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Automatic Bridge Monitoring System Using Wireless Sensor Network

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Abstract: As wireless smart sensor network are performing very important role in the application of remote monitoring in wide spread geographical areas. Such wireless smart network becomes cost effective and possible way to monitor structural health status of bridges that connect roads in both rural and urban areas. Many of these bridges are subject to deterioration due to external and internal factors. Online, real time structural health monitoring is a resourceful tool to facilitate rapid field inspection. Bridge maintenance and infrastructure managers can easily use this application to secure the performance and safety of these vital structures. This paper presents useful wireless sensor network system to monitor structural health in bridges, field inspection. Vibration sensing mechanism is used to detect the bridge scour by using the accelerometer sensor. Humidity and strain is measured with the help of humidity sensor and strain gauge.
Keywords: Zig bee, WSN, height, humidity, vibration.

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I. Introduction

Bridges are important aspect of traffic. Human life and property will be in severe situation when bridges are damaged. In many countries, many bridges have exceeded their 50-year life span. Old bridges can not face to the severe nature disasters. In other words, the bridges in such countries are likely to suffer from the damage. Since bridge pier scour is the main cause for bridge failure and collapse. How to monitor the bridge scour and to maintain structural health becomes an important task. [1]

Structures, including pipelines, aircraft, ships and civil infrastructures, such as bridges, buildings, dams are major parts of society's economic and industrial success. Bridges are one of the critical cross points of a country's transport network but they are expensive to build and maintain. So care should be taken of bridges. For that purpose wireless sensor network is used. The idea of controlling dynamic parameters through vibration monitoring analyses is effective for preventing from crisis scenarios. Indeed, deterioration or damage of a structure leads to changes in its structural characteristics such as height of bridge. They are reflected thorough changes in dynamic parameters such as the natural frequency of the structure itself. [2]

At the both end of bridge, two transmitter nodes are created. Each node has wireless sensor network (WSN). Wireless sensor network consists of 3 axis accelerometer, ultrasonic sensor, strain guage and zig bee based microcontroller. These sensors continuously monitor desired parameter such as structure's acceleration, height, strain. Bridge parameters are monitored using wireless sensor network (WSN).

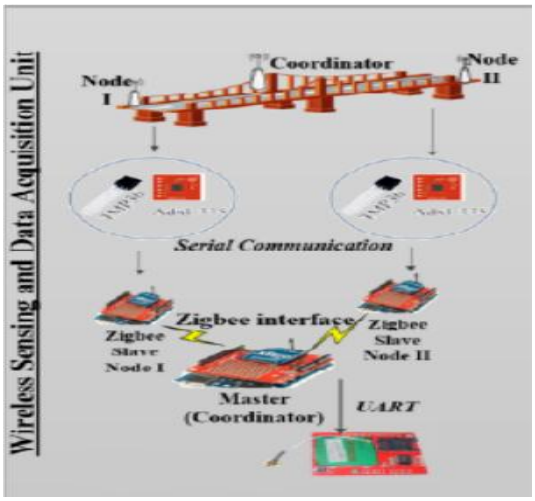


Fig. 1 Proposed system

The receiver receives collected data from transmitter node, save them temporarily into a local buffer. The whole process or procedures is done in real time. Finally, a gate will close the road to warn an abnormal behaviour. [3] These are the graphs that show characteristics of accelerometer and output parameters. [3]

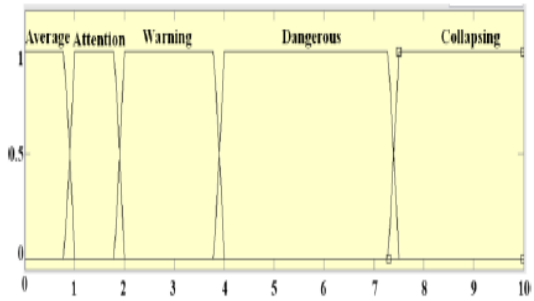


Fig. 8 Membership functions of the Structure Acceleration parameters

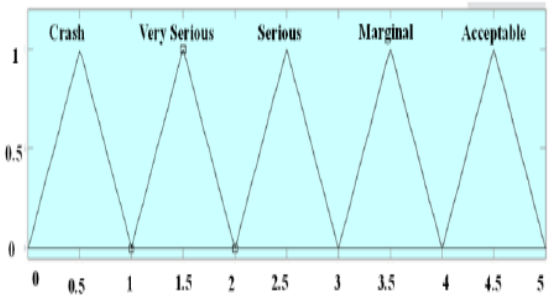


Figure 9: Membership functions of the output variable (Bridge-Status)

