Building's Health Monitoring System using Internet of Things

S. Rajaprakash, S. Muthuselvan, Pradeep P V , Balamurugan.A, Praveen M, Rishi kumar S

Abstract*: Buildings are susceptible to damage due to various factors Moreover; those same structures can suffer long-term damage if their strength is allowed to deteriorate gradually over time. The fix of these damages is very costly. Structural Health Monitoring (SHM) can relieve high repair costs by distinguishing and estimating harming wonders as they happen. In like manner, Structural Health Monitoring can moderate long haul harm by persistently observing the auxiliary state of key segments. In this work is to monitor the buildings and to alert the users by giving early indications through notifications. Structural monitoring of buildings using Internet of Things, Continuous monitoring can give early indications of structural malfunctioning of buildings. The developed WSN system continuously collects structural response data from a network of sensor nodes & uploads it to a cloud server. The response data (parameters) such as temperature, pressure, crack which can be monitored lively and represented graphically. The data imported from the cloud server has applied into analytic and if the limit is exceeded, the server will pop the alert message to the user's mobile application. Thus it helps to improve the knowledge concerning structural behavior and early damage detection.

***Index Terms*: raspberry Pi, Structural Monitoring System, damage detection**

I. INTRODUCTION

Buildings are a major constituent of a country's architectural development. Their preservation is a major concern but until and unless if some devastating event occurs in our nation it doesn't concern us or draws our attention towards it. The 2014 Chennai building collapse shook everyone in the country. Structures have a particular age and after that their quality begins decreasing, however everybody is so occupied with the new that they surrenders the old. The nations around the globe are utilizing different strategies for seismic designing. India is also adopting these new strategies.

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S. Rajaprakash, Department of CSE, Aarupadai Veedu Institute of Technology, Vinayaka Missions University.

S. Muthuselvan, Department of CSE, Aarupadai Veedu Institute of Technology, Vinayaka Missions University.

Pradeep P V Dept. of Computer Science and Technology, Aarupadai Veedu Institute of Technology, Vinayaka Missions Research Foundation Chennai, India.

Balamurugan A Dept. of Computer Science and Technology, Aarupadai Veedu Institute of Technology, Vinayaka Missions Research Foundation Chennai, India

Praveen M Dept. of Computer Science and Technology, Aarupadai Veedu Institute of Technology, Vinayaka Missions Research Foundation Chennai, India

Rishi kumar S Dept. of Computer Science and Technology, Aarupadai Veedu Institute of Technology, Vinayaka Missions Research Foundation Chennai, India

but the question is if the structures are performing as per the design. For this monitoring of structures is required. The future can never be predicted and we have to be ready in case of any situation. People are still living in old houses and structures which are more hazardous than present day structures when they go under the impact of seismic exercises. They are more vulnerable to building collapse. These structures require review, examination, legitimate checking for the identification of harms, disadvantages or any sort of issues with the goal that they can be repaired, refitted and reestablished otherwise, it might lead to a disaster. To prevent this monitoring of buildings using IOT is required.

This monitoring can be achieved by using sensors to get data to detect cracks, vibrations and temperature. These devices once deployed collect data by monitoring the given area. The developed WSN network continuously gathers structural data from a network of sensor nodes and uploads them to the cloud server. The data is imported from the cloud server and Once they detect any change in the area they pop alert message to the user's mobile immediately. The sensors are connected to a raspberry Pi device which is powered by raspbian OS. Thus they help to improve knowledge concerning structural behavior and early damage detection.

A raspberry Pi is a single board portable PC. It was developed by an UK firm called Raspberry Pi foundation. It can be used as a traditional PC. It is based on a SoC with ARM processor. The RAM and processing power of a Pi is not close to a power house machine that we use at home but they are used as a cheap alternative to do limited tasks. It can be plugged to a monitor, keyboard and speakers to be used as a traditional PC. It provides a great environment for hardware integration. We can connect hardware to the Pi's GPIO (general purpose input/output) pins to integrate external hardware like sensors. The main advantage of Raspberry Pi is its inexpensiveness. Since it is just adequately powered it is available at a cheap price. The Raspberry Pi has a huge number of ports and pins. Some of them are USB, HDMI, Stereo audio SD card, CSI connector, Ethernet, DSI connector. Each port and pin has their own dedicated purpose. Raspbian OS is one of the official Operating Systems accessible for free to download and utilize. The framework depends on Debian Linux and is streamlined to work proficiently with the Raspberry Pi PC. As we definitely know an OS is an arrangement of fundamental projects and utilities that keeps running on predetermined equipment, for this situation the Pi.

Debian is lightweight and settles on an incredible decision for the Pi. The Raspbian incorporates apparatuses for perusing, python programming and a GUI desktop.

