Full Stack Development of UBERA System

by

Akib An Noor
22173007

A project submitted to the Department of Computer Science and Engineering
in partial fulfillment of the requirements for the degree of
M.Engg. in Computer Science

Department of Computer Science and Engineering
Brac University
May 2023

Declaration

It is hereby declared that

1. The project submitted is my/our own original work while completing degree at Brac University.
2. The project does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The project does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. We have acknowledged all main sources of help.

Student's Full Name & Signature:

Akib An Noor
22173007

Approval

The project titled "Full Stack Development of UBERA System" submitted by

1. Akib An Noor (22173007)

Of Spring, 2023 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of M.Engg. in Computer Science on May 25, 2023.

Examining Committee:

Supervisor:
(Member)

Dr. Md. Ashraful Alam
Assistant Professor
Department of Computer Science and Engineering
Brac University

Program Coordinator:
(Member)

Dr. Amitabha Chakrabarty
Associate Professor
Department of Computer Science and Engineering
Brac University

Head of Department:
(Chair)

Dr. Sadia Hamid Kazi
Chairperson and Associate Professor
Department of Computer Science and Engineering
Brac University

Abstract

The system named 'UBERA' is a web application which is undertaken as a system which has the ability to assess buildings and produce an output result if they are vulnerable to earthquake or not. It is an automatic decision making system that evaluates the risk of buildings during an Earthquake. It utilizes modern Artificial Intelligence techniques along with civil engineering concepts to make the decision. A detailed structural evaluation is recommended to any building flagged as by the system. For building evaluations an effective system should be introduced in order to address this alarming earthquake risk. And with the help of this system anyone can access the system to know about any information about any types of buildings, its structural condition, awareness related information, evaluation facilities, automatic image processing result etc. This web application has several features, from google map API integration to the image processing facility of getting proper building evaluation results through the system. Moreover, generating a complete report page, maintaining the FEMA standard to calculate the threshold automatically are being developed as features of the system to make it an all in one building assessment and evaluation platform. The aim of the application is to develop awareness amongst general people about their building for any structural defects that might make the building vulnerable to earthquake and provide information with a proper report about the total building conditions.

Keywords: Earthquake; Deep Learning; Image Processing; Convolutional Neural Network; Structural Health Monitoring; Machine Learning

Acknowledgement

I am honored to have the opportunity to complete the project and this report and I am pleased to express my gratitude towards the people who have helped me accomplish the work.
This project is performed under the supervision of Dr. Md Ashraful Alam, Assistant Professor, Department of Computer Science and Engineering, Brac University, Dhaka. He has helped me by providing numerous journals and materials and other facilities as well as the motivation and continuous support and guidance I needed to complete my work for which I am grateful to him. He has also assisted me with his expertise and pearls of wisdom which helped me in many ways. I am immensely grateful to him for his guidance, support and cooperation.
I would also like to express my sincere thanks to all the faculty members of Department of Computer Science and Engineering, Brac University for their continuous support and motivation, and to those people who directly and indirectly helped me complete my work. Without their blogs, journals, videos I would not be able to perform my work properly.
Last but not the least, I would like to express my gratitude towards my friends and family who continuously supported me, believed in me and expected nothing less from me. They have been providing me with spiritual support and motivation which I needed most during my project work.

Table of Contents

Declaration i

Approval ii

Ethics Statement iii

Abstract iii

Dedication iv

Acknowledgment iv

Table of Contents v

List of Figures vii

Nomenclature viii

1 Introduction 1
- 1.1 Overview . . . 1
- 1.2 Motivation . . . 1
- 1.3 Research Scopes(Gaps Addressed) . . . 2
- 1.4 Objectives . . . 3
- 1.5 Project Contribution . . . 3
- 1.6 Project Organization . . . 4
- 1.7 Project Orientation . . . 4

2 Building Assessment Parameters 5
- 2.1 Importance of Structural Assessment . . . 5
- 2.2 Pounding Effects in Structures . . . 6
- 2.3 Vertical Irregularities in Structures . . . 7
- 2.4 Plan Irregularities in Structures . . . 8
- 2.5 Existing Artificial Intelligence Approaches to Structural Evaluation . 9
- 2.6 Deep Learning Approaches in Structural Evaluation . . . 10
- 2.7 Smart cities with IOT . . . 10
- 2.8 Improving the performance of structural engineering with AI . . . 11

