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Implementation of a System for Bridge Safety Measures using IoT

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ABSTRACT: 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.

KEYWORDS: Bridge Safety, Internet of Things, Disaster Management, Structural Health Monitoring

I. INTRODUCTION

SHM is a vital tool to enhance the safety and maintainability of critical structures like bridges. SHM delivers realtime and accurate information about the concerned structure giving detailed information about its condition. Now-a-days due to incidents of bridges or change in deflection of the bridge structure, or bridge piers severely damaged by moisture, or by excess variation in vibration are frequently reported annually. Different disasters and damaged sites require different professional disaster rescue knowledge and equipment so as to realize optimal rescue results. However, lack of data about the damage site can impede information management at the rescue center and operation, leading to poor rescue efficiency or maybe preventable casualties.

Generally, to perform SHM, firstly, data must be collected using sensors. The different types of sensors are often used by SHM to generate the signals traveling through solid configurations. Later, this data is collected from the sensors and must be analyzed by applying different signal processing techniques, because a minor variation within the system is triggered by various factors like noises, temperature changes, environmental effects, might cause significant changes within the response from the sensors, concealing the potential signal changes due to structural defects. Therefore, during this study, the IoT, Sensor networks are adopted to resolve the above-mentioned problems of bridge safety information transmission and management by developing an IoT-based bridge safety monitoring system capable of monitoring the environmental data of a bridge and transmitting the data to the mobile devices of bridge safety management.

The system developed in this study can help promote the advancement of bridge safety management and control by providing breakthroughs to the above-mentioned problems of conventional systems. For developing bridge monitoring system, following technologies are going to be used. Diverse theories have been proposed and implemented to fulfill distinct requirements of structures. Integration of these various theories has helped not only to enhance the efficiency and performance of the SHM systems but also to scale back the computational time and costs. In order to share data and ensure reliability, the SHM systems use network-based services to coexist and interact with smart interconnected devices that are referred to as the IoT. The IoT brings new opportunities for our society. With the maturity of the IoT, one of the recent challenges within the structural engineering community is development of the IoT SHM systems which can provide a promising solution for rapid, accurate, and low-cost SHM systems. Moreover, the combination of SHM, and therefore the IoT enabled ubiquitous services and powerful processing of sensing data streams beyond the potential of traditional SHM system. In this paper, an entire SHM platform embedded with IoT is proposed to detect the damage in bridges.

. Following are some of the advantages of SHM system:

- The continuous monitoring of the structure since sensors are a part of it
- The possibility of real-time damage detection.
- The possibility of using sensor or actuator networks.

- Robust data analysis that can provide relevant information about the damage.
- An automated inspection process to reduce the number of unnecessary maintenance tasks, thereby improving the economic benefits.
- Operational and environmental evaluation conditions.

II. 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.

III. PROPOSED APPROACH

BLOCK DIAGRAM

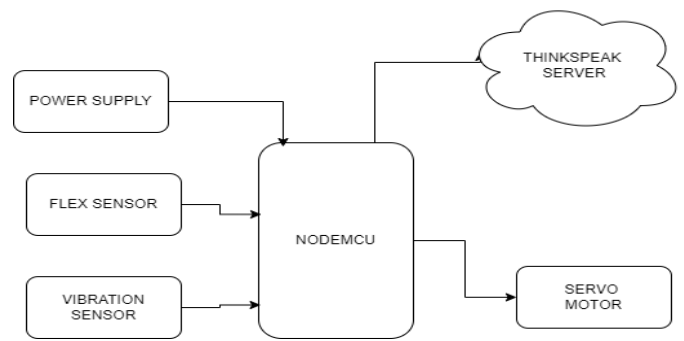


Fig. 1: IoT-based bridge safety monitoring system

In these project we used Node MCU as microcontroller. we used flex sensor and vibration sensor as input which is connected to NODE MCU to give data . the servo motor is connected as output device to microcontroller using IOT think speak is connected to microcontroller.