II. OBJECTIVE

The main object of this project is to monitor the buildings and alert the users. Continuous monitoring can give early indications of structural malfunctioning of buildings. The WSN collects data and uploads to the cloud server. The data such as cracks, vibrations, temperature can be monitored continuously and represented graphically. The data is imported from the cloud server and is applied into analytics and if the limit is exceeded, The server will pop the alert message to the user's mobile. This helps in early damage detection. In 2016 shawn et al [1] have proposed a model or work on structural health monitoring systems using two types of piezo-electric systems. They are active and passive systems. Finally the effect on environmental conditions like heat are discussed. Results of active interrogation of the structure with and without temperature compensation are presented. They have used several types of sensors for SHM which includes Piezo-electric, Fibre optic, MEMS, Strain-gauges.

III. PAST WORK

The past works have found that composite structures are susceptible to hidden or barely visible damage caused by impact or excessive loads that if unchecked may lead to lower structure reliability, higher life cycle cost and loss in operational capability. There are generally three methods of updating structural parameters, namely, Optimum matrix update method, Sensitivity based updating method, Eigen-structure assignment method. Most of the existing structural health monitoring is not connected to the IOT.

Tracy Kijewski, Martin Haenggi et al. in (2006) studied about structural health monitoring and introduced the concept of multi-scale wireless sensor networks with the restricted input network activation scheme. The design features a NEMA4X grade enclosure containing a Remote Bridge Monitoring Unit (RBMU).It consists of Sensor boards, a MICA2 or MICAZ. The damage detection will be achieved similarly through Time series analysis. [6]

In 2014 Abid Ali Khan [2] have elaborated a principle, advantages and benefits of using such systems on modern day aircraft structures. In addition the challenges being faced by the designers for implementation of available techniques and the use of available sensors have been compared for the stability to health monitoring. Most recent advancements is measuring and recording hundreds of parameters with exceptional frequency through computer based multi channel recorded system such as FDR(Flight Data Recorder), Electro Mechanical Mission Computer(EMMC).The paper provides an overview of structural health monitoring systems that has evolved from health monitoring. CBM (Condition Based Monitoring) to apply have a Space structure as a potential to reduce inspection time and improve air worthiness by earlier damage detection

In 2009 Ramashankar [3] has proposed that there are generally three methods of updating structural parameters, namely Optimum matrix update method, Sensitivity based updating method, Eigen-structure assignment method. `The different types of sensors which can be used for SHM in general the performance of PZT sensor is better than other sensors and also very cost effective. PZT is capable of serving as a sensor of the global dynamic technique and can suitably quantify such damages as well as locate them.

In 2006 Tracy Kijewski [4] have proposed concept of multi-scale wireless sensor networks is introduced in this study with the restricted input network activation scheme and the integration of data from heterogeneous sensor array to improve damage detection for low order models. Hardware overview-The design features a NEMA4Xgrade enclosure containing a Remote Bridge Monitoring Unit(RBMU).It consists of Sensor boards, aMICA2 or MICAZ. The input to the system are generically assumed to be white noise, through the ARX modeling. In the modified scheme presented here, damage detection will be achieved similarly through Time series analysis, though regressively modeling the relationship between strain and acceleration instead of random white noise input.

Ahmed Abdelgawad (2017), the author says, a entire uninterrupted IoT stage for SHM was proposed. The proposed stage includes of a Wi-Fi module, Raspberry Pi, DAC, ADC, cradle, and PZTs. The two PZTs are mounted on the structure and connected with a fast ADC. A cushion was utilized as a dimension change what's more, to ensure the Raspberry Pi. The Raspberry Pi creates the excitation flag and the DAC variations over it to simple. In development, the Raspberry Pi was utilized to identify if the structure has harm or not. Furthermore, the Raspberry was used to send the structure well being position to the Internet server. The info was put away on the Internet server and can be checked remotely from any smart phone. The structure has been accepted using a genuine verifying ground in the lab. The Results demonstrate that the proposed IoT SHM stage effectively checked if the sheet is sound or not with 0% blunder. What's more, the proposed stage has a limit of 1.03% blunder for the damage area and a limit of 8.43%error for the damage width. [5] This paper gave a concise prologue to shrewd detecting innovation, recognizing some of the chances, just as a portion of the related difficulties. Brilliant sensors dependent on the Mote worldview will give the force to advancement of the up and coming age of auxiliary wellbeing observing frameworks, opening new skylines for innovative work. Multi-operator framework innovation offers a computational system for new calculations execution. [6] Xinlong Tong et al, study on the progress of a low-power wireless acceleration sensor and deployment of the sensors on a wireless gateway and cloud platform following the Internet of Things (IoT) protocols for bridge monitoring.

