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Bridge Health Monitoring System using IoT

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Abstract: The occurrence of bridge collapse in India has become a normal news that someone comes across. The bridges are inspected mostly visually and these inspections are carried out once or twice a year. The real time condition of the bridge is unknown and sudden changes may happen due to environmental conditions or many other reasons which result in the changes in current condition of the bridge. The bridge monitoring system with the help of Internet Of Things (IOT) sensors could provide the real time condition of the bridge. This proposed system is capable of providing real time monitoring of the features of the bridge which contribute in safety of people and transport. This system output will be helpful for maintenance authorities to make decisions regarding maintenance and repairing budgets.

Keywords: Bridge Health Monitoring, IOT.

I. INTRODUCTION

Bridges often suffer structural damage due to aging and lack of proper maintenance also because of various external factors that affect the bridges. The bridges in rural areas have probably more risk for water flooding on it as the bridges are of less height and hence near to the flow of water. Similarly, the bridges in urban areas tend to have risks related to the traffic that is load on the bridge or cracks on the bridge. The most common objective of the proposed system is to obtain the real time feedback and to obtain the real time condition of the bridge.

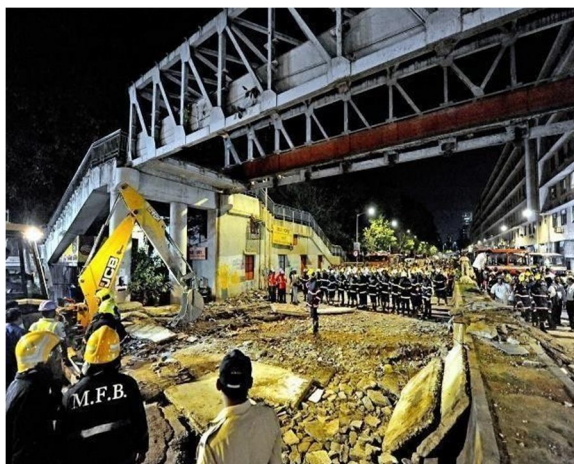


Fig.1. Mumbai Collapse in 2018 [1]

The Internet of Things i.e. IOT is the trending technology which have explosive growth of devices connected and controlled by the internet through mobile application or web application. This results in improved efficiency, economic benefits, and reduced human exertions. IOT is a system of interrelated computing devices, which have the ability to transfer data over internet without requirement of human to human or human to computer interaction.

Traditional embedded systems, sensors, real time analytics, automation all contribute to enable Internet Of Things into the consumer market. This proposed system application would give and retrieve data within short amount of time thus making it real-time application. Alerts will be provided to the officials and a buzzer for indicating a calamity. If status of any parameter is beyond the specified limit then it will generate the alarm. Bridge condition can be monitored by the users as well through the android application. The data is collected from sensors, processed by controller & data is transferred over wireless modules using any of the routing protocol. The proposed system basically focuses on vibration detection and water level detection. The system collects the sensors data from a bridge and evaluates the bridge health status using a logic-based system.

II. LITERATURE SURVEY

- 1) 2016 International Conference on Global Trends in Signal Processing, Information Computing and Communication A Survey: Structural Health Monitoring of Bridge Using WSN (Department of Electronics and Telecommunication, Sandip Institute of Technology and Research center, Nashik)[2]
 - a) *Problem:* The government generally appoints an engineer who uses the method of visual inspection for every 2-3 years.
 - b) *Methodology & Technology Used:* The data is collected from sensors, processed by controller & data is transferred over wireless modules using any of the routing protocol.
 - c) *Conclusion:* The system collects the sensors data from a bridge and evaluates the bridge health status using a logic-based system.
 - d) *Future Scope:* Use of Adhoc networks, Cross layer design issues, Multichannel data collection, time synchronization and security issues of network are the areas for future work.

- 2) Application of Damage Detection for Bridge Health Monitoring (Communication System Laboratory Sys'Com National engineering School of Tunis, University Tunis El Manar, Tunisia)2017 [3]
 - a) *Problem:* In this paper, the goal is to locate and detect damages in bridges using wireless sensor network.
 - b) *Methodology & Technology Used:* Several elements are used in this application (sensors, server, database, raspberry and Arduino carts, etc), these elements have different roles. Wsn and Iot are the technologies used.
 - c) *Conclusion:* This paper basically focuses on detecting damage location using algorithms of machinelearning.

- 3) Structural Health Monitoring system using WSN for bridges (International Conference on Intelligent Computing and Control Systems ICICCS 2017) [4]
 - a) *Problem:* In this paper, our principal objective is to detect tilting angle of bridge and water level simultaneously.
 - b) *Methodology & Technology used:* Several elements are used in this application like Wsn, Visual Basic Software and Androidapplication.
 - c) *Conclusion:* This paper basically focuses on vibration detection and water level detection.
 - d) *Future Scope:* Addition of other measures which would help in structural monitoring.