To monitor bridge status bridge parameters has to be considered that are sensed by different sensors. To measure or sense different parameters different sensors are used. To measure the height of bridge from water level ultrasonic sensor is used. To sense bridge vibration 3 axis accelerometer is used. Humidity and strain is measured with the help of humidity sensor and strain gauge

These parameters are compared with threshold value and also transmitted through wireless transmitter. As shown in table if parameters are much less than threshold value then status will show as acceptable. If sensed parameters are less than threshold value then status will show like marginal. If sensed parameters are greater than threshold value then status will show like serious. If sensed parameters are much greater than threshold value then status will show like crash.

When sensed value crosses threshold value then at the base node indication is given and gate will close the road.

Rule		**Acceleration**		**Status**
1		Average		Acceptable
2		Attention		Marginal
3	I F	Dangerous	T H E N	Serious
4		Collapsing		Crash

II. Literatyre Survey

1. Chih-Chyau Yang and Ssu-Ying Chen [1] developed an "A Rugged Sensor System for Real-time Bridge Safety Monitoring" which presents a rugged sensor system with proposed algorithm to detect the bridge scour in real time. The presented rugged sensor system consists of under-water sensor nodes with the wired Ethernet communication protocol, a PoE switch and a data logger. The developed under-water sensor node adopts the vibration sensing mechanism to detect the bridge scour by using the accelerometer sensor. The experimental results in the field show the presented rugged sensor system can detect the bridge scour effectively with proposed scour detection algorithm in real time.

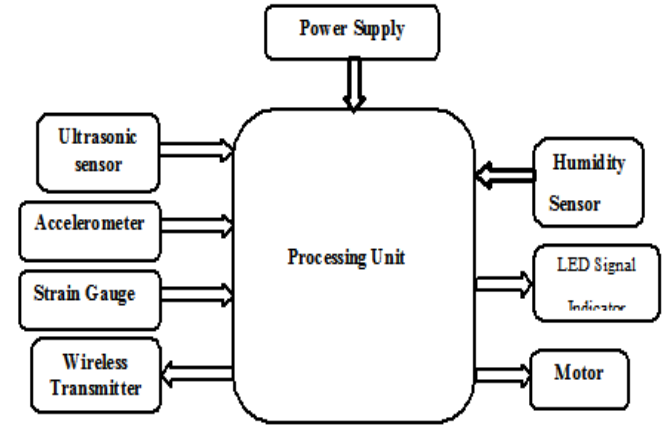
2. Alessandro Sabato Laboratorio di Tecnica del Controllo Ambientale Dipartimento di Ingegneria Meccanica, Energetica e Oestionale (DIMEO) - University of Calabria [2] developed "bridge vibration monitoring using a wireless MEMS accelerometer board" that uses Micro Electro-Mechanical System (MEMS) based equipment has revealed to be an emerging technology for vibration monitoring of large-sized civil structures such as bridges and buildings. Once problems related to the MEMS-based sensors resolution at very low-frequency and low-amplitude vibrations were solved.
3. Amro Al-Radaideh, A. R. Al-Ali, Salwa Bheiry, Sameer Alawnah [3] developed an "A Wireless Sensor Network Monitoring System for Highway Bridges" which presents an autonomous wireless sensor network system to monitor structural health in highways bridges. The system consists of a wireless Data Acquisition Unit (DAQ), management middleware. The sensors gather the bridge health signs and transmit them promptly via wireless transmitter to the management and evaluation middleware for further processing.
4. Ren-Guey Lee1, Kuei-Chien Chen [4] developed an "A Backup Routing with Wireless Sensor Network for Bridge Monitoring System" which has efficient and reliable backup scheme for bridge monitoring system. It is mainly using the wireless sensor network (WSN)to gather the related environment parameters, and transmitting the numerical data to the gateway through multiple-hop relay, and then it further stores data in the back-end database for the professional monitoring staffs to analyze and study.

III. Methodology

The proposed system mainly consists of following systems which will be better than traditional system.

