IoT connected structure

B.E. Dissertation

Submitted in partial fulfillment of the requirement of

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For the Degree of

Bachelor of Engineering

(Electronics & Telecommunication Engineering)

by

Saif Kazi (16DET57)

Ibadullah(15ET20)

Khan Ahtesham(15ET28)

Under the guidance of

Prof. Awab Fakih

Department of Electronics & Telecommunication Engineering

Anjuman-I-Islam's Kalsekar Technical Campus,

Sector 16, New Panvel, Navi Mumbai - 410206

(Affiliated to University of Mumbai)

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Anjuman-I-Islam's

Kalsekar Technical Campus

Plot No. 2 3, Sector - 16, Near Thana Naka, Khandagao, New Panvel,

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Saif Kazi (16DET57)

Ibadullah (15ET20)

Khan Ahtesham (15ET28)

and is submitted in the partial fulfillment of the requirement for the degree of

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in

Electronics & Telecommunication Engineering

to the

University of Mumbai

Guide	**Project Co-ordinator** (Prof. Siraj Pathan)
Head of Department	**Director**

Certificate of Approval by Examiners

This is to certify that the dissertation entitled **"IoT Connected Structure"** is a bonafide work done by **Saif Kazi**, **Ibadullah**,and **Ahtehsham Khan** under the guidance of **Prof. Awab Fakih** This dissertation has been approved for the award of **Bachelor's Degree** in **Electronics & Telecommunication Engineering**, **University of Mumbai**.

Examiners:

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Examiner 1

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Examiner 2

Declaration

We declare that this written submission represents ours ideas in ours own words and where others ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in ours submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Saif Kazi (16DET57)

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Ahtesham Khan (15ET28)

_____

Ibadullah (15ET20)

Date: .

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Saif Kazi (16DET57) _____

Ahtesham Khan (15ET28) _____

Ibadullah (15ET20) _____

Abstract

The IoT connected structure is concept implemented using some open source hardware's and software's such as Esp32, Load Cell and hx711 weighing scale amplifier. Here we aim attention at Connecting Concrete Structural elements and beam to internet allowing us to monitor the sensors data in realtime over a web-application along with Augmented Reality based android app. Introduction: The main goal of doing this project is to monitor the structural element before detoration of structure to avoid incidence that happened due to collapsing of bridges and various structure through the concept of Internet of things(IoT). In this project, we aim to connect the structures and beam to Internet allowing us to monitor vibrations in real time through various sensors .

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Chapter 1

Introduction

1.1 History

For the last one and a half century, cement concrete has been extensively used for various structures which man could dream or conceive of with the misconception that they will last forever. Most of the failures or non functioning of the structure to its desired service condition is mainly attributed to the lack of understanding of the environmental condition and lack of proper, systematic and scientific maintenance.
There is traditional way of montitoring the stress and vibration of structure on a gauge

1.2 What is Concrete

Concrete is a construction material composed of cement, fine aggregates (sand) and coarse aggregates mixed with water which hardens with time. Portland cement is the commonly used type of cement for production of concrete. In a building construction, concrete is used for the construction of foundations, columns, beams, slabs and other load bearing elements.

1.3 Statement of Project

The Smart Structure using Augmented Reality is concept implemented using some open source hardware's and software's such as Esp32, Load Cell and Hx711 to monitor the bend or vibration in the concrete elements or concrete structure

1.4 About Project

- we focus on Connecting Concrete Structural elements and beam to internet allowing us to monitor the sensors data in realtime over a web-application as well as Augmented reality based android app
- Augmented reality is the displaying of digital information with the user's environment in real time.
- Augmented reality uses the existing environment and superimposes new
- Augmented Reality at Construction site could provide all data to Execution engineer allowing him to monitor sensors data in realtime
- Think of it like An Execution Engineer pointing his smartphone camera at desired column which shows all the parameter of that columns superimposed on the real.

1.5 Objective

- The main objective of doing this project is to monitor the structural element before detoration of structure to avoid incidence that happened due to collapsing of bridges and various structure with the help of Internet of things(IoT).
- In this project, we intend to connect the structures and beam to Internet allowing us to monitor the parameter of structure and beam such as moisture , vibrations , temperature and flexer in real time with the help of various sensors .
- We also aim to log such sensor data to database for further analysis of structures.

1.6 Use Of Low Cost Materials in Structures :

Increasing demand for the assessment of structures especially important structures have awakened the need for use of low cost materials (sensors) in Structural health monitoring. with

growing number of deterioration of old buildings and bridges there is need for fast track assessment of building. Sensors could be installed at critical point of structures to measure stresses, deflections, temperature and vibrations to get day to day health of structures. The structures like bridges if is getting badly deteriorated which could be pass by sensors and thereby to officers to declare a high alert message which will not allow any vehicle to pass on deteriorated Bridges.Present study deals with testing of RCC beams in structural Laboratory and sensors will be installed at critical point on or inside beam to understand behavior of RCC beam subjected to load, Indirect Load (Temperature), Vibrators.The RC beam shall be tested upto the failure to understand complete behavior for a particular parameters.Four RC beam nominal designed beam shall be casted and they shall be Subjected to load, temperature, vibration and moisture. Results will be obtained of critical point through sensors which will be analysed and processed.

1.7 Internet Of Things (IoT)

The Internet of things (IoT) is the extension of Internet connectivity into physical devices and everyday objects. Embedded with electronics, Internet connectivity, and other forms of hardware (such as sensors), these devices can communicate and interact with others over the Internet, and they can be remotely monitored and controlled

The definition of the Internet of things has evolved due to convergence of multiple technologies, real-time analytics, machine learning, commodity sensors, and embedded systems. Traditional fields of embedded systems, wireless sensor networks, control systems, automation (including home and building automation), and others all contribute to enabling the Internet of things. In the consumer market, IoT technology is most synonymous with products pertaining to the concept of the "smart home", covering devices and appliances (such as lighting fixtures, thermostats, home security systems and cameras, and other home appliances) that support one or more common ecosystems, and can be controlled via devices associated with that ecosystem, such as smartphones and smart speakers.