Circuit Diagram

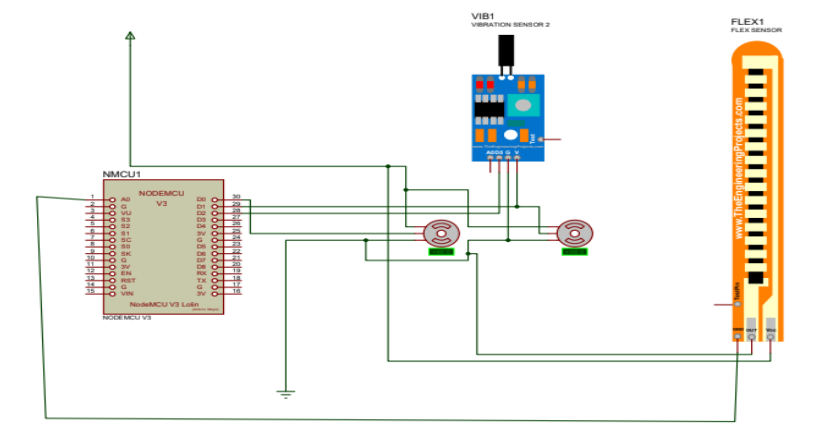


Fig. 2: Circuit Diagram

IV. CIRCUIT COMPONENTS

- NodeMCU ESP8266
- Flex Sensor
- Vibration Sensor
- Servo Motor SG-90
- SG90 Servo Motor
- TowerPro SG-90 Features
- ThingSpeak
- Arduino IDE

ThingSpeak is IoT Cloud platform where you can send sensor data to the cloud. You can also analyze and visualize your data with MATLAB or other software, including making your own applications.

The ThingSpeak service is operated by MathWorks. In order to sign up for ThingSpeak, you must create a new MathWorks Account or log in to your existing MathWorks Account.

ThingSpeak is free for small non-commercial projects.

ThingSpeak includes a Web Service (REST API) that lets you collect and store sensor data in the cloud and develop Internet of Things applications. It works with Arduino, Raspberry Pi and MATLAB (premade libraries and APIs exists) But it should work with all kind of Programming Languages, since it uses a REST API and HTTP.

One such IoT application platform that offers a wide variety of analysis, monitoring and counter-action capabilities is 'ThingSpeak'. Let us consider ThingSpeak in detail.

What is ThingSpeak

ThingSpeak is a platform providing various services exclusively targeted for building IoT applications. It offers the capabilities of real-time data collection, visualizing the collected data in the form of charts, ability to create plugins and apps for collaborating with web services, social network and other APIs. We will consider each of these features in detail below.

The core element of ThingSpeak is a 'ThingSpeak Channel'. A channel stores the data that we send to ThingSpeak and comprises of the below elements:

- 8 fields for storing data of any type - These can be used to store the data from a sensor or from an embedded device.
- 3 location fields - Can be used to store the latitude, longitude and the elevation. These are very useful for tracking a moving device.
- 1 status field - A short message to describe the data stored in the channel

To use ThingSpeak, we need to signup and create a channel. Once we have a channel, we can send the data, allow ThingSpeak to process it and also retrieve the same. Let us start exploring ThingSpeak by signing up and setting up a channel.

Getting Started

Open <https://thingspeak.com/> and click on the 'Get Started Now' button on the center of the page and you will be redirected to the sign-up page (you will reach the same page when you click the 'Sign Up' button on the extreme right). Fill out the required details and click on the 'Create Account' button.

Now you should see a page with a confirmation that the account was successfully created. The confirmation message disappears after a few seconds and the final page should look as in the below screen:

Go ahead and click on 'New Channel'.

You can change the name to fit your need and you can add a description corresponding to the channel. You can add any other useful description into the metadata field. In the same page, you should see the fields for Latitude, Longitude and Elevation. Also, when you scroll down you should see a check box that says 'Make Public?'. Let us consider the significance of the various fields and the tabs:

- Latitude, longitude and elevation - These fields correspond to the location of a 'thing' and are especially significant for moving things.



