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IoT based bridge monitoring system

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ABSTRACT

A bridge monitoring system is significant to the structural health monitoring of both old/new bridges and flyovers an infrastructure daily used by citizens of their respective countries. The following report is proposed and developed an architecture for bridge monitoring on a more secure level taking into consideration the various parameters that are involved in the structural health of bridges. A 3-level distributed structure is adopted in the monitoring system, which includes a central server, intelligent acquisition node, and local controller. Acquisition nodes are located across the bridge. One local controller manages all the acquisition nodes. Every acquisition node has 8 channels, which can easily and approximately sample the deviation of the line of sight, the vibration of the bridge due to a load of various transports and as well the water level which when cross a threshold lead to a flood. To get high precision data, a 10 bits A/D converter is being used. Compared to the traditional method, the proposed architecture has two features. The acquisition node is a smart device based on a powerful controller. Signals of field sensors are analyzed and real-time compressed in the acquisition node. Only the processing results are sent to the local controller through the IEEE 802.11 wireless network. This operation can relieve the load of a central server. The intelligent monitoring system has run on a large span bridge. Running results show that the proposed system is stable and effective.

Keywords— *Sensors [A.I.], Input/output and data communications, Microcontroller– Node MCU, M-7053D, tGW-715. [Barrier Lifting]*

1. INTRODUCTION

This system detects a load of vehicles (high amplitude vibrations), water level, and deviation from the line of sight. If any of the water level, water pressure, vehicle load on the bridge and the line of sight deviates from its threshold value then it generates the alert through buzzer and auto barrier. At present, there have been various systems proposed but what makes the following proposed system different from the rest is making utmost use of the technology and various software modules which will along with the various detection based on parameters also notify the user if the bridge undergoes any damage. Whenever bridge undergoes any damage or even collapses, there is tremendous property loss as well as human life loss. One of the main reasons being the people being completely unaware of the condition of the bridge in their location. Technology being so wide, the users are still not notified about the condition of the bridges, if they can use the bridge or no. Currently, there have been some water level detectors but in existing system water level is checked manually.

In this application, various parameters will be considered at both the ends of the bridge. To check the water level we the water sensor is being used i.e. if the water level crosses the set threshold limit then the bridge will not be allowed to use, to the user or the localities.The additional features that have been added in the proposed system are that if the water level crosses the threshold limit, if the line of sight deviates from its original measure or if high amplitude vibrations are detected on the bridge then immediately alert message will be broadcasted to the police station, municipal office and to the risk team. This implies that a prior measure is being taken to monitor the bridges and provide mere safety to the citizens.

2. LITERATURE SURVEY

This project aims to simplify the system for selecting bridge tracking devices. Many bridges within India are obsolete or structurally deficient to safely increase the life of those bridges, the inspection would be vital. Bridge engineers have many duties and it's far not possible to expect one to know. Our device will sense the crack inside the bridge and signal might be given to govern rooms. The sensors and the LCD are interfaced with the Atmega. The sensors used are Flex. The value is set so that if there is any sort of tilt or little crack and if it crosses our set value then the crack is detected. [1]

In the Bridge Health Monitoring System, a 3-level distributed structure is adopted in this system which includes central server, intelligent acquisition node and local controller. The acquisition node is a smart device based on a powerful ARM processor. Signals of various sensors are analyzed and real-time the data is compressed in the acquisition node. Only the processing results are sent to the local controller through wireless networks. This operation can relieve load of a central server and decrease the demand for communication bandwidth. [2]

This system is composed of monitoring devices installed in the bridge environment; and the cloud-based server a dynamic database that stores bridge condition data; and a cloud-based server that calculates and analyzes data transmitted from the monitoring devices. This system can monitor and analyze in real time the conditions of a bridge and its environment, including the waters levels nearby, pipelines, air and other safety conditions. The detected data and images are transmitted to the server and database for users to have real-time monitoring of the bridge conditions via communication devices. [3]

In this paper, it shows the number of nodes and only one gateway sensor node. Each node is connected to one or more sensors. The topology of the WSNs can vary from a star network to a multi-hop mesh network. In each node consisting several important parts: a microcontroller, a radio transceiver with an internal antenna or connection to an external antenna, an electronic circuit and power unit or battery. In this project, two wireless sensors are used which is accelerometer sensors and ultrasonic sensor. These two sensors are collecting information about bridge structures. This sensor data is transmitted to the central station. [4]

In this paper, several sensor platforms which measure deformations or movements of the bridge structures such as strain gauge and accelerometer. Apart from the specifical target data, sensor platform selection is primarily based upon physical and engineering properties of the structural member such as support type and shape. In this study, pre-stressed concrete bridge girders which are major components of an expressway in Bangkok were investigated. The network protocol named LXRS is developed for the Microstrain sensor platform. It is compatible with the IEEE 802.15.4 standard for the 2.4 GHz frequency range. According to, time synchronization can be achieved in 32 microseconds. An outdoor and line-of-sight communication range is up to 2 kilometres. [7]

In this project, an idea of bridge health monitoring system using wireless is proposed. For short distance (among sensors in the bridge) IEEE 802.11wireless communication, Zigbee is used as a wireless network, and GSM is used for long distance (between the bridge and the management centre) data communication. This technology can be called MBM (Monitoring Based Maintenance) that enables the bridge maintenance engineers to monitor the condition of the bridge in real time. The sensors installed on various parts of the bridge monitors the bend, traffic, weight of the vehicles etc. [8].

