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EMBEDDED IOT ARCHITECTURE FOR FLOOD DETECTION AND VEHICLE SAFETY IN SUBMERGED UNDERPASSES

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ABSTRACT
Flooded underpasses pose serious threats to vehicles and pedestrians, often leading to accidents during heavy rainfall. This project introduces an automated system designed to enhance safety in such conditions. The setup includes water level sensors to detect flooding, a motorized gate to restrict entry, motion detection to identify human presence near closed gates, and a drainage system that activates automatically. The entire process is managed through sensor-based logic without the need for remote communication or internet connectivity. The system effectively prevents access, alerts individuals in danger, and removes excess water — offering a practical, low-cost solution for real-time flood management in urban area.but also pose serious threats to vehicle occupants and pedestrians, sometimes leading to fatal accidents. Traditional warning systems are either manual or too slow to respond effectively in real-time conditions. To overcome these challenges, this project introduces an automated flood safety and monitoring system that focuses on early action and physical prevention. The system employs water level sensors to detect flooding and activates a motorized gate to block entry when danger is detected. If a person attempts to bypass the gate, a motion detection mechanism triggers an audible buzzer to alert them and nearby individuals. At the same time, a drainage motor is activated to remove excess water from the underpass, restoring it to safe conditions without manual intervention. This system provides a reliable, low-maintenance, and proactive solution to urban flooding issues, enhancing public safety through automation and real-time response.

Keywords-
LCD, Arduino UNO, Moisture Sensor, Buzzer, Relay, Servomotor

INTRODUCTION

Urban underpasses are essential for maintaining smooth traffic flow in densely populated areas, but they often become danger zones during heavy rainfall due to poor drainage and water accumulation. These sudden floods not only disrupt Transport.

Patel and Jivani proposed a flood detection model using ultrasonic sensors and GSM technology to issue alerts during rain, but it did not incorporate physical control elements like automatic gates [1]. Do et al. created a sensor-based monitoring solution that provided water level visualization, though it lacked real-time responsive capabilities [2]. Chavan et al. built a notification system using SMS and app alerts, but their design did not prevent individuals from entering flooded zones [3]. Wanjale and Patil implemented a drainage solution using motor-driven pumps and sensors, yet it didn't integrate access safety features [4]. Kadam et al. introduced an LED-based warning method for flood detection but missed out on mechanisms for restricting movement into dangerous areas [5]. Kumbhar and Gawali offered a budget-friendly sensor system, focusing on alerts without automated actions [6]. Rohit and Yadav designed a physical gate system that activated during floods, contributing to safer underpass usage [7]. Karthik and Reddy's threshold alert mechanism was useful for monitoring but lacked physical interventions such as gates or pumps [8]. Muley and Kulkarni proposed a smart city-oriented flood safety model using embedded systems, though it remained largely theoretical [9]. Pawar et al. developed a water-level based gate control setup to enhance safety during waterlogging incidents [10]. Mazidi and his co-authors laid the groundwork for microcontroller-based system development, essential to this project's logic design [11]. Webster and Eren detailed sensortechnologies applicable to flood detection and environmental control [12]. The Arduino

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microprocessor principles that supported the control architecture of the project [14]. NDMA guidelines offered real-world standards for urban flood safety, which served as a foundation for this system's practical relevance [15]

LITERATURE REVIEW

Many researchers have explored methods to improve safety during urban flooding, especially in underpasses. Patel and Jivani [1] introduced a basic alert system using ultrasonic sensors and GSM modules to send messages during water rise, but it didn't include safety barriers. Do et al. [2] worked on a real-time monitoring system to show water levels on screen, but it couldn't stop people or vehicles from entering. Chavan et al. [3] developed an early warning model with SMS alerts, which helped raise awareness but lacked automatic physical control. Wanjale and Patil [4] proposed a drainage mechanism using sensors and pumps to remove water, though it didn't stop access to danger zones.

