

BRIDGE COLLAPSE AND FLOOD DETECTION USING QUICK RESPONSE

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Abstract—The Bridge Collapse and Flood Detection System using Quick Response is designed to enhance public safety by providing early warnings of bridge failure or flooding conditions. The system uses multiple sensors such as a DHT11 (temperature and humidity sensor), water level/county sensor, and ultrasonic sensor (SR04) to continuously monitor environmental and structural conditions of the bridge. The heart of the system is an ATmega328 microcontroller, which processes sensor data and detects abnormal parameters like excessive water level, humidity, or bridge displacement. In the event of critical conditions indicating possible flooding or bridge collapse, the system immediately triggers buzzer alarm and controls a servo motor (SG90) for mechanical response (e.g., barrier control). Simultaneously, through ESP8266 Wi-Fi and GSM module interfacing, the system transmits real time alerts to authorities or users' mobile devices, ensuring rapid response. The system is powered by a regulated +5V DC supply derived from an LM7805 voltage regulator circuit connected to a bridge rectifier and transformer. This project effectively demonstrates an IoT-based safety monitoring system capable of early detection and instant communication, reducing risks of accidents due to bridge collapse or flooding

key words- DHT11, GSM module, LM7809 voltage regulator, ESP8266 Wi-Fi, ATmega328Microcontroller, Servo motor.

I. INTRODUCTION (HEADING 1)

The Bridge Collapse and Flood Detection System using Quick Response is an innovative embedded system designed to monitor the structural health of bridges and detect rising water levels that may lead to flooding or collapse. The circuit is built around an ATmega328 microcontroller, which acts as the central processing unit for interfacing and controlling all the sensors and modules. The system integrates multiple sensors such as the ultrasonic sensor (SR04) to measure water level or detect obstacles, and the DHT11 sensor to monitor environmental conditions like temperature and humidity. A contact or continuity sensor is used to detect physical displacement or damage to the bridge structure. The collected data from these sensors are processed by the microcontroller, which then activates output devices such as a buzzer for local alert and a servo motor (SG90) for mechanical action like closing a barrier. The circuit also includes ESP8266 Wi-Fi and GSM modules that enable wireless data transmission and quick alert messages to concerned authorities. A regulated +5V DC power supply using a bridge rectifier, LM7805 voltage regulator, and filter capacitors ensures stable operation of all electronic components. Additionally, an LCD display issued for real-time data visualization of the system's status. This system provides a reliable and fast-response solution for monitoring bridges, warning users, and preventing disasters caused by floods or structural failures.

II. AIM AND OBJECTIVE

The main aim of this project is to design and develop a microcontroller-based Bridge Collapse and Flood Detection System using Quick Response that ensures safety by providing early warnings of possible bridge failure or flooding conditions. The system utilizes an ATmega328 microcontroller as the main controller to collect and process data from various sensors such as the ultrasonic sensor (SR04) for water level detection, DHT11 sensor for temperature and humidity measurement, and a continuity sensor to monitor structural integrity. The processed information helps in identifying any abnormal conditions that may lead to bridge collapse or flooding. The primary objectives of this project include continuously monitoring environmental and structural parameters, detecting any unusual variations, and generating immediate alerts. The system activates a buzzer and operates a servo motor (SG90) for quick mechanical response, such as barrier control. Additionally, through the integration of ESP8266 Wi-Fi and GSM modules, it sends instant alerts to the concerned authorities for timely action. The circuit also incorporates an LCD display for real-time data visualization and an LM7805-based regulated power supply for stable operation of all components. Overall, the project aims to provide a reliable, quick-response, and cost-effective solution to enhance bridge safety and minimize disaster risks caused by structural damage or flooding.