- 4) An Internet of Things (IoT) Based System to Analyze Real-time Collapsing Probability of Structures (Department of Computer Science & Engineering Institute of Engineering and Management, Kolkata, India Kolkata, India)2018 [5]
 - a) *Problem:* To detect structural damage and warn people without need of human intervention.
 - b) *Methodology & Technology Used:* Internet of Things and Wireless Sensor Network with Android.
 - c) *Conclusion:* This paper focuses on detection and avoidance of mishap by warning people if danger is detected.

III. PROBLEM STATEMENT

The current bridge monitoring is based on visual inspections and the overall critical inspection is done only once or twice a year. The rising cases of bridge collapsing is one of the major concerns which needs to be looked upon seriously. The inspections are not powerful enough to detect the condition of the bridge and hence results in great loss of humans after bridge accidents. The other concern is overflowing rivers cover the bridges and the bridge becomes unavailable for the people to use.

The real time condition of the bridge is not known to the government officials and the people. The overall cost of the Bridge Monitoring System is low as compared to total cost of the bridge development. Importance should be given to time to time maintenance of the bridge which is neglected due to unknown condition of the bridges. Not only the destruction of the bridges but also thenatural disasters are responsible for the damage of the bridges. The proposed system stands as a tool for accurate condition mapping and a cheap solution. The Bridge Monitoring System helps in detecting the flaws and the real time condition early and providing the information to the local bridge authorities.

IV. PROPOSED SYSTEM

The Internet of Things is the technology used for evaluating the real time condition of the bridge. The proposed system consists of sensors like vibration sensor, water level as sensing devices. The sensors will detect the vibration and water level. Android application using Android Studio for users to access condition of bridge.

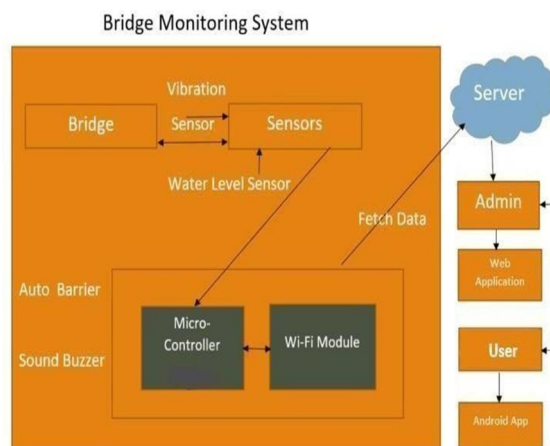


Fig.2. System Architecture

The system collects the data from sensors and the status is collected by the controller and is transferred to wireless network. This data at transmitter is sent to the receiver and is analyzed by the Arduino. Analyzed data is sent to the ubidots [5] platform and an alert message is sent to the bridge authority in case of danger. We will use sensors like vibration sensor, water level point contact sensor as devices.

The sensors will be responsible for sensing the load on the bridge, level of the water rising in the river.

The data collected by sensors will get converted into an electrical signal to be sent to the NodeMCU. The electrical signal will get transmitted to the NodeMCU Microcontroller. The data is collected in the real-time database ubidots cloud which provides real time data to the android application.

V. IMPLEMENTATION DETAILS

The water level sensor and vibration sensor are connected to the NodeMCU. The NodeMCU collects the data from the sensors and converts the analog data to numeric values which can be processed. The values of the sensors can be seen on the ubidots [5] cloud. The ubidots is the IoT cloud platform which collects the data obtained from the sensors and process it for further actions. The data obtained can be visualized through widgets and also through graphs. Below figure shows the dashboard.

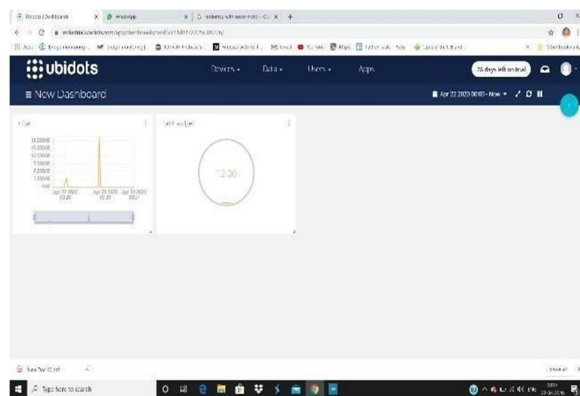


Fig.3. Ubidots Dashboard

The sensors individual values also can be monitored easily. The values are visually represented using graph. The active status of sensor is also represented using a blinking dot and the last time when the sensor was active. The ubidots IoT platform can serve as admin side where the admin gains all the data related to sensors. A device in ubidots represents as a structure where the sensors are placed. The variables represent the sensors attached to the structure. The values are stored on the cloud and can be accessed by the bridge authorities whenever needed. The API label of the sensor by ubidots identifies the sensor uniquely to gather the data. Below figure shows the sensors.