3 Technologies Used 13
- 3.1 Back-end . . . 13
- 3.2 Front-end . . . 14

3.3 Deep Learning for Image Processing 15
3.4 TensorFlow Inception Deep Learning Model 16
3.5 Database 16
3.6 Structural Evaluation Database Table 17

4 Development Process and Application Features 19
4.1 System Login and Signup Feature 19
4.2 Home Page and Menus 20
4.3 Evaluate Your Building Feature 21
4.4 Building Evaluation List 22
4.5 Building Evaluation Edit Feature 23
4.6 Building Profile Feature 23
4.7 Building Evaluation Delete Feature 24
4.8 Adding and Training ML.Net Machine Learning Model 25

5 Assessment Result and Evaluation Report 27
5.1 FEMA Model 27
5.2 FEMA Score Calculation 27
5.3 Getting the Output 29

6 Conclusion 30

Bibliography 31

List of Figures

2.1 Pounding Effect in Structures 6
2.2 Vertical Irregularities in Structures 8
2.3 Plan Irregularities in Structures 9

3.1 Generated Database Table 18

4.1 System Login and Signup Feature 19
4.2 Home Page 20
4.3 Building Evaluation Page 21
4.4 Building Evaluation List 22
4.5 Building Evaluation Edit Page 23
4.6 Building Evaluation Profile Page 24
4.7 Building Evaluation Delete Page 24
4.8 ML.Net Integration 26

5.1 Output Result with Report 29

Nomenclature

The next list describes several symbols & abbreviation that will be later used within the body of the document

AI Artificial Intelligence

API Application Program Interface

CNN Convolutional Neural Networks

CSS Cascading Style Sheet

DL Deep Learning

$FEMA$ Federal Emergency Management Agency

$HTML$ Hyper Text Markup Language

IOT Internet Of Things

ML Machine Learning

MVC Model-View-Controller

SHM Structural Health Monitoring

UBC Uniform Building Code

$UBERA$ Urban Buildings Earthquake Resistance Assessor

UI User Interface

WHO World Health Organization

Chapter 1

Introduction

1.1 Overview

Earthquake is sudden jerking of the earth which occurs by sudden movement among tectonic plates towards a fault line in the earth's lithosphere. Earthquake may cause many damages to the earth like cracks,ground vibrations, land melting, landslides. It also may have bad impact on other aspects of nature by causing fire, avalanches and tsunamis. It is able to strike suddenly and without warning. According to the World health Organization(WHO) earthquakes took place from 1998 to 2017, caused death to almost 750,000 lives worldwide and most concerning fact is that a large number of deaths were connected to natural calamities. During that period of time, people over 125 million, experienced sufferings due to earthquakes. It not only made them injured but also destroyed their homes .For this reason many people had to take shelters in safe places during the crucial period of the disaster. Most earthquakes are smaller vibrations,on the other hand larger earthquakes normally start with mild vibrations, quickly develop into one or more strong vibrations and finish with shaking of continuous decreasing strength called "Aftershocks". An earthquake is one type of structure of wave motion energy that creates in a restricted area which gradually distributes in every direction from the center point of the trouble. This normally happens in a very short period of time within few seconds. The core point in the ground where the origin of earthquake lies is called the focus, from where the vibrations generate towards every possible directions.Bangladesh is inadequate in earthquake monitoring facilities. The Bangladesh Meteorological Department founded a observatory at Chittagong which is seismic in 1954. It's a matter of grief that our country possesses only this one observatory till now.In Bangladesh if we see the records,we can observe that the number of earthquakes (moderate to large) is more than 100 since 1900. Moreover almost 65 percent of them took place after 1960. This shows that there is a rise in the rate of earthquakes in the previous 30 years. To people most of the troubles comes from the human made structures and the vibrations.The most patronizing factor for people is being crushed in a collapsing structures or trapped under a landslide. [1]

1.2 Motivation

In current situation,we don't have any reliable method in our hands for doing important predictions about the timing, strength or duration of an upcoming earthquake.

