ISBN: 978-93-87793-74-3

Structural Health Monitoring of Bridges Using IOT

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ABSTRACT

We begin to co-exist and interact with smart interconnected devices that are known as the Internet of Things (IOT). The IOT brings new opportunities for our society. Yet, most of the existing Structural Health Monitoring (SHM) systems are not connected to the IOT. SHM is a system to monitor the structural health of buildings and bridges. In this paper, a complete real-time SHM platform is integrated with the IOT system. The proposed platform consists of a Wi-Fi module, and Raspberry Pi. If there is any damage, the system will determine the damage location and send this information to the Cloud. Raspberry Pi collects the data from many sensors. The Raspberry Pi will upload the data to the cloud using a Wi-Fi module. The data will be stored in the cloud and can be checked remotely from any mobile device.

Keywords: cloud, Internet of Things (IOT), mobile devices, Raspberry Pi, Structural Health Monitoring (SHM), Wi-Fi module.

I. INTRODUCTION

As lifeline engineering, bridges are in a stage of rapid development at present, and the community has attached great importance to the operational safety of bridges. Therefore, how to ensure the healthy operation of long-span bridges has become a hot topic that is difficult to address in this field. Through the service period that ranges from decades to even a hundred years, bridges will be affected by external loads like cars, climate, and rivers. Bridges will also be affected by internal effects like material aging, fatigue, and other factors. These factors will result in inevitable damage and serious accidents.

With the maturity of the smart technology, one of the recent challenges in the structural engineering community is the developing of the IOT SHM systems that could provide a promising solution for rapid, accurate, and low-cost SHM systems. Moreover, the combination of SHM, cloud computing, and the IOT will enable everywhere services and powerful processing of sensing data streams beyond the capability of traditional SHM system. Cloud platform allows the SHM data to be stored and used intelligently for smart monitoring and actuation with smart devices. To avoid all the economical and life damages we are using Structural Health monitoring of Bridges using IOT. Yet, there

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is no real implementation of SHM in the IOT. This paper proposes a complete real-time SHM platform based on the IOT.

II. BLOCK DIAGRAM AND WORKING:

The system in this paper proposes consist of Raspberry pi3 Model B+, servo motor, Vibration sensor, water level sensor. The sensors are installed on various parts of the bridge as shown in the above block diagram, monitors the vibration, water level, breaking of the bridge etc. At any point of time if any of these parameters cross their threshold value the system informs the monitoring office giving an alarm for taking precautionary measures. The complete parameters of the bridge are taken by a Raspberry pi 3 Model B+ and sent to cloud. Here the communication established is using wifi module that uses wireless Transmitter and Receiver circuitry. The receiver module takes the parameters from the transmitter and sends a message with all the parameters to a database centre.

The block diagram of proposed system is as follows.

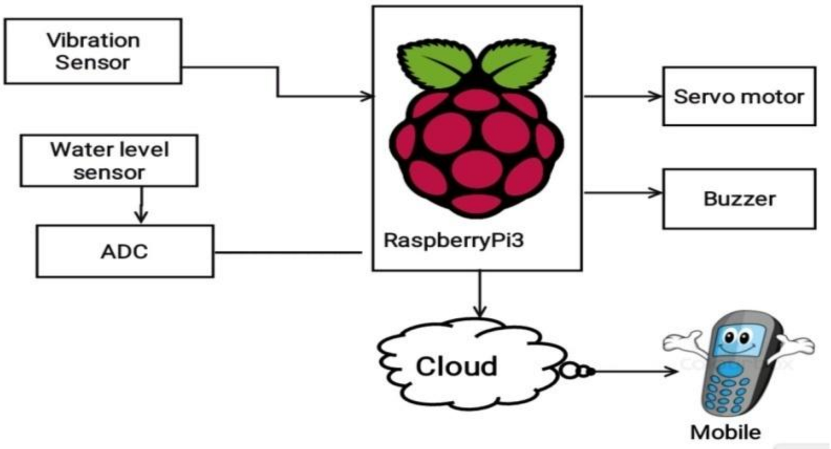

Fig.1: Block Diagram

The sensory inputs are process to represent the condition of the bridge against vibrations, water level etc. If any of these parameters cross their threshold value system informs the monitoring centre giving an alarm for taking precautionary measures and the barrier will be automatically closed on the bridge and buzzer alarms.

