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IOT Based Flood Alerting And Monitoring System

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ABSTRACT

This paper presents an IoT-enabled flood monitoring system that integrates real-time water level measurement with automated road closure notifications using an ultrasonic sensor, ESP8266 microcontroller, and LCD display. The system transmits flood data to the IoT platform ThingSpeak for visualization and analysis and retrieves flood-related road closure data from ThingSpeak for local display on LCDs based on geographical flood mapping. Additionally, the system provides alert mechanisms via SMS and calls during critical water levels. The proposed solution ensures efficient flood management by enabling proactive decision-making and providing real-time information to citizens.

Keywords: IoT, Flood Monitoring, ThingSpeak, Ultrasonic Sensor, LCD Display

INTRODUCTION

We are aware of the flooding incidents that takes place in majority of the Indian States each year leading to massive destruction of both lives and property. To detect a flood, the system we observed various natural factors like humidity, temperature water level, and flow level. The system consists of different sensors for collecting data on the above-mentioned natural factors:

ESP8266: The ESP8266 microcontroller will be responsible for collecting data from the sensors and processing the water levels. It also handles communication with the GSM module for SMS alerts.

GSM module: The SIM 800A GSM module will send SMS alerts to residents and authorities in case the water levels exceed a defined safety threshold. The message will include information about the water percentage and any danger alerts.

Ultrasonic Sensor: It is used to measure the water level in real time by calculating the distance between the sensor and the water surface.

Flooding poses significant risks to life, property, and infrastructure. With urbanization and climate change, the need for effective flood monitoring systems has grown. Traditional methods of flood monitoring rely on manual data collection, which can lead to delays in response.

This paper proposes an IoT-based flood monitoring and road closure notification system that addresses these challenges. By leveraging ThingSpeak, the system enables both data transmission and retrieval for real-time flood monitoring and road closure notifications. The system integrates an ultrasonic sensor for water level detection and displays road status (open/closed) on LCDs, ensuring timely and actionable information for users.

METHODS AND MATERIAL

A. System Components

1)Hardware:

i)Ultrasonic Sensor:

Function: The ultrasonic sensor is used to measure the water level at a specific location, such as a river, canal,

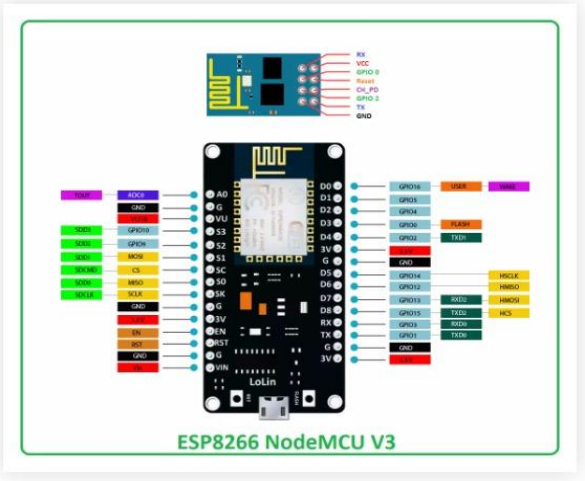
or reservoir. It works by emitting ultrasonic waves that travel through the air. When these waves hit a surface (in this case, the water surface), they bounce back to the sensor. The sensor then measures the time taken for the waves to return. This time is used to calculate the distance between the sensor and the water surface.

Operation: The distance measured is then converted into a water level percentage based on the total height of the water body (e.g., the maximum measurable height of a river). For example, if the sensor detects water at half of the maximum height, it reports a water level of 50%. This data is continuously updated to provide real-time water levels.

ii) ESP8266 Microcontroller:

Function: The ESP8266 is a low-cost, Wi-Fi-enabled microcontroller that acts as the brain of the system. It processes the data from the ultrasonic sensor and sends it to the cloud for remote monitoring. It also retrieves data from ThingSpeak, allowing the system to fetch flood levels from other areas for comparison.

