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Infrastructural Health TrackingThrough IOT

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Abstract

Critical infrastructure monitoring is one of the most important applications of smart city. Structural health monitoring (SHM) is the appealing field in civil engineering which offers the potential for continuous and periodic assessment of the safety and integrity of civil infrastructures. Data sensing is the core of any SHM, tracking the data anytime anywhere is a prevailing challenge. The objective is to monitor the integrity of the structures (e.g., buildings, bridges) and detect the locations of possible events (e.g., damages, cracks). In this paper a cloud-based health monitoring application that could detect damages in buildings is done with an IOT framework. IOT is the network of smart sensors that combines sensing and wireless transmission of vital safety parameters of buildings, to distant computing units which continuously do the processing and monitoring of these parameters. The data/information of the damage in building is collected using wireless sensor networks. The results are then accessed using connected clients like browsers or mobile applications in real time.

Keywords*-integrity, tracking, monitor, damage*

I. INTRODUCTION

The three key features of smart cities, such as intelligence, interconnection, & instrumentation, have been provided by the Internet of Things (IOT). The wireless sensor network (WSN) is network that sense the data and transmits the data which has been sensed through a wireless medium. In structural health monitoring, the stress inserted on the structures, bridges is sensed and analyzed to install the necessary preventive measures. As the aging of such structures increases beyond their permitted life it may causes great damage. And if any sudden change in structure properties occurs, then continuous monitoring of such structures is required for life safety & economic point of view. The process of continuous monitoring of such structures is called as structural health monitoring (SHM). SHM is very important concept as it involves disaster management because it is related to saving the life of people directly or indirectly by properly maintain, monitoring replacement of structure or its components.

A. Background

Infrastructural health monitoring means install a system to detection a damage for infrastructural using WSN. Here the term damage points towards changes in the material or geometric shapes of a infrastructural system, including change in the boundary conditions and connectivity and integrity of the infrastructural system, which will badly affect the performance of system. The infrastructural health monitoring process includes the observation of a system over time using periodically sampled response measurements, which are sensed by various sensors. To implement a long-term infrastructural health monitoring, the output of this process has been periodically updated which is information regarding the ability of the structure to perform its defined function in light of the inevitable aging and damages due to operational environments. After extreme events, such as earthquakes or blast loading, infrastructural health monitoring provides rapid condition screening and aims to provide, real time, reliable information regarding the integrity of the structure. Infrastructure inspection of the structures like road network and bridges have a key role in public safety in regard to both long-term damage accumulations. Due to the vast developments in data-driven technologies that are transforming many fields in engineering and science, machine learning and computer vision techniques are increasingly capable of reliably diagnosing and classifying patterns in image data, which has clear applications in inspection contexts.

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B. Relevance

As there is economic prosperity and increased awareness in social effects of aging, extreme events on civil infrastructure have accompanied by recognition of the need for advanced structural health monitoring and advanced damage detection tools. In current time monitoring and inspection is done by visual inspection and very traditional methods such as the tap test. As it is labor-intensive task the frequency of implementation is less than once every two years for bridges, and on an as-needed basis for other infrastructures such as buildings. Structural health monitoring techniques is based on changes in the dynamic characteristics have been studied for the last three decades. For substantial damage, these methods have some success in determining if damage has occurred. A number of new research Papers have been funded to improve the damage detection methods including the use of innovative signal processing, new sensors, and control theory. This survey paper highlights these new research directions.

II. LITERATURE SURVEY

In recent years many researchers published papers on Infrastructural health monitoring, and we studied few of them as follows.

Sreevallabhan, K., Chand, B. N., & Ramasamy, S. in [1] deals with analyzing large structure like bridges, dams and heavy machines. Here MEMS Accelerometer is used to measure vibrations and strong motion of such structures. WSN is used to embed sensors in wireless network to transmit data wirelessly and can measure data wirelessly at any remote location.AT-MEGA 328P microcontroller is used in WSN node and radio transmitter is used for transmitting data wirelessly.

Ghayvat, H., Mukhopadhyay, S., Gui, X., &Suryadevara, N. in [2] used WSN technology to embed sensors in wireless network. Standard ZigBee Digi X Bee series 2 RF communication protocol is used. Mesh networking topology for routing. LM35 temperature sensor and PIR (Passive infrared) Sensor for movement detection are used.

III. PROPOSED SYSTEM

The model proposed in this paper, consists of building in which there are three floors to check the damages (e.g. cracks, strain) and temperature. We are using wireless sensor networks (WSN) node on each floor to collect the information about defined parameters. This collected information from each floor is then passed to cloud. This information is then accessed on PC from cloud. The functioning components of system are listed below.