The IoT concept has faced prominent criticism, especially in regards to privacy and security concerns related to these devices and their intention of pervasive presence.

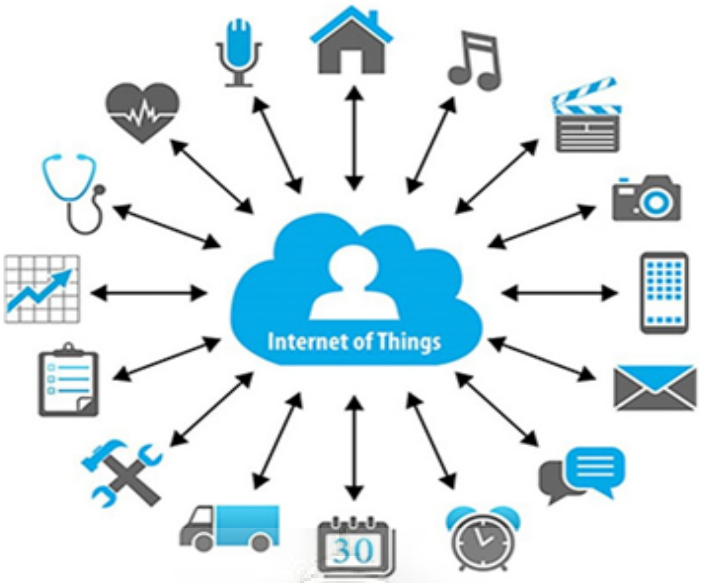

Fig. 1.1: **Internet Of Things**

1.8 How IoT can be used to monitor building ?

The main objective of doing this project is to monitor the structural element before detoration of structure to avoid incidence that happened due to collapsing of bridges and various structure with the help of concept of Internet of things(IoT). In this project, we intend to connect the structures and beam to Internet allowing us to monitor the parameter of structure and beam such as vibrations and bend in real time with the help of various sensors .

Chapter Overview	
Chapters	Oververview
Chapter 2	Chapter 2 shows the literature surveys that has been made on concrete structures
Chapter 3	Chapter 3 shows the Proposed Desgin
Chapter 4	Chapter 4 shows the working Principle
Chapter 5	Chapter 5 shows the Result of Operation
Chapter 6	Chapter 6 shows the Conclusion and Future Scope
Refrences	Refrence paper Referred for this project

Chapter 2

Literature Survey

Deterioration of reinforced concrete structures continues to cause concern in many parts of the world.The principal cause of deterioration is the corrosion of embedded steel reinforcement Coating the steel reinforcement is one of the effective methods of controlling corrosion of steel in concrete Although many types of coatings are available, epoxy coating on the steel reinforcement is adopted in most part of the world to control the corrosion of steel in concrete.Several manufacturers now supply reinforcement coated with a tough fusion-bonded epoxy to isolate bars from aggressive conditions Coated reinforcing bars are manufactured according to ASTM A775 in United States In United Kingdom it Is according to BS 7295, and in Japan coated reinforcements are produced in conformity with specifications of Japan Society of Civil Engineers.Coating alters the surface condition of the reinforcement and therefore alters the structural interaction of bond between the reinforcement and concrete.The transfer of forces across the interface between concrete and steel is of fundamental importance in reinforced concrete. Surface texture of a coating is smoother than the mill-scale finish of ordinary reinforcement, and therefore it alters the bond behaviour of the bar along Its length Recent studies have indicated decreased bond between the epoxy coated bar and the concrete.Therefore, many international codes suggest to increase the length of embedment in concrete for better anchorage with concrete and to achieve same bond strength as that of uncoated bar.Until recently, little attention has been paid to examine the influence of rib geometry of reinforcing steel due to coating.

Increasing demand for the assessment of structures especially important structures have awak-ened the need for use of low cost materials (sensors) in Structural health monitoring.

withgrowing number of deterioration of old buildings and bridges there is need for fast track assess-ment of building. Sensors could be installed at critical point of structures to measure stresses,deflections, temperature and vibrations to get day to day health of structures. The structureslike bridges if is getting badly deteriorated which could be pass by sensors and thereby toofficers to declare a high alert message which will not allow any vehicle to pass on deteri-oratedBridges.Present study deals with testing of RCC beams in structural Laboratory and sensors2 will be installed at critical point on or inside beam to understand behavior of RCC beam sub-jected to load, Indirect Load (Temperature), Vibrators.The RC beam shall be tested upto thefailure to understand complete behavior for a particular parameters.Four RC beam nominaldesigned beam shall be casted and they shall be Subjected to load, temperature, vi-bration andmoisture. Results will be obtained of critical point through sensors which will be analysed andprocessed.

Chapter 3

Proposed Design

3.1 Methodology

The IoT Connected Structure is a very soon emerging communication paradigm, in which the Structures will be rigged with microcontrollers and suitable protocol stacks that will make them able to give or exchange information with the users, becoming an integral part of the Internet. The IoT concept, hence, intend at making the construction site a safer place and maintenance easier.

