IOT based Android application for Smart Bridge Monitoring System

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Abstract*: Transport networks be it roadways or railways consist of a huge number of bridges which are critical in reducing the distance and time of travel. As the bridges experience huge amount of traffic it is significant to deploy and maintain a Bridge Monitoring System. This system should monitor the various safety parameters of the bridge such as load, vibration and tilt continuously so that preventive action can be taken if any anomaly is detected. In this paper we propose a smart bridge monitoring system using IoT. Various IoT enabled sensors are deployed over the bridge which periodically measure the safety parameters and then relays it to the micro-controller. The micro-controller takes appropriate action and send this data to the cloud which in turn notifies the end user on his android application.

Keywords—Bridge Monitoring, Sensors, IoT, Load on Bridge , micro-controller.

I. INTRODUCTION

The bridges are key part of a country's transport infrastructure as it facilitates the movement of cargo and citizens from one place to another. With the progress in auto mobile technology and proliferation of railway and road infrastructure and also fuelled by a highly consumerist society we see a massive increase in the traffic. Bridges that are integral to both road and railway networks in reducing the distance and time of travel are witnessing increase in their traffic and load that they can withstand. Such critical infrastructure has to be maintained and administered in a safe manner, which demands the deployment of a Bridge Monitoring System. This system determines the health of the bridge by continuously monitoring various safety aspects of a bridge like the load, tilt, strain and vibration. These measurements if taken manually result in delayed decision making and hence should be automated. The developments in IoT enabled sensor based technologies has made it possible to accumulate data generated from remote sensors and store them on the cloud. Whenever the measurement exceeds a given threshold or indicate the occurrence of an unfavourable situation it can be easily notified to the end users and other stake holders instantly. After which appropriate corrective action can be taken in response to such notifications. In this paper we propose a model that enables the safety of a bridge by monitoring the safety parameters of the bridge continuously by using sensors that are connected to the cloud by means of a microcontroller, which constantly reads values from load and vibration sensors fitted on the bridge and takes any corrective actions in case of any anomaly being detected in the safety parameters. Apart from this the micro-controller relays this processed information to the cloud. When any error condition is detected it alerts the end users by sending them notifications to their android application installed on their smart phones. When such notifications are received the person can avoid the usage of this bridge and take some other alternate route. The transport officials can now take corrective or repair actions to fix the bridge. This system also reduces the requirement of manual periodic checks on the bridge as it is now taken care by the proposed system. The maintenance operations on the bridge can also be scheduled in a better manner.

The content of this paper is organized as follows. Section II outlines the literature survey that describes the current work carried out in this regard. Section III describes the proposed system model and its design. Section IV discusses implementation details such as interfacing the micro-controller with the sensors and the cloud. Finally it is followed up by the conclusion.

I. LITERATURE SURVEY

Some of the existing works related to our work is summarized here. Mr. Anand Kumar Jha(2016)[1] proposed a three level distributed architecture for bridge monitoring system, which includes central server, intelligent acquisition nodes and local controller. Aquisition nodes can be located randomly across the bridge. Data collected from acquisition nodes are sent to local controller. Data will be processed in local controller and processed data will be sent to central server, which reduces the load on central server. The parameters considered for bridge monitoring are displacement, acceleration and strain of bridge.

Ren-Guey Lee, Kuei-chien chen, Shao-shan chiang, Chien-chin lai, Hsin-sheng liu, Ming-shyan wei(2016)[2] developed an efficient system for bridge monitoring system. The proposed system used wireless sensor network to gather information about bridge and sends data to a back end database through multiple intermediate hops. The data can be analyzed by experts which is stored in back end database.

Joan R. Casas and Paulo J.S.. Cruz,M. ASCE(2003)[3] discussed the techniques involved in usage of Fibre optic sensors to monitor bridges. This will improve the life time and reliability of bridges and decreases maintenance activities.

Sunaryo Sumitoro, Yoshimasa Matsui, Masaru Kono, Takuji Okamoto, Katashi Fujii(2001)[4] developed a reliable monitoring device to monitor the bridges during earthquakes. The device has a self check function to check the disorder of the system. The reliability

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of the device is analyzed using simulation results.

Himalay B. Sawant, Shivdas H. Shinde, Dhiraj V. Chandak,Prof. Sujit P. Jagtap, Prof. Amarsinh A. Ranaware((2018)[5] proposed a bridge monitoring system with sensors and GSM technique which informs condition of the bridge to the nearby officers.

Atharva Kekare, Pranit Huddedar, Rohit Bagde(2014)[6] proposed a low cost wireless bridge monitoring system with the sensors like accelerometer, load cell, anemometer, temperature sensor to monitor different parameters of the bridge. Along with these sensors, the monitoring system also contains a GSM module to inform monitoring authority about status of the bridge.

II. Proposed Design

To monitor the health of bridge continuously, we propose to use two sensors namely vibration sensor and load sensor. Vibration sensors are used to detect the bridge tilt. Vibration sensors monitor the motion of bridge in 3 axes. Bridge tilt may occur due to natural calamities like wind or due to heavy load on bridge. Vibration sensors are placed at fixed positions across the bridge to check the condition of a bridge at any given point of time. These sensors can measure the level of deformity in the bridge due to load being applied on it by the traffic passing on it. These readings over time can be used to measure the structural integrity of the bridge. The readings from the sensor are passed on to the micro-controller for decision making. Modal Assurance Criterion (MAC) & Coordinate Modal Assurance Criterion (COMAC) are used to measure modal node displacement to detect and locate damage. Over a period of time if there is any anomaly detected then this indicates structural wear and tear in the bridge. Once detected maintenance operations can be performed to rectify the identified defects. In case of serious deformation safety measures should be undertaken like notifying the authorities and closing the bridge till it is safe for operations.

