engineering proceedings

Proceeding Paper

The Development of Early Flood Monitoring and a WhatsApp-Based Alert System for Timely Disaster Preparedness and Response in Vulnerable Communities †

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† Presented at the 2nd Computing Congress 2023, Chennai, India, 28–29 December 2023.

Abstract: Although many innovations have been achieved and natural disasters are well known to be extremely detrimental to persons and property, there is still no 100% assurance that alerts and real-time monitoring will work. Vulnerable communities sometimes relied on crude warning systems, such as flood gauges, observation towers, and local messengers, to deal with the unpredictable nature of floods. However, the effectiveness and reach of these strategies were constrained, leaving many people vulnerable to the disastrous effects of flooding. Therefore, the integration of cutting-edge technology and a system that is integrated and innovative overcomes the limits of conventional flood monitoring systems. The incorporation of WhatsApp, a widely used messaging service, into the flood monitoring and alerting process is a unique aspect of our system. We increase the reach and efficiency of our early flood warning system by combining standard SMS with WhatsApp messages. Additionally, our system includes sophisticated flood monitoring features that continuously monitor crucial parameters, including water levels. Administrators and authorized operators can respond quickly when the system sends alerts in reaction to aberrations from established thresholds. This invention bridges the gap between cutting-edge hardware and modern communication methods, representing a substantial advance in flood management technology. In conclusion, this research emphasizes how technology has the potential to improve catastrophe preparedness and response. It offers evidence of how innovation may be used to solve pressing problems and protect vulnerable areas from natural catastrophes, ultimately boosting resilience to flood events.

Keywords: flood monitoring; IoT; cloud; alert and notification

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Citation: Kavitha, P.; Yatheesh.K.C.; Anand, A.; Sreenivasan, S.; Mohammed S, H.; Borah, N.; Saikia, D. The Development of Early Flood Monitoring and a WhatsApp-Based Alert System for Timely Disaster Preparedness and Response in Vulnerable Communities. *Eng. Proc.* **2024**, *62*, 18. https://doi.org/10.3390/engproc2024062018

Academic Editors: Geetha Ganesan, Xiaochun Cheng and Valentina Emilia Balas

Published: 20 March 2024

1. Introduction

The old-fashioned manual monitoring techniques are now dispersed and inconvenient. These methods have some drawbacks, such as their high cost and reliance on shaky network connectivity. The efficiency of a real-time flood warning and control monitoring system based on wireless sensor networks has been shown by simulation results. This solution ensures communication at a lower cost and provides real-time monitoring capabilities [1]. Using the help of SMS Gateway, a prototype flood warning system has been created that controls an ultrasonic water level monitor and an alarm buzzer using an Arduino microcontroller. By delivering SMS alerts to preconfigured mobile phones, this system's main objective is to inform homeowners of potential water level increases in their area [2].

In locations where large-scale, rigid barriers are impractical, flood alerts are especially important for identifying and foreseeing flood hazards. The suggested system makes use of sensors and GSM modules to convey flood-related information and track the state of neighboring dams [3]. To alert the public in a timely manner about probable flash floods and lessen their effects, a prototype image-based flash flood early warning system for Android phones has been developed [4]. For real-time flood monitoring, a wireless sensor network system with sensor hubs strategically placed in flood-prone locations has been created. Due to its adaptability and effective data collection capabilities, this technology can be used for a variety of real-time projects [5]. For monitoring and managing undesirable occurrences like intrusions and dangerous situations, a wireless security system using GSM and ZigBee modems has been proposed [6].

The Internet of Things (IoT)-based early detection and alert systems are essential for saving lives during natural catastrophes. A model is being developed to keep track of water levels, temperature, precipitation, and humidity close to dams and riverbanks, sending out alerts via a special website and SMS messages when conditions are out of the ordinary [7].

2. Review of the Literature

About 10–15 s are needed for sensor-to-server data transmission, depending on a number of variables such as sensor response, server performance, and cellular network quality. The IoT-based EFDe system provides accurate water level readings and is easily accessible via web browsers or Android devices [8]. Flood warning systems frequently and significantly rely on local staff and knowledge, which may not be enough in the event of sudden flash floods. The public can access flood information with the use of an image-based flash flood early warning system made for Android phones [9]. The main goal is to create an IoT-based system for early flood warning and environmental monitoring. In this system, sensors gather data and send them to a centralized base station for in-depth analysis [9].

To enable real-time monitoring and detection of flash floods and overflow occurrences and to give inhabitants crucial preparation time, sensor nodes have been strategically placed in flood-prone regions [10]. The findings of this study support the use of the proposed framework to solve heat-related problems and improve climate modeling for the construction of resilient infrastructure [11]. WeMos D1 Mini ESP8266 and Arduino technologies have been used to create a flood warning system that uses sirens and indicator lights to alert people of potential floods [12]. In this situation, ensuring efficient live monitoring and prompt response is still quite difficult [13].