III. LITERATURE SURVEY

[1]. Bridge Weigh-in-Motion (B-WIM) — foundations & sensor choices Lydon, M., Taylor, S. & Robinson, D., "Development of a Bridge Weigh-in-Motion Sensor: performance comparison using fiber optic and electric resistance strain sensor systems," IEEE Sensors Journal, vol. 14, no. 12, 2014. What it covers: development and field comparison of FBG (fibre-optic) vs electrical strain sensors for B-WIM; performance metrics, sampling and filtering needs. Why it matters: describes sensor tradeoffs (accuracy, sampling rate, robustness) when converting bridge response into axle/gross weight estimates — directly relevant for choosing sensors for WIM on bridges. Bridge Weigh in Motion (B-WIM) uses advanced sensing systems to transform existing bridges into a mechanism to determine actual traffic loading. This information on traffic loading can enable efficient and economical management of transport networks and is becoming a valuable tool for bridge assessments and damage detection. B-WIM can provide site-specific

traffic loading on deteriorating bridges, which can be used to determine if the reduced capacity is still sufficient to allow the structure to remain operational and minimize unnecessary replacement or rehabilitation costs and prevent disruption to traffic. There have been numerous reports on the accuracy classifications of existing B-WIM installations and some common issues have emerged. This paper details some of the recent developments in B-WIM which were aimed at overcoming these issues. A new system has been developed at Queens University Belfast using fiber optic sensors to provide accurate axle detection and improved accuracy.

[2]. Recent developments & review of B-WIM technology. Lydon et al., “Recent Developments in Bridge Weigh-in-Motion (B-WIM),” research repository/ review (2017) What it covers: comprehensive review of B-WIM methods, sensor systems (strain gauges, FBG, load cells), algorithms for axle detection and gross weight estimation, calibration and multi-vehicle issues. Why it matters: gives an overview of B-WIM strengths/weaknesses — good for your literature review background. Bridge Weigh in Motion (B-WIM) uses advanced sensing systems to transform existing bridges into a mechanism to determine actual traffic loading. This information on traffic loading can enable efficient and economical management of transport networks and is becoming a valuable tool for bridge assessments and damage detection. B-WIM can provide site specific traffic loading on deteriorating bridges, which can be used to determine if the reduced capacity is still sufficient to allow the structure to remain operational and minimize unnecessary replacement or rehabilitation costs and prevent disruption to traffic. There have been numerous reports on the accuracy classifications of existing B-WIM installations and some common issues have emerged. This paper details some of the recent developments in B-WIM which were aimed at overcoming these issues. A new system has been developed at Queens University Belfast using fiber optic sensors to provide accurate axle detection and improved accuracy.

[3]. Field evaluation of load-cell based B-WIM What it covers: experimental trials of load-cell B-WIM on a real slab-beam bridge, methods for axle detection and weight calculation (reaction force & area methods). Why it matters: your prototype’s load-cell + HX711 approach maps directly to this study’s conclusions about calibration and real-world accuracy. Objectives of the research presented in this paper were to develop and quantitatively evaluate a B-WIM system utilizing load cells for the GVW, axle information (weights, number, and spacing’s), vehicle classification, and average vehicle speed. Full-scale field tests were conducted with different trucks on a slab-beam bridge instrumented with load cells at the bearing pad locations. Several algorithms were evaluated using the test data and were proceeded to obtain GVW and axle information. These algorithms included the area method and the reaction force method. A detailed quantitative assessment is provided in this study with conclusions and recommendations for utilizing load cells within B-WIM system.

[4]. Data-driven / acceleration-based BWIM approaches A Data-Driven Approach for Bridge Weigh-in-Motion from Acceleration Responses — (Wiley /2023). What it covers: algorithms using acceleration responses to estimate moving vehicle loads; discusses filtering, vehicle entry/exit detection and robustness to multiple vehicles. Why it matters: shows alternative methods (useful if you want to compare load-cell approach vs bridge-response /accelerometer approaches in your discussion). Bridge weigh-in-motion (BWIM) serves as a method to obtain the weight of passing vehicles from bridge responses. Most BWIM systems proposed so far rely on the measurement of bridge global vibration data, usually strain, to determine the vehicle load. However, because the bridge’s global response is sensitive to all vehicles on the bridge, the global vibration-based BWIM techniques usually suffer from inaccuracy in the case where multiple vehicles are present on the bridge. In this paper, a data-driven approach is proposed to extract the passing vehicle’s weight and driving speed from vertical acceleration at the bridge joint. As a type of local vibration, the impulse acceleration responses at a bridge joint can be recorded only during a short period when a vehicle is passing over the joint and are thus not sensitive to vehicles at other locations of the bridge. A field test is conducted at a bridge to prepare labeled training data for the use of a convolutional neural network. One accelerometer is installed on the bridge joint to record impulse acceleration, while the vehicle’s weight and driving speed are obtained from a WIM station and a camera near the bridge, respectively.

