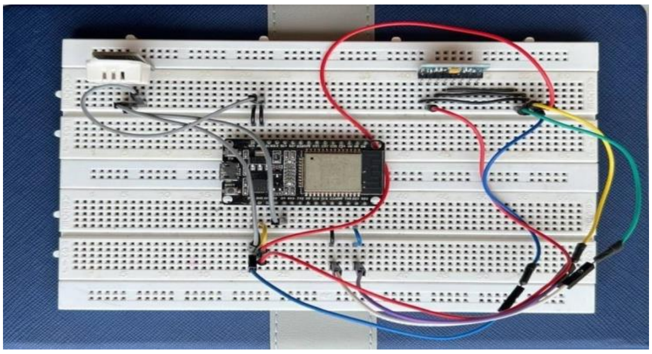

Figure 2. Circuit Design of IoT- based disaster management

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The loop () was continuously running to read values ofthe sensors, refresh the OLED screen, and send data to Blynk in intervals of two seconds thanks to a timer. Another purpose, check Connections(), was being called after every five seconds to ensure the stability of Wi-Fi and Blynk connection to detect a possible disconnection as quickly as possible.

2.4 Objective 3: to evaluate the performance and reliability of the IoT-based early warning system for periodic tree monitoring without real-time data.

Testing and Deployment on the Real World

The system was now built in totalityand programmed accordinglyand then tested in real terms. To observe its behavior in the naturalweather, the whole set up was set up close to a tree and left there to observe its behavior after an hour. In order to emulate environmental changes,theDHT22sensorwassubjectedto someheat and moistureandtheMPU6050was manuallytilted to create aneffect which would occur incase trees move. The OLED screen has been able to displaythe values and the Blynk application has been able to display the values and inform the users in case of abnormal sensor readings. This confirmed the capability of the system to work under real life outdoor situations.

Real Time Data Lacking Periodical Monitoring

At another stage of testing, periodic monitoring with out areal-time transmission of data was also tested on the system. The sensors in this arrangement were programmed to take data at specific time intervals instead of monitoring the data continuously. Data gathered was stored on a local server or uploaded on a cloud server in bulk. This would enable the system to be evaluated in terms of its accuracy, battery efficiency, signal efficiencyand completeness of the data. The rationale was to establish how well the system can be deployed long term in remoteorlow-connectivity regions, where real-time continuous streaming of the data can not be done.

3. RESULTS AND DISCUSSION

3.1 Data Collection and Monitoring of Sensors

When the sensors were attached to ESP32, and code uploaded via the Arduino IDE, the system started functioning properly.The code was created in suchaway that it could enable the DHT22 (temperature and humidity) andMPU6050(tilt) toconveydatato theESP32.This data, which was presented on the Arduino Serial Monitor. The system also sent constant values such as temperature, humidity, and the tilt which made it clear tha tth esensors were operating properly and all the data was being received and read by the ESP32. Along with the Serial Monitor, same data was displayed directlyon device using OLED screen. It became simple to readon- site values of temperature, humidity, and tilt without having a computer. The system became convenient and reliable in monitoring activities around the tree since both the Serial Monitor and the OLED screen were functional

