Research Article

Structural Health Monitoring of Bridges Using WSNs

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Abstract— Wireless sensor networks (WSNs) for Structural health monitoring (SHM) has earned immense attention in research as it has potential to decrease expenses associated with the maintenance cum installation of these monitoring systems. SHM systems, traditionally are being utilized to screen perilous substructures such as bridges, tall buildings, fields and is capable to increase structure lifetime and safety of public. Earlier wired networks were used by SHM. But this resulted in heavy cost in terms of maintenance and deployment. This project introduces a wireless sensor network using Bluetooth nodes for detection of damage if any in any type of structure in which the data is processed locally in real time and helps in sending alerts once the damage is identified.

Keywords— GSM, Sensors.WSN, agriculture, precision

1. INTRODUCTION

Bridges are endlessly exposed to very harsh environmental effects such as aging of materials, extensive rust of steel bars in tangible erections, rusting of steel erections and its parts, growing heaps of traffic and overfilling, or just complete weakening and old. All these elements together with negatives of proposal, creation, and unintentional damage, triggers the worsening of bridges and results in the injury of bridges in terms of carrying sufficient load. The state of extensively used built-up bridges is even inferior, one in four is categorized as not able to adapt modern vehicle masses or as aging and volumes of congestion. Therefore, a major amount of these erection needs firming, restoration, or replacement, but due to lack of public funds mostly offered for the essential renewal of standing buildings or creation of innovative ones. Bridges can undergo physical deprivation due to aging, mismanagement, or less maintenance. One major factor that has been not considered is the insufficient checking and supervising of prevailing structures, among the many factors which have led to the substandard state of bridge structures. In order to sanction some of the design parameters made, also to deliver real-time opinion at the time of construction (specifically right for novel bridges), and to estimate the actual present status of the bridge, it should allow the engineers to take well-versed choices regarding upcoming aspects and repair actions or to propose preservation (specifically for enduring bridges).Obtaining the quantitative data with respect to the structural behavior, is the most important objective for monitoring a bridge. In the subsequent part, in order to safeguard the structure, the monitoring structure is used that which offers early warning of an acceleration of the notorious deterioration that are being noticed.

And then to carry out a controlled lifetime allowance of the bridges with known problems, application of SHM to existing bridges has significantly amplified in current years.

2. EXISTING WORKS

The existing bridge monitoring system for public safety uses MBM (Monitoring Based Maintenance) technology that qualifies the engineer to screen the status of bridge, but not in real time. The sensors are clinged on load cables and everything is connected via wired. Highway bridge systems and flyovers are life-threatening in various areas, as they are being used since many years. The health of these poor conditioned bridges is important to be monitored and report should be generated when there are maintenance operations required. Recent advancements in sensor technology have made it possible for the automation of factual-time bridge health checking system. However, prevailing structure uses complex and high rate wired network amid sensors in the bridge and high rate optical cable between the management hub and bridge. In this venture, an idea of autonomous structural health checking of bridges using wireless sensor network is proposed.

Table.1: Comparison of Various Wireless protocols

Wireless protocols	Advantages	Disadvantages

1. Wi-Fi	High speed and higher data rates.	High power consumption.
2. ZigBee	Low power consumption	Not compatible with smartphones
3. Bluetooth	Compatible through smartphones	Low data rates (but sufficient for sending alerts)

We propose the Bluetooth technology to implement the WSN for SHM because of its low cost and complexity, medium range (around 10m), considerably good data transfer rate (around 1Mbps) and low power consumption. It is easy to implement a WSN using Bluetooth protocol.

The main reason we have chosen Bluetooth for our project is because it is present in almost all mobile devices and it is easy to send alerts to the commuters using this protocol.

3. DESIGN METHODOLOGY

3.1 Design of Detection Module

1. Arduino Uno R3: A dual-inline package with ATmega328 microcontroller at core with an operating voltage of 5V. It comprises of 14 digital input/output pins. Has a Flash memory of 32KB and SRAM of 2 KB. It communicates through SPI, I2C and UART serial communications. It weighs 25g. It acts as the core of the system which helps to coordinate data movement from the sensor and the SIM808 module.

2. Flex Sensors: Variation in resistance is directly proportional to sum of curve on the device. They alter the variation in curve to electric confrontation. They are usually a shrill band of 1’’-5’’ lengthy variation in confrontation. It is to detect the depth of bend in the structure.

3. LM35: An electronic device that helps in heat measure of its surroundings and alters the input data to electronic data to record, watch or indicate heat variations. LM35 out pin is connected to any one analog input pin of the Arduino.