- Make Public? - If the channel is made public, anyone can view the channel's data feed and the corresponding charts. If this check box is not checked, the channel is private, which means for every read or write operation, the user has to pass a corresponding API key.
- URL - This can be the URL of your blog or website and if specified, will appear on the public view of the channel.
- Video ID - This is the ID corresponding to your YouTube or Vimeo ID. If specified, the video appears on the public view of the channel.
- Fields 1 to 8 - These are the fields which correspond to the data sent by a sensor or a 'thing'. A field has to be added before it can be used to store data. By default, Field 1 is added. In case you try posting to fields that you have not added, your request will still be successful, but you will not be able to see the field in the charts and the corresponding data. You can click on the small box before the 'add field' text corresponding to each field to add it. Once you click the 'add field' box, a default label name appears in the text box corresponding to each field and the 'add field' text changes to 'remove field'. You can edit the field text that appears by default when a field is added to make more sense. For example, in the below screen, I have modified the text for Field 2 to 'SensorInput'. To remove a field which is added, just check on the 'remove field' box. Once you click this, the text 'remove field' changes back to 'add field' and the corresponding field text is cleared.

Once you have edited the fields, click on 'Save Channel' button. You should now see a page like the below in which the 'Private View' tab is defaulted:

Once standard libraries are connected, it's time to add user's library to the library bar. Uncheck "Get libraries from folder" and the list of active libraries and buttons between two lists will become active. Press "..." ("Add Library from local drive") button and specify folder with the library, that we've created before, in "Pattern Creation" subsection of this course. Press OK and then "Close" buttons. Make sure that all standard and user libraries are on the bar.

Select library on the bar and then select pattern, using list to your left-hand side. Left click on the pattern and move it to the design area. Then left click again to place it. Continue clicking to place several patterns. Notice that pattern becomes attached to the mouse arrow and moves with it around the design area, when it is selected.

Place several packages from different libraries. Try different ways to place patterns.

Left click on one of the pads and move mouse arrow to another pad and left click it. You'll see a thin blue line, it's a connection line. Please, create several connections between pads of different components.

Notice, if you try to connect some pad, that is already connected to another net, DipTrace will ask if you want to merge nets. However, pad can be deleted from the net. Right click it and select "Delete from Net" from the submenu.

Don't forget to use Connection Manager ("Route / Connection Manager" from main menu). Please, try to add and delete pads and nets with it.

Once you've practiced with making connections manually, we need to delete all components from the design area. Press "Ctrl+A" to select all, then press "Del" to delete selected.

Open schematic file ("File / Open"), which you've created, during practical lessons of "Designing Schematic" subsection of this training book. If all components in the circuit have attached patterns, there won't be any errors. In other cases DipTrace will worry you about possible problems. If you got a message, that some patterns are missing — please return to the Schematic module and attach necessary patterns to symbols.

On this panel you can turn OFF some layers, by removing blue check marks next to corresponding layer or set layer color by left clicking on a color rectangle. Notice that there are hot keys for each layer, listed next to it's name in the brackets. For Top and Bottom layers "T" and "B" hot keys are used respectively.

For complex projects it becomes very hard task to work with single layer, when you see objects on all layers of the board. There are several layer display modes: "All Layers", "Current Only", "Contrast". You can modify contrast from 0 to 100%. Layer display mode is selected from the drop-down list right under the list of layers. For Contrast level selection, there is a quick-access button to the immediate right from the layer display mode drop-down list.

13) Vias and Via Styles

Vias allow to change trace layer on the board.

In DipTrace vias can be trace or static, depending on the way of creation. Trace vias appear automatically, when trace goes from one layer to another in manual routing mode. Static vias are usually placed by user, fanout feature and shape router.



Vias are divided into Through and Blind/Buried by physical properties. Through-hole vias go through all layers of the board, creating a hole in it. While blind/buried vias are present only in selected layers and don't create a through hole in the board. In double-layer board all vias are through hole, but in multi-layer boards blind/buried vias help to route very complex projects.