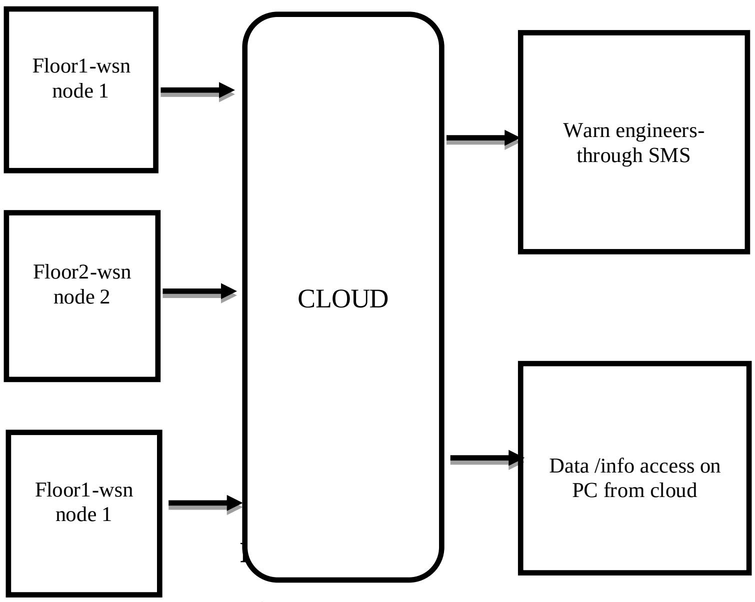

Figure 2.

Figure 3. Block Diagram of Proposed System

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A. Wireless Sensor Network (WSN)

It consists of temperature sensor, vibration sensor, strain sensor, MSP430 Controller, ESP8266 WIFI module. The information about damage on each floor is sensed through sensors and send to the controller. This information from controller is send through ESP8266 (WIFI Module) to the cloud. The data from the cloud will be compared with the defined threshold values of each parameter. The WIFI module provides the net connectivity and is used to upload the data on cloud. Also, the alert of damage will be communicated to engineer through SMS if the value exceeds the defined threshold values.

B. Wi-Fi module

The ESP8285 is an ESP8266 with 1 MB of built-in flash, allowing for single-chip devices capable of connecting to Wi-Fi. The ESP8266 is a low-cost Wi-Fi microchip with full TCP/IP stack and micro-controller capability produced by manufacturer Express if Systems in Shanghai, China. The very low price and the fact that there were very few external components on the module, which suggested that it could eventually be very inexpensive in volume.

C. Sensors and parameters

To install proposed system mentioned in this paper sensors plays important role, as they sense the data and transmits it. The factors of sensors like sensing parameters, sensing rang, power consumption of sensor affects the overall network design, hence they should select according conditions. In this system to detect damage in infrastructure various sensors are used. They are as follows

- Vibration sensor: - It will give response when there is change in frequency.
- Temperature sensor: - It is used to measure temperature of the surrounding.
- Strain Gauge Load Cell: - Strain Gauges load cell is used for weight measurement.

IV. DAMAGE DETECTION AND LOCALIZATION

In WSN for Infrastructural health monitoring sensor nodes collect parameter data such as vibrations, strain, temperature. The sensed data is in raw form which is collected by controller via WSN and collected data is processed to find out type of damage. Hence a controller is used to detect both damage detection and localization. In this section we have discusses commonly used damage detection and localization techniques.

A. Damage Detection

The important function of Infrastructural health monitoring to detect the damage in system. The process of Damage detection is collection of sensed data from sensors via WSN by controller, who examine the collected data which helps to extract parameters related to the structure’s overall health. Natural frequency and model shape are the most common parameters used in damage detection. Modal parameter estimation can be performed in both the time and frequency domain. Once modal parameters are extracted, damage detection algorithms are used to determine whether damage has occurred.

B. Damage Localization

After structural damage has been detected, it is then important to determine the damages location. This process requires the installation of enough sensors such that sufficient sensor coverage is provided to locate damage anywhere in the structure. Insufficient sensor coverage can result in damage detection without localization.

V. CHALLENGES IN WSN FOR INFRASTRURAL HEALTH MONITORING

In particular, WSN for Infrastructural health monitoring nodes collect, process, and transmit large amounts of data from the sensors, sensor node densities can be high, and the number of hops from node to base station can be large. In Infrastructural health monitoring systems, we require small delays. But SHM systems is acceptable for long delays in monitoring a structure’s long-time health. For example, if nine-hour delay is required to collect, process and aggregate data at the base station can be acceptable as long as data transmission is reliable. However, the purpose of Infrastructural health monitoring systems is to monitor a structure’s health in the event of an earthquake or other natural disaster. To deal with such disasters we require a much smaller delay. Although delay is generally not a concern, synchronization of sensor nodes with other nodes in system and also with the base station is particularly important in WSN for Infrastructural health monitoring. If there is improper synchronization it will result in loss of data and data mismatch.

