

Development of FAST (Flood Alert System by Trigger): A Smart IoT-Based Approach to Flood Detection and Road Safety

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Abstract

One of the biggest risks to public safety is flooded roads they put people at risk, cause accidents, and slow down emergency crews when every second counts. This paper introduces FAST (Flood Alert System by Trigger), an intelligent IoT-based solution for real-time flood detection and automated road safety management. The system continuously tracks water levels through ultrasonic sensor, and it helps to stop cars from driving into danger zones and an Arduino Uno microcontroller processes the obtained data and manages the operational activities. An ESP32 module sends out instant alerts. The system flashlights, sounded alarms, showed live information on an LCD as the water passed a given line and lowered a servo-controlled barrier to halt the traffic. This renders the inclusion of on-board features like buzzers and LEDs useful in communicating with drivers without necessarily involving human resources. High detection accuracy, response time of 2-3s and low power consumption were found in protest testing. The proposed system, FAST, clearly showcases the possibilities of the IoT and embedded systems in disaster prevention and improving road safety for the future.

Keywords: Arduino Uno, Automated Barrier, Embedded Systems, ESP32, Flood Detection, IoT, Real-Time Monitoring, Road Safety, Smart Cities, Ultrasonic Sensor.

1. Introduction

Flooding has been considered as one of the most common forms of natural disaster that has been facing road transport systems across the globe. Heavy rainfalls, ineffective drainage systems and high rates of climate change have increased flooding of roads today and may cause casualties both to pedestrians and vehicles. Overwhelmed roads are known to cause car breakdowns, accidents, traffic and delay in emergency services and this is where efficient monitoring and control mechanisms are needed. Conventional flood surveillance systems are very manual with the use of stationary warning signs, which are almost useless when sudden floods occur. Due to the development of embedded systems and the Internet of Things (IoT), nowadays intelligent systems could be designed that are able to monitor, process, and provide automated response to data in real-time. In this paper, it is suggested that

FAST (Flood Alert System by Trigger) is an IoT-based flood sensor and road safety that is an automated system that monitors and controls the access of vehicles to floods by detecting surging water levels. This system combines cheap sensors, microcontrollers, and alert systems to provide a response in a timely manner with the minimum involvement of human intervention. The primary concept of this work is to enhance road safety and effective, scalable and affordable flood management solution which can be exercised in smart cities and disaster management solutions. [1-5]

2. Proposed System and Methodology

2.1. System Overview

The FAST system is geared towards tracking the real-time water levels of the roads and to implement precautionary measures to be taken in case the state of the flooding is detected. The system will be

composed of a water level ultrasonic sensor, an Arduino Uno to process the data and an ESP32 to offer the opportunity of communication and sending the notification. The product of the work is LEDs and buzzers, LCD display and a barrier controlled by a servo motor, which may be used to warn the road users, and to introduce certain physical barriers to the movement of vehicles. [6-10]

2.2. Hardware Components

- **Ultrasonic Sensor:** This component assists in the determination of the related distance between the sensor and the water surface to ascertain the water level.
- **Arduino Uno:** The Arduino Uno serves as the brain of the operation which smoothly process data from the sensors and directing all the system's outputs with ease.
- **ESP32 Module:** This component mainly assists in the real-time communication between other systems/users by notifying them. [11-15]
- **Servo Motor:** This component assists in the automatic control of the road barrier by receiving information from the Arduino Uno.
- **LCD Display:** This component assists in the display of the water level information to the user. [16]
- **Buzzer and LEDs:** This component helps the user during a flood condition.

2.3. Working Principle

The ultrasonic sensor is used for constant checking of the amount of water on the road. The calculated value of the distance is sent to Arduino Uno where these are compared with a programmed level. At the point the water level is higher than the threshold the controller triggers several safety measures simultaneously. The LEDs, audible signals and visible data of the LCD are activated. The servo motor can also be employed to open the barrier mechanism to prevent the access of vehicles to the flooded area. The ESP32 module comes with notifications of alarms, which enables it remote monitoring. This system is autonomous and hence, responds very fast in the event of an emergency.

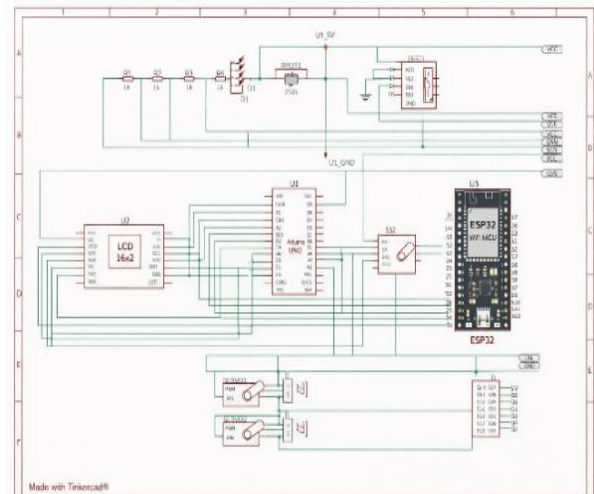


Figure 1 Proposed IoT-based flood detection and automatic road barrier system circuit diagram with Arduino and ESP32