The next sensor we are using is a load sensor. Load sensor is used to check the weight on the bridge. For any bridge one can specify a threshold limit on the amount of load that it can handle for the safe operation. If the weight exceeds the toleration level, then it leads to bridge collapse. To avoid this we are placing load sensors at the entry and exit points of the bridge in either direction.

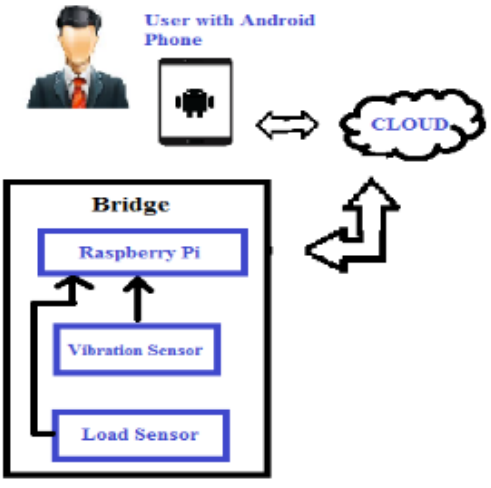

Figure 1: Architecture of Bridge Monitoring System

The load sensor at the entry point measure the load of incoming vehicles and sum them up to find the overall load on the bridge at any point in time. The weight of the outgoing vehicles is deducted similarly at the exit point. The decision whether to allow a vehicle on to the bridge is made as follows.

If the weight of incoming vehicles is greater than threshold, when it is added to the current load on bridge, then gate of the bridge will get closed automatically. The corresponding vehicle will not be allowed to enter into bridge until other vehicles currently on bridge will move out. Once other vehicles on bridge will move out, then gate will be opened automatically to allow other vehicles to pass through the bridge. If the weight of any vehicle is less than threshold, when it is added to current load on bridge, then such vehicles will be allowed to pass through the bridge. The algorithm for the operation of the load sensor is given below

A. *Algorithm for Load Sensor*

while(True)

if a Vehicle V_i is about to enter a bridge

calculate the load of the vehicle w_i

$\sum W_i = \sum W_{i-1} + w_i$

if $\sum W_i > \sum W_{thresh}$

Close the gate. $\sum W_i = \sum W_i - w_i$

else

Allow the vehicle V_i

if a Vehicle V_i exits the bridge

calculate the load of the vehicle w_i

$\sum W_i = \sum W_i - w_i$

The architecture of bridge monitoring system is outlined in figure 1. The drivers of vehicles should have android app installed in their smart phone to receive continuous updates on condition of the bridge through text messages.

There will be a display system, an LCD screen, at the entrance of the bridge which will display the real time condition of the bridge and weight of vehicle which is about to enter the bridge. Here the administrator can take necessary actions during serious conditions like midway accidents, bad weather conditions etc. The administrator will have access to data of bridge health.

III. Implementation

Both vibration sensors and load sensors collect data about bridge and the traffic continuously and send that data to a Raspberry Pi, which is a decision making entity. The business logic will be implemented in a Raspberry Pi. The interfacing of the Raspberry Pi is shown in the figure below.

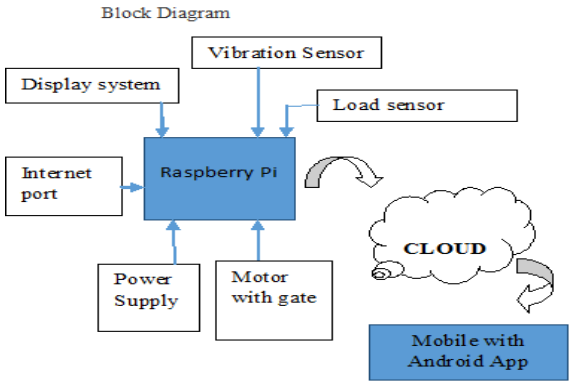

Figure 2: Interfacing of Raspberry Pi with sensors

Based on the data collected from the sensors, Raspberry Pi arrives at a decision and the decision will be sent to cloud. If the incoming vehicle exceeds the safe load limit then the bridge gate is closed which is controlled by a servo motor. The operation of the servo motor is controlled by the Raspberry Pi. From the cloud, the health status of bridge will be broadcast to all users of android app through message. Depending on the condition of the bridge, the drivers will take necessary actions like whether to take alternate path or to pass through the bridge.

Apart from the data sent to the cloud, the Raspberry Pi will send necessary data to a display system which is located at the entrance of the bridge. By the received data the display system displays the current status of bridge. This helps the drivers who does not have android app to know current condition of bridge.

The drivers who have the android app need to login to the app to know condition of a bridge. Here the driver gets a notification about the upcoming bridge and current traffic status on the bridge based on which he can choose the route. When he nears the bridge he can also know whether he can enter the bridge or has to wait by means of notifications on the phone.

IV. Conclusion

It is necessary to keep the bridges safe. For that it is required to monitor the bridges continuously and maintain the required infrastructure. This is mainly done with the help of sensors which measures the condition of bridge and detects problems that occurred in bridge. Through which necessary actions can be taken. The administrator will be the decision maker during emergencies like accidents on bridge. The usage of IoT and sensors has made monitoring the bridge an automated system. This Automated Decision making results in timely actions to be taken. Automation reduces human error as well as labour cost.

This system is proposed to continuously intimate the people about the condition of the bridge which will help them to take appropriate route to reach the destination early.

As an enhancement to this proposal, many other sensors can be used along with vibration sensors and load sensors. They are crack sensor, deformation sensor etc which can be useful for effective monitoring of the bridge.

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