Bridge Monitoring System using IoT

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Abstract - *Bridge monitoring system is significant to health diagnosis of railway bridges. This paper proposed and developed a novel architecture for large span bridge monitoring. A 3-level distributed structure is adopted in the monitoring system which includes central server, intelligent acquisition node and local controller. Acquisition nodes are located across the bridge. All the acquisition nodes are managed by one local controller. Every acquisition node has 8 channels which can sample displacement, acceleration and strain of bridge. To get high precision data, a 10 bits Analog to Digital converter is used. Compared to the traditional method, the proposed architecture has two features. First, the acquisition node is a smart device based on powerful DSP processor. Signals of field sensors are analyzed and real time compressed in the acquisition node. Only the processing results are sent to local controller through IEEE802.11 wireless network. This operation can relieve load of central server and decrease demand of communication bandwidth. Second, 2G wireless network is utilized to provide enough bandwidth for real-time data transmission between local controller and central server. The intelligent monitoring system has run on a large span railway bridge for six months. Running results show that the proposed system is stable and effective.*

***Key Words*: Digital Image Processing (DIP), Acquisition node (AN), 2G wireless network and A/D converter**

1. INTRODUCTION

In this project an idea of bridge health monitoring system using wireless is proposed. For short distance (among sensors in the bridge) RF module is used as wireless network, and GSM is used for long distance (between the bridge and the management center) data communication. This technology can be called MBM (Monitoring Based Maintenance) that enables the bridge maintenance engineers monitor the condition of the bridge in real time. The sensors installed on various parts of the bridge monitors the bend, beam sustainability, weight of the Train etc. At any point of time if any of these parameters cross their threshold value the communication system informs the management center giving an alarm for taking precautionary measures. The complete parameters of the bridge are taken by an ARM processor and sent to another module which is located in a short distance. Here the communication established is using RF module that uses wireless Transmitter and Receiver circuitry. The receiver module takes the parameters from the transmitter and sends a message with all the parameters to a database center. The communication established between the intermediate module and the database center is using GSM technology. The sensory inputs are process to represent the condition of the bridge against seismic loads, loads etc.

1.1 Problem Statement

- The research community has been developing Structural Health Monitoring (SHM) techniques to aid in the ongoing bridge management efforts of local bridge authorities.
- The current standard bridge inspection practice is based on biannual visual inspections, which are subjective by nature.
- The transition of the traditional SHM techniques from the research community to the practical field implementation still needs to overcome difficult challenges due mainly to technical and economic considerations.

1.2 Aim

Aim of our project is to develop an IoT-based bridge safety monitoring system which 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 that calculates and analyses data transmitted from the monitoring devices. This system shall monitor and analyse in real time the condition of a bridge and its environment, including the water levels and other safety conditions.

2. EXISTING SYSTEM

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 physical inspection of the bridge and determining its health; thus, very few data samples are actually collected. This real-world constraint turns the indirect bridge SHM into a semi-supervised classification problem.

2.1 Limitations of Existing System

- Fails to collect data or monitor on-site conditions in real time.
- Data collection through visual assessments or use of large size electronic equipment has higher cost or higher power consumption. This often results in inaccurate data.
- They require a sophisticated and expensive electronic infrastructure with installation, maintenance and power support.
- It also involves physical inspection of the bridge and determining its health.
- Very few data samples are collected.

3. PROPOSED SYSTEM

The system sends real-time monitored data to cloud server as well as to system server for backup purpose. There is a login interface using which user or the administrator can login to system. The sensors installed on various parts of the bridge monitors their respective parameters. Crossing their threshold value, the communication system informs the management center giving an alarm. The complete parameters of the bridge are taken by a PIC microcontroller and sent to user control room. ZigBee is used for communication. Bridge overflow is detected using Water Level Sensors. Crack detection is done using Image Processing and intimated to the concerned authority if the cracks diameter is found to be more than the specified threshold and take actions accordingly. Seismic sensors are also used to record any ground motion. Also, the IR sensor detects the vehicles that enter the bridge and keeps count of it.

4. METHODOLOGY

4.1 Different sensors used

- **Seismic sensor:**

It is an instrument used to measure the ground motion when it is shaken by a perturbation. The seismic waves are measured by seismometers which are sensors converting the acquired data into electrical voltage

- **Ultrasonic level sensor:**

It is used to measure water levels from a bridge by sending out sound waves. It measures the time taken for the echo to hit the target and return to the sensor

- **IR sensor:**

It keeps count of the vehicles that enter the bridge. If the count of the vehicle increases the threshold then the gate is closed and the gate is opened once the vehicles are out of the bridge by performing increment and decrement operations

- **MEMS sensor:**

Micro-Electro-Mechanical-Systems form the heart of network nodes. Sensing of moisture, temperature, strain and other data continuously can be achieved using these sensors

- **ZigBee:**

It is used as wireless network for short distance data communication among the various sensors used in the bridge

- **LCD:**

It displays the condition of the bridge constantly. It is easy to interface with a micro-controller because of an embedded controller

4.2 Digital Image Processing(DIP)

Images refers to two-dimensional intensity function f(x,y), where x and y denotes spatial coordinates and the value of f at any point (x,y) is proportional to the brightness of the image at that point.