Earthquakes can be of various sizes.The main strength remains at the center of an earthquake and its duration can last from seconds to minutes. To predict earthquakes, we must need clear precursor signs. In earlier days, seismologists have observed several changes in the atmosphere before earthquake, such as an increase in the concentration of a certain type of gas named radon.They also observed some diversity in electromagnetic activity, predictions.Their observations also included some events of deformation of ground, chemical variation in groundwater and even behavioral transformation in some animals as well.
The changes in the water level of ground,lead some earthquakes.With the rise of tectonic stress, rocks certainly grow cracks that change the rock's relation with water. As the buildup pressure crush the rocks, change the flow of groundwater chemicals,reform underground water flow, the springs hydro chemistry can be changed.
First, there is no uniformity of underground structures that occur along faults. No one has a clear understanding of all the different forces and structures at depth in most earthquakes to make a meaningful quantitative analysis of what's going on. Scientists are constantly analyzing the failure of materials, but how can you do that with unknown structures underground? There simply isn't enough detail to even begin to assess the risks.
Second, even if you could piece together a detailed understanding of what's going on, there's no way to get meaningful data about the structural components and forces acting along the fault zones at risk. Most earthquakes occur at depths of 5 to 30 miles (much deeper earthquakes can occur along subduction zones). Even if there is a risk of an earthquake due to the accumulated stress in a certain group of locked rocks, how could you get the data to assess it?
Third, small earthquakes keep happening in the same materials, which can then cause much larger earthquakes. In other words, knowing that one location is at risk of failure tells you nothing about how far the earthquake will spread into adjacent formations. Large earthquakes are a cascading event in which failure in one location induces enough force to trigger failure in many other equally weak locations. Forecasting that requires accurate data on local conditions over a fault length of several hundred miles. The 2011 Tohoku earthquake in Japan ruptured about 300 miles long and 120 miles wide. Imagine the data needed to predict a fault over such a large area. It was accompanied by fore-shocks and aftershocks of more than 7, and how could you calculate that? [2]
So this idea of developing "UBERA" system has come forward and with the help of this system we will not be able to actually predict earthquake but we will be able to assess any buildings from the Google map and the system will automatically generate the score of the building from which we will have a clear idea about the vulnerability of that building during earthquake. Also it will give an output suggestion if further detailed building evaluation is required.

1.3 Research Scopes(Gaps Addressed)

Limited work has been done to explain the influential elements related to the inhibition of earthquake of modern buildings using ML and AI technologies. There is also no work identified to target the function of exploring, learning and interaction in data prediction from building images. In addition, all currently used statistical methods are insufficient for interpretation. Moreover, no work has been done in the

existing literature to investigate the prediction of structural quality when it comes to portability of structural image data. Finally, existing models of artificial intelligence still stay in nature black-box. They are not transparent enough to provide an explanation of why and how they arrived at their accurate predictions. And besides many other studies used either too few or too many parameters, which is not effective enough in predicting structural quality. In general, the application of artificial intelligence in the area of quality assessment of constructions is still an under-researched thematic area.

1.4 Objectives

To develop a software system which can assess and evaluate earthquake resistance of urban buildings in Bangladesh.
To raise awareness as well as to offer structural suggestions regarding earthquake.
To integrate Google Map API into the system for accessing any building from the map and to evaluate it.
To use machine learning approaches for image processing accuracy.
To implement the FEMA threshold for calculating the output results.
To implement image upload and cropping system to get more accurate data extraction.
To implement user interaction into the system including user sign-up and login.
To implement Front-end, Back-end and Database functionality which will maintain a proper full stack development cycle.

1.5 Project Contribution

I have designed interpretable machine learning models for structural quality prediction using different functions as well as developed the UI(Front-end), Back-end and database part which makes it a full stack web application development process. I have used interpretable approaches to explain the characteristics contributing to the predicted outcomes to understand how the machine learning algorithms arrived at the predicted results. Below is a summary of my contributions to this project:
I have analyzed structural quality variables using machine learning.
I have modeled and trained different machine learning (ML) classifiers to make predictions of structural quality in an attempt to determine the quality of the structure.
I have evaluated the performance of the trained classifiers.
I have designed, developed and deployed this system and implemented machine learning image processing technique to interpret the prediction for easy understanding of how the ML models went.
Such conclusions and improve the transparency and possibilities of their adoption technology in structural evaluation.
I have developed machine learning model with different structural images for structural quality and tested it on a real data-set for real building images with features and with many specific samples. The proposed model showed that it is possible to remember and be accurate 90 percent relative to the data set. Results may require translation of the study results into full structural evaluation practice through professional agencies and governments on structural evaluation management, policy

and decision-making. It is below summary of my contributions.
I have performed exploratory data analysis on the image data-set.
I have modeled and trained different machine learning (ML) classifiers to make predictions of structural quality in an attempt to determine the potability of the structure.
Based on various structural parameters, I have evaluated the performance of these ML models and provided an explanation for the predictions.
I have then modeled a robust image data model that can be used effectively classification of structural potability prediction based on inputs.
And finally, I have calibrated the final model to be generalized for structural quality forecast.