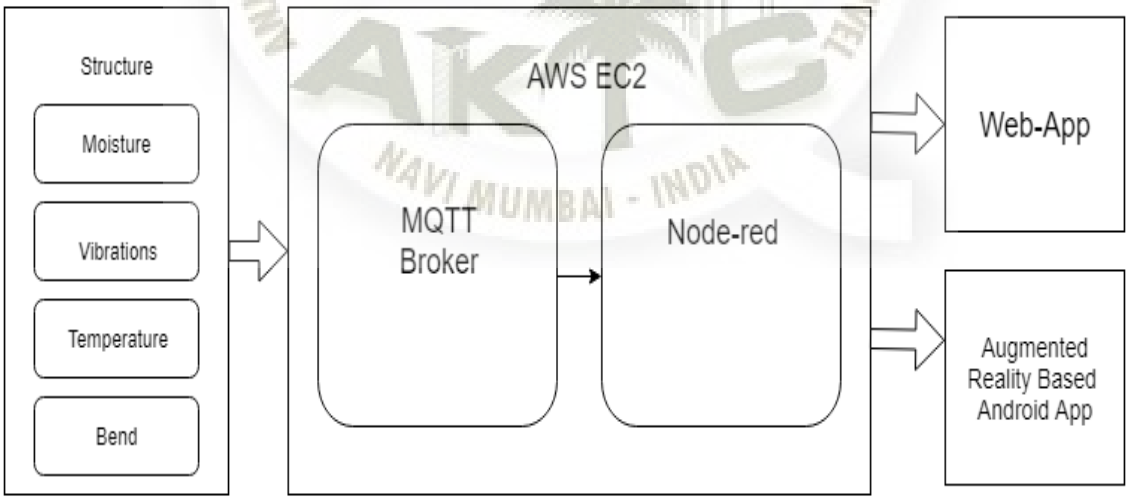

Fig. 3.1: **Flow of Data in infrastructure**

- A wifi Enable Micro-contoller named as esp32 is connected to AWS Ec2 server
- This Micro-controller is also interfaced with sensor like load cell and humidity sensor
- Micro-controller, Web app which is also known as node-red and Augmented Reality android app is acting as a server
- Where as AWS Ec2 is acting as a server
- The communication between Client and server is through mqtt protocol
- Mqtt Protocol work on the concept of Publish/subscribe
- In IoT connected structure the Augmented reality app and Web-app are acting as a client
- The augmented bridge will change the color of the column as the there is a stress or vibration apllied on it

Chapter 4

Working Principle

4.0.1 MQTT Broker:

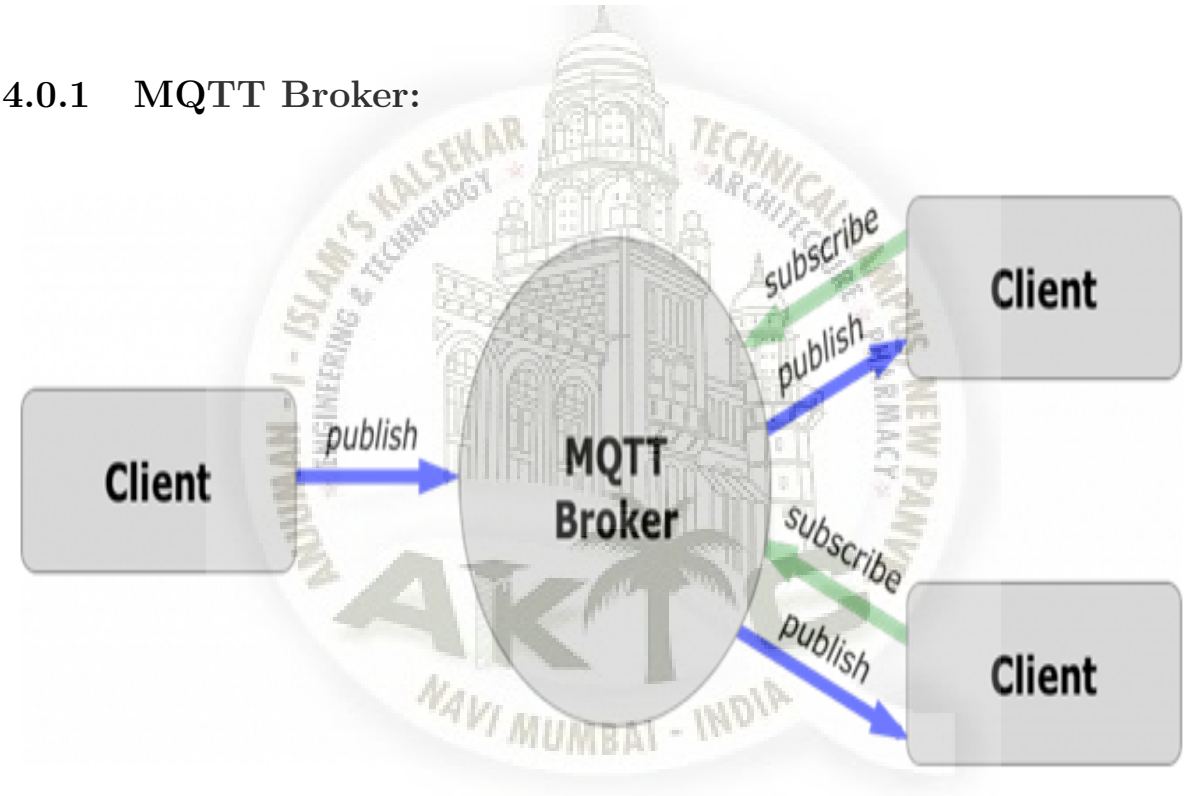

Fig. 4.1: **Mqtt Communication**

MQTT is a protocol developed by IBM in 90's specially made for internet of things.It is a lightweight messaging protocol for small sensors and mobile devices.The working principle of this protocol is based on publish and subscribe concept

Fig. 4.2: **Publish/Subscribe Concept**

4.0.2 MQTT – Messages

Messages are the information that you want to exchange between your devices. Whether it's a command or data

- For example Device 1 publishes on a topic
- Device 2 is subscribed to the same topic as device 1 is publishing in.
- So, device 2 receives the message.

4.0.3 MQTT – Topics

Another important concept are the topics. Topics are the way you register interest for incoming messages or how you specify where you want to publish the message.

4.0.4 EC2(Elastic Cloud Computing) :

Amazon Elastic Compute Cloud (Amazon EC2) is a web service that provides secure, resizable compute capacity in the cloud. It is designed to make web-scale cloud computing easier for developers.