4. SW420: This sensor safeguards piezoelectric transducer. Voltages are generated when the mechanical neutral axis of transducer is displaced, and this displacement results in tension of piezoelectric element. It detects unfamiliar quivering in structure during earthquake.

5. SIM900: Is a quad-band GSM/GPRS module which combines GPS technology. Works on voltage supply in the range of 3.4-4.4V and consumes less energy. It is also Bluetooth compliant and the GPS receiver has 22 channels and 66 tracking channels for procurement. It helps to send messages and update the cloud using the GSM/GPRS technology.

6. HC-05: It is a Bluetooth module which is designed for wireless communication. This is used in Master-slave configuration. It interconnects with microcontrollers using serial communication (UART).

3.2 Considerations for a Crack in bridge

Inertial Measurement Unit (IMU) sensors integrate combinations of flex sensor, temperature sensor and vibration sensors. Standard parameter values are -55 degree Celsius to 150 degree Celsius for temperature senor and 60K -110K ohms for the flex sensor any variation above or under these values can be taken into consideration.

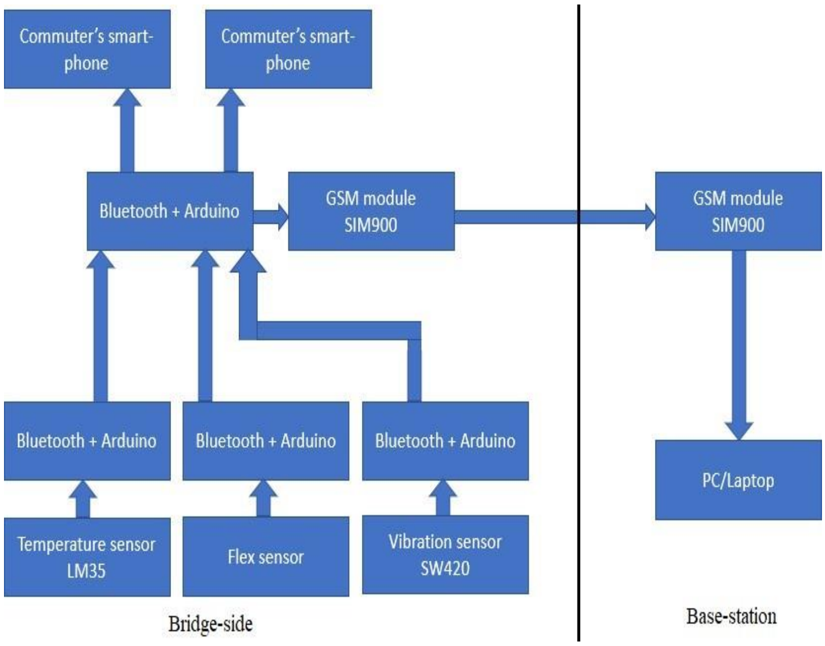

Fig 1. Basic Block Diagram

Various parts of the bridge are installed with sensors as depicted in the above block diagram. This continuously observes the bend, vibrations, temperature of the structure, etc. At any provided fact of time, the communication system notifies the base station giving an alarm for taking necessary deterrent measures, if any of these constraints cross their verge of edge value. The communication between the nodes is established using Bluetooth modules. The receiver module and sends an alert message to the base station that takes the data from the transmitter. The communication is established between the transitional Bluetooth node and the base station using GSM module. The sensory inputs are processed to signify the condition of the structure.

Fig 2. Flowchart depicted of SHM system

3.3 Alert System

The Arduino code is developed to do all tasks of a alert system that includes constantly checking if the crack has occurred, reading the location, sensor data from the UART communication, making Places Search. Notify the team to repair the location. Sending SMS to all nearby people traveling on that road. Sending the alert message to all nearby essential services. In case, of emergency everyone will be ready.