[5]. Bridge Structural Health Monitoring (SHM) and IoT — survey DEng, Z., “The Current Development of Structural Health Monitoring for Bridges: A Review, “Buildings / MDPI (2023) — review of sensors, data processing, damage detection methods. What it covers: recent SHM advances: sensor tech, data denoising, damage detection, WSN and IoT integration. Why it matters: helps justify combining multiple sensors (weight + vibration + water level) and using IoT/GSM for alerts. (Open access). The health monitoring system of a bridge is unimportant guarantee for the safe operation of the bridge and has always been a research hotspot in the field of civil engineering. This paper reviews the latest progressions in bridge health monitoring over the past five years. This paper is organized according to the various links of the bridge health monitoring system. Firstly, the literature on monitoring technology is divided into two categories, sensor technology and computer vision technology, for review. Secondly, based on the obtained monitoring data, the data processing methods including preprocessing, noise reduction, and reconstruction are summarized. Then, the technical literature on abnormal data early warning systems is summarized. The recent advances in vibration-based and non-destructive testing-based damage identification methods are reviewed in the next section. Finally, the advantages and disadvantages of the existing research and the future research directions are summarized. This review aims to provide a clear framework and some reliable methods for future research.

IV. BLOCK DIAGRAM

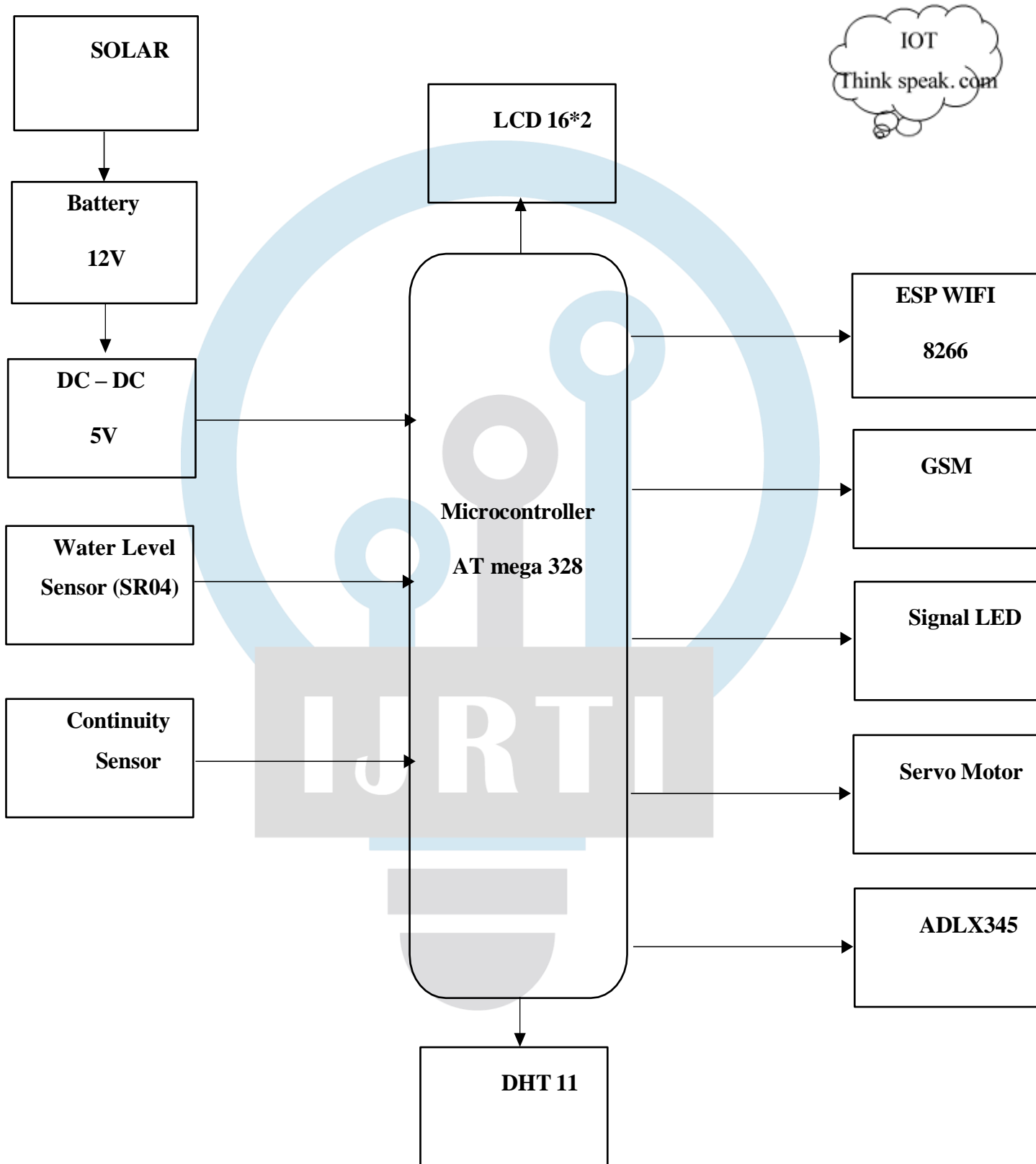


FIG 1: BRIDGE COLLAPSE AND FLOOD DETECTION USING QUICK RESPONSE SYSTEM

The Bridge Collapse and Flood Detection System using Quick Response works on the principle of continuous monitoring and immediate alert generation using sensors, a microcontroller, and wireless communication modules. The entire system is powered by a regulated +5V DC supply obtained from a bridge rectifier, filter capacitor, and LM7805 voltage regulator, which ensure stable power for all components. The ATmega328 microcontroller acts as the brain of the system. It receives inputs from different sensors:

- The ultrasonic sensor (SR04) measures the water level below the bridge. If the water rises beyond a set limit, it indicates possible flooding.
- The DHT11 sensor measures temperature and humidity to detect environmental changes that could affect bridge safety.
- The continuity sensor checks the structural condition of the bridge by detecting any breaks or displacement in the structure.