When compared to most WSN, WSN for Infrastructural health monitoring have similar reliability and quality of service requirements. Data transmission is required to be reliable so as to get the real time information about the structure. There is a chance of Packet loss in monitored structures as transmission of packets may require wireless propagation through materials such as concrete and steel. It is required that the Sensor nodes installed on structures like bridges and wind turbines must be able to sustain harsh weather conditions such as rain and snow. Network time synchronization errors must be minimized for this purpose following factors are considered.

A. Network Scalability

Scalability means the ability of network to grow in size along with providing a quality of service that meets application requirements with an acceptable complexity. Scalability becomes more challenging in WSN due to the large amount of data collection and transmission required for effective damage detection and localization. If we want to monitor health of infrastructure in wider areas the number of nodes needed to monitor the structure successfully will continue to increase. If we go on increasing nodes in Infrastructural health monitoring system, it will improve the system's ability to detect and localize damage. Factors such as data transmission rate, data storage availability, power consumption, time-synchronization error, and processing algorithms all affect a network's overall scalability.

B. High Synchronization Requirements

In past decade WSN time synchronization has been considered an important research area. There is a lack of synchronization in Infrastructural health monitoring between sensor nodes that introduces errors in damage detection and damage localization. Hence WSN for Infrastructural health monitoring needs precise time synchronization due to extensive sensor data sharing. Factors affecting time synchronization error were identified as clock synchronization errors, non-simultaneity in sensor start-up, differences in sampling frequency and non-uniform sampling intervals.

C. Sensor Placement Optimization

In infrastructural health monitoring, placing sensors at particular positions is considered as an important factor in wireless sensor network design. From a civil engineering (CE) perspective sensor placement determines how effectively the sensor can collect structural information. If we fail to choose good sensors locations, the collected information will limit the system's ability to detect and localize damage. From a network design perspective sensor placement affects the network's lifespan, overall connectivity, robustness and routing protocol decisions.

VI. EXPERIMENTATION AND RESULTS

Simulation of interfacing of various sensors is done to check the design of proposed system. Results received in simulation are shown in following figures.