In this paper, a new idea of bridge health monitoring systems suggested GSM for long distance (between the bridge and the management centre) data communication is tested. The accelerometer, thermometer, strain gauge anemometer are the sensors which sense bridge conditions these are interface using PIC microcontroller. If there are any changes of bridge parameters sensors since it sends information to control room by using GSM network which is a mobile network. It also displays these parameters on the LCD. It consists of PIC microcontroller. [9]

There 4 sensors used in the block diagram namely Temperature sensor Anemometer Accelerometer and strain gauge. The accelerometer is used to detect the bridge tilt. It senses the motion of the bridge in 3-axis. We are going to connect the accelerometer in the middle of the bridge. Then the temperature sensor can measure the temperature of the bridge components. The temperature sensor can be connected to any part of the bridge. There is a strain gauge which can measure the weight the bridge is carrying at the time. We have used a load cell for this purpose. The load cell is connected at the centre of the Bridge. The anemometer is a sensor which measures the speed of the wind. [10]

3. SYSTEM AND FUNCTIONAL DESCRIPTION

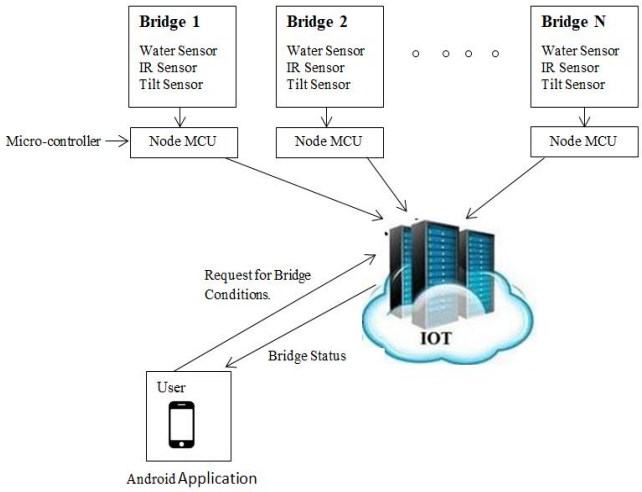

Fig. 1: System description

3.1 Water Sensor

A water sensor is a device used in the detection of the water level. Water sensor brick is designed for water detection, which can be widely used in sensing rainfall, water level, and even liquid leakage. The water sensor is used to detect the presence of Water and provide an alert to the user. There are three pins in water sensor, Signal Input, Power Supply and GND.

Fig. 2: Water Sensor

3.1.2 Water-Level Module Algorithm

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

Step 1: Initialize.
Step 2: Detect the water level.
Step 3: If the water level exceeds capacity, it alerts.
Step 4: Notify user about flooding.
Step 5: Send data to a cloud server.
Step 6: Stop.

3.2 Tilt Sensor

A tilt sensor is an instrument that is used for measuring the tilt in multiple axes of a reference plane. Tilt sensors measure the tilting position. Tilt sensors are devices that produce an electrical

signal that varies with an angular movement. These sensors are used to measure slope. There are three pins in this device, GND, VCC and DO – Output of tilt sensor.

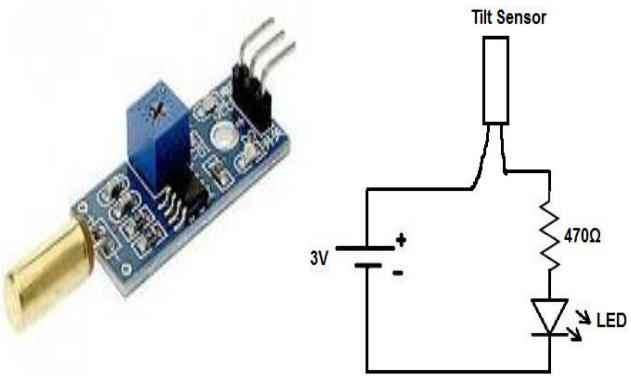

Fig. 3: Tilt Sensor [SW – 520D]

3.2.1 Tilt Sensor Module Algorithm

Step 1: Initialize.
Step 2: Measure the bridge position.
Step 3: Find the degrees at which bridge is tilted.
Step 4: Detect movement of the bridge.
Step 5: Send data to a cloud server.
Step 6: Stop.

3.3 IR Sensor

Infrared Sensor is used to know the nature of the Object present, also naturally to detect the short-range objects. It uses Infrared lights to detect the object. These sensors use the intensity of the reflected light to detect the objects. The sensor has a Transmitter (Tx) to emit the light and Receiver (Rx) to collect the reflected energy from the object.