The entire system was authorized in a field test on the Chijing bridge in Shanghai. Field assessments indicated that the developed IoT bridge observing system could achieve the roles of real-time data gaining, transmission, storage and analytical processing to synthesize safety information of the bridge. The established system was promising as a complete, practical, readily available, low-cost IoT system for bridge health checking. [7] Wireless sensor systems are one of the supporting innovations in basic well being observing. Through keen, self-sorting out methods, they associate sensor hubs, with a wide range of test items and working standards into a system alongside elements of information preparing and incorporation. Basic well being checking is an intermingling region, with an assortment of sensor and data preparing advances. In this examination, we considered clock-synchronization over a WSN and how clock-float issue was illuminated on the checking site. [8]

Samgmin et al. in 2018 proposed a model in AR-based Smart Building and Town Disaster Management System to solve problem like fire accident in a big building. In his modal test the proposed system using geographic information system, building information, and radio frequency identification etc., and the modal system installed in a ten system device like electric leak detectors, humidity sensors, networks cameras etc. [9]

In 2018, Shehal R.Shinde et al. proposed a smart way to monitor environment with low cost system. Shehal tested based on the four parameters. The information passed through from the system using IoT concept and tested successfully. [10]

Tuan Nguyen Gia et al. proposed a model for remote monitoring system of glucose in human body using IoT based architecture. Based on this model doctors can easily monitor for the doctors. In his model, the author identified three attributes and sensor to measure level of the glucose. [11]

A. Limitations

LANL scheme input to the system are generically assumed to be white noise, through the ARX modeling will detect the damage in smaller radius.

Composite structures are susceptible to hidden or barely visible damage caused by impact or excessive loads that if unchecked may lead to lower structure reliability, higher life cycle cost and loss in operational capability. There are generally three methods of updating structural parameters, namely Optimum matrix updating method; Sensitivity based updating method, Eigen-structure assignment method. Most of the existing structural health monitoring are not connected to the IOT.

- Schedule risk.
- Cost risk.
- Technical feasibility.
- Physical events beyond direct control.

IV. METHODOLOGY

The proposed system consists of a raspberry pi controller, piezo electric, IR, Ultrasonic sensors. These sensors are mounted on the structure to monitor them and collect the data continually. A proposed embedded model is implemented on the Raspberry Pi to detect the health of the structure using Piezo-electric sensor and IR Sensor. The IR will determine the damage (crack) location and size, and sends this information to Raspberry-Pi Controller. The implemented sensors that gathers data from structure and transfers data to the connected Controller. Hence the Raspberry Pi will transfer the data to the cloud server and the data is further available from any device, anywhere, at home or elsewhere. Python script for Raspberry Pi collects data from sensors and uploads it to a cloud server. Using AWS (Amazon Web Services), we can connect the Raspberry Pi to a cloud server. Some Frameworks such as Ruby on Rails and Sea File Server allows setup the API quickly. The response data (parameters) such as temperature, vibration, crack which can be monitored lively and represented graphically. The data imported from the cloud server has applied into analytics and if the limit is exceeded then server will pop the alert message to the user's mobile application

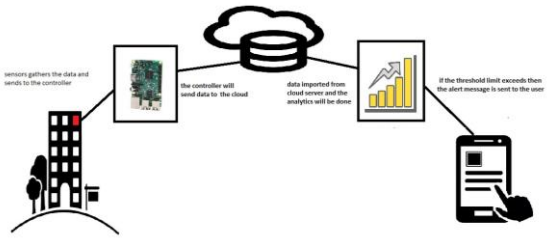

Fig. 1 Flow diagram for Building Monitoring System

V. IMPLEMENTATION

The proposed platforms consists of a raspberry pi controller, piezo electric, IR, Ultrasonic sensors are mounted on the structure to collect the data continually. A proposed Embedded model is implemented on the Raspberry Pi to detect the health of the structure using Piezo-electric sensor and IR Sensor. The IR will determine the damage location and size, and sends this information to Raspberry-Pi Controller. The implemented sensors that gathers data from structure and transfers data to the connected Controller. Hence the Raspberry Pi will transfer the data to the cloud server and further analytics is done to prevent the structural malfunctioning.