Several types of vias with different sizes and physical properties are usually used in medium and complex projects. Via styles organize working with vias. Go to "Route / Via Styles" from main menu. And you'll see this dialog box:

On the left side of the panel, there is a list of all via styles of current project. Default via style is always available, you can not delete it. Number of vias, belonging to this style is shown in brackets.

Add new via style by pressing "Add" button. Then select new style from the list. Now you can type in its name, change type and sizes of vias. If you've selected blind/buried type, you need to specify layer pair (top and bottom layer), involved in this particular via style.

Net Classes

For complex projects it's almost impossible to remember all parameters and requirements of different nets, especially if designer works with several projects at the same time. For example, some nets should be capable of conducting high current, other nets must be well isolated (big net clearance) e.t.c.

Net Classes are really helpful, as you don't need to keep in mind all that values. Go to "Route / Net Classes" to open net classes dialog box and customize them.

All nets of the project belong to one net class by default. The exception is situation, when you load project, created in previous versions of DipTrace, when there were no net classes feature. In this case program automatically groups nets into net classes by their properties.

There is a list of all net classes to the left. You can add or delete selected net class with corresponding buttons below the list. Default net class can't be deleted. In the brackets, next to net class name you can see number of nets belonging to this net class.

Once net class has been selected, you can set its parameters in the center of dialog box. It's possible to rename net class and set different parameters for routing. In current version of DipTrace net class type selection isn't active yet, but in future releases, you will be able to use net class type for low-voltage differential signaling, buses, e.t.c.).

In the upper-right corner of the dialog box you can see the list of nets, that belong to this net class. Right under, there is a list of all nets of the project, with their net classes listed in the brackets. Use up and down arrow buttons to move nets to/from the net class.

Let's see how to customize net classes. Their parameters are in two tabs: "Class Properties" and "Autorouting".

Class Properties

In the "Class Properties" tab you can specify trace width, clearances between traces and different objects on the board, trace length limits and vias, used by nets of this class.

Trace width and clearances can be common for all layers, or you can set specific value for each layer. It means that traces will have different parameters on different layers. Uncheck "All Layers" item, select layer from the list and specify its parameters.

"Trace width" width of all net traces, which belong to this net class. However, some width variations can be allowed in some places. Therefore, minimum and maximum width can be specified in the fields right below.

"Clearance" distance between different objects. You can set common clearance for all objects or press "Clearance Details" button and set clearances by objects type.

Clearance values are used by autorouter. You can check "Use Clearance in DRC" and DipTrace will also use these values as design rules.

"Trace Length limits" feature restricts maximum length of traces. This is used for high-speed data buses, differential pairs, e.t.c.

In "Via Styles" subsection of this tab, you can select, which vias will be used in this net class. If "Use All Styles" is checked, DipTrace uses all available via styles. If it is unchecked, you can specify, which vias are appropriate for this net class and which are prohibited.

Autorouting

In "Autorouting" tab of Net Class dialog box user can specify autorouting parameters for this net class.

It's possible to set "Priority" for routing nets of this net class. Check corresponding box and type in any value from 0 to 200 into corresponding field to set priority level.

"Max vias in Net" feature restricts number of vias that can be used for one net. If you'll type "0" in this field, DipTrace will try to route nets of this class without vias.

You can also set maximum incorrect way for the trace and select Routing layers. If "Use Router Settings" is checked, DipTrace takes settings of current autorouter ("Route / Autorouter Setup"). If this option is unchecked, you need to select layers for nets of this class manually. Just move layers from the right list to the left with corresponding buttons.

Class To Class Clearance

If there are several net classes in the project, clearances of different classes may conflict with each other. In this case you need to set Class to Class Clearances. Press corresponding button in the Net Classes dialog box to access class-to-class clearances panel.

Select two net classes and type in desirable clearance value in corresponding field. Uncheck "All Layers" and you'll be able to set different class-to-class clearances by layers.

