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Design of Bridge Monitoring System based on IoT

Snehal Sonawane, Nikita Bhadane, Sayali Zope, Ashitosh Pangavhane and V. S. Tidake

Department of Computer Engineering, NDMVPS's KBTCOE, Savitribai Phule Pune University, Pune - 411007, Maharashtra, India; 1991snehalsonawane@gmail.com

Abstract

Bridges may get collapsed or tilted due to flooding or some concrete problem, natural calamities. So there is a need to design a system which will continuously monitor condition of bridges. It is useful for public safety and reduction in human losses. Such system will help in disaster management and recovery. IoT-based bridge safety monitoring system is developed using the WSN Technology. This 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, cloud based server calculates and analyzes data transmitted from the monitoring devices. This system can monitor and analyze in real time the condition of a bridge and its environment, including the water levels and other safety conditions. This paper presents a comprehensive survey of SHM using WSNs outlining and algorithm like damage detection and localization, network design challenges and future research direction.

Keywords: Bridge Safety Monitoring, Internet of Things, Structural Health Monitoring, Wireless Sensor Network

1. Introduction

Now-a-days because of incidents of bridges or bridge piers severely damaged by typhoon floods and earthquakes are frequently reported each year. In addition to floods, typhoons and earthquakes may also cause disastrous accidents of fires, explosive gas leakage and liquid chemical leakage. Different disasters and damaged sites require different professional disaster rescue knowledge and equipment in order to achieve optimal rescue results. However, lack of information about the damage site can impede information management at the rescue center and rescue operation, resulting in poor rescue efficiency or even preventable causalities.

Therefore, in this study, the IoT, Wireless Sensor Network (WSN) and smart building technologies are adopted to solve the above-mentioned problems of bridge safety information transmission and management by developing an IoT-based bridge safety monitoring system capable of monitoring the environmental data of a bridge and transmitting the data to the mobile devices of bridge safety management staff for reference and documentation[1]. The data can be used for bridge safety management and, in the occurrence of a disaster, for disaster rescue. For its monitoring

*Author for correspondence

and information communication, this system uses the WSN technology, a technology characterized by low power consumption, high safety and support of a large number of network works.[2,3] The system developed in this study can help promote the advancement of bridge safety management and control by providing breakthroughs to the above-mentioned problems of conventional systems. For developing bridge monitoring system, following technologies will be used.

1.1 Wireless Sensor Network

Wireless Sensor Network can be used to monitor the condition of civil infrastructure and related physical processes closed to real time. WSN is similar to Wireless ad-hoc network in the sense that they rely on wireless connectivity and spontaneous formation of networks so that sensor data can be transported wirelessly.

1.2 Cloud Server

A cloud server is a logical server that built, hosted and delivered through a cloud computing platform over the internet. There are two types of cloud server: physical and logical. A cloud server is considered to be logical when it is delivered through server virtualization and physical server is logically distributed into two or more logical server. In our system cloud server send sense data to the registered user.

1.3 TCP/IP Protocol

TCP/IP or Transmission Control Protocol/Internet Protocol is a suite of communication protocol used to interconnect network devices on the internet. TCP/IP can used as communication protocol in private network.

2. Related Work

Existing System of bridge safety management have the problems like: Failure to collect data or monitor on-site conditions in real time. Data collection through visual assessments or use of large size electronic equipment have higher cost or higher power consumption, often resulting in inaccurate data. In proposed system, we are going to use WSN technology.[3] Here the detected data images are transmitted to the server and database for users to have real time monitoring of the bridge conditions via mobile telecommunication devices. Bridge Structural Health Monitoring (SHM) has been an intense research area for some time. Traditional, direct approaches are to collect acceleration signals by installing sensors on a bridge. The drawback of such direct approaches is that they require a sophisticated and expensive electronic infrastructure with installation, maintenance and power support. Moreover, although it is easy to get a large number of data samples, it is expensive to label them (which involves physically inspecting the bridge and determining its health); thus, very few data samples are actually. This real-world constraint turns the indirect bridge SHM into a semi-supervised classification problem. The author proposed a novel semi-supervised classification framework that takes advantage of supervised Multi Resolution Classification (MRC),which extracts hidden features in localized time-frequency regions (subbands), and a semi-supervised learning algorithm, which uses both labeled and unlabeled samples.[4,5]

This is followed by a semi-supervised weighting algorithm that combines information from all the subbands of all the signals to make a global decision.