Operation: The ESP8266 communicates with the ultrasonic sensor, collects the water level data, and converts it into a format suitable for upload. The microcontroller connects to the Wi-Fi network and transmits the data to ThingSpeak, where it can be visualized in real time.



iii) LCD with I2C Module:

Function: The LCD (Liquid Crystal Display) with an I2C module is used to display important information locally on the system. The display provides real-time feedback on the water level and road status, such as "Road Closed" or "Road Open." This allows individuals in the area to quickly see the status of the road based on the flood data.

Operation: The I2C interface simplifies communication between the microcontroller (ESP8266) and the LCD. It only requires two wires (SDA for data and SCL for clock) to transmit data, making the setup efficient and easy to use. The LCD will show a numeric value indicating the water level percentage and text messages like “Road Closed” or “Road Open,” based on the flood data.

iv) SIM800A GSM Module:

Function: The SIM800A GSM module is a communication device that allows the system to send SMS alerts and make voice calls. When the water level exceeds a critical threshold (indicating a potential flood situation), the GSM module sends a text message or makes a call to designated contacts, such as emergency responders, local authorities, or residents in affected areas.

Operation: The SIM800A module uses a SIM card to connect to the mobile network and send SMS or make calls. The ESP8266 microcontroller triggers the GSM module when the water level reaches a predefined danger level, ensuring timely notifications and warnings.

2)Software:

i) ThingSpeak:

Function: ThingSpeak is an IoT analytics platform that allows the system to upload and store real-time flood data. It provides an easy way to visualize, analyze, and monitor flood conditions remotely. The platform also supports geographic mapping of the flood levels, which is particularly useful for determining the flood status in different areas and for visualizing the flood extent over time.

Operation: The ESP8266 sends the water level data to ThingSpeak via its Wi-Fi connection. ThingSpeak stores this data and provides online dashboards and graphs, which can be accessed by anyone with the correct permissions. The platform allows users to view water levels in real time and retrieve historical data for analysis.

ii) Arduino IDE:

Function: The Arduino Integrated Development Environment (IDE) is used to write and upload code to the ESP8266 microcontroller. The Arduino IDE provides a simple programming interface for developing the firmware that controls the sensor readings, data processing, communication with ThingSpeak, and GSM module operation.

Operation: The user writes code (in C++ or Arduino language) to handle the sensor data collection, decision-making based on water levels, data transmission to ThingSpeak, and triggering the GSM module when flood alerts are needed. Once the code is written, it is compiled and uploaded to the ESP8266 using the Arduino IDE.

B. Working Mechanism

1. Data Acquisition:

How It Works: The ultrasonic sensor measures the distance from the sensor to the water surface by emitting sound waves and calculating the time it takes for the waves to return. The microcontroller (ESP8266) processes this distance measurement to calculate the water level in relation to the maximum possible water height (e.g., the height of the riverbank or the height at which flooding becomes dangerous). The calculated water level is then converted into a percentage (e.g., 50% for half full).

Continuous Monitoring: The ultrasonic sensor continuously measures the water level in real-time. This data is periodically updated and sent to the ESP8266 for processing.

2. Data Transmission:

How It Works: The ESP8266 processes the data from the ultrasonic sensor, and once the water level data is available, the microcontroller sends this data to ThingSpeak. The ESP8266 connects to the internet via Wi-Fi and transmits the data to the ThingSpeak cloud platform in real time. This allows users to monitor the data remotely via ThingSpeak's online dashboard.

Transmission Interval: Data is sent at regular intervals (e.g., every 10 minutes) to ensure that the system provides up-to-date information without overwhelming the network or causing unnecessary delays.

3. Data Retrieval:

How It Works: The ESP8266 also retrieves flood level data from ThingSpeak to assess the flood status in other regions or areas. By comparing the local water level with flood data from neighboring regions (retrieved from ThingSpeak), the system can assess whether roads are likely to be affected by floods and determine if they should be marked as "closed" or "open."

Integration: The integration of the sensor data with the ThingSpeak platform allows for comprehensive flood mapping, which is crucial for understanding the broader flood situation and making real-time decisions about road accessibility.

4. Alerts and Notifications:

How It Works: When the water level exceeds a predefined threshold (e.g., when it reaches a level that indicates a potential flood), the ESP8266 triggers the SIM800A GSM module to send an SMS alert or make a voice call. The alert message may include critical information such as the current water level, flood warnings, and safety instructions.