A digital image is a representation of two-dimensional image as a finite set of digital values, called picture elements or pixels.

Digital image processing focuses on two major tasks:

1. Improvement of pictorial information for human interpretation.
2. Processing of image data for storage, transmission and representation for autonomous mission perception.

There are mainly three levels of processing images as shown in below figure:

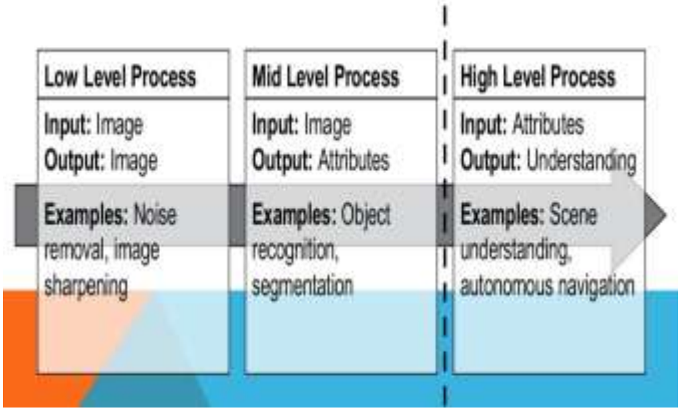
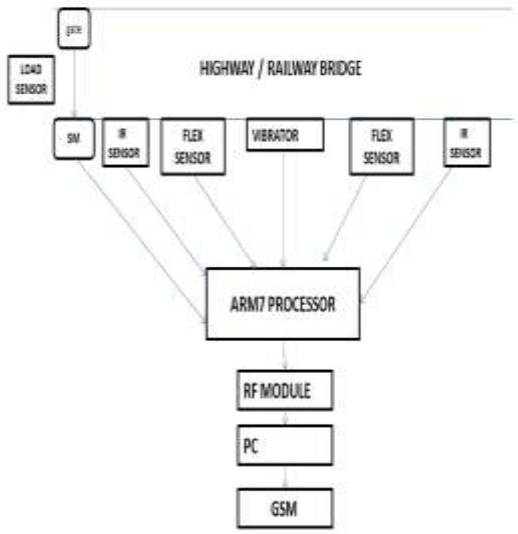


Fig-1 : Digital image processing

5. BLOCK DIAGRAM



6. LITERATURE SURVEY

- **Paper 1:**

"Development of an IoT-based Bridge Safety Monitoring System" by Jin-Lian Lee2, Yaw-Yauan Tyan3, Ming-Hui Wen1, Yun-Wu Wu2

Year of publication: 2017 IEEE International Conference.

Methodology used: Developed using ZigBee technology.

(1) Monitoring devices installed in the bridge environment.

(2) Communication devices connecting the bridge monitoring devices and the cloud-based server.

(3) A dynamic database that stores bridge condition data.

(4) A cloud-based server that calculates and analyses data transmitted from the monitoring devices

Merits:

Helps in health monitoring of bridges

Demerits:

Just deals with health monitoring of bridges and does not deal with load management on the bridge.

- **Paper 2:**

"A Continuous Water-Level Sensor Based on Load Cell and Floating Pipe" by Sheng-Wei Wang; Chen-Chia Chen; Chieh-Ming Wu; Chun-Ming Huang

Year of publication: IEEE International Conference

Methodology used:

It has a water level sensor incorporated with a load cell and a floating body which provides an accurate water level measurement system.

Merits:

Avoids accidents due to overflow of water on bridges

Demerits:

Just detect water level and heavy vehicles.

- **Paper 3:**

"Real Time Wireless Monitoring and Control of Water Systems using ZigBee" by Saima Maqbool1, Nidhi Chandra

Year of publication: 2013 IEEE International Conference on Digital Object Identifier.

Methodology used:

Monitor the water level with the help of water level sensors, ZigBee 802.15.4, 74HC14 inverter and GSM technology. It can also be used to remotely monitor the flood areas wirelessly and information can be sent.

Merits:

This approach would help in reducing the water overflow

Demerits:

Does not include any crack detection technologies

HARDWARE REQUIREMENTS

- Vibration sensor
- Flex sensor
- Load cells
- IR sensors
- Automated gating system with Stepper motor
- ARM (Advanced RISC Machine) processor
- Voltage regulator for power supply
- ARM (Advanced RISC Machine) processor
- RF Module
- GSM Module
- LCD display

SOFTWARE REQUIREMENTS

- Kiel Compiler
- Embedded C
- Flash Magic

7. CONCLUSIONS

- Even in developed nations like USA, it has been found that more than one out of every four bridges are structurally deficient
- This IOT technology could avert the kind of bridge collapse that killed 13 and injured 145 along Minneapolis on Aug. 1, 2007 at one-hundredth the cost of current wired systems
- This system can help in monitoring the bridge in an efficient, cost effective and reliable manner
- The immediacy, low cost, low energy and compact size add up to a revolution in bridge safety monitoring, providing a heightened level of early-warning capability

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