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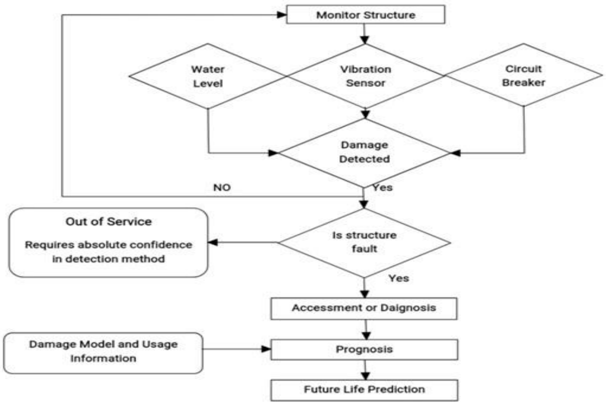

Fig.2 a flow chart dedicated for SHM system

Problem Detection

Highway and flyover bridge systems are critical for economical growth, being used over hundreds of years. It is very important to have a system to monitor the health of these bridges and report when and where maintenance operations are needed. Advancements in sensor technology have brought the automatic real-time bridge monitoring system (BMS). However, current system uses complicated wiring which makes the installation and repair/replacement process difficult and expensive.

In this project an idea of bridge monitoring system using wireless system is proposed. For long distance IoT is used as wireless network, and cloud is used for long distance (between the bridge and the monitoring centre) data communication. This technology can be called MBM (Monitoring Based Maintenance) that enables the bridge maintenance engineers monitor the condition of the bridge in real time. The sensors installed on various parts of the bridge monitors the vibrations, water level, collapse of the bridge etc. At any point of time if any of these parameters cross their threshold value the communication system informs the monitoring centre giving an alarm for taking precautionary measures and the barrier will be automatically closed located on the bridge.

The main objective of our project is to

- Monitor the water level under the bridge.
- Monitor the vibrations in the bridge.
- To detect the collapse of bridge using circuit Breaker
- Indicates when there are earthquakes, cracks and bending in the bridges.
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III. HARDWARE DESIGN

3.1 Raspberry pi 3 Model B +

The Raspberry Pi is a series of small single-board computers developed in the United Kingdom by the Raspberry Pi Foundation to promote teaching of basic computer science .

Fig.3 Raspberry Pi 3 Model B +

The Raspberry Pi 3 Model B+ is the latest product in the Raspberry Pi 3 range, boasting a 64-bit quad core processor running at 1.4GHz, dual-band 2.4GHz and 5GHz wireless LAN, Bluetooth 4.2/BLE, faster Ethernet, and PoE capability via a separate PoE HAT. The dual-band wireless LAN comes with modular compliance certification, allowing the board to be designed into end products with significantly reduced wireless LAN compliance testing, improving both cost and time to market. The Raspberry Pi 3 Model B+ maintains the same mechanical footprint as both the Raspberry Pi 2 Model B and the Raspberry Pi 3 Model B.Processor: Broadcom BCM2837B0, Cortex-A5364-bit SoC @ 1.4GHz, Memory: 1GB LPDDR2 SDRAM, Connectivity: 2.4GHz and 5GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2, BLE Gigabit Ethernet over USB 2.0 (Maximum throughput300Mbps)
4 × USB 2.0 ports

3.2 MCP 3008

The MCP3008 is a low cost 8-channel 10-bit analog to digital converter. The precision of this ADC is similar to that of an Arduino Uno, and with 8 channels you can read quite a few analog signals from the Pi. This chip is a great option if you just need to read simple analog signals, like from a temperature or light sensor. The MCP3008 connects to the Raspberry Pi using a SPI serial connection. You can use either the hardware SPI bus, or any four GPIO pins and software SPI to talk to the MCP3008.

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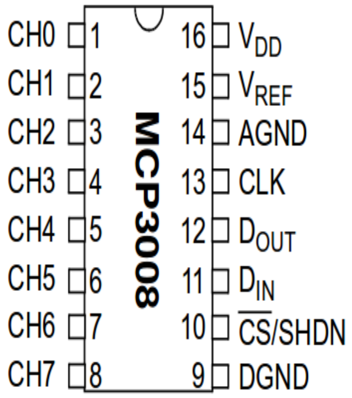

Fig.4 MCP 3008

It has 10-bit resolution ,± 1 LSB max DNL, ± 1 LSB max INL,4 (MCP3004) or 8 (MCP3008) input channels Analog inputs programmable as single-ended or Pseudo-differential pairs On-chip sample and hold SPI serial interface (modes 0, 0 and 1, 1)

3.3 Water Level Sensor

Fig.5 Water Level Sensor

Basic level sensors can be used to identify the point at which a liquid falls below a minimum or rises above a maximum level. There are a number of different types of liquid level sensor used to detect the point level of a liquid. Some types use a magnetic float, which rise and fall with the liquid in the container.