Loading/Saving Design Rules

Experienced PCB designer, who has completed a lot of projects, can group boards into several most common types by similar parameters and functionality. Specifying same settings for number of similar boards again and again might be very annoying. Fortunately, DipTrace offers feature that allows you to save parameters of one project and load them later and apply to any other design. DipTrace loads all settings, design rules, layers, net classes and via styles. You don't need to make all customizations again.

However, this is very helpful not only for professionals but for hobbyists as well. For example, when you used to order your boards with one manufacturer. In this case clearances, trace width and hole sizes, can be entered only once. No need to type that values again, if you want to order new board.

If you want to save your rules and create template for further projects. Make sure that you have necessary settings. Then go to "Route / Save Rules" from main menu. Type in name of the file and select it's location.

If you need to load rules, go to "Route / Load Rules" from main menu and select file with ".rul" extension, which contains settings from a previous project. Notice that you can also select ".dip" files as source of rules. And extract settings directly from other project.

Placement and Route Keepouts

Sometimes you need to have component- and traces-free areas on the board. DipTrace allows you to set these restrictions easily. Auto-placement and autorouter will not place any part or route any net in this area. Restrictions are checked with DRC (optional, applied only to route keepout).

If you need some component-free areas on the board — use Place Keepout feature. Select Place Keepout layer from the drop-down list on the drawing toolbar, then create shape on the board, you can use rectangles, circles and lines. Keepout can have complex shape, but the contour has to be closed. You can apply keepout to all layers and change its properties by selecting corresponding item from the right-click submenu.

Place Keepout doesn't allow DipTrace to place components on that area, but routes can be created there. To ban autorouter from some area, select "Route Keepout" layer from the drop-down list on the drawing bar and draw a shape. Route Keepout can be placed right above the place keepout.

During this lesson we are going to learn how to:

create board outline and make board cutouts of different shapes using different methods. For our project we need to create board outline, according to the drawing below:

