Real-Time Monitoring of Bridge and Water Craft System Using IoT

REKHA S KUMAR[1], Dr. MADHU B[2]

[1]Student, Department of Computer Science and Engineering, Dr. Ambedkar Institute of Technology, Bengaluru-560056, Karnataka, India
[2]Assistant Professor, Department of Computer Science and Engineering, Dr. Ambedkar Institute of Technology, Bengaluru-560056, Karnataka, India

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Abstract - *There are many diverse bridges built across the world that are used by people in their day-to-day lives. Among these, most of them are not under proper maintenance. Therefore, it is critical to have a system to monitor the health of the bridge's infrastructure such as vibration, cracks, strain on the bridges and report the concerned problems when required. Things like natural calamities, ageing or overloading of the bridge may cause the bridge to collapse thereby leading to severe damage to life, economy and destruction. To overcome this, we use a real-time monitoring system using different types of sensors that monitor the health and tenacity of the bridge. We have also implemented a small sensor system to avoid crashing of the boats by intimating the data information to the sailor about the water surface level by preventing accidents and loss of lives, thus creating a better and safe environment for people to use it conveniently.*

Keywords: *bridge monitoring, watercraft system, sensors, Wi-Fi, Internet of Things, Arduino.*

1. INTRODUCTION

The constructed bridges tend to get worn out and damaged due to extensive usage by all kinds of vehicles over a continuous period. This might be hazardous and risky to carry out the usual procedure [1]. Proper observance should be made for increasing the lifetime of these bridges in real-time and for the convenient operation of them for travelling by examining the health and state of bridges so that all the vehicles moving on it will be safe from any mishap. Therefore, regular rounds should be conducted as a routine for the inspection of the conditions and health of bridges by scrutinizing the overall affairs and constraints of the constructed bridge for conventional safety and security. To resolve this problem, the represented prototype for monitoring the health of the bridge has been constructed using wireless data communication. This is done through IoT (Internet of things) based technology using many sensors for different purposes, which has helped put forth the automated real-time monitoring of the bridge. The shift from inspection through human examination and interpretation to automated analysis and predictions has been of great help for a greater cause [8,9]. This project is an effort to avoid any dangerous accidents of vehicles on the bridge due to poor health condition of the bridge, or even worse, collapsing of the entire bridge structure leading to a great loss of life and property. As mentioned earlier, we have used a wireless data transmission network i.e., IoT. Consequently, many sensors are installed on various parts of the bridge and all the required data from the sensors [9] are sent to the server present in the control room to take required actions against the shortcomings when it crosses a specified threshold. The proposed system consists of two models i.e., the bridge model and the boat model for proper guidance of boats under the bridge using ZigBee and Wi-Fi communications which will be further discussed below further in this paper.

2. LITERATURE SURVEY

Constructional assembly of engineered structures requires systematic surveillance. They bring about economic and communal growth [1]. That being the case, the health of these structures needs to be monitored carefully, be it the fractures, tenacity or any sort of breach. Thanks to Kevin Aston, who coined the term "Internet of Things" in 1999 [2], we can see enormous development in this field till the present day. This very IoT was raised to a resolution that all things are associated with the Internet through information recognizing devices known as RFID (Radio-frequency Identification) [3]. The traditional techniques of the bridge monitoring system failed to manage the data that were collected. The use of optical cables for communication caused the entire setup to be too complex and also their overbearing expense added more concerns for the development of the overall framework. Regular visual supervision by men led to inaccurate information causing misinterpretation of the data. We can overcome these concerns by simply shifting to an IoT-based system setting. The data can be collected efficiently without any failure, use of sensors [4,9] for the data communication computes to a simpler configuration and also reduces the expense considerably [5]. With the help of all the data from the sensors, we can monitor the bridge regularly and prevent any disastrous event from occurring. In addition, the Bridge clearance (BC) is to be taken care of [6], i.e., by using an ultrasonic sensor to measure the water surface level, if the boat can pass under the bridge. All the communication is done with the help of Zigbee and the Wi-Fi communication network [7]. Details about the system configuration are further discussed in this paper.

3. PROPOSED WORK

The Proposed System mainly deals with the prediction of the height of the bridge, water level, and traffic control on the bridge. It compares the height of the boat with that of the bridge's height and checks whether the boat can pass under the bridge safely or not.

