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Development Of IoT Based Bridge Safety Monitoring System

Akshatha. K, Anusha. S, Shabha Tasleem Taj, Syeda Rubeena, Jyothi. T
Department of information science and engineering, GSSSIETW, Mysuru, Karnataka, India

ABSTRACT

Bridges are one of the critical cross points of a country's transport network but they are expensive to build and maintain. Bridges suffer over all structural deterioration due to aging, overloading and lack of proper maintenance. Bridges are expected to have a higher level of reliable inspection and condition assessment to protect human lives and economic activities from unsafe bridge structures. An IoT bridge safety monitoring system is developed using the Wi-Fi technology. The system can monitor and analyse in real time the conditions of a bridge and its environment, including the bridge weight, waters levels and other safety conditions with the help of few sensors like: water level sensor and Weight sensors which are connected to the IoT device. The detected data is transmitted to the server and database for users to have real-time monitoring of the bridge conditions via mobile telecommunication devices.

Keywords: IoT, Wi-Fi technology.

I. INTRODUCTION

Engineering structures are responsible for economic growth, development, and evolution of the every nation. The engineering structure includes buildings, dams, roads, and bridges, which affect day to day life of people. Along with their own weight, the environment also affects them. In 2016, a bridge collapsing incident occurred on Savitri river in Mahad district due to sudden floods in the river[2]. Apart from this, the problem of collapsing may arise on airport boarding bridges and railway bridges also.

Among the emerging trends of industrial development, IoT and smart building are not only international trends but also the sources of competitiveness for future development. As Wireless Sensor Networks (WSNs) are evolving in the past decade and becoming more cost effective[12]. The IoT wireless sensor network and smart building technologies are adopted to solve the problems related to bridge health monitoring.Wireless sensor network(WSN) is also called as wireless sensor and actuator network. The characteristics of wireless sensors are, ability to cope with node failures, ability to withstand harsh environmental conditions and power consumption constraints for nodes using batteries[11]. Engineers dealing with the sensing and communications technologies and are seizing the opportunity to design, build and implement continuous health monitoring tools for bridge systems and for detecting statistical patterns of stress and strain that pertain to the structural health.

Traditional methods of bridge safety management have the following problems:
(1)failure to collect data or monitor on-site conditions in real time.
(2)failure to comprehensively record or analyse the collected data of on-site conditions in real time, resulting in poor disaster rescue efficiency.

(3)Data collection through visual assessments or use of large-size electronic equipment, often resulting in inaccurate monitoring results or higher costs and higher power consumption.

An IoT-based bridge safety monitoring system is developed using the Wi-Fi technology to overcome the above mentioned failures The developed system is composed of: monitoring devices installed in the bridge environment, communication devices connecting the bridge monitoring devices and the cloud-based server,
a dynamic database that stores bridge condition data, and a cloud-based server that calculates and analyses data transmitted from the monitoring devices.

II. LITERATURE SURVEY

Jin-Lian Lee, Yaw-Yauan Tyan, proposes the system which can monitor and analyse in real time the conditions of a bridge and its environment, which includes the waters levels nearby, pipelines, air and other safety conditions[1]. Varsha kusal proposed a Bridge Monitoring and alert generation system using IOT, to alert using buzzer and auto- barrier when there are signs of collapsing the bridge[2]. In the next paper, a signal processing based SHM is proposed where a simple Butterworth filter was used to remove noises. Cross-Correlation was used for damage detection. If there was any damage found, using a mathematical model, damage size and location were determined by Md Anam Mahmud, Ahmed Abdelgawad[3]. The bridge shape survey using the leveling measurement and bridge continuous shape measurement system was carried out after the earthquake. By comparing the data before and after the earthquake, the numerical values of the two method were similar. The experimental results show that the proposed system is an effective measurement method Yan YANG, Fang LIU[4].

III. DESIGN AND IMPLEMENTATION OF THE SYSTEM

The system consist of following modules:
(1)Monitoring Unit
(2)Communication System
(3)Cloud Based Server
(4)Mobile Application

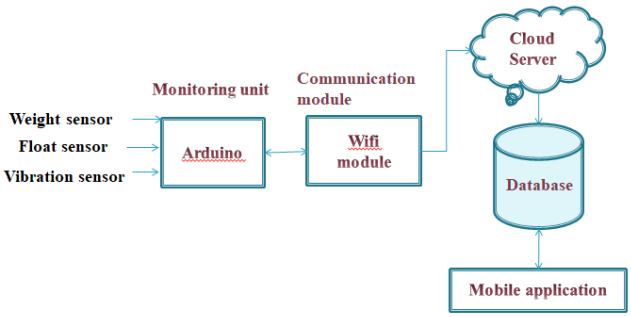


Figure 1. Bridge safety monitoring system and notification mechanism.

Monitoring unit:

The monitoring units are designed to be energy-efficient, low-cost, small-sized and capable of sensing the environment. Each monitoring unit is like a microcomputer, equipped with a sensor, a computing device and a wireless transmission device. The monitoring units include Ardinuo-uno, sensors, and comparator. These devices can monitor and collect data of bridge conditions with important factors in a bridge environment like water level, weight, and vibration on the brige and then process the data through simple computing before sending the processed data to the data storage server via wireless transmission.

