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Project AMY: A Water Level and Water Current Surveillance System in Flood-Prone Areas

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ABSTRACT

"PROJECT AMY: A Water Level and Water Current Surveillance System in Flood-prone Areas". This system is aimed at monitoring flooding by improving such safety measures associated with floods, especially in flood-prone areas where frequent floods are experienced. The project applies several critical components, such as a water flow sensor, a waterproof ultrasonic sensor, and NodeMcu ver. 1.0(esp8266) with the Arduino Uno R3. These will form an effective solution when the raining intensifies and alert in time for taking proactive measures in flood-prone regions. Using experimental research methods, Project AMY undertakes several very hard steps of testing: unit, integration, and system testing. These will allow all the components of the system to work perfectly not only independently but also together. Live data will be processed and transmitted to a mobile application using Firebase, which will allow them to send instant alerts from the mobile application directly to smartphones regarding rising water levels and flooding alerts. The mobile application was designed on purpose to be as minimal as possible to make it friendly for the user interface and high usability even for people who are not technologically astute. Besides this recommendation for future research will focus on other environmental situations that would better the prediction of water accumulations and result in an effective system in terms of feasibility. Such insights gathered through this study can contribute significantly in the design of IoT-based flood monitoring systems that may adequately support affected communities and infrastructures plagued by flooding. Incorporating cutting-edge sensor technology with real-time transmission capabilities in Project AMY design improves the effectiveness of a response action during floods and increases community safety in flood-prone areas. This will result in greater resilience and better preparedness for clients against flooding events while emphasizing community awareness and involvement in strategies designed for flood management.

Keywords: *Flood monitoring system, water flow sensor, waterproof ultrasonic sensor, NodeMcu ver. 1.0(esp8266), Arduino Uno R3, areas prone to flooding, mobile app, firebase, water levels, potential flooding, instant alert, IoT-based flood monitoring systems*

INTRODUCTION

Flooding poses a significant and immediate threat to lives, infrastructure, and the environment, particularly in flood-prone areas characterized by heavy rainfall, inadequate drainage systems, and proximity to rivers or coastal regions. The frequency and severity of flooding events have intensified in recent decades, largely due to climate change and urbanization (Navarro et al., 2020). The impacts of flooding extend beyond immediate threats to human safety; they can result in widespread displacement, destruction of property, loss of livelihoods, and long-term psychological trauma for affected communities (Saleh, Yuzir, and Abustan, 2020). Despite the implementation of various flood mitigation measures, many strategies have proven insufficient in effectively addressing the persistent challenges posed by flooding (Smasuri, Abu Bakar, & Unjah, 2018). As urban areas continue to expand and climate variability increases, the need for innovative solutions to manage flood risks in vulnerable regions becomes increasingly urgent.

Through the project, there was an advanced stage of developing a high-tech flood monitoring system that fused concepts in robotics and Internet of Things (IoT). The hybrid system is targeted to monitor water levels and currents in water-prone areas without relying on humankind, providing real-time data and early warnings to local authorities and residents. Project AMY incorporates waterproof ultrasonic sensors and water flow sensors to enhance emergency preparedness with real-time alerts output through an accessible mobile application. The project would be heavily experimental, involving unit, integration, and system testing to ensure reliability. Project AMY will contribute to the reduction of direct hazards by supplying the instant alert regarding the likely flooding, thus developing long term resilience for the community against flooding.

MATERIALS AND METHODS

Project AMY has provided a flood warning system through Firebase which connects the real time information to a mobile application in alerting the residents of the condition of flooding. Thus, this innovative approach will enable instant communication of critical information, hence enhancing readiness and safety in a community upon an event of flooding. Data collection was conducted in an aquarium and a mini bridge designed to simulate the F. Torres

Bridge, where experimental conditions can simulate real flood events. It offers runoff calculations and insight about water behavior under conditions of flooding in a city.

The F. Torres Bridge area is also susceptible to overflow and siltation due to the elevated position of the area and its surrounding other infrastructure. As a connecting point in Davao City, this area's hydrological dynamics is highly critical to be addressed well for effective management of flooding. Simulation of conditions of the flood would focus on developing responsive early warning systems that can enhance much through the response strategy and protect local communities against adversities caused by flooding.

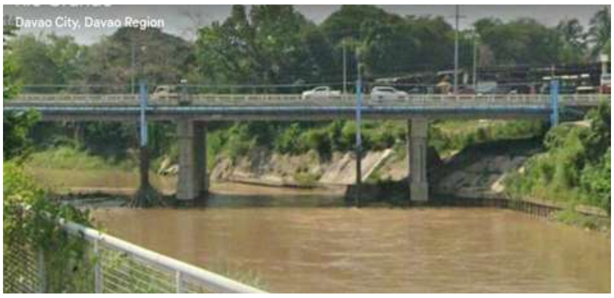

Figure 1. F. Torres Bridge

The experimental setup, featuring the simulation model with a total height of 47 cm, closely simulated reality flooding cases. From the ultrasonic sensor, it had 20 cm of the aquarium that was a blind spot, while the bottom 27 cm was used in the measurement of water depth accurately. This setup allows for accurate data gathering since the 1:1 scale, whereby 1 cm in the aquarium corresponds to 1 foot in real life, enables the researcher to be able to set up a model of flood conditions at the F. Torres Bridge. Project AMY will look into changes in water level as well as sensor readings as it fine-tunes its capabilities regarding flood monitoring so as to be more precise with its early warning alerts. The systematic approach to understanding the dynamics of flooding will add value not only in understanding the flood dynamics but also in developing workable strategies for mitigating flood risks in vulnerable urban areas.