4. RESULTS

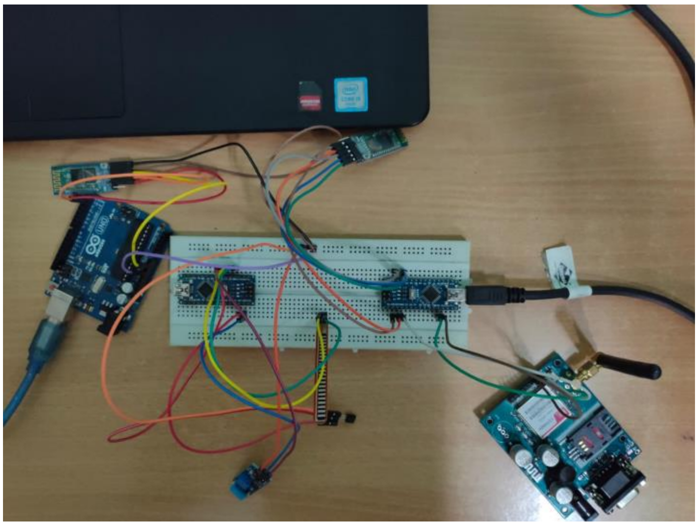

Fig.3 AT commands bluetooth master and slave

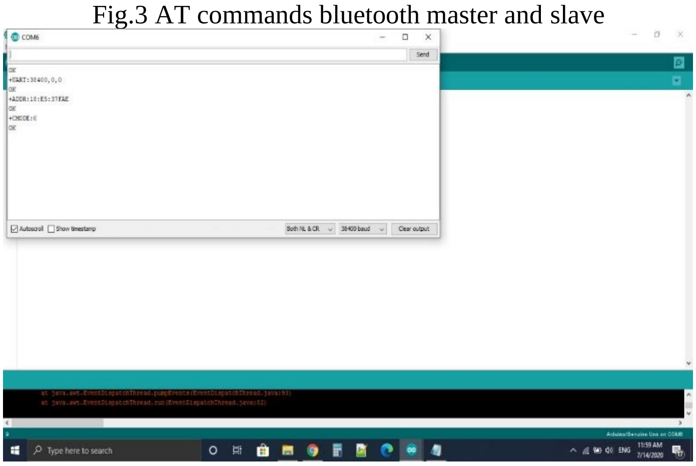

Fig.4 CMODE=0 means slave is active

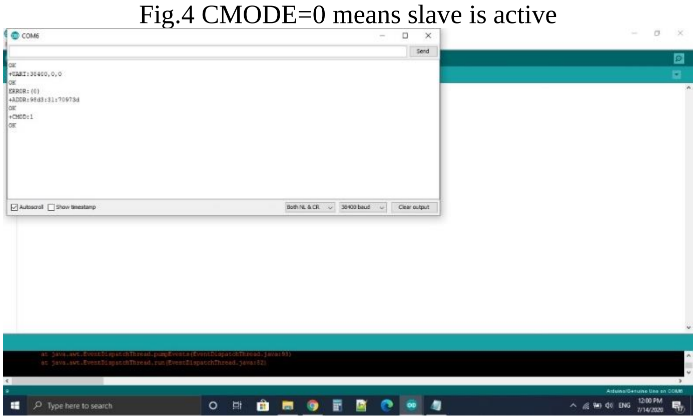

Fig.5 CMODE=1 means master is active

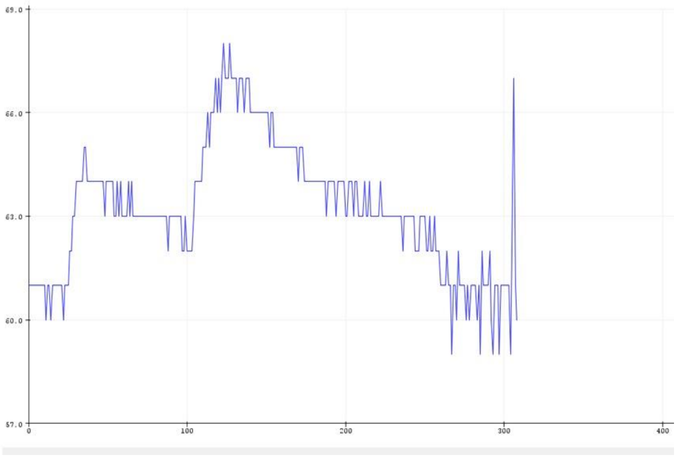

Fig.6 Temperature sensor graph

5. CONCLUSION

The Wireless Sensor Network for autonomous Structural Health check of a bridge is built and its functionality is verified in the simulation software. The network is built using Bluetooth protocol and the alerts are transmitted to the base-station using GSM module. This system can help in saving life and property by informing about the damages beforehand. The total system cost is very less, and the power consumption is also very less as the data is being transmitted only when there are damages detected.

6. FUTURE SCOPE

In future, all the smart phones will have BLE (Bluetooth Low Energy) chips inside them. The SHM systems can be built around this new technology which will lead to significant decrease in power consumption. It will also be compatible to send alerts to the commuters' devices.

The concept of 5G and smart cities which are believed to be a reality in future is also responsible for driving interest in this field. In a world where every "thing" will be connected to every other "thing", WSN will form an integral part of our lives. We can incorporate this technology in SHM throughout the world.

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