Communication system:

The major function of the wireless communication system is to connect all the components in the bridge safety monitoring system, including the sensors, computing system and signal receptors. The data from the sensors is passed on to the comparator, through the comparator the analog signals are transmitted to the ardinuo-uno for convertion of the analog signals into the digital values. Further the converted digital values from monitoring units are transmitted to the cloud server using the Wi-Fi technology(ESP8266) for further computing and

decision making. The decisions made by the system, related analysis contents and alert messages are transmitted by the server system via the internet to the management center and mobile devices of management staff for them to have real-time and comprehensive understanding of the bridge's surrounding environment and keep records of the data for appropriate responses when a disaster occurs.

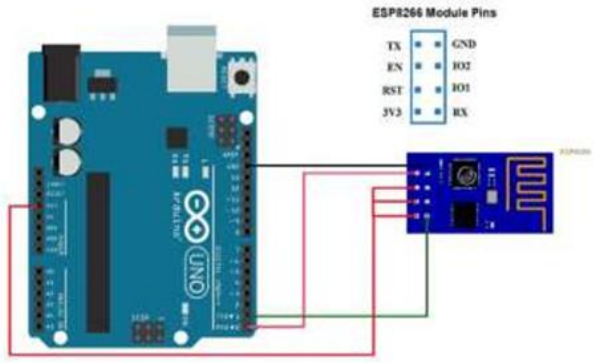


Figure 2. Interface between microcontroller and Wi-Fi module.

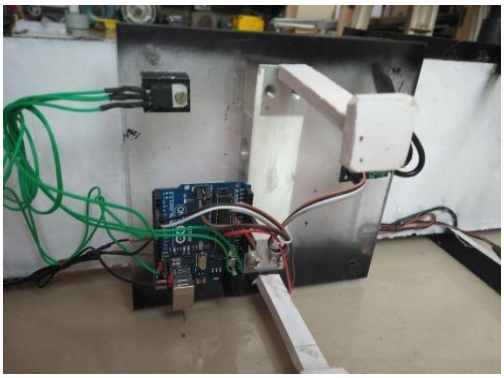
Cloud *based server:*

The cloud server will receive data from a microcontroller using Wi-Fi module(ESP8266), the received data such as water level and the weight on the bridge is stored onto the cloud server. The data is maintained on cloud database, the monitoring staff can access the data and can be compared with the master dataset for threshold match and further for evaluation purpose. The cloud server is also used to store the user's information which they provide while registering/ subscribing to our application for notification.

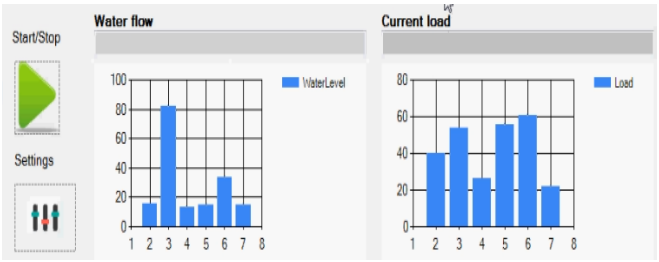
Mobile application:

The added value to the proposed system is the early warning indicators by using "Android application" using Android-Java to display the real-time status of bridge on the app. The application is made user friendly and easy to use, while subscribing to the application by providing their details. Whenever any critical or unsafe conditions are detected in the bridge environment, the alert messages are sent by the server system via mobile application to the management staff and to the users who have already subscribed to have real-time conditions of the bridge environment.

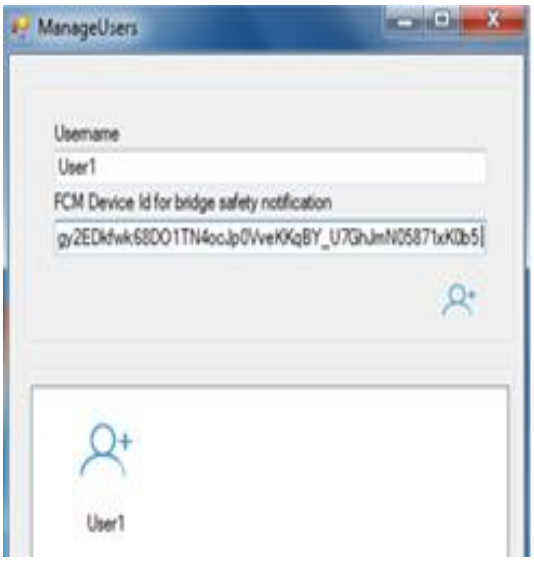
IV. RESULTS AND DISCUSSION



Snapshot 1. Bridge model along with hardware components



Snapshot 2 .Graphical representation of water and water level values



Snapshot 3. Used to store user alert information like username and device-id

Snapshot 4. Updation and Deletion in the Database

V. CONCLUSION

In this paper, an Arduino based a low cost and flexible Bridge safety system using IoT is proposed and implemented. The proposed architecture utilizes the Wi-Fi network at site and mobile notification for users/commuters to have live(24*7) updates of the bridge. This data can be further processed at Data Centers and assessment of structural integrity of bridges can be done. The resulting output can help in detecting structural damage that affects the performance of a structure. In future this can be integrated with Google Map to have safe passage through the bridges.

VI. REFERENCES

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