Figure 2. Aquarium for Simulation

A relevant study that would align with Project AMY is the "IoT-based Flood Monitoring and Alerting System using Arduino Uno." It created a smart flood detecting device that employs water level sensors and rain sensors to track the water levels and rainfall intensity so that alerts are immediately transmitted to communities in nearby areas prone to flooding. Sensors store data on environmental conditions, which get transmitted to an Arduino microcontroller. The system sends alarms to the authorities, in charge of alerting the residents, once the water level exceeds a set limit. This allows the local authorities and residents to take appropriate precautions (Behera & Parida, 2020).

The device works on the principle of the integration of water sensors that measure the depth of water in lakes or rivers nearby and the rain sensors that evaluate the rate of rainfall at the place. Thus, this information is processed by the Arduino, and through GSM or Wi-Fi, alerts are given to inform residents in case of flooding. The IoT approach reflects that flood management should incorporate such systems as Project AMY uses Firebase for alerts. Such innovations help these systems enhance community safety and preparedness in flood-prone areas.

Costing of Materials

This section outlines the expenses associated with acquiring and utilizing materials necessary for the Project AMY's completion.

Item	**Cost**
Arduino Uno R3 x2	₱ 809
MB102 Breadboard Power Supply Module	₱ 175

Wifi module esp 8266	₱ 200
Jumper Wires	₱ 90
Waterproof Ultrasonic sensor x2	₱ 596
Water Flow Sensor Flowmeter	₱ 320
9V Battery	₱ 105
9V Battery Button Power without Dc Plug	₱ 30
Lithium Battery Charger Module	₱ 34
Breadboard	₱ 35
NodeMcu Base Board V1.0	₱ 300
Water Level Sensor Float Switch	₱ 149
Water Level Sensor x3	₱ 165
Solid Core Wire	₱ 20
Solar Panel	₱ 250
Solder Lead	₱ 67
Styrofoam	₱ 72
Transparent Tube (For Simulation)	₱ 24
Simulation Model Designs (Spray Paint, Fake Leaves, etc.)	₱ 303
TOTAL:	₱ 3714

Preparation of Materials

Figure 3. Wiring of Project AMY

OPERATING VOLTAGE AND CURRENT DRAW:

Ultrasonic sensor - working voltage 3-5.5V DC, Working current 40mA

Water flow sensor - operating voltage 4.5V to 18V DC, working current 15mA

ESP8266 - operating voltage 3.3V, working current 70mA

Total Current Draw : 506mA

Breadboard power supply - input 6.5 V to 12 V (DC) or USB Power Supply, Output voltage 3.3V / 5V , maximum output current: 700 mA

Connection of sensors:

1. Waterproof Ultrasonic Sensor
    - 5v ultrasonic to 5v arduino
    - Gnd ultrasonic to gnd arduino
    - Trigpin ultrasonic to pin9 arduino
    - Echopin ultrasonic to pin10 arduino
2. Flow meter:
    - Positive to 5v arduino
    - Gnd to gnd arduino
    - Pin out to pin11 arduino
3. ESP8266
    - Gnd to gnd arduino
    - D5 to pin6 arduino
    - D6 to pin5 arduino

Breadboard power supply - input 6.5 V to 12 V (DC) or USB Power Supply, Output voltage 3.3V / 5V , maximum output current: 700 mA

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Prototype Making

Figure 4 & 5. Assembling

The researcher assembled the Project AMY prototype using the materials on Table 1 and asked help to the consultant for the correct wirings.

Software Development

Figure 6. Arduino IDE used for coding

Using the Arduino IDE, the researcher created codes with the help of the corresponding connections of the sensors listed above.

Mini Testing

Figure 7. F. Torres Bridge Simulation Testing

Using the aquarium model for the simulation, the researcher have done a mini testing as a presentation of the function of the prototype.

RESULTS AND DISCUSSION

This section will present the results and discussion of Project AMY that will answer the research questions and accomplish the research objectives. The researcher will determine the accuracy of the reading to the water level of the ultrasonic sensor that our model proposed by using the Mean Absolute Error (MAE) method. This method provides us with a means of quantifying performance by finding an average absolute difference between two sets of readings that will ultimately be telling us more about how this device can function in terms of reliability and efficiency in flood monitoring applications.