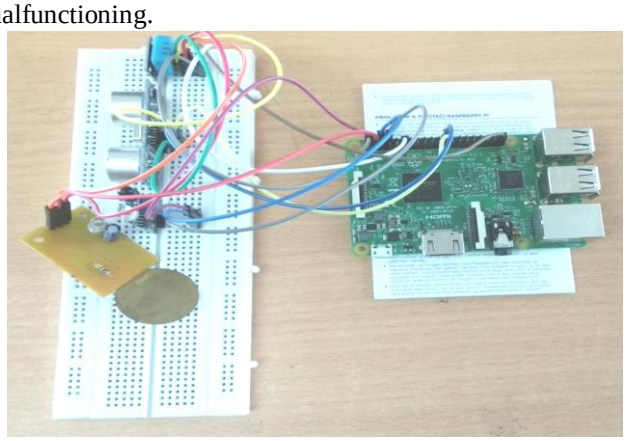

Figure 2 Circuit diagram for Building monitoring system

A. IR Sensor Output

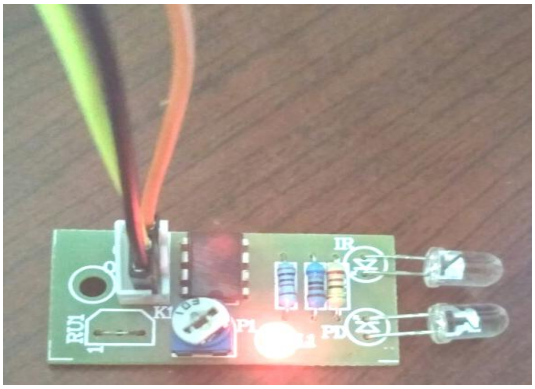

Figure 3 Diagram for IR sensor output

B. After Detecting

Figure 4 Diagram for after detecting

C. Data Storing

The data collected from the sensors will upload it to a cloud server, available from any device, anywhere, at home or elsewhere. Python script for Raspberry Pi collects data from sensors and uploads it to a cloud server. Using AWS (Amazon Web Services), we can connect the Raspberry Pi to a cloud server. Some Frameworks such as Ruby on Rails and Sea File Server allows setting the API up quickly..

D. Hardware Assembly

The Raspberry Pi 3 model B is built with 802.11 n Wi-Fi and Bluetooth along with wired 10/100 Ethernet connections. It features a 64 bit, 1.2 GHZ quad-core Broad comm. BCM 2837 SoC based ARM's cortex-A53 CPU.

Figure 4 Diagram for Hardware Assembly

E. Sensors

Piezo electric sensor, DHT-11, SWT-420, Ultrasonic and IR sensors are connected with Raspberry Pi 3.

F. Data Gathering

The GPIO pins on Raspberry pi brings it great extendibility to all kinds of sensors.

G. Writing Data to a CSV File

Storing small amount of structured data and do data analytics. The advantage of using .csv format is you can operate .csv files with any spreadsheet for visualization and data analytics.

H. Data Analytics

The response data (parameters) such as temperature, pressure, crack which can be monitored lively and represented graphically. The data imported from the cloud server has applied into analytics and if the limit is exceeded, The server will pop the alert message to the user's mobile application.

VI. CONCLUSION

In this proposed work the wireless sensor networks are used to gather the real time data. This not only prevents structural damage but also prevents structural collapse by alerting the concerned officials buy sending alerts in mobile phone. This alert disappears only when the cracks are rectified. Otherwise it keeps on playing notification sounds in the phone. Along with this the data is stored over cloud and can be accessed anytime using the login id. The concerned official can also monitor the statistical value from any place.

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AUTHORS PROFILE

Dr.S.Rajaprakashis M.sc, M.Phil M.E Ph.D. currently working as Associate professor of CSE in Aarupadai Veedu Institute of Technology an ambit institution of Vinayaka Missions Research Foundation (Deemed to be University), Tamil Nadu, India. He has 17 years of experience in academics, research, and development activities. Published 20 research papers in referred Journals and Conferences. His area of Interest Artificial Intelligence, Computational Intelligence, Discrete Mathematics and Automata theory. .Received grants from Tamil Nadu State Council for Science and Technology .He has peer Reviewed Manuscripts in reputed international Journals and Conferences. He is a member in following professional societies: CSI and ISTE and Ramajunam Mathematicsl Society.

Mr.S.Muthuselvan MCA ME (PH.D) currently working as Assistant professor Aarupadai Veedu Institute of Technology an ambit institution of Vinayaka Missions Research Foundation (Deemed to be University), Tamil Nadu, India published more than 13 national and international journal and conference and organizing committee for 4 international conference ,2 national conference and 11 years of teaching experience with 4 years of research experience. He is a member in following professional societies: CSI and ISTE.

Pradeep P V IV year CSE Aarupadai Veedu Institute of Technology an ambit institution of Vinayaka Missions Research Foundation (Deemed to be University), Tamil Nadu, India.

Balamurugan A IV year CSE Aarupadai Veedu Institute of Technology an ambit institution of Vinayaka Missions Research Foundation (Deemed to be University), Tamil Nadu, India

Praveen M IV year CSE Aarupadai Veedu Institute of Technology an ambit institution of Vinayaka Missions Research Foundation (Deemed to be University), Tamil Nadu, India.

Rishi kumar S IV year CSE Aarupadai Veedu Institute of Technology an ambit institution of Vinayaka Missions Research Foundation (Deemed to be University), Tamil Nadu, India