Other studies, such as those by Kadam et al. [5] and Kumbhar and Gawali [6], focused on visual alerts like LED indicators, but these didn't fully prevent entry into risky areas. Rohit and Yadav [7], and Karthik and Reddy [8] introduced gate control concepts, offering improved safety, but lacked smart drainage. Muley and Kulkarni [9], and Pawar et al. [10] discussed embedded systems for smart city flood response, but real-time implementation remained limited. These reviews show a gap in systems that combine alerting, access control, and drainage in one solution. This project aims to fill that gap with a simple, automatic gate-and-drain setup to enhance safety during floods.

PROPOSED SYSTEM

The proposed system is designed to prevent accidents and improve safety in underpasses during flooding by utilizing a fully automated, hardware-based control mechanism. The setup begins with a water level sensor installed at the base of the underpass to continuously monitor water accumulation. When the water rises above a predefined safe limit, the system automatically activates a gate mechanism to restrict the entry of vehicles and pedestrians into the flooded zone.To further ensure safety, a human detection sensor—such as a motion or infrared sensor—is placed near the gate. If any individual attempts to cross the closed gate, a buzzer is triggered to alert them of the danger and discourage further movement. In parallel, the system activates a submersible or surface pump to drain out the accumulated water. The pump operates automatically based on water level readings and continues until the water recedes below the critical threshold.All operations are managed by a microcontroller, which coordinates input from sensors and controls the output devices like the gate motor, buzzer, and drainage system. The design emphasizes fast response, minimal human involvement, and reliable performance in emergency conditions. It offers a cost-effective and scalable solution, ideal formunicipalities and infrastructure planners aiming to enhance flood safety in urban transport corridors.

HARDWARE COMPONENTS USED

- **LCD**

Fig. 1 Liquid Crystal Display

An LCD (Liquid Crystal Display) is used to show real-time system information like water levels and alerts.
It helps users easily understand the current status without needing external devices.
In this project, it enhances safety by displaying clear warnings and system actions

- **BUZZER**

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Fig. 2 Buzzer for Audio Signaling

A buzzer is an acoustic signaling component employed in electronic systems to generate audible alerts or notifications
In this project, the buzzer activates when someone approaches a closed gate, warning them of potential danger. It adds an extra layer of safety by providing an immediate and clear audible alert

SERVO MOTOR

Fig. 3 Servo Motor

A servo motor is a precision-controlled motor commonly used for position-based tasks in automation systems .In this project, it is used to open or close the gate automatically based on flood conditions.
Its accurate angular control makes it ideal for ensuring the gate operates smoothly and safely.

- **MOISTURE SENSOR**

moisture sensor is a device that detects the presence and level of water or dampnessSurface, Environment. In this project, it is used to sense water accumulation in the underpass and helps determine if flooding has occurred

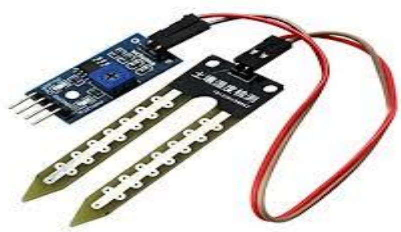

Fig. 4 Moisture Sensor

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- **BATTERY**

Fig. 5 Battery

The battery functions as the central power unit for the system, delivering uninterrupted energy to maintain operational continuity during electrical outages. It provides stable voltage levels required for the reliable performance of critical components, including sensors, actuators, and the micro controller unit (MCU)

- **IR SENSOR**

An IR (Infrared) sensor detects motion or the presence of objects by sensing.

Fig. 6 Infrared Sensor

In this project, it is used to identify if a person or vehicle tries to pass through the gate during flooding.
This enables the system to trigger alerts, such as activating the buzzer, to warn and prevent accidents.

- **RELAY**

Fig. 7 Relay

A relay is an electrically operated switch used to control high-power devices using low-power signals.
In this project, it connects the microcontroller to the water pump, allowing the system to turn the pump on or off automatically.
It ensures safe and efficient operation of heavy loads without directly exposing the controller to high voltage.