Water Level reading from the Ultrasonic Sensor	Actual Reading from the Simulation Model	Absolute Errors
4.26 cm	4.20 cm	0.06 cm
4.86 cm	4.83 cm	0.03 cm
5.05 cm	5.02 cm	0.03 cm
5.87 cm	5.84 cm	0.03 cm
6.38 cm	6.34 cm	0.04 cm
7.43 cm	7.41 cm	0.02 cm
8.53 cm	8.49 cm	0.04 cm
9.32 cm	9.27 cm	0.05 cm

10.32 cm	10.31 cm	0.01 cm
11.16 cm	11.13 cm	0.03 cm
11.98 cm	11.96 cm	0.02 cm
12.61 cm	12.57 cm	0.04 cm
13.37 cm	13.29 cm	0.08 cm
14.13 cm	14.11 cm	0.02 cm
14.97 cm	14.95 cm	0.02 cm
15.78 cm	15.74 cm	0.04 cm
16.57 cm	16.55 cm	0.02 cm
17.24 cm	17.21 cm	0.03 cm
17.93 cm	17.88 cm	0.05 cm
18.65 cm	18.60 cm	0.05 cm
19.37 cm	19.33 cm	0.04 cm
20.08 cm	20.02 cm	0.06 cm
20.87 cm	20.84 cm	0.03 cm
21.69 cm	21.67 cm	0.02 cm
22.48 cm	22.45 cm	0.03 cm
23.21 cm	23.18 cm	0.03 cm
23.89 cm	23.85 cm	0.04 cm
24.67 cm	24.62 cm	0.05 cm
25.45 cm	25.43 cm	0.02 cm
26.33 cm	26.28 cm	0.05 cm

Sum the Absolute Errors: Add all the absolute errors together. The total sum of all absolute errors is **1.09 cm**.

Calculate MAE: Divide the total absolute error by the number of readings to find the MAE. The Mean Absolute Error is **0.036 cm** (rounded to three decimal places).

Project AMY showed better accuracy in flood monitoring compared with the previous systems, giving a better alarm when the water level went into flood levels. To further improve its performance, strategic placement of Project AMY is suggested in areas that have experienced floods or areas which are flood-prone in general, which will give more positive outputs in comparison to random placement.

In addition, offering tools for better analysis and community engagement options would make it easier to adapt Project AMY to any region that is prone to flooding. Overall, in all its pioneering uses for monitoring floods, these features will catapult Project AMY's effectiveness in diverse environments.

CONCLUSION

In conclusion, Project AMY represents an advancement in flood monitoring and management technology. There has been a revolution in flood monitoring and management technology with the union of IoT and robotics, which has been able to track the real-time data of levels and currents of water. It ensures emergency preparedness among communities at risk from flooding. Firebase has been integrated into the monitoring system through a mobile application to send immediate alerts to residents in case of rising floodwaters and preventive measures taken by them. The experimental setup used in this project simulating the aquarium representation of the F. Torres Bridge clearly depicts its dedication towards gathering actual data and carrying out proper flood response strategies.

Some suggestions put forward by the article "IoT-based Flood Monitoring and Alerting System using Arduino Uno" states that sensor technology is effective in the detection of floods. Behera & Parida's study monitored water levels with water and rain sensors connected to an Arduino Uno and gave out signals in case of flooding, demonstrating a practical approach towards flood management (Behera & Parida, 2020). Project AMY thus demonstrates the above factors through ultrasonic sensors and an improved transmission system, which allow for effective and productive use of flood-mitigating strategies. The integration of such IoT technologies into this project is therefore an indication of the potential enhancement in disaster response and community safety.

Although the short-term benefit of Project AMY is immediate risk reduction from flooding, long-term community resilience also comes through this project. Project AMY will be able to demonstrate its ability to develop novel technological and methodological approaches in promoting future research and development in disaster management systems, whereby the promptness of information differences between disaster and safety to vulnerable populations.

RECOMMENDATIONS

There should be further research in the coming future to further improve the competencies of Project AMY by studying and analyzing further the other possible interfaces that can be integrated into its flood monitoring system for other environmental variables. These are types of soils, uses of land, and other infrastructure within urban areas that influence flood dynamics. The most advanced analytical techniques that will be employed include a number of permutations and combinations of machine learning algorithms in maximizing the accuracy of flood predictions and early warning alarms.

Moreover, Further studies should also be attempted to expand the scope of data collection beyond water levels and currents. For example, including meteorological data such as that concerning rainfall intensity and duration would add a much more detailed concept of flooding. Finally, the study on the relationship between runoff calculations and flood occurrences may help create more predictive models that include additional environmental factors affecting the system.

It is also recommended that the researcher/s implement community-based training programs targeting the strengthening of local capacity to effectively use the technology provided under Project AMY. Involving the community in data collection and analysis will empower them and make them own the flood management efforts. By including such recommendations in further research, Project AMY can significantly improve its effectiveness in mitigating flood risks and enhancing community resilience.

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