Amazon EC2's simple web service interface allows you to obtain and configure capacity with minimal friction. It provides you with complete control of your computing resources and lets you run on Amazon's proven computing environment. Amazon EC2 reduces the time required to obtain and boot new server instances to minutes, allowing you to quickly scale capacity,

Fig. 4.3: **EC2**

both up and down, as your computing requirements change. Amazon EC2 changes the economics of computing by allowing you to pay only for capacity that you actually use. Amazon EC2 provides developers the tools to build failure resilient applications and isolate them from common failure scenarios.

Reliable

Amazon EC2 offers a highly reliable environment where replacement instances can be rapidly and predictably commissioned. The service runs within Amazon's proven network infrastructure and datacenters.

Secure

Amazon EC2 works in conjunction with Amazon VPC to provide security and robust networking functionality for your compute resources. Your compute instances are located in a Virtual Private Cloud (VPC) with an IP range that you specify. You decide which instances are exposed to the Internet and which remain private.

- Security Groups and networks ACLs allow you to control inbound and outbound network access to and from your instances.

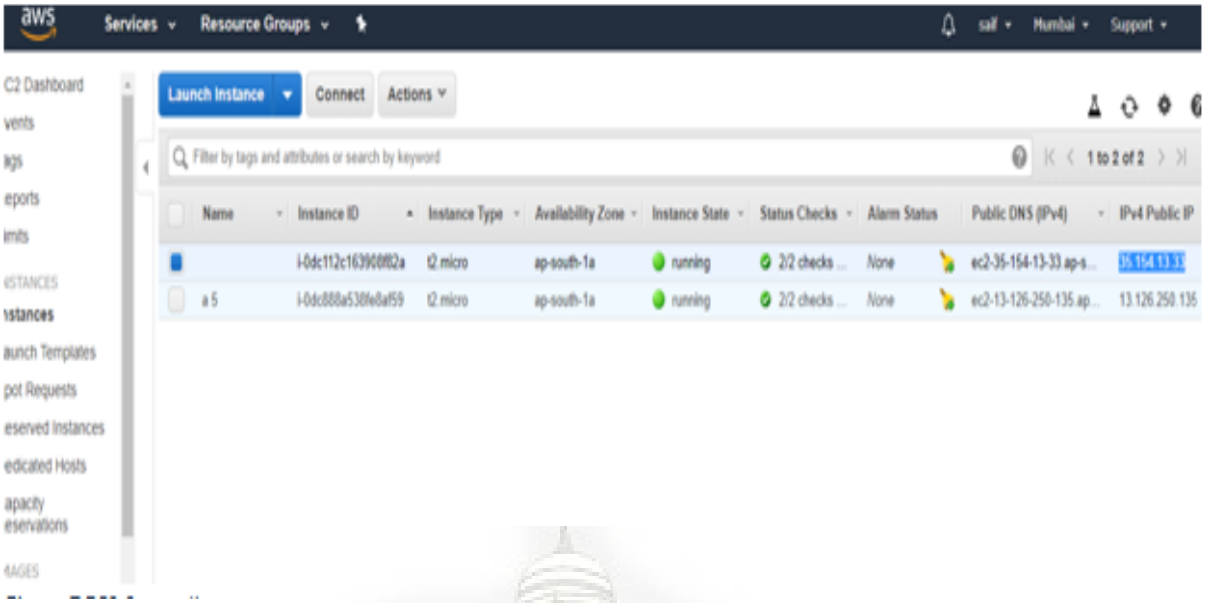

Fig. 4.4: **server list**

- You can provision your EC2 resources as Dedicated Instances. Dedicated Instances are Amazon EC2 Instances that run on hardware dedicated to a single customer for additional isolation
- If you do not have a default VPC you must create a VPC and launch instances into that VPC to leverage advanced networking features such as private subnets, outbound security group filtering, network ACLs and Dedicated Instances.

4.0.5 Node-Red:

Node-RED is a flow-based development tool for visual programming developed originally by IBM for wiring together hardware devices, APIs and online services as part of the Internet of Things

Node-RED provides a browser-based flow editor, which can be used to create JavaScript functions. Elements of applications can be saved or shared for re-use. The runtime is built on Node.js. The flows created in Node-RED are stored using JSON. Since version 0.14 MQTT nodes can make properly configured TLS connections

Node-RED can not only be used for Internet of Things applications, but it is a generic