1. Very accurate measurement of vibration, humidity, strain of bridge and height of sensor module with respect to ground.
   Accelerometer is used to keep the track of bridge vibration. Ultrasonic sensor measures the height of sensor module from ground. Using the humidity sensor bridge's humidity can be monitored and also the strain gauge is used to check the amount of strain on bridge's pillars. The values of these parameters are sent to micro-controller and wireless transmitter is used to transmit these parameters to base node.
   We had given the threshold point to micro controller. If measured value crosses threshold value then status and parameters can be shown by using LED signal indicator and barrier like gate will close the road.
2. Monitor the bridge parameters.
   Wireless transmitter sends measured parameters. These parameters are received by wireless receiver which is far away from sensor module. We can keep track of these parameters using database server. These parameters will be uploaded on the web. One can access the data from anywhere using server.

Transmiter Node:



Receiver Node:

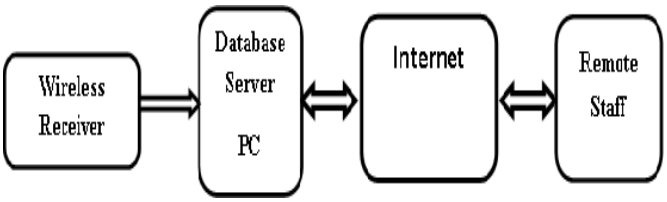


Fig.2 Block diagram of proposed work

The whole system is divided into two parts – In first part all parameters are sensed with the help of sensors. These parameters are send to receiver node and record is created at database server. In second part, all physical parameters are uploaded. In fig.3 the humidity, height, strain, vibration of bridge is sensed using moisture sensor, ultrasonic sensor, strain guage, accelerometer respectively. Sensed data is read by microcontroller. Microcontroller compares sensed value with set cut off value and takes corrective action if sensed value exceeds set value. That is gate will close the road.

Flow chart:

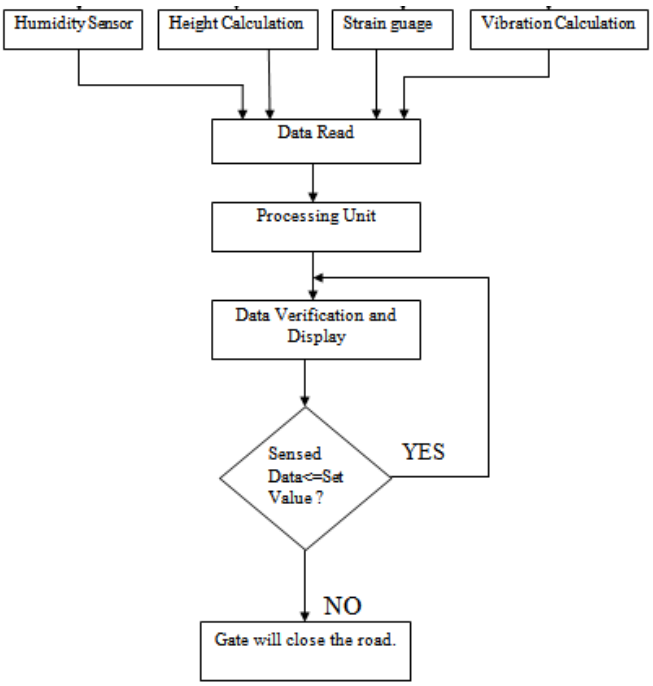


Fig.2 Flow chart

The Fig.4 shows the flow chart of uploading data on internet. All parameters like humidity, height, strain. After displaying, the signal is sent to the computer with the help of Xbee. At receiver side Xbee receiver receives all parameters and maintain record on database server. Simultaneously these values are uploaded on internet. So that anyone can monitor structural health of bridge without physical existence.

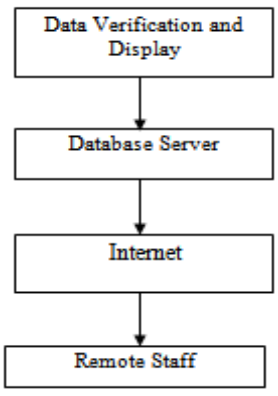


Fig.3 Flow chart

IV. Conclusion

This work titled as 'Automatic Bridge Monitoring System Using Wireless Sensor Network' gives idea of controlling dynamic parameters for preventing from crisis scenario. The theoretical study, which we did in the start of our project, tells us the significance of measuring different parameters as a heath indicator of bridge. The proposed system continuously monitors the bridge parameter value and judges whether the bridge is safe or not for travelling. This implementation is greatly useful for to provide the safety for human lives'

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