V. RESULT

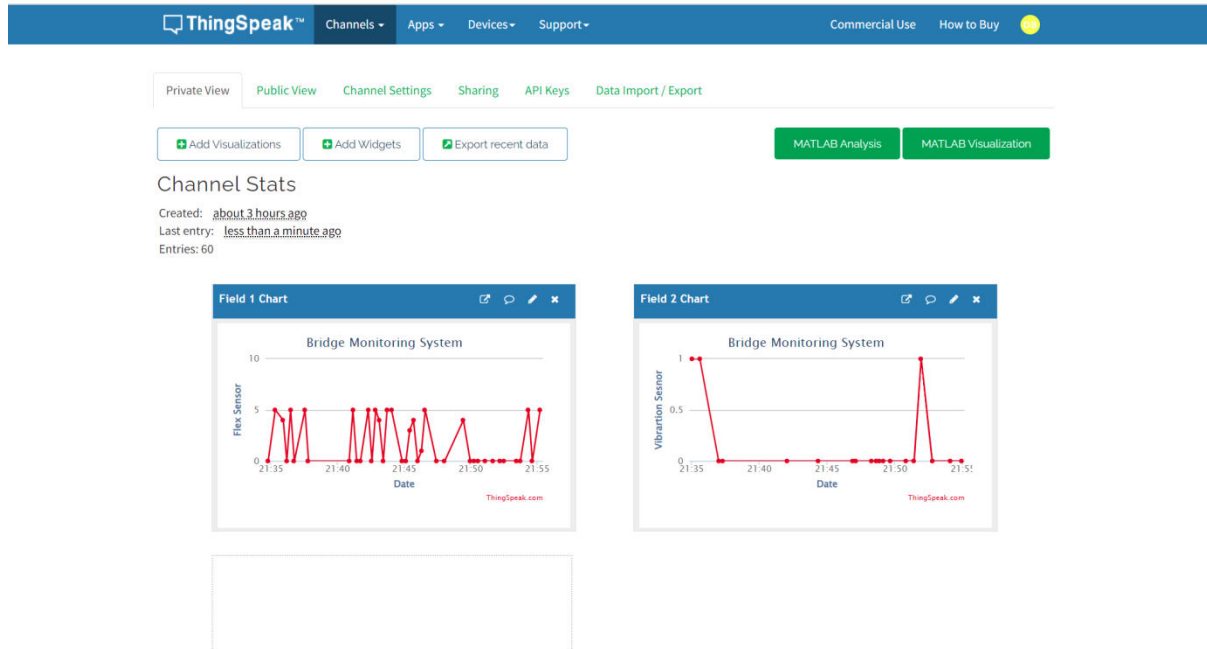


Fig. 3: Output of the system

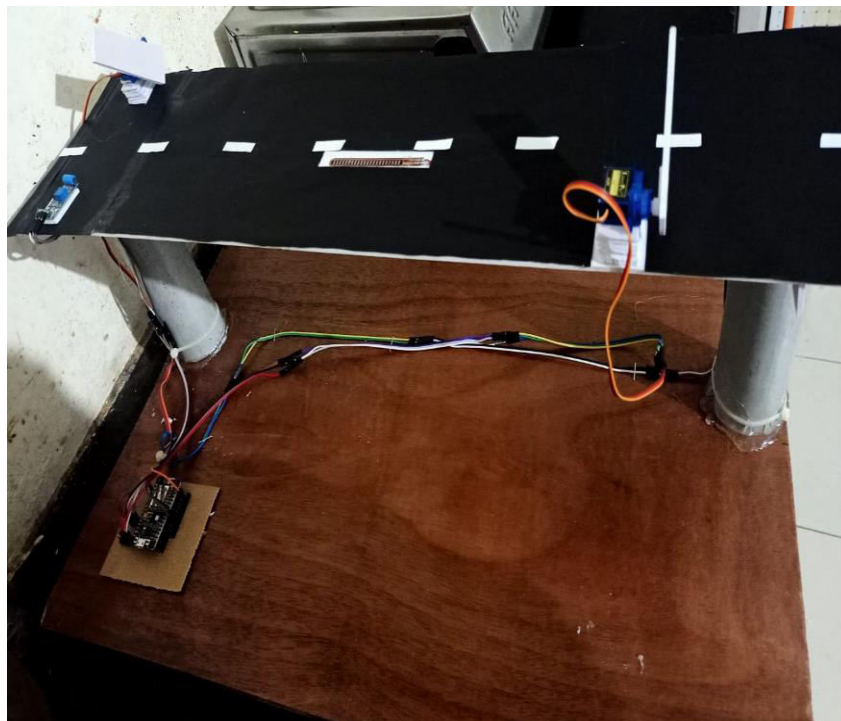


Fig. 4: Hardware of System

VI. FUTURE SCOPE

· Proposed system is a basic approach of bridge monitoring here we speak about data acquisition from one single node, many such sensor nodes can be deployed to monitor more than one structure at a time.



· Storage of data plays a vital role in monitoring systems it also serves to be a limitation in the proposed system in order to overcome this change in the sensing subsystem processing subsystem, power subsystem and communication subsystem can be done.

Use of Adhoc networks, Cross layer design issues, Multichannel data collection, time synchronization and security issues of network are few areas to be looked upon for future work .

VII. CONCLUSION

Bridge health condition monitoring in real time is very popular issue. The sensor technology is continuously and condition monitoring has never been accurate and easier before. With the help of wireless technology and water level sensor, smart system is developing for securing bridges. This system checks the water level and the position of bridge for safety purpose. In the emergency conditions like earthquake, flood, etc. the facility of broadcasting the message is added. This System is unique in its ability to monitor the bridge environment, it transmits environmental data through wireless communication and sends alerts to the bridge management staff i.e. Monitoring Centre in real time for prompt action also to user's. The main objective of Bridge Monitoring System using IOT is to save the lives of the people, to protect from accident.

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