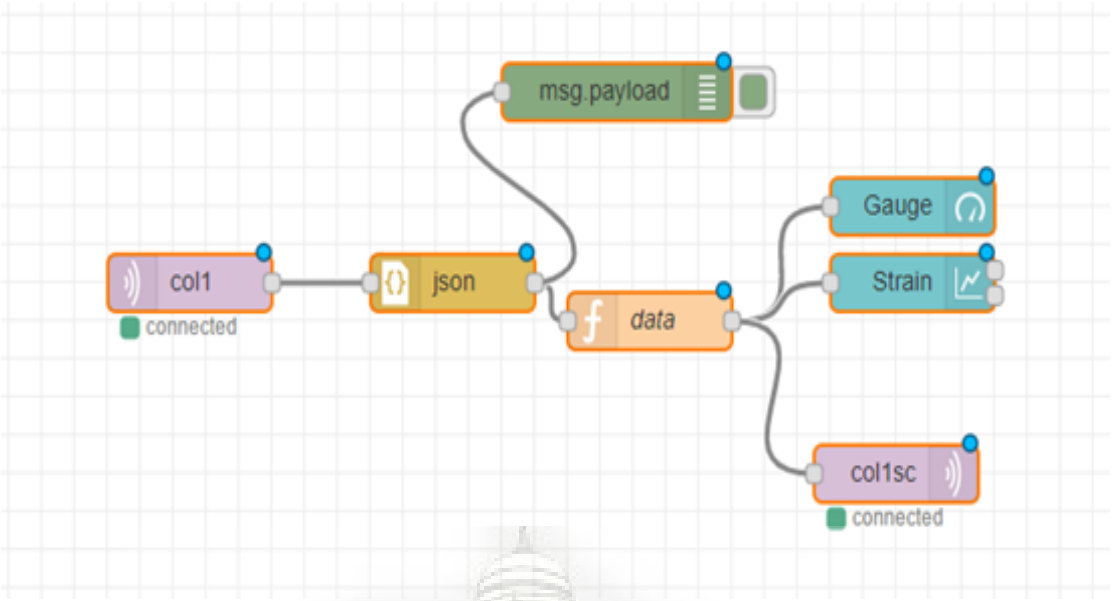

Fig. 4.5: **Node-red**

event-processing engine. For example you can use it to listen to events from http, websockets, tcp, Twitter and more and store this data in databases without having to program much if at all. You can also use it for example to implement simple REST APIs. Ryan Baxter provided just last week a Node-RED sample that isn't an IoT app. You can find many other sample flows on the Node-RED website

4.0.6 Esp-32:

ESP32 is a series of low-cost, low-power system on a chip microcontrollers with integrated Wi-Fi and dual-mode Bluetooth.

ESP32 is power packed with hardware features. The high speed dual core processors along with the numerous built in peripherals it is set to replace micro-controllers in connected products. The WiFi, Bluetooth Classic and BLE make it great choice to build anything connected. Even if a project does not require a particular feature initially, it could be utilized as required. The built-in hardware accelerator enables secure code storage and securely connecting to the Internet

Fig. 4.6: **Esp 32**

Specification

- The ESP32 is dual core, this means it has 2 processors.
- It has Wi-Fi and bluetooth built-in.
- It runs 32 bit programs.
- The clock frequency can go up to 240MHz and it has a 512 kB RAM.
- This particular board has 30 or 36 pins, 15 in each row.

4.0.7 Load Cell:

A load cell is a transducer that is used to create an electrical signal whose magnitude is directly proportional to the force being measured. The various load cell types include hydraulic, pneumatic, and strain gauge.

Strain gauge load cells are the most common in industry. These load cells are particularly stiff, have very good resonance values, and tend to have long life cycles in application. Strain gauge load cells work on the principle that the strain gauge (a planar resistor) deforms when the material of the load cells deforms appropriately. Deformation of the strain gauge changes

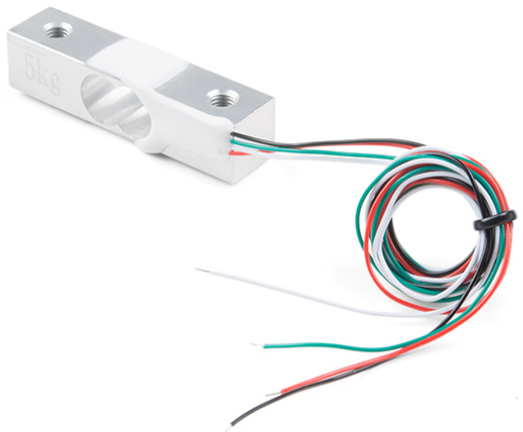

Fig. 4.7: **Load Cell**

its electrical resistance, by an amount that is proportional to the strain. The change in resistance of the strain gauge provides an electrical value change that is calibrated to the load placed on the load cell.

A load cell usually consists of four strain gauges in a Wheatstone bridge configuration. Load cells of one strain gauge (quarter bridge) or two strain gauges (half bridge) are also available.[1] The electrical signal output is typically in the order of a few millivolts (mV) and requires amplification by an instrumentation amplifier before it can be used. The output of the transducer can be scaled to calculate the force applied to the transducer. Sometimes a high resolution ADC, typically 24-bit, can be used directly.

The gauges themselves are bonded onto a beam or structural member that deforms when weight is applied. In most cases, four strain gauges are used to obtain maximum sensitivity and temperature compensation. Two of the gauges are usually in tension can be represented as T1 and T2,and two in compression can be represented as C1 and C2, and are wired with compensation adjustments. The strain gauge load cell is fundamentally a spring optimized for strain measurement. Gauges are mounted in areas that exhibit strain in compression or tension. When weight is applied to the load cell, gauges C1 and C2 compress decreasing their resistances. Simultaneously, gauges T1 and T2 are stretched increasing their resistances. The change in resistances causes more current to flow through C1 and C2 and less current to flow

through T1 and T2. Thus a potential difference is felt between the output or signal leads of the load cell. The gauges are mounted in a differential bridge to enhance measurement accuracy.When weight is applied, the strain changes the electrical resistance of the gauges in proportion to the load.Other load cells are fading into obscurity, as strain gauge load cells continue to increase their accuracy and lower their unit costs.

4.0.8 Load Cell Measuring Circuit :

HX711

This module uses 24 high precision A/D converter chip HX711. It is a specially designed for the high precision electronic scale design, with two analog input channel, the internal integration of 128 times the programmable gain amplifier. The input circuit can be configured to provide a bridge type pressure bridge (such as pressure, weighing sensor mode), is of high precision, low cost is an ideal sampling front-end module.

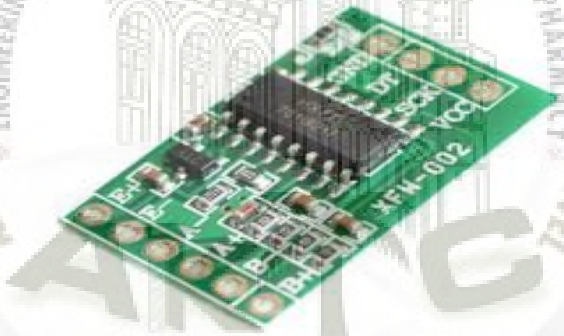

Fig. 4.8: **HX711**

Specification

- Differential input voltage: 40mV (Full-scale differential input voltage is 40mV)
- Data accuracy: 24 bit (24 bit A / D converter chip.)
- Refresh frequency: 10/80 Hz
- Operating Voltage: 2.7V to 5VDC