Table 1. Literature Survey of Bridge monitoring System

Year	Author	Paper Name	Publication details	Technology used	Limitation
2017	Jin-Lian Lee, et al[1]	Devlopment of an IOT Based Bridge Safety Monitoring System	A multi sensor, dense wireless network for bridge monitoring	Real-Time	15 Accelerometer, 8 Strain
2015	Y. Sun[3]	Research on railroad bridge monit-oring plat-form based on IoT	log data from 3 channels 12 nodes over a sampling time of 4 minutes	Post sample delivery of logged data	36 Accelerometer
2013	M.T. Laz[2]	Design of a WSN platform for longer environ-mental monitoring for IoT applications	2 local networks, each having 4 nodes, a single-board computer base station connected to an IEEE 802.11b wireless radio	Real-time	20 Triaxis Accelerometer
2011	J. Zhang et al[7]	Design of wireless sensor network based monitoring system for bridge control	A wireless sensor network on a concerate box girder bridge alongside a wired system	Real-time	14 Accelerometer

3. Proposed Framework

The public or government can used this bridge monitoring system for bridge monitoring which will provide bridge condition as well as safety to public. The architecture of our system shown in following figure.

In this system we are going to design login interface using which user can login to system. If user fails to login then emergency option is provided by our system. Arduino is to be connected with sensors using TCP/IP protocol and by using Wi-Fi module it will send real time monitor data to cloud server as well as to system server for backup purpose, in case of failure of cloud server. This application includes two types of users: User and Administrator.

4. Mathematical Model

Let S be the proposed system of bridge monitoring.

S = {I, F, O}

I=set of inputs

I = {I1, I2}

I1=Id

I2= Password

I3= Position

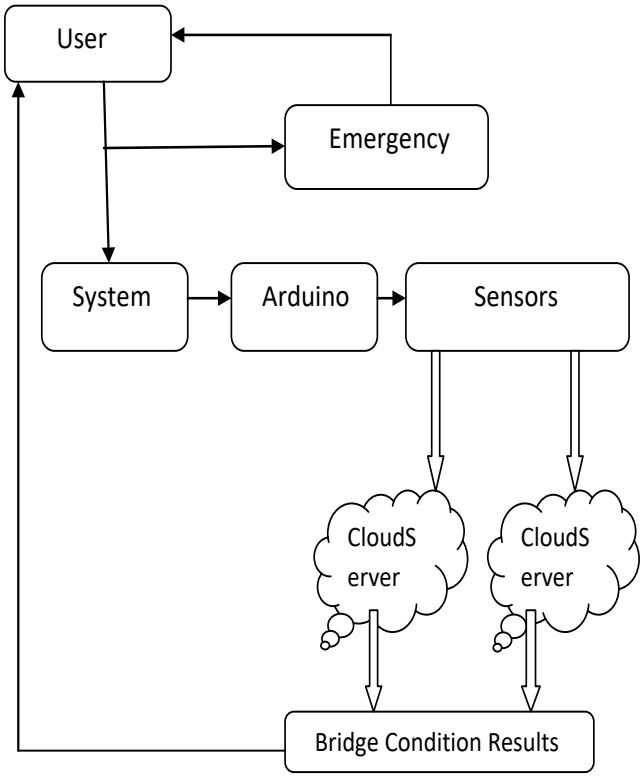

Figure 2. Framework of Bridge Monitoring System.