In order to lessen the effects of large floods and improve overall flood protection, flood alerts are essential. The system uses a variety of sensors installed at strategic locations near dams and rivers to assiduously monitor important characteristics such as the level of water, velocity, and rainfall as well as temperature [13]. The implementation of strategies to reduce and manage occurrences connected to flooding is the main emphasis of this project, along with early flood detection. In the end, it prevents people from suffering the negative effects of flooding by utilizing sensor nodes for real-time tracking and the identification of sudden floods and overflowing events [14].

3. Proposed Strategy

A collection of flood detection sensors, each of which plays a crucial part, is at the heart of this system. These sensors include instruments for measuring water levels, rainfall, temperature, and maybe other pertinent environmental monitoring systems [15].Their main duty is to regularly collect information on vital variables such as temperature variations, rainfall severity, and river or stream water levels. The system's functions depend heavily on these data. The ATmega8 controller board takes on the role of the system's central processing unit and is in charge of managing the entire setup. It interacts with flood tracking sensors, receiving information via digital input/output (I/O) ports and analog-to-digital converters (ADCs). These incoming data are processed by the microcontroller, which also controls other system elements and employs decision logic to identify flood situations.

There is a GPS modem with a GPS receiver built into the system. The precise geographic location data provided by this module are crucial for correctly identifying the locations that may be impacted by prospective flood disasters. The ATmega8 microcontroller receives these position data from the GPS modem, which improves the system's precision and efficacy for flood monitoring. Real-time alerts and notifications are made possible by the GSM modem, which is an essential communication tool. The system can send SMS notifications thanks to the GSM module and SIM card interface it comprises. A serial communication interface is used for communication with the ATmega8 microcontroller, ensuring quick delivery of flood-related alarms to authorized workers and administrators.

The integrated WhatsApp module, which enables warnings and notifications to be sent via the widely popular messaging app WhatsApp, is a novel feature of this system. In order to communicate with the ATmega8 microcontroller, this module may need to be connected to the Internet. The reach and immediateness of flood notifications are considerably increased by this linkage, ensuring that important stakeholders are promptly informed.

This block contains the decision-making logic for the system (Figure 1). In order to detect flood conditions or inconsistencies and send out notifications, it analyzes information collected by the flood monitoring sensors. With specific communication interfaces built between the mobile network modem for SMS and the integrated WhatsApp module for WhatsApp alerts, alerts are generated for both SMS and WhatsApp. This procedure ensures that information about alerts reaches the appropriate flood management personnel as soon as possible.

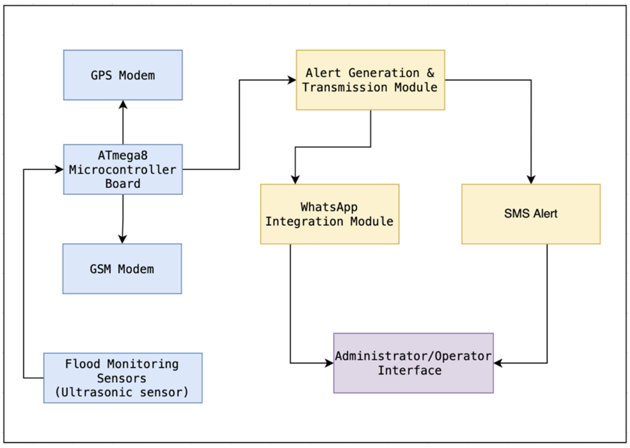

Figure 1. Proposed strategy block diagram.

Administrators and operators in charge of flood response and management receive these flood alerts. They receive these warnings on their mobile devices, allowing them to act quickly in the case of a flood or other irregularities that are noticed. SMS and WhatsApp alerts are sent to their mobile devices, ensuring that they are informed of the issue in real time. A trustworthy power supply is necessary to sustain the system's operational continuity. Depending on the particular needs and position of the monitoring system, this power source may come from batteries or from outside sources. A reliable power source guarantees continuous monitoring and alerting capabilities, as suggested in the proposed technique in Figure 2. LED lights are an example of an external indicator that can be used as a visual signal to indicate the system's condition and alert acknowledgment. These metrics improve the overall usability and efficiency of the system by providing real-time feedback on its performance and recognition of received warnings.