- Operating current: ¡10 mA
- Size: 24x16mm

4.0.9 Connections:

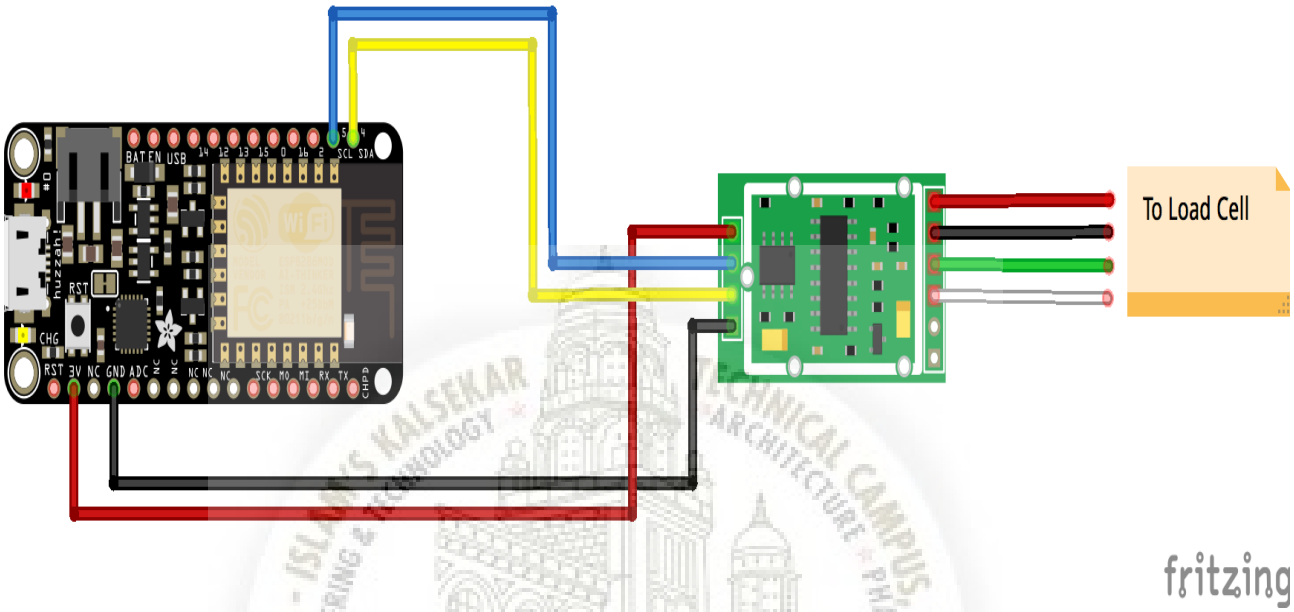

Fig. 4.9: **Connection**

4.0.10 Unity(Game Engine)

Unity is a cross-platform real-time engine developed by Unity Technologies, first announced and released in June 2005 at Apple Inc.'s Worldwide Developers Conference as an OS X-exclusive game engine. As of 2018, the engine has been extended to support 27 platforms. The engine can be used to create both three-dimensional and two-dimensional games as well as simulations for its many platforms

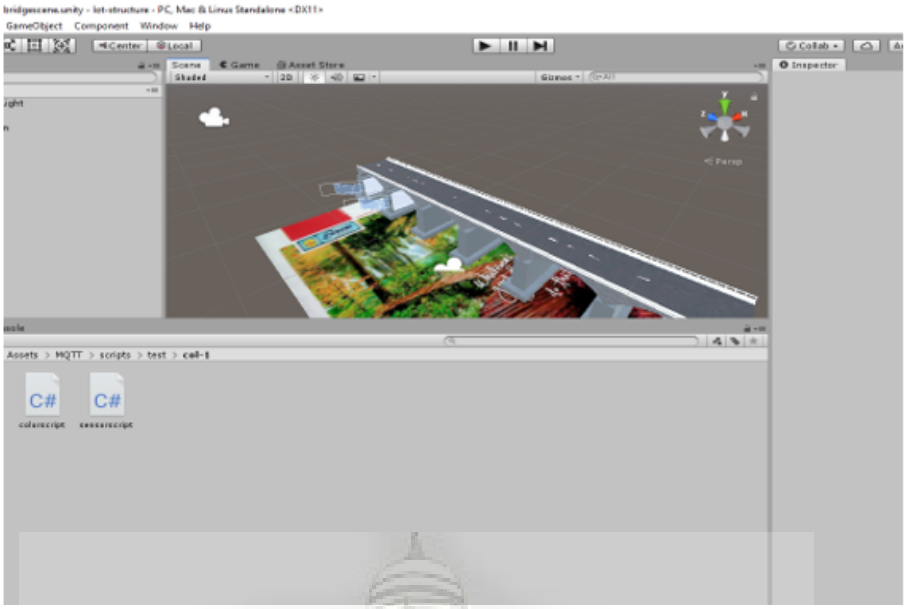

Fig. 4.10: **Unity Bridge modelling**

4.0.11 Augmented Reality:

Augmented reality is the displaying of digital information with the user's environment in real time.It uses the existing environment and superimposes new Augmented Reality at Construction site could provide all data to Execution engineer allowing him to monitor sensors data in realtime.Think of it like An Execution Engineer pointing his smartphone camera at desired column which shows all the parameter of that columns superimposed on the real enviroment .Augmented Reality and Internet of Things Could Revolutionized things in construction resulting in better productivity and time efficiency

Augmented reality (AR) is an interactive experience of a real-world environment where the objects that reside in the real-world are "augmented" by computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, somatosensory, and olfactory. The overlaid sensory information can be constructive (i.e. additive to the natural environment) or destructive (i.e. masking of the natural environment) and is seamlessly interwoven with the physical world such that it is perceived as an immersive aspect of the real environment. In this way, augmented reality alters one's ongoing perception of a real-world environment, whereas virtual reality completely replaces the user's real-world environment with a simulated one.Augmented reality is related to two largely synonymous

terms: mixed reality and computer-mediated reality.