The microcontroller continuously processes the sensor readings. When any sensor detects a value beyond the safe threshold, the system identifies it as a warning or danger condition. In response, the microcontroller activates a buzzer to give a local sound alert and drives a servo motor (SG90) to take preventive mechanical action, such as raising a barrier or gate to stop vehicles from crossing. At the same time, the ESP8266 Wi-Fi module and GSM module are used to send real-time alerts to the concerned authorities or users via the internet or SMS. The LCD display (16x2) continuously shows the live readings of all sensors and the system status (Normal, Warning, or Danger). This working process ensures that the system provides early detection, quick response, and timely alerts, thereby helping prevent accidents due to bridge collapse or flooding.

V. METHODOLOGY

The Bridge Collapse and Flood Detection System using Quick Response is designed to continuously monitor the bridge's environmental and structural conditions and provide early warnings during abnormal situations. The system operates using a step-by-step process that integrates sensor data acquisition, processing, and alert generation. The system's core component, the ATmega328 microcontroller, receives input signals from multiple sensors connected to it. The ultrasonic sensor (SR04) measures the distance between the bridge surface and water level to detect rising floods. The DHT11 sensor monitors temperature and humidity to identify weather conditions that could affect bridge safety. A continuity sensor checks the structural integrity by detecting any breakage or disconnection in the bridge components. All sensor data are processed by the microcontroller, which compares the readings with predefined threshold values. When any parameter exceeds its safety limit—such as high water level or structural damage—the system activates an alarm mechanism using a buzzer to alert nearby users. Simultaneously, the servo motor (SG90) can be triggered to perform mechanical actions like lifting a barrier to restrict movement on the bridge. For remote monitoring, the microcontroller communicates with the ESP8266 Wi-Fi module and GSM module to send instant alerts or notifications to the concerned authorities through messages or IoT platforms. The LCD display (16x2) shows real-time sensor data and system status for local monitoring. The circuit is powered by a regulated +5V DC supply using a bridge rectifier, filter capacitors, and an LM7805 voltage regulator, ensuring reliable operation. This integrated methodology ensures that the system can detect, process, alert, and respond quickly, minimizing the risk of accidents due to bridge collapse or flooding.