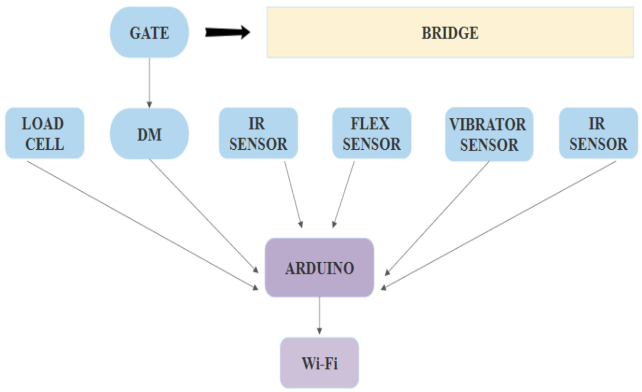

Fig-1: Bridge Module

The proposed system consists of two modules: the bridge and boat modules. In the case of bridge module, there is an implementation of various sensors like IR sensors to count the number of vehicles that enter and exit the bridge, flex sensors and vibration sensors to identify the bends and cracks on the bridge, load cell to weigh each vehicle that enters the bridge through the gate as well the overall weight on the bridge, which is installed using a DC motor. If any of these parameters cross the provided threshold value, then those specific data parameters are communicated to the monitoring center through an alarm to take standard precautionary measures. The complete parameters of the bridge are taken by an ARDUINO microcontroller and are sent to another module which is located at a nearby distance.

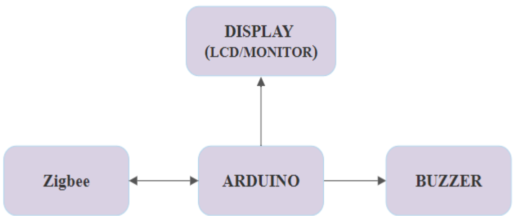

Fig-2: Boat Module

The ultrasonic sensor is used to check the water surface level under the bridge for establishing safe watercraft movement. Implementation of a Wi-Fi module for the communication between the bridge module and the data monitoring system center. module. On the other hand, the Boat module is established with a ZigBee communication that uses wireless Transmitter and Receiver circuitry. The receiver module takes the data information from the transmitter and sends the message with all the parameters to a database center. It is implemented with an LCD where the message notification received will be displayed and a buzzer to alert when the message is received for the convenience of the sailor. The communication established between the intermediate module and the central database server uses IoT technology, which helps provide near real-time message information to the sailor to take appropriate decisions to avoid accidents and loss of life in the case of the boat module. Our project idea is based on the structural insights of the Howrah Bridge which is located in West Bengal.

4. IMPLEMENTATION AND RESULTS

The main agenda of this study is to demonstrate how real-time bridge monitoring and watercraft system works and how efficient can it be. We have implemented our two structural modules i.e., the bridge model and the boat model using various sensors as mentioned. The following pictorial representations depict how the implicated process works and the overall result in each scenario. Fig-3 shows how our system is set up and the overall prototype design.

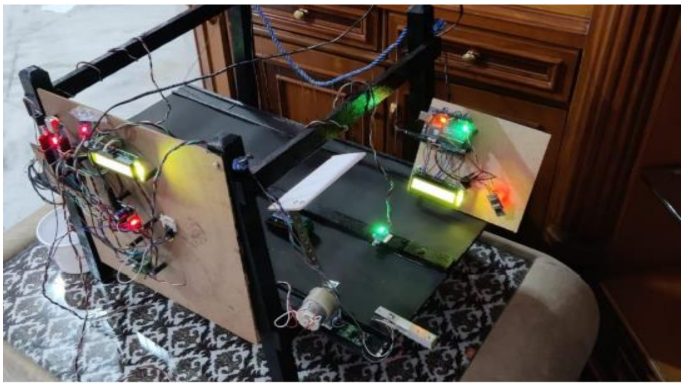

Fig-3: Bridge model setup

Fig-4: Gate open

Fig-4 displays the message that the gate is open and ready for the vehicles to enter the bridge.

Fig-5: Vehicle count

Fig-5 shows the count of vehicles that enter the bridge which is done with the help of IR sensors at the entry and exit of the bridge.

Fig-6: Weight of vehicles

Fig-6 shows the weight of each (here, first) vehicle that enters the bridge at the gate with the help of the load cell.

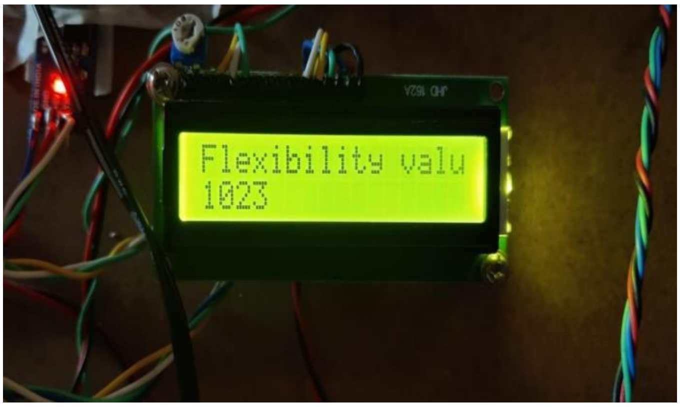

Fig-7: Flexibility value

Here the flexibility value of the bridge is displayed with the implementation of flex sensors.