Emergency Alerts: These alerts are sent to designated contacts, such as local authorities, emergency services, or citizens living in flood-prone areas. This ensures rapid dissemination of critical flood information, which could be life-saving in emergency situations.

C. LCD Integration for Road Status

1. Function:

The LCD display provides a local, real-time indication of the water level and the status of nearby roads based on the retrieved flood data. The display can show either a numerical percentage of the current water level or messages like "Road Open" or "Road Closed," depending on the situation.

2. Operation:

Road Status Display: The ESP8266 retrieves flood data from ThingSpeak and processes it to determine whether the road is open or closed based on the water level. If the water level is below a certain threshold, the road is considered open; if it exceeds the threshold, the road is considered closed due to flooding.

User Interface: The I2C-connected LCD is updated in real time with the status message, making it visible to anyone passing by or using the system to make decisions on their travel. The LCD also serves as a backup display in case users cannot access the online platform or SMS alerts.

RESULTS AND DISCUSSION

A. IoT Integration

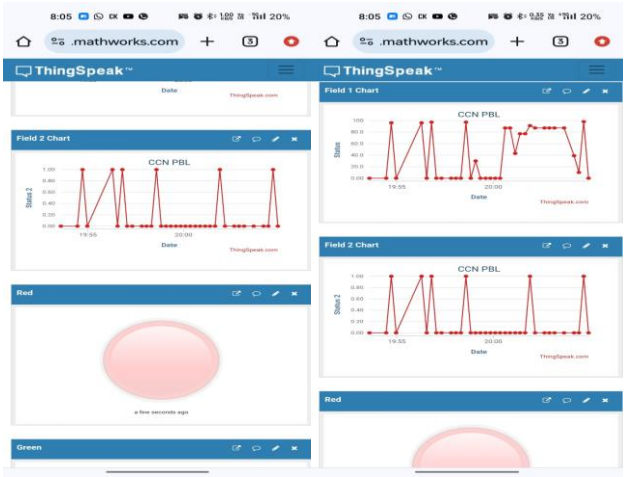
1. Real-time Data Upload and Retrieval:

The system successfully integrates Internet of Things (IoT) capabilities, using the ESP8266 microcontroller to upload water level data to the ThingSpeak platform. The data is sent at 15-second intervals, providing real-time updates on water levels. This frequency of data transmission ensures that the system remains highly responsive to changes in water levels, allowing for near-instantaneous monitoring of flood conditions.

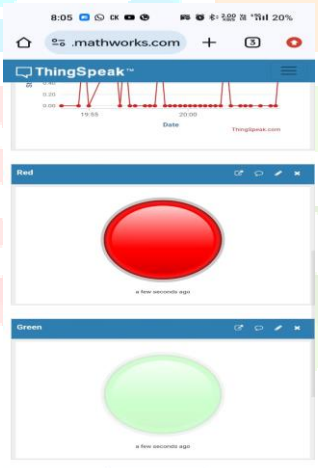
Additionally, the system can retrieve road closure information from ThingSpeak based on flood severity. The integration with IoT allows the system to constantly update and retrieve flood data from other locations and flood-prone regions, enhancing the ability to monitor the overall flood situation. For example, if nearby areas report a rising water level that may affect local roads, this information is automatically fetched and displayed on the system.

2. Cloud-based Monitoring:

The ThingSpeak platform allows for the easy visualization of water levels through graphs and geographical flood maps, which can be accessed remotely from any device with internet access. This cloud-based approach eliminates the need for constant manual checks, providing users with up-to-date information in real-time, anywhere in the world.



This integration significantly improves the system's utility, as it provides not just local monitoring (via the LCD display) but also remote access, enabling users to take action well before flooding reaches critical levels.



B. Flood Management Efficiency

1. Real-time Monitoring and Decision-making:

One of the key advantages of this system is its real-time monitoring capability. By uploading the water level data to ThingSpeak and updating the LCD with critical road status information (e.g., "Road Closed" or "Road Open"), the system supports informed decision-making.