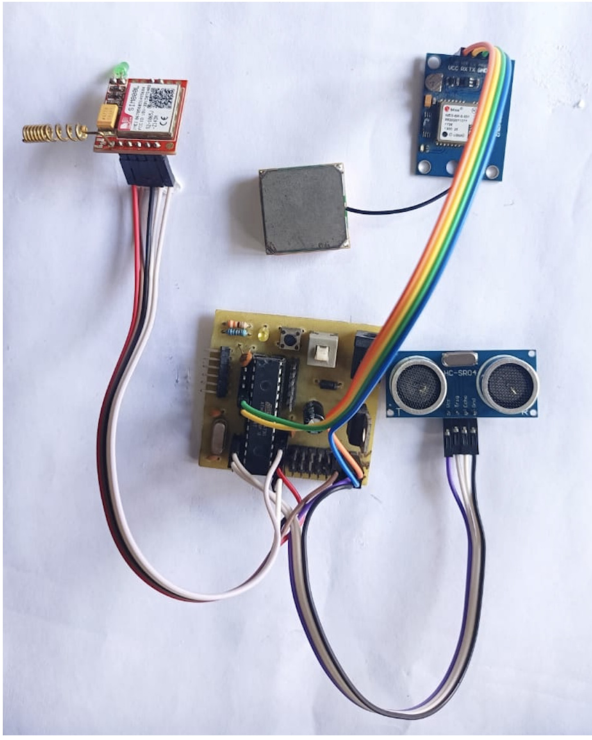

Figure 2. Proposed hardware of the proposed innovation.

4. Implementation of the System

4.1. Breakdown Code Explanation for the System

It is critical to include necessary header files for programming AVR microcontrollers in the system's code. Access to essential functionality, including timing control via delay functions, interrupt handling, and I/O register definitions, is made possible via these headers. These supporting elements are crucial for ensuring the microcontroller functions correctly. The next step is to create constants for the GPIO pin assignments, which reflect the precise pins to which the sensors are linked. The microprocessor and the sensors communicate with one another through these pins. The pin numbers for each sensor must be precisely specified in order to allow for efficient data interchange between the hardware elements.

It is time to adjust the sensor setups in accordance with the hardware connections after the pin assignments have been made. In accordance with the predetermined GPIO assignments, precisely specify the right pin numbers for each sensor. This phase makes sure the microcontroller can communicate with the sensors that monitor flood levels efficiently. The initialization of the GSM modem should be covered in a separate section of the code. Setting up a connection to the GSM network, registering the GSM module, and defining communication parameters are some of the processes involved in this. These actions are essential for the system to send SMS alerts consistently.

Make an SMS send function so that the system can send SMS messages using the GSM module. Enter the address of the recipient's mobile number and the message's content in this function. The system may deliver timely SMS alerts to specified recipients thanks to this feature. Add a section for establishing the GPS module as well. This includes installing the GPS receiver, setting up the GPS module, and defining the connection parameters. This step is essential to pinpointing the system's position precisely.

Then, we create a function for obtaining GPS location data and storing location data in a variable after obtaining GPS coordinates from the GPS module. This information is necessary to include location details in flood alerts. Define additional initialization functions for the WhatsApp integrating APIs. Any verification and connection steps necessary to set up interaction via the WhatsApp platform should be covered by these features. Create a feature that allows you to send WhatsApp messages. This method should have the code required to use the WhatsApp interaction module to send messages to specific recipients with predefined message content. The system may now send alerts via WhatsApp and SMS thanks to this feature. Follow-up procedure for the system:

- Call to set up procedures for the GSM, GPS, and WhatsApp modules in the main function. This step configures the modules and communication, getting them ready for system operation;
- Read sensor data, such as water level and rainfall, inside the main loop (usually formatted as "while (1)"). Using this information, decide whether to identify a flood based on predetermined thresholds;
- If a flood is discovered, obtain the GPS position information to add to the warnings. Send notifications about the flood occurrence by SMS and WhatsApp to the designated recipients;
- Incorporate a delay function to stop the system from issuing repeated alarms quickly. This reduces the need for unwanted alerts;
- In order to improve the system's ability to function and customize it to your project's particular requirements, you can include extra control logic as well as information analysis within the main loop.

The code serves as a basic framework that should be modified to fit the hardware, instrument interfaces, methods of communication, and flood detection techniques particular to your project. The proposed hardware is depicted in Figure 3. For the system to be reliable and resilient, it must have appropriate error management and safety features.

Figure 3. Output of the innovation.

4.2. Algorithm for the System

The ATmega8 microcontroller is initialized before system operations begin, and its GPIO pins are set up to communicate with different pieces of hardware in an efficient manner. The GSM modem is initialized as the first step of this procedure to enable SMS communication. The GPS modem is then set up to obtain exact geographical information, which is necessary for reliable reporting of flood events. The system is then ready to send texts via the WhatsApp platform after the initialization of the WhatsApp integration module. The system maintains continual monitoring and decision-making by running in an indefinite main loop. As the system's main component, this loop carries out a series of operations meant to monitor surroundings and react appropriately. The system starts reading information from the flood surveillance sensors inside the main loop. These sensors collect data on variables, including water level, precipitation, and other pertinent environmental elements. The information collected from the sensor is stored in the appropriate variables for later processing.