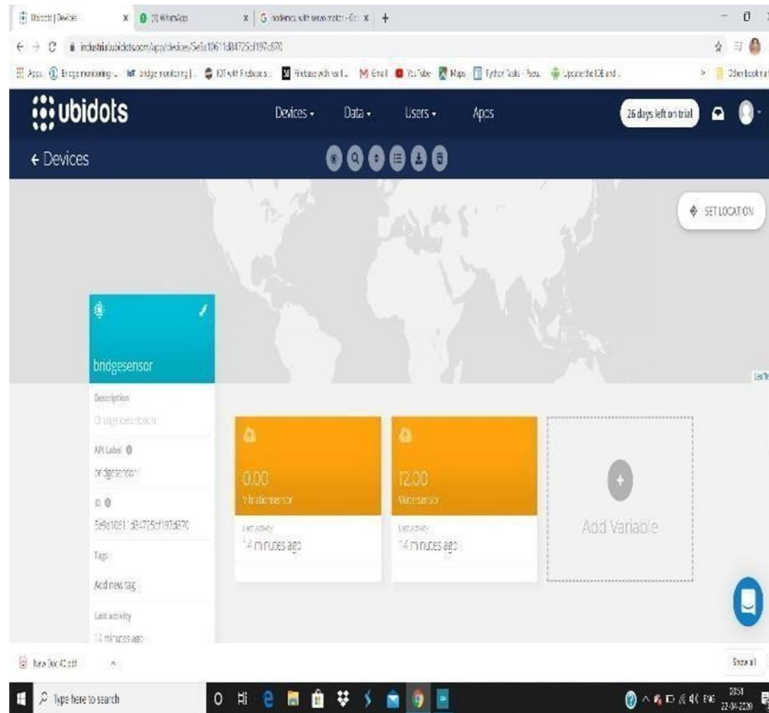


Fig.4. Ubidots sensors

The data is sent from the microcontroller through HTTP protocol. The ubidots library enables to recognize the account through a unique token and send the data to the cloud. It is very essential as it provides real time data and that accurately in span of few seconds. Each and every value obtained is recorded with the respective date and time which makes it more accurate to make decisions upon.

The Figure no 5 below shows the data collected by the water level sensor with all the values and graph.

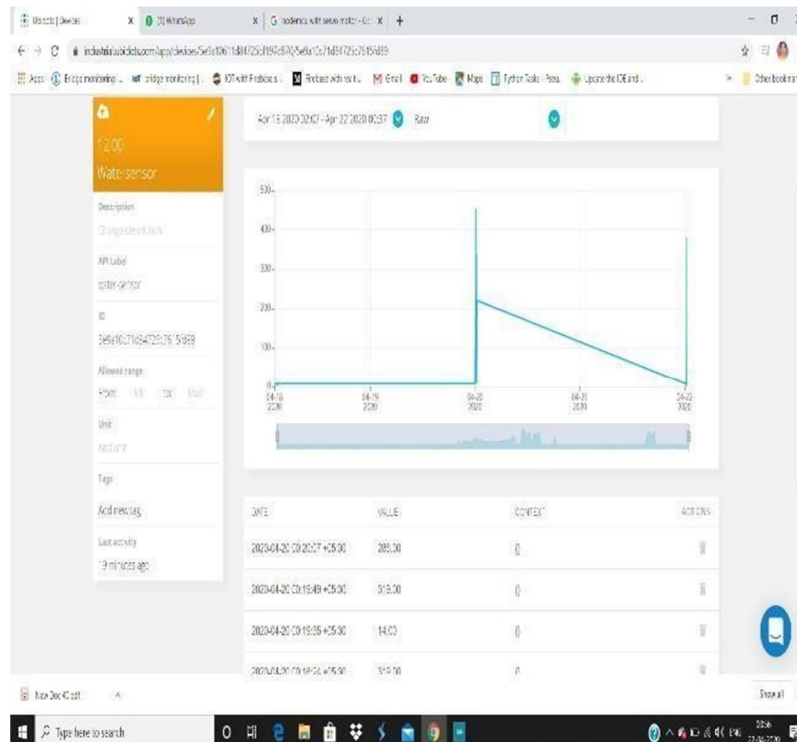


Fig.5. Ubidots Water level sensor data.