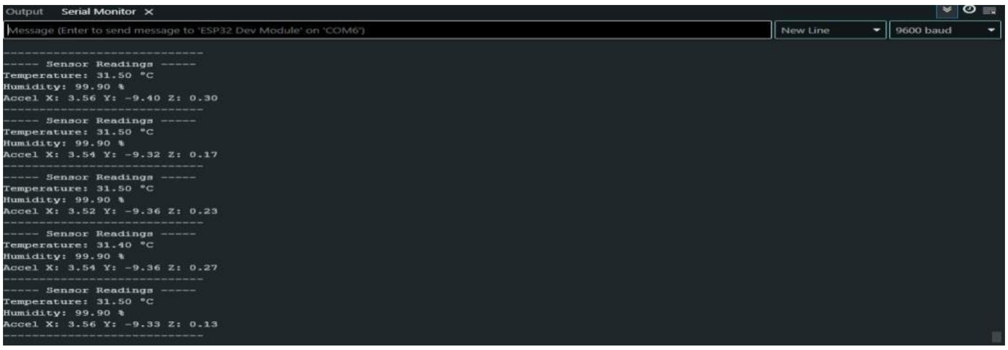

Figure 3. Results of serial monitor

3.2 Data Transmission and Display by using Blynk

The sensor data was alsosent via Wi-Fiby ESP32 to the Blynk cloud and was visual izedin the Blynk mobile app. It was an app that provided live graphs, gauges of temperature, humidity, and tree tilt. This enabled one to monitor the wellbeing of the tree through a smartphone. In an example, when the tree was tilted,it was able to detect the changes on the X,Y and Z axis and the graph in the app would show the movement in different colours. In one of the tests, the sharp decline inX-axis at 5:15 PMand fluctuation at 6:30 PM indicated that the system had a good ability of detecting the move ment of trees. This was of assistance to demonstrate the ways in which the tilt sensor had been functioning well and how thes ystem coulddet ect the stability of trees. The DHT22 meanwhile continuously up dated temperature and humidity information and was useful in identifying weather events that made trees fall easily.

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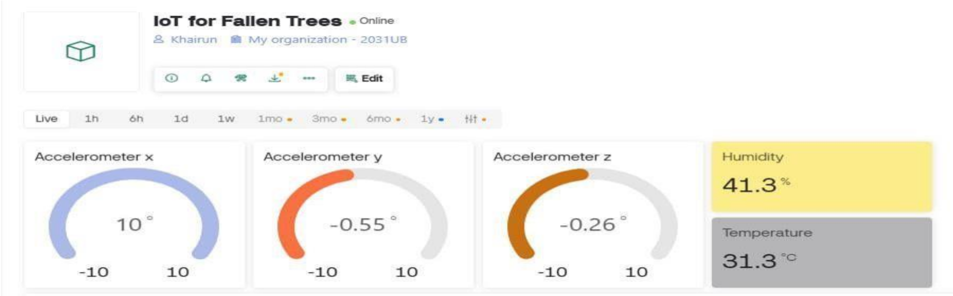

Figure 4. Blynk Data base

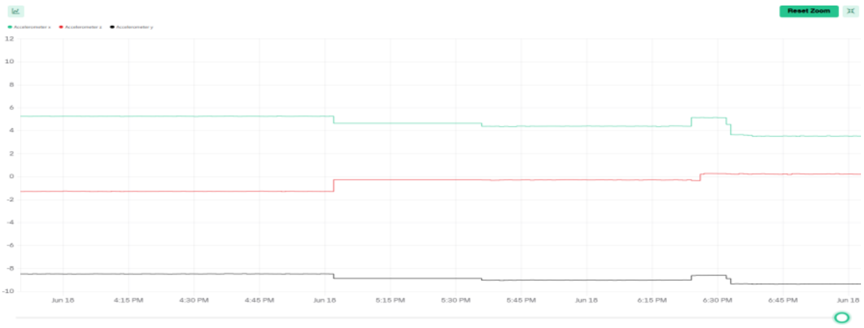

Figure 5. Graph Resultsin Blynk

3.3 Blynk-Smart Notification System

Possibility to receive alert notification via the Blynk app is among the most useful features of this system. In the testing, the ESP32 was able to send the data as soon as the MPU6050 triggered a strong tilt or as soonas the DHT22 had registered dangerous temperature or Moisture levels. The application followed it by alerting the individual on his or her smartphone notifications in several seconds. The alerts were also clearand prompt; there fore, usersdid not have to keep checking the app on the phone. When something was not right, the system was able to warn its users automatically and they would have time to respond and maybe avoid imminent danger. The additional safety and utility of this system interms of disaster prevention was added by this smart feature of the notification.

4. CONCLUSION

1. The creation ofan IoT-based disaster management and earlywarning systemof fallen trees have proved that aworkable and effective pattern of keeping track ofthe tree statuses in the right then and there. Through implementing the varying essences of the project including the most influential sensors like MPU6050 to detect the motion insidethe tree and DHT22 to monitor the environ mental condition, and the ESP32 microcontroller to act asthe brain of the whole system, the project was able to collect and analyze data to identify the early stages of tree instability successfully.
2. Any Wireless data transfer and visualization on mobile devices in real-time occurred effortlessly,and the system could be used inremote and distant are as duetoenabling the Blynk IoT platform. It made the users more responsive and safeby in traducing live feed back in terms of OLED display and smartphone notification in disaster-affected regions. The proposed systemcan beused as aneffective and affordable solutionto hazard caused byfalling trees in areas most proneto storms, heavy precipitation, and high winds. It showsthe waysonhow to use the power of the IoT technologies to make the environmental space safer, allow to intervene before some thing wrong happens, and have a chance to save lives and property against natural hazards.

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