The system continuously evaluates the sensor data using a specified flood detection algorithm. This program compares sensor values to predetermined thresholds to determine whether flood conditions exist. The device proceeds to create alerts if an instance of flooding is discovered; otherwise, it carries on with its monitoring tasks. When a flood event is detected, the system obtains exact GPS location information through the GPS modem. This geographic information guarantees that the incidence of the flood may be determined with accuracy. A warning of the flooding incident and the specific geographical coordinates of the area that was impacted are included in the information that the system produces for alert messages. The system starts alert transmission as soon as the alert material is ready. In addition to informing recipients of the flood event, it also sends SMS notifications to preset emergency contact numbers with the specific GPS location for later use. Additionally, the technology sends WhatsApp warnings with full information about flood detection, which contains GPS coordinates, to authorized administrators. The results of the suggested innovation are shown in Figure 3.

A delay technique is put in place to stop the system from quickly delivering notifications for the same flood event many times. By delaying the alert transmission, quick and perhaps redundant notifications are avoided. The system resumes its environmental condition monitoring after sending out alarms. This includes constant sensor data collecting and analysis for flood detection, enabling the system to keep an eye out for any changes in the observed parameters. The project's unique requirements force the integration of extra command logic and data analysis into the main loop. These jobs could involve logging data, updating system performance indicators, or controlling different system states, all of which would improve the system's effectiveness and adaptability. The flood alerting and monitoring system's base is its methodical and durable algorithm, which enables it to react to flood events effectively and deliver crucial information to authorized workers and emergency contacts.

5. Conclusions

In summary, this study represents a substantial development in flood monitoring and early warning systems. In order to produce a comprehensive solution specifically suited for monitoring and alerting in flood-prone areas, the project at hand has successfully combined a variety of hardware elements, including monitoring devices for flood sensors, microcontroller boards, GSM and GPS modems, and WhatsApp integration modules. This system excels in reliably collecting data from numerous environmental sensors, analyzing that data to detect flood conditions, and quickly transmitting alerts to appropriate parties and emergency contacts. The system makes sure that important flooded-related information receives key users in real time by utilizing the features of SMS and WhatsApp communications, allowing them to act quickly and wisely to prevent potential damage caused by floods and save lives.

This project's accuracy in using GPS coordinates to locate the precise site of flood events is a remarkable strength. This accuracy is greatly improved by the precision, both in terms of alerts and aftereffects of actions. By preventing recipients from being overrun with repeated notifications, the delay mechanism also exemplifies a considerate approach to preserving alerting efficiency. Even though this research is an important proof of concept and a significant step toward strengthening flood alerting and monitoring systems, it is crucial to recognize that actual implementation might necessitate additional thought. Scalability, energy efficiency, and connection to the network may all be factors to take into account, especially at remote locations.

There are many ways to improve this system in the future. The use of cutting-edge sensors, such as those for weather, soil moisture, and water quality, is one potential direction. The system would be able to generate more accurate and meaningful notifications as a result of this expansion since it would give an increased awareness of the environmental factors that cause floods. Accurate flood prediction could be greatly improved by putting artificial intelligence and machine learning technologies to use. The system may produce more accurate flood predictions by examining historical data, current sensor data, and weather forecasts, which can be extremely helpful for early warning and preparation.

Its usability and accessibility would be improved by enabling remote monitoring and management of the infrastructure through a dashboard accessible via the Internet or a mobile app. In order to ensure real-time oversight and responsiveness, such a feature would enable administrators to remotely verify the system's status, modify settings, and obtain notifications. Data logging capabilities can be incorporated to save previous sensor data, which can be used for trend analysis, long-term and ongoing flood prediction, and research. Researchers and agencies looking for ways to comprehend flood patterns and develop efficient flood control plans may find these data to be helpful. Additionally, creating tools that simplify cooperation between emergency personnel, regional authorities, and people in the community can greatly enhance flood response operations. During emergencies, automated alert routing to the closest response teams, along with the incorporation of services that are location-based, can be quite helpful. The system's adaptability and global relevance would be further improved by tailoring it for deployment in various geographic locations and situations, taking into account changes in sensor specifications, infrastructure for communication, and flood dynamics.

Author Contributions: Conceptualization, P.K. and Y.K.C.; methodology, A.A.; software, S.S.; validation, H.M.S. and N.B.; formal analysis, D.S.; investigation, D.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not Applicable.

Informed Consent Statement: Not Avaialble.

Data Availability Statement: The manuscript itself contained the data.

Conflicts of Interest: There is no conflict of interest among the authors.

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