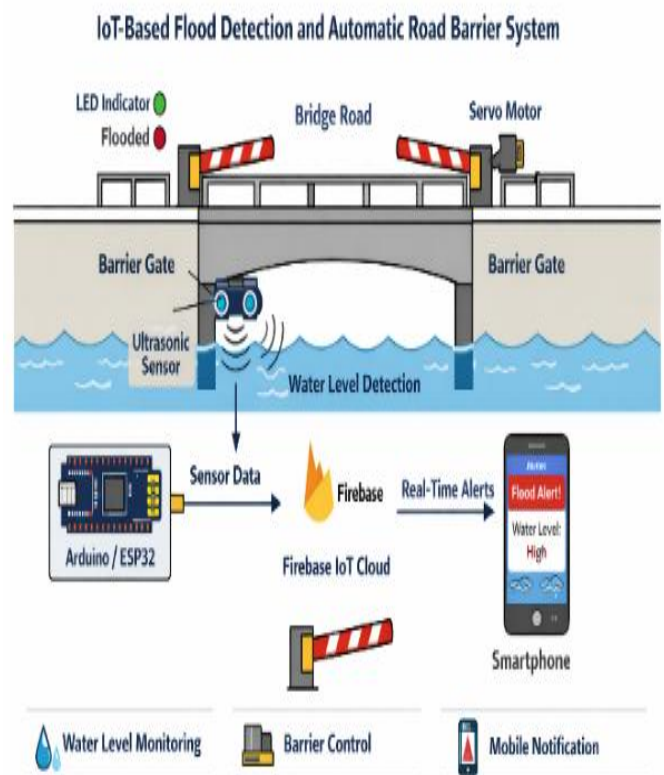


Figure 2 System architecture illustrating the identification of water level by the ultrasonic sensor, control over barriers by the servo motors and real time monitoring by Firebase cloud and a mobile application.

3. Comparison

Table 1 Aspect

Aspect	IoT-Based Flood Detection & Alert System	Flood Detection with Automatic Barrier / Gate	Smart Flood Barrier Systems
Key Idea	Sensors measure water level and send alerts through IoT	Detects flood level and automatically operates a gate/barrier	Detects flooding and deploys a barrier automatically
Technologies Used	Arduino / NodeMCU, Ultrasonic or water level sensors, GSM / Cloud notifications	Arduino, Ultrasonic sensors, Motor/Stepper motor, LCD, Buzzer	Sensors, Automated barrier mechanism, Smart control system
Functionality	Monitoring + Alert system only	Monitoring + Physical barrier control	Monitoring + Automatic flood protection
Example Study	Joshi & Murali (2025); Obinna & Mathew (2024)	Arduino-based flood door control system (98% accuracy)	Smart Flood Barrier (SFB) for internal flooding
Application Area	General flood monitoring (rivers, rainfall, urban areas)	Buildings, drainage systems	Buildings and houses
Advantages	Early warning system, remote monitoring	High accuracy, automatic control	Fully automated, no human intervention
Limitations	Does not physically prevent accidents or vehicle entry	Limited mostly to infrastructure protection	Not designed for road traffic scenarios
Difference from FAST Project	Only sends alerts; no vehicle control	Focuses on building protection, not road safety	Focuses on water entry prevention, not traffic control

4. Results and Discussion

4.1. Results

The FAST prototype is proposed, and its testing has been carried out by simulation of various levels of water. The rising amount of water has been detected with accuracy in the suggested system. Other than that, the proposed system has been effective in raising the alarm when it is past the mark. It was also discovered that the system took a response time of between 2 to 3 seconds. The automated barrier was functional such that it prevented vehicles to move into flooded zones. Power consumption analysis indicated that the system is energy efficient and suitable for long-term deployment. Table 1 shows Aspect [17]

4.2. Discussion

The experimental results demonstrate the effectiveness of the proposed system in real-time flood detection and road safety management. The

integration of ultrasonic sensing with automated control mechanisms significantly reduces the dependence on human intervention. Compared to conventional warning systems, FAST provides faster response and enhanced safety through physical vehicle restriction. The low-cost hardware components make the system economically feasible for large-scale deployment in both urban and remote areas. [18]

Conclusion

This paper presented the development of FAST, an IoT-based flood detection and automated road safety system. The proposed method effectively monitors the water levels and gives the timely alerts and also restricts vehicle to access during flood conditions. The experiment demonstrates that it has high accuracy, fast response time, and consumes low power. This proposed system helps with Disaster preparedness and also road safety. There are

improvements that can be made in the future in this proposed design, by integrating it with cloud platforms, mobile applications, and analytics to provide advanced flood forecasting.

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