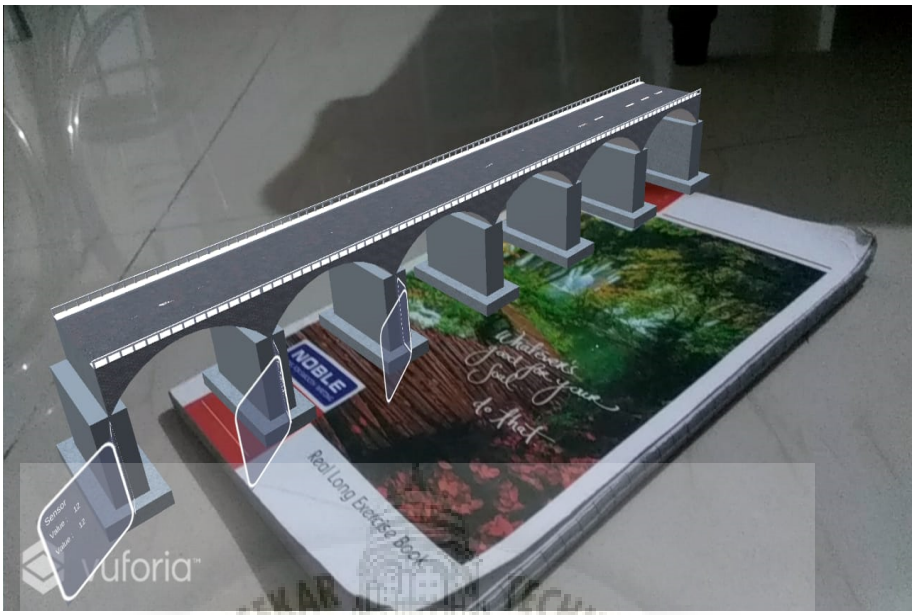

Fig. 4.11: **Augmented Bridge on book**

The above image shows Bridge structure Augmented on the book the same can be done with layout plan

4.0.12 Sketchup3D:

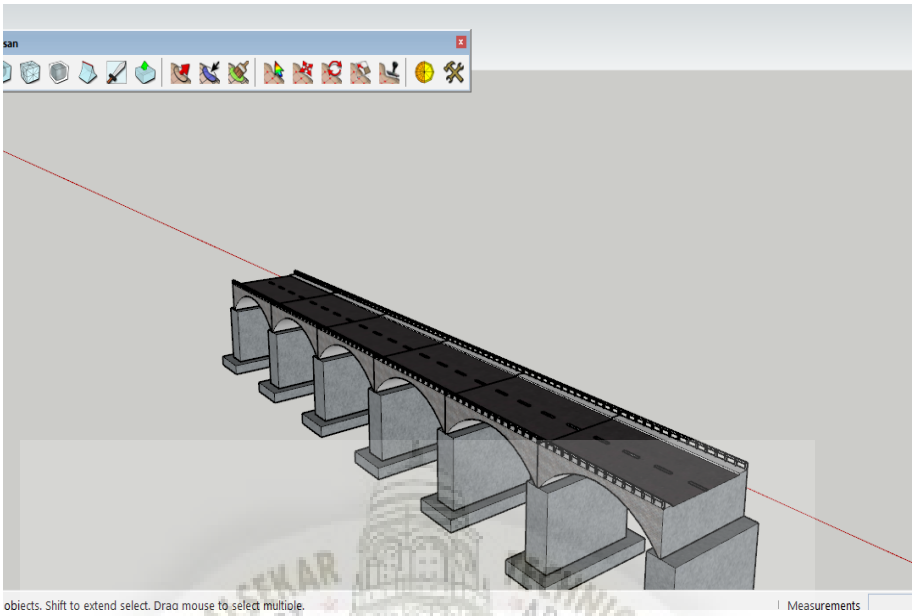

Fig. 4.12: **Modelling Bridge on Sketchup**

SketchUp, formerly Google Sketchup, is a 3D modeling computer program for a wide range of drawing applications such as architectural, interior design, landscape architecture, civil and mechanical engineering, film and video game design. It is available as a web-based application, SketchUp Free, a freeware version, SketchUp Make, and a paid version with additional functionality, SketchUp Pro.

SketchUp is owned by Trimble Inc., a mapping, surveying and navigation equipment company.There is an online library of free model assemblies (e.g. windows, doors, automobiles), 3D Warehouse, to which users may contribute models. The program includes drawing layout functionality, allows surface rendering in variable "styles", supports third-party "plug-in" programs hosted on a site called Extension Warehouse to provide other capabilities (e.g. near photo-realistic rendering) and enables placement of its models within Google Earth.

4.0.13 Vuforia AR SDK:

Vuforia is an augmented reality software development kit (SDK) for mobile devices that enables the creation of augmented reality applications. It uses computer vision technology to

Fig. 4.13: **Vuforia Augmented Reality**

recognize and track planar images (Image Targets) and simple 3D objects, such as boxes, in real time. This image registration capability enables developers to position and orient virtual objects, such as 3D models and other media, in relation to real world images when they are viewed through the camera of a mobile device. The virtual object then tracks the position and orientation of the image in real-l time so that the viewer's perspective on the object corresponds with the perspective on the Image Target. It thus appears that the virtual object is a part of the real-world scene.

Vuforia provides Application Programming Interfaces (API) in C++, Java, Objective-C++ (a language utilizing a combination of C++ and Objective-C syntax), and the .NET languages through an extension to the Unity game engine. In this way, the SDK supports both native development for iOS and Android while it also enables the development of AR applications in Unity that are easily portable to both platforms. AR applications developed using Vuforia are therefore compatible with a broad range of mobile devices including the iPhone, iPad, and Android phones and tablets running Android OS version 2.2 or greater and an ARMv6 or 7 processor with FPU (Floating Point Unit) processing capabilities.