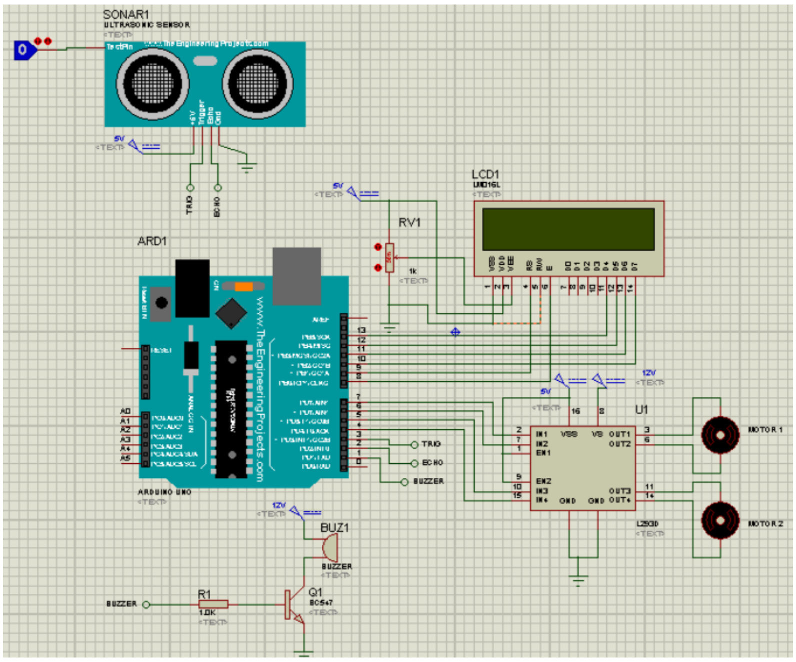

Figure 4. Interfacing of Ultrasonic sensor

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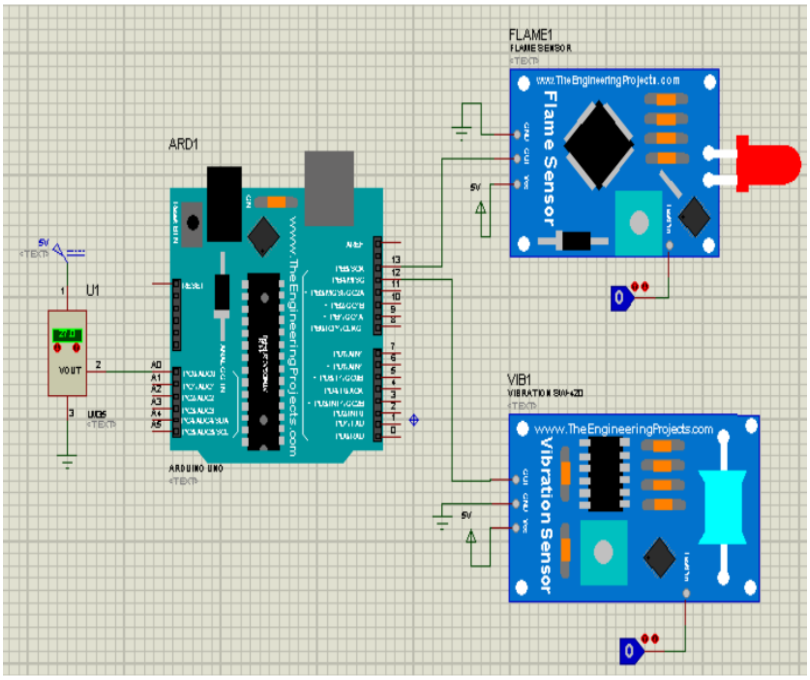

Figure 5. Interfacing of Flame and vibration sensors

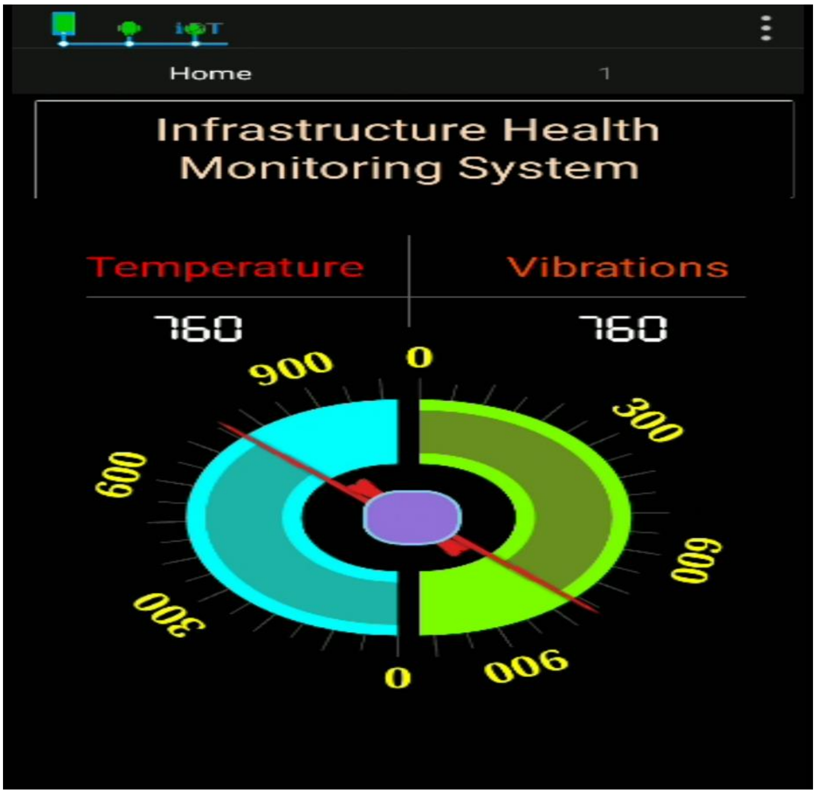

Figure 6. Screen shot of App

VII. ADVANTAGES

This paper helps in reduces the monitoring cost of infrastructure and increases human safety due to continuous monitoring. Sensors send real time data about the damage in building to cloud and accordingly health and life of the structure (building) is decided. If any damage is found, then repair schedule is planned accordingly. Health assessment of engineered structures of Bridges, Buildings and

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other related infrastructures. Locating the damage. Identifying the types of damages. Quantifying the severity of the damage.

VIII. `

Infrastructural health monitoring system is developed. This technique is low cost, easy to monitor the data and also less maintenance required. As the whole network works on WSN, it is possible to setup the sensor board at any place in the structure and also further extension of more sensors to the WSN network is also quite easy. As the data transmission and receiving from the multiple sensors at different locations is easy through WSN.

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