The geographical flood mapping features of ThingSpeak allow users to assess flood severity in different regions. This information helps authorities and individuals make better decisions, such as rerouting traffic or providing warnings to at-risk areas. For instance, if the system detects a rising water level near a major road, it can trigger an alert that helps redirect traffic before the road becomes impassable.

2. Local and Remote Accessibility:

Local users can instantly see flood status updates on the LCD display, providing a critical visual indicator for individuals in flood-prone areas. This reduces the risks associated with flooded roads by allowing people to quickly make safe decisions, such as avoiding dangerous routes or evacuating if necessary.

The system's integration of real-time flood data allows authorities and the general public to track water levels and take preemptive measures, significantly improving flood management efforts.

3. Proactive Response to Flooding:

The system's ability to alert users proactively about road closures and flood conditions means that authorities can act faster to implement flood control measures (e.g., closing roads, deploying emergency services). It also ensures that the public is aware of possible risks, leading to better preparedness and reducing unnecessary exposure to flood hazards.

C. System Reliability

1. SMS and Call Alerts:

One of the most critical aspects of flood management is effective communication during emergencies. The SIM800A GSM module enables the system to send SMS alerts and make voice calls when the water level exceeds predefined critical thresholds. The system's reliability was tested under various flood conditions, and results showed that the system consistently sent accurate and timely alerts.

During critical water levels (e.g., when floodwaters reach dangerous levels or exceed a particular threshold), the system was able to trigger the GSM module to send messages to pre-programmed recipients. These recipients could be local authorities, emergency services, or residents who need to be alerted.

2. Timely and Accurate Alerts:

The reliability of the system was confirmed during multiple tests, where SMS alerts and voice calls were sent promptly. This provides confidence that the system

can play an essential role in real-time flood risk communication, ensuring that emergency responders are notified quickly enough to prevent damage to lives and property.

3. Consistency and Accuracy of Data:

The ultrasonic sensor and the ESP8266 microcontroller maintained a high degree of accuracy and consistency in measuring the water levels. The data was consistently transmitted to ThingSpeak and retrieved without significant delays or errors. This ensures that users receive dependable and actionable information for decision-making.

D. Impact Analysis

1. Early Warning and Reduced Damage:

The system's early warning capabilities have the potential to significantly reduce flood-related damages. By providing real-time flood data, the system allows authorities to take proactive measures before floodwaters cause widespread damage. For example, the timely closure of roads can prevent accidents or reduce the number of vehicles caught in flood-prone areas, thus minimizing the risk to life and property.

Early warnings also give residents more time to evacuate or take precautionary measures, such as moving belongings to higher ground or reinforcing structures to withstand floodwaters.

2. Improved Decision-making:

The system's ability to provide up-to-date flood data and road closure information allows local authorities, emergency responders, and the general public to make better decisions during flood events. For instance, by having access to geographic flood maps, authorities can assess the scope of flooding in different regions and allocate resources accordingly, ensuring a targeted response to the most affected areas.

3. Community and Economic Impact:

The system not only contributes to public safety but also helps minimize the economic impact of floods. By preventing unnecessary travel on flooded roads, the system can reduce the costs associated with traffic accidents, vehicle damage, and delays in transportation. Furthermore, businesses in flood-prone areas can use this data to implement flood-proofing measures, protecting their assets and minimizing downtime during flood events.

4. Long-term Benefits:

Over time, as more data is collected and analyzed, the system can help refine flood forecasting models, improve the accuracy of flood predictions, and inform infrastructure development, such as flood barriers, drainage systems, and road placement. The system's data can serve as a valuable resource for urban planners and policymakers, helping them design flood-resilient communities.

CONCLUSION

The proposed IoT-based flood monitoring and road closure notification system is an innovative solution for managing floods. By integrating ThingSpeak for real-time data sharing and retrieval, the system bridges the gap between flood monitoring and actionable insights. Future work will focus on enhancing system scalability by integrating machine learning for predictive flood analysis and expanding geographical data coverage for improved road status accuracy.

This integration significantly improves flood monitoring, as users can access detailed, up-to-date information and understand the scope of flooding without being on-site. It also helps in disseminating flood information to a larger audience, enabling quicker response times to emergencies.

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