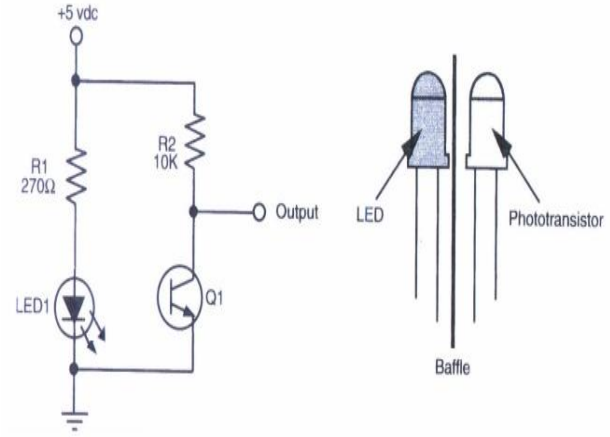

Fig. 4: IR Sensor- REES52

$$VO = (1 + R3/R2) \times VIN$$

When the intensity of emitter led is high, more energy will fall on detector led and resistance of detector is low, so the value of the potential (VIN) is high. Similarly, when the intensity is low, the resistance of the detector is high and so the value of potential is low. This potential is compared with a reference potential. According to these compared potentials, the output will be 1 or 0 i.e. 'ON' or 'OFF'.

3.4 Node MCU

Node MCU is an open source IoT platform. It includes firmware which runs on the ESP826 Wi- Fi SoC from Espress if Systems, and hardware which is based on the ESP-12 module. Node MCU Development board is featured with Wi-Fi capability, analogue pin, digital pins and serial communication protocols.

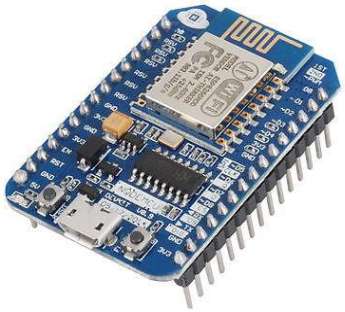

Fig. 5: Node MCU

3.5 Node MCU Pin Diagram

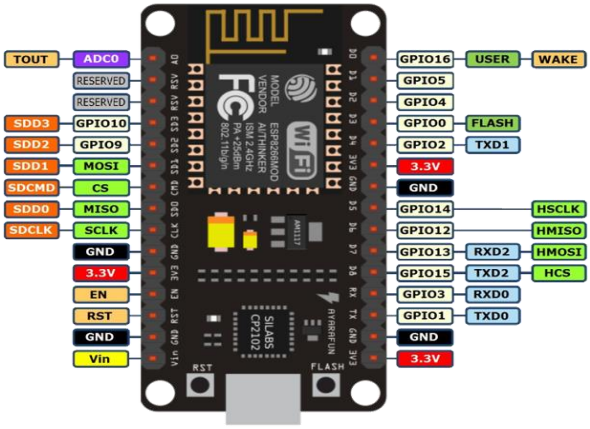

Fig. 5: Node MCU Pin Diagram

3.6 Wi-Fi Module Algorithm

Wi-Fi module is used to make connections between the cloud server and Node MCU.

Step 1: Initialize.
Step 2: Create a Wi-Fi connection to send data from sensors to Node MCU.
Step 3: Creates radio waves for network connectivity.
Step 4: Send information to Node MCU.
Step 5: Stop.

4. MATHEMATICAL MODEL

Relevant Mathematics Associated With the Project

- Input: no of the broken cable Danger level of water.
- Output: Flood detection whether the bridge is damaged or not.
- Mathematical formulation: Mathematical model for bridge safety: Let S is the proposed system. S=Input, functions, Output, success, failure Where,
- Input= I1, I2, I3, I4 where I1= no of broken cables of bridge I2= the water level below bridge I3= threshold value of bridge damage I4= danger level of water.
- Output= O1, O2, O3, O4 where, O1= whether the bridge is damaged or not, O2= flood detection, O3= notification to the officials about bridge condition, O4= message to nearby citizens about the flood.
- Functions=F1,F2,F3,F4where, F1=checkConditionOfBridge(), F2=checkWaterLevel(),
- F3=sendofficialnotification(), F4=sendWarningMessageToPeoples ().
- Success=S1, S2, S3 where, S1= bridge condition detected, S2= flood condition detected, S3= message send successfully.
- Failure=U1 where U1= message cannot be sent due to network problems.

5. RESULTS AND CONCLUSIONS

In this application, we have checked the water level and the bridge condition also. In the emergency condition, we have added the facility of broadcasting the message not only to the police station but also to the municipal office, risqué team and to the users.The main aim of this application is to save the lives of the people, to protect from accident, to help the people who are stuck after the bridge is a collapse.

6. FUTURE SCOPE

In the existing application, we have tried to incorporate all the necessary and secure application that will be of beneficial use to the citizens and their surrounding environment. In the future, a system could be implanted that could along with detection also notify to the municipal services about the future life of the bridge as to how long the bridge will sustain. The existing system could also be built using a solar panel around it so it uses solar energy and sustains for a longer period of time.

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