4.1 Project Requirements

4.1.1 Software Requirements

Software Requirements	
Details of Software Requirement	Price
Unity Graphic Designing	N/A
Ec2	N/A
C sharp Scripting	N/A
Vuforia Augmented Reality	N/A
Node-Red	N/A
Android Studio	N/A

4.1.2 Hardware Requirements

Hardware Requirements	
Details of Hardware Requirement	Price
Esp32	700Rs
Strain Gauge sensors	1500Rs
Sht10 Humidity and Temprature sensors	1800
Vuforia Augmented Reality	N/A
Cement Bag	400
Steel Rod	1600

Chapter 5

Result

We are sucessfully able to monitor the structural data with help of concept of IoT using opensource tools and hardware such as Node-red, MQTT broker,esp32 and sensors like LoadCell.We had been able to succesfully imposed the digital information on the AugmentedBridge with the help of software called Unity and Vuforia which is a SDK for building Augmented Apps

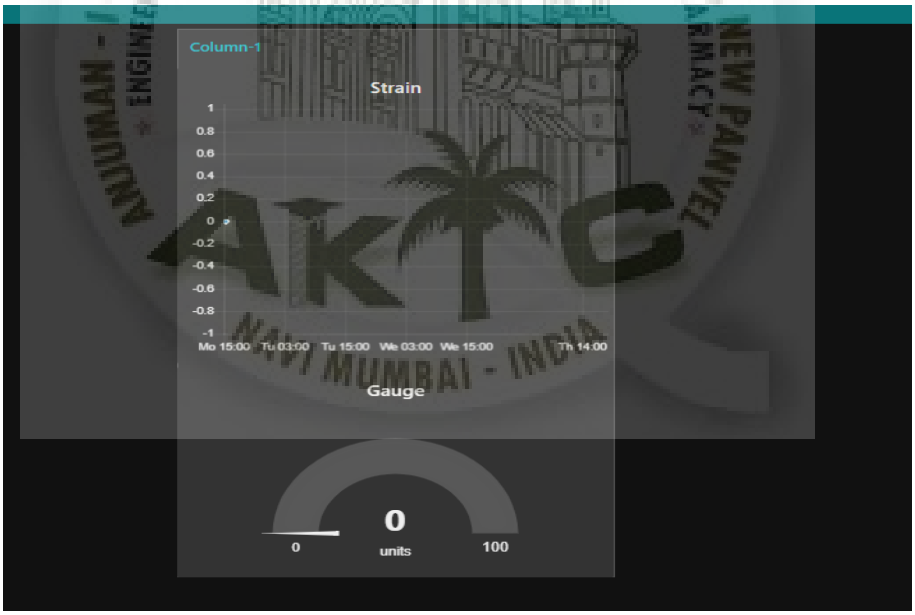

Fig. 5.1: **Dashboard**

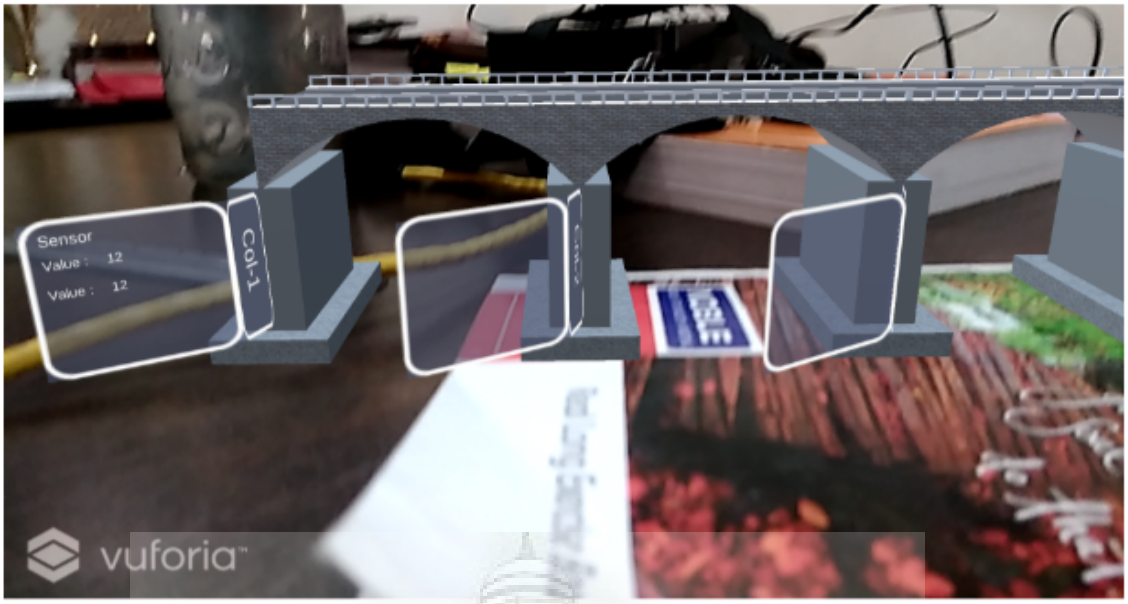

Fig. 5.2: **Augmented Reality**

We are succesfully able to change the color of columns in Augmented bridge when the load is applied on the load cell in real time providing the graph and value

Chapter 6

Conclusion and Future Scope

The main social benefit of this project is that we are able to monitor the structure or beams for data such as Vibrations and Bend. This help us to detect the deterioration of structural elements with the help of emerging technology .Augmented Reality at Construction site could provide all data to Execution engineer allowing him to monitor sensors data in realtime. Think of it like a Execution engineer pointing his smartphone camera at desired column which shows all the parameter of that columns superimposed on the real enviroment . Augmented Reality Could Revolutionized things in construction resulting in better productivity and time efficeny.

In the near future it might also be possible to monitor various parameter like temperature and moisture providing the keen information of leakages and seepages in the structure further preventing the incident of collapsing of structure

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