VI. HARDWARE & SOFTWARE REQUIREMENT

Hardware Requirements

1. Microcontroller (ATmega328): Acts as the main control unit that processes data from all sensors and manages communication with output devices.
2. Ultrasonic Sensor (HC-SR04): Used to measure water level or detect obstacles under the bridge.
3. DHT11 Sensor: Measures temperature and humidity for environmental monitoring.
4. Continuity Sensor: Detects physical damage or disconnection in the bridge structure.
5. ESP8266 Wi-Fi Module: Enables wireless data transmission and online alert communication.
6. GSM Module: Sends SMS alerts to authorities or users for quick response during emergencies.
7. Servo Motor (SG90): Used for mechanical response such as raising or lowering a barrier.
8. Buzzer: Provides audible alerts when a fault, flood, or collapse risk is detected.
9. LCD Display (16x2): Displays real-time sensor readings and system status.
10. Power Supply Unit: Includes a 12V transformer, bridge rectifier, filter capacitor, and LM7805 voltage regulator to provide a stable +5V DC supply.
11. Switch and Resistors: Used for manual reset, pull-up operations, and circuit stabilization.
12. Crystal Oscillator (16 MHz): Provides clock pulses to the microcontroller for accurate operation.

Software Requirements

1. Arduino IDE: Used to write, compile, and upload the program code to the ATmega328 microcontroller.
2. Embedded C / Arduino Language: Programming language used to develop sensor interfacing and control logic.
3. Proteus / Multisim (Optional): For simulating and testing the circuit design before hardware implementation.

4. Serial Monitor or IoT Dashboard: Used for real-time monitoring of sensor data and Wi-Fi communication feedback.

5. Drivers and Libraries:

- o ESP8266 Wi-Fi library
- o DHT sensor library
- o Servo motor library
- o Liquid Crystal library for LCD

VII. RESULT

The Bridge Collapse and Flood Detection System using Quick Response successfully monitors bridge conditions and surrounding environmental parameters in real-time. The system detects any unusual rise in water level, increase in humidity, or structural breakage using the ultrasonic sensor, DHT11 sensor, and continuity sensor respectively. When a critical condition is detected, the ATmega328 microcontroller immediately activates the buzzer for local alert and operates the servo motor to perform safety actions such as barrier movement. In addition, the ESP8266 Wi-Fi and GSM modules effectively transmit warning messages to the concerned authorities, ensuring a quick response. The LCD display continuously shows the current readings of water level, humidity, and bridge status, helping in real-time monitoring. Overall, the system performs efficiently and provides a reliable solution for early detection and prevention of bridge collapse or flood-related accidents.

VIII. CONCLUSION

The Bridge Collapse and Flood Detection System using Quick Response is a smart and reliable solution designed to improve public safety by continuously monitoring bridge conditions and detecting potential flood risks. The system integrates several sensors—ultrasonic sensor (SR04) for water level measurement, DHT11 sensor for temperature and humidity detection, and a continuity sensor for identifying structural damage. All these components are controlled and coordinated by the ATmega328 microcontroller, which serves as the heart of the system. The circuit efficiently processes sensor data and responds immediately when any abnormal or unsafe condition is detected. It activates a buzzer for audible alerts and controls a servo motor (SG90) to perform mechanical operations such as lifting a barrier to restrict movement. The inclusion of ESP8266 Wi-Fi and GSM modules enables the system to send instant warning messages to the concerned authorities, ensuring quick action in case of emergencies. Real-time data and system status are displayed on the LCD module, while a regulated +5V DC power supply using an LM7805 voltage regulator provides stable operation for all components from testing and analysis, the system demonstrates accurate performance in detecting water level changes, structural faults, and environmental variations. It fulfills its objective of early detection and quick response, helping prevent accidents due to bridge collapse or flooding. With minor enhancements—like solar power integration, cloud monitoring, and waterproofing—the system can be deployed for real-time field use. Thus, this project effectively showcases how embedded systems and IoT technology can be applied for disaster prevention and public safety.

IX. REFERENCES

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