After the collection of all the data, if the sensor reaches the threshold value then it creates a trigger. A message regarding the condition of the bridge at a particular time with the particular sensor vale is generated and send to the bridge authorities. The message describes the sensor value at the particular moment and hence alerts about the danger. When the bridge is in danger there led light bulb glows as well as the buzzer starts beeping sound and indicates danger. The auto barrier closes the road hence avoiding people to use the bridge before any authority takes action as to avoid further damages as well as further loss to human. An alert is also generated when the sensor values go below the threshold value. Figure 6 shows the message generated at the time of danger.

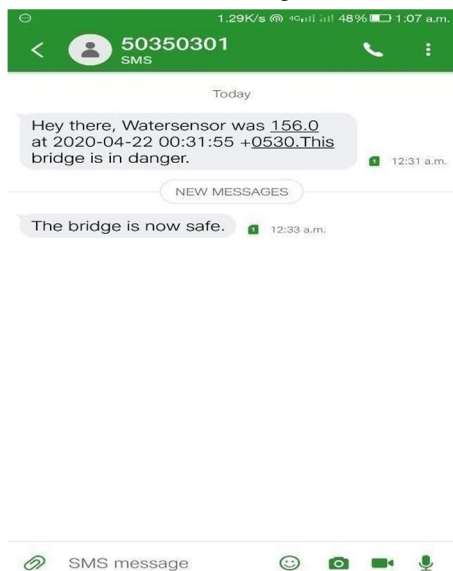


Fig.6. Alert generated.

The android application shows the current status of the bridge to the user. The android application created using android studio will be used to show the condition of bridge on the google map.

VI. MATHEMATICAL MODEL

Let S be the system of bridge monitoring. $S = \{I, F, O\}$

I represent set of inputs. $I = \{I1, I2\}$

$I1$ = Input from Vibration Sensor. $I2$ = Input from Water Sensor.

F represent set of functions. $F = \{F1, F2, F3, F4\}$

$F1$ = Function to get data from inputs. $F2$ = Function to send data to cloud. $F3$ = Function to store data collected.

$F4$ = Function to generate alarm in case of emergency O represents set of outputs.

$O = \{O1, O2, O3\}$

$O1$ = Output to glow led light, ring buzzer, Auto Barrier, message alert.

$O2$ = Output to cloud for storage and accessing data. $O3$ = Output for safe condition of bridge.

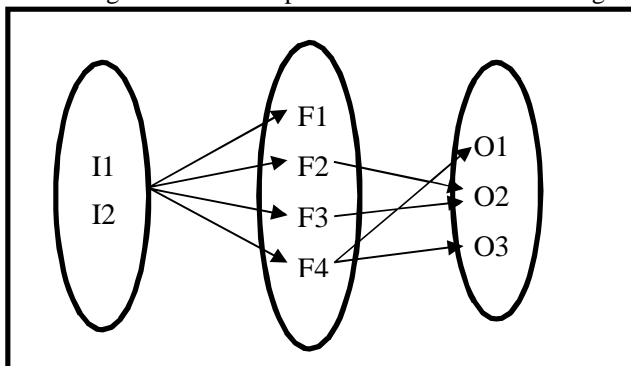


Fig.7. Mapping of different operations.

VII. FEATURES

- A. Real time monitoring of the condition of bridge is possible and hence maintenance of the property becomes easier. The ill condition of bridges, status of both parameters is obtained at realtime.
- B. If the status of any parameter is beyond the limit, then an alarm is generated at the physical existence of the bridge as well as the auto barrier closes the road. The traffic light turns red indicating to stop the vehicles from using bridge.
- C. An alert is generated and sent to the bridge authority for taking appropriate actions.
- D. The bridge condition can be monitored by users as well.

VIII. FUTURE SCOPE

In future, some more advance parameter of structures can be monitored using IoT enabled devices or sensors for enhancing safety. Parameters like internal cracks, etc. Prototype of this system can be implemented in various structures like giant walls, other than buildings and bridges which makes it robust, portable and more user friendly than the already existing technologies.

A. Advantages

- 1) Avoid future accidents because of early damage detection.
- 2) Damaged bridges can be monitored and repaired.
- 3) Real time situation gathering.
- 4) Quick response and action.

B. Disadvantages

- 1) Failure of sensors in case of emergency.
- 2) Sensor failure needs to be detected.

IX. APPLICATION

Can be used for monitoring old bridges especially old and degraded bridges.

X. CONCLUSION

Bridge monitoring system generates alert in case of accident and alerts the officials preventing big disasters and saving lives of many people. This can provide a great solution for timely maintenance as well as monitoring. Bridge collapse result in great human and financial loss. The system gives accurate values through the sensors and alerts in case of emergency. The system will help reduce big disasters in future.

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