I4= Water-level

F=set of functions

F= {F1, F2, F3, F4, F5, F6, F7}

F1=get_data ()

F2=put_data ()

F3=store_data ()

F4=tiltness ()

F5=position ()

F6=corr_per ()

F7=water_level ()

O= Set of outputs

O= {O1, O2}

O1= Tiltness of bridge

O2= Water-level

5. Algorithm for Bridge Monitoring System

Various algorithms used in the system are described next.

5.1 Accelerometer Module Algorithm

Accelerometer sensor is dynamic sensor capable of vast range of sensor. Accelerometer sensors are available that can measure acceleration in one two or three orthogonal axes. It can be used for measurement of velocity and position. Accelerometer sensors also measure the vibration or impact.

Step 1: Initialize.

Step 2: Measure the bridge position.

Step 3: Find the degrees at which bridge is tilted.

Step 4: Detect movement of bridge.

Step 5: Send data to cloud server.

Step 6: Stop.

5.2 Water-Level Module Algorithm

Water-level sensor is basement type water-level sensor that trips and alarm to announce excess water in the basement. With this module we can easily get water surface level.

Step 1: Initialize.

Step 2: Detect the water level.

Step 3: If water level exceeds capacity, it alerts.

Step 4: Notify user about flooding.

Step 5: Send data to cloud server.

Step 6: Stop.

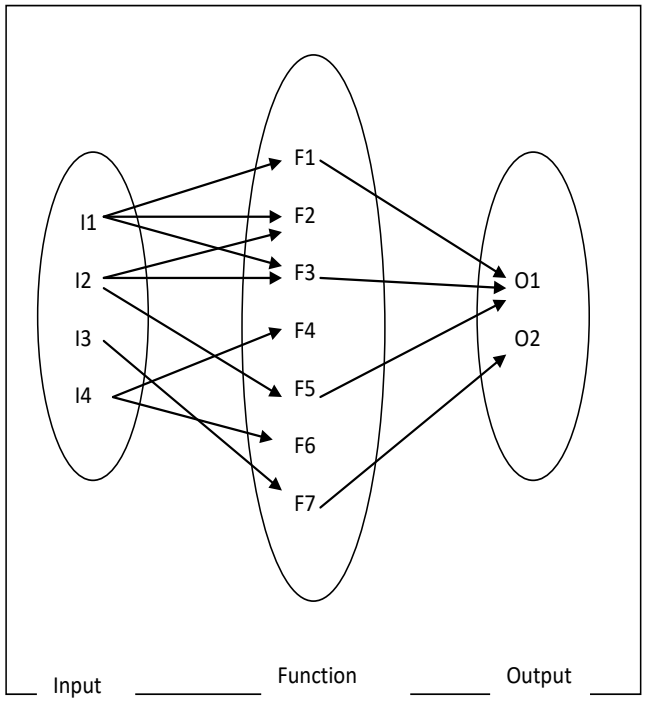

Figure 2. Mapping of different operations in proposed system.

5.3 Wi-Fi Module Algorithm

Wi-Fi module is used to make connections between cloud server and Arduino.

Step 1: Initialize.

Step 2: Create Wi-Fi connection to send data from sensors to Arduino.

Step 3: Creates radio waves for network connectivity.

Step 4: Send information to Arduino.

Step 5: Stop.

6. Experimental Setup

The experimental setup for the proposed system will consist of cloud server for storing sensor data. A different platform and technology, which are used for building this proposed system are as follows:

Operating system: Windows 7 onwards

Server: Cloud server

Language: C#, Android

Mobile: Android Smart phone

7. Expected Results

With the help of methods and algorithm mentioned in proposed system, bridge conditions monitoring system will be developed. Expected outcomes for the system are as follows:

1. By how much position bridge gets tilted.
2. Detection of water level under the bridge.
3. Detection of the collision of bridge.

8. Conclusion

A bridge monitoring system is needed for public safety. Such system can be designed using TCP/IP protocol for connection between sensor and Arduino, Wi-Fi module to send data on the cloud server. The system can also give notification about tiltness of bridge and some concrete problems time to time which will help for maintenance. In future similar system can be designed for building and railway monitoring.

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