3.4 Vibration Sensor

Sensors for vibration are sensors that operate according to different mechanical or optical principles to detect vibrations of an observed system. Vibration sensor outputs digital signal. Before taking a vibration measurement, you need to attach a sensor that can detect vibration behaviour to the machine that is being measured.

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Fig.6 Vibration Sensor

The measurement of vibrations can be done using various types of sensors. Although there are no direct vibration sensors, vibrations can be measured indirectly, deducing values from classic mechanical or optical quantities. These sensors differ in some features. Among other things they can be divided based on active and passive behavior, there are sensors that measure relative and others absolute. Other distinctive features are frequency range, signal dynamics and the quality of the measurement data.

3.5 Circuit breaker

Circuit breaker essentially consists of fixed and moving contacts. These contacts are touching each other and carrying the current under normal conditions when the circuit is closed. When the circuit breaker is closed, the current carrying contacts, called the electrodes, engaged each other under the pressure of a spring. During the normal operating condition, the arms of the circuit breaker can be opened or closed for a switching and maintenance of the system. To open the circuit breaker, only a pressure is required to be applied to a trigger.

3.6 **Servo motor**

Servo motor works on PWM (Pulse width modulation) principle means its angle of rotation is controlled by the duration of applied pulse to its Control PIN. Basically servo motor is made up of Decimator which is controlled by a variable resistor (potentiometer) and some gears.

IV. RESULTS

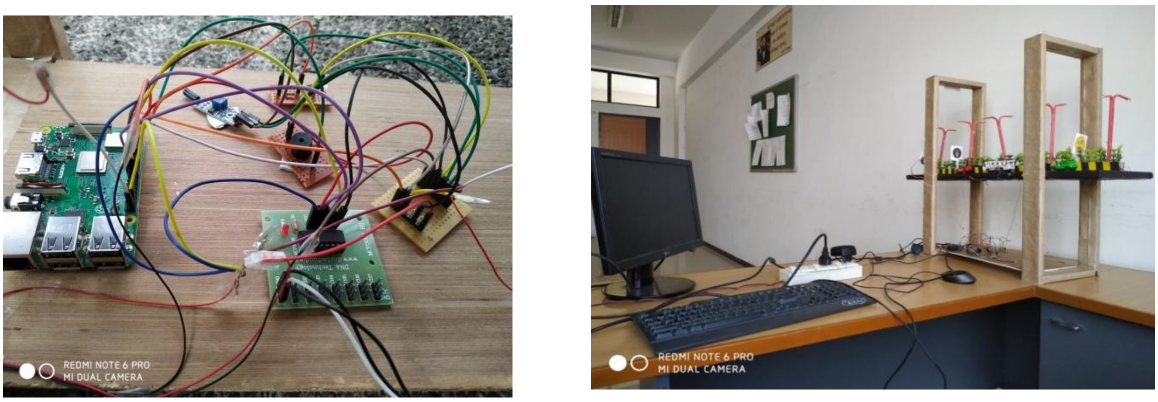

Fig.7 the components of the Bridge Monitoring System

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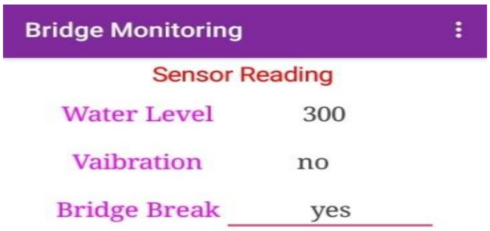

Fig.8 Readings on MIT App

V. ADVANTAGES

- Increased safety
- Detecting early safety risks
- Longer life span
- Collapse Warning

VI. CONCLUSION

Even in developed nations in Europe, it has been found that more than one out of every four bridges is structurally deficient. This wireless technology could avert the kind of bridge collapse that killed 27 along Mahad on Aug. 2, 2016 at one-hundredth the cost of current wired systems. This system can help in monitoring the bridge in an efficient, cost effective and reliable manner. The immediacy, low cost, low energy and compact size add up to a revolution in bridge safety monitoring. The efficiency of Bridge Monitoring System (BMS) can be increased by using more number of sensors and variety of sensors to monitor the damages of bridge.

Future work

- Web camera can be fitted so that the density of the vehicles can determine.
- We can use UV sensor for detecting the cracks in bridge.
- We can use flex sensor to identify the bending of bridge.

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