- **WATER PUMP MODULE**

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Fig. 8 Water Pump Module

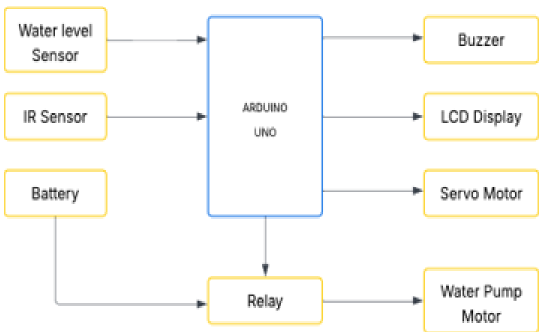
A water module is designed to detect the presence and level of water through its conductive,properties. In this project, it helps identify flooding in the underpass by sensing water contact or rising levels. This triggers the system to take action, such as closing gates or activating drainage, to ensure safety.

SOFTWARE TOOLS

➢ **ARDUINO IDE**

The Arduino Integrated Development Environment (IDE) is a software framework designed for writing, compiling, and uploading firmware to Arduino microcontroller boards, facilitating rapid development and prototyping in embedded systems.
It provides a user-friendly interface and supports various programming libraries for controlling hardware,components.
In this project, Arduino IDE is used to program the system's logic, enabling sensors, motors, and alerts to work in coordination.

BLOCK DIAGRAM



RESULT

The system was tested under artificial flood conditions and responded effectively. The water level sensor accurately detected rising water and triggered the gate to close automatically. The motion sensor successfully identified human presence near the gate and activated the buzzer for alert. The drainage motor efficiently removed water and stopped once safe levels were restored. All components worked smoothly under the control of the microcontroller, confirming the system's reliability and quick response in emergency situations.

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Fig 1 says, When the moisture level is Below 30. The LCD displays ‘WELCOME’. And every vehicle can pass the Gate.if (moisture_percentage <= 30) {
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("WELCOME");
delay(150);
digitalWrite(motorPin, HIGH);
noTone(buzzer);
pos = 90;
myservo.write(pos); // Move servo to 90 degrees (open)
}

Fig 2 says, When the moisture level is above 30 and below 50 The LCD displays ‘HEAVY VEHICLES CAN PASS’.at this moisture level only heavy vehicles can pass like Bus, lorries, Cargo Trucks And every vehicle can pass the Gate.
else if (moisture_percentage >= 31 && moisture_percentage < 50) {
lcd.setCursor(0, 0);
lcd.print("Heavy vehicles");
lcd.setCursor(0, 1);
lcd.print("can pass");
delay(150);
digitalWrite(motorPin, HIGH);
noTone(buzzer);
}

Fig 3 says, When the moisture level is Above 50. The

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LCD displays ‘NO ENTRY’And NO vehicle can pass the Gate. If any vehicle can pass the IR sensor gives the signal to buzzer and the buzzer will gives alert Sound.

```
else if (moisture_percentage &gt;= 50) {
lcd.clear();
lcd.setCursor(0, 0);
lcd.print(&quot;NO ENTRY&quot;);
delay(150);
digitalWrite(motorPin, LOW);
pos = 0;
myservo.write(pos); // Move servo to 0 degrees
(closed)
```

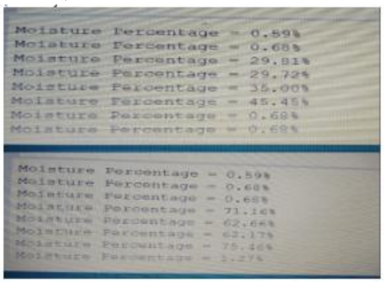

Fig 4 says , that it shows the Moisture level is Below 30 or Above 30 , or Below 50 or Above 50

CONCLUSION

The proposed system successfully offers a smart and efficient solution to prevent accidents in flooded underpasses. It combines water level detection, gate control, intrusion alerts, and automatic drainage into one integrated setup. With real-time monitoring and IoT connectivity, it ensures safety through quick response and minimal human intervention. This low-cost, scalable system is well-suited for smart cities to enhance flood safety and protect lives.

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