Fig-8: Vibration Value

If there is a vibration detected then the message will be displayed as vibration value 1 on the LCD but if there was no vibration detected it will display 0. This is done using vibration sensors.

Fig-9: Vehicle count

Fig-10: Weight on the bridge

Fig-9 shows the vehicle count on the bridge (here the 7th one) and Fig-10 shows the weight of each vehicle that enters and also the total weight on the bridge.

Fig-11: Maximum count

As in the current model, the threshold is given as 7 (Fig-9) for the maximum number of vehicles to enter the bridge. So once this happens a message is displayed as shown in Fig-11.

Fig-12: Vehicles exit

Fig-12 shows the vehicle count that exits. Once the vehicles exit the bridge an exit message is displayed. As so, new vehicles enter at the bridge's entry, and this entire process repeats on a loop.

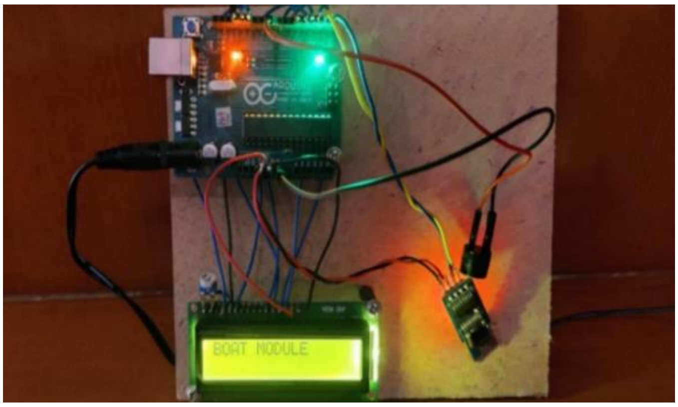

Fig-13: Boat module

Fig-13 is a boat module circuitry that is used to check the water surface level under the bridge and convey the needful message to the sailor.

Fig-14: Display message on boat module

Once the boat module starts functioning the displaying message looks as shown in Fig-14.

Fig-15: Water level

The water level under the bridge is sensed by the ultrasonic sensor installed under the bridge. Different water level values are given i.e., high, mid and low.

Fig-16: Water level

As shown in Fig-15 and Fig-16 if the water level is either low or mid, a message is displayed that says the boat can pass. In case the water level is high, the message on LCD reads that the water level is high and the boat cannot pass.

5. ADVANTAGES

- Safety of bridges is achieved.
- Cracks can be monitored at the early stage thus can prevent any major damages from taking place.
- Avoids Traffic on Bridges.
- Prevention of accidents.
- Easy to implement as there are no complications of optical cables involved between each connection, thus no complex networks involving wires.
- As it is based on objective monitoring, higher accuracy is obtained compared to periodic visual inspection.
- It is scalable and hence can accommodate new nodes/devices at any given period.

6. APPLICATIONS

- The proposed model of the case study can be used for the hanging bridges (e.g., Howrah Bridge).
- This ideology can also be implemented on monitoring the safety of regular highways.
- This can not only be used for bridges; it can also be used to detect cracks and check the tenacity of large buildings or apartments.
- The prototype can be applied to monitor the conditions of railway bridges for proper and safe transportation.

7. CONCLUSION AND FUTURE SCOPE

This proposed study is to develop a real-time bridge monitoring system and watercraft system to ensure the protection and safety of the bridge as well as the water transportation that integrates wireless communication technology like IoT and ZigBee. Even in developed nations like the USA, it has been found that more than one out of every four bridges are structurally weak. One such case reportedly killed 13 and injured 145 in Minneapolis on Aug. 1, 2007, where the current traditional wired system is a hundred times costlier than wireless networking. The proposed wireless technology could avert this kind of bridge collapse and provide effective functioning. The proposed system can help in monitoring the bridge in an efficient, cost-effective and reliable manner which can prevent major damages to society and human life. The ease of accessibility, size, less energy usage and being economical, brings out a revolution in bridge safety monitoring by giving a uniform performance at an intensive level in the forefront. This ideology can be applied for new and existing bridges too, by which we can monitor the bridge's health and take proper precautions priorly in time. The boat module helps in measuring the water level under the bridge by intimating the sailors about specific information.

In addition to this, along with the use of sensors, the implementation of cameras for the detection of cracks or bends in the bridges using artificial intelligence can be used for better monitoring of the bridge. GPS (Global Positioning System) can be used for tracking the boats' location with accurate positioning, navigation and timing services by minimizing the miscommunication to the very least. Implementation of GSM (Global System Mobile for Mobile Communication) for communication of data parameters instead of ZigBee makes the entire model more reliable and robust. The system developed in this case study is in an introductory stage. Further research is required to improve the presented system by scrutinizing the data collected by the system and developing more primitive computing models and functional practices for the proposed system.

8. ACKNOWLEDGEMENT

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