1.6 Project Organization

The organization of the work is based on the development of the software system web application and machine learning approaches for image processing and image classification and coded using the latest Microsoft Asp.Net MVC Core technology which is a cross platform development environment.

1.7 Project Orientation

The topics of this final report is organized as follows:
Chapter 2 briefly describes how other researchers have used AI-based models to predict determine and evaluate structural quality.
Chapter 3 discusses the components and the used technologies of our proposed model and their implementation.
Chapter 4 describes the development process and application features of this system.
Chapter 5 summarizes the output results and generated reports of the application.
Chapter 6 concludes the entire discussion.

Chapter 2

Building Assessment Parameters

2.1 Importance of Structural Assessment

When an earthquake occurs, structural evaluation or assessments are very important as structural designs and the codes of the building confirms the security of life. If the structure will still survive during an earthquake cannot be told before. Moreover, different companies that provide insurance may require an assessment of the damages caused by earthquake. If we can make the structural assessment very quickly and writing down the damage of the earthquake, we can minimize the uncertainty which is related with measuring the reason of a specific damage.
There are a total number of two structural evaluations which are typically performed when we assess a structure. Firstly the inspection which is totally visual should be completed within the next 24 hours from the incident caused. Visual inspection is very necessary to protect the safety of life of people before entering the building again. A visual assessment will begin on the outside of the structure, where the technician looks for displacements and damage to the structural elements. Once inside, the engineer will look for damaged columns, shear walls, and other structural elements. This is also an opportunity for the engineer to document minor damage, such as cracks, for an insurance claim. Please note that a structural engineer will not deal with systems such as plumbing or mechanical systems.
The second type of assessment is the detailed and elaborated structural evaluation which is in the assessment. This usually takes place a few days after the event and with the help of the type or the shape of the building, it might take one or two days. This assessment is important because visual inspections cannot reveal the full extent of earthquake damage. This assessment may include non-destructive testing such as tactile testing or crack monitors. This will allow the technician to find hidden damage and test the members for adverse settlement or deflection that may indicate weakened fasteners. These weakened joints can be covered with plasterboard or other materials. Destructive testing or removal of covers may be required to reveal these structural elements. Visual inspection helps the engineer determine the level and extent of testing and type of evaluation needed during a detailed structural evaluation. It is recommended to have and organize any structural drawings or building information to assist with this detailed inspection. This will help the technician speed up the inspection process.
Analyzing the system should be the very first phase whenever we can assume that a brand new system is to be coded. And to figure out the requirements of the new

system which will be developed, a detailed study of the existing system is included in the analysis phase. The vast and elaborated study of different functions and tasks which the system performs and also their connection within and also outside the system is called analysis. And whenever the analysis process is done, the data related to the system are collected for studying from the available files, different types of transactions and judging points which are connected to the current system. Different types of tools are used for the system analysis and some of them are questionnaire, interviews and on-site observation.

2.2 Pounding Effects in Structures

Earthquakes cause sudden ground movement and tremors in the surface of the earth that are transmitted from the ground to the superstructure through the foundations. Usually we can see a practice of building structures which are very close to each other. To be more specific, different types of corporate buildings and residential buildings are built very near to each other with very small or absolutely no gaps at all in different densely populated areas. So whenever an earthquake strikes, due to the created vibration and violent shaking of the ground, these buildings which are built very close to each other may hit one another by colliding with each other which resulting in extended damage than expected. The pounding effect is exactly this type of collisions of buildings. So whenever due to the great force generated by earthquake the ground shakes violently then if two buildings strike and collide with each other, it is the pounding effect in structures. If two adjacent structures collide with each other then it is called seismic pounding. Because of having special characteristics of the adjacent structures and different dynamic designs, the collision of adjacent structures with each other can be very effective and can result to shake out of phase whenever an earthquake strikes. So it causes excessive damage because of very little gap or totally no gaps at all or wrong power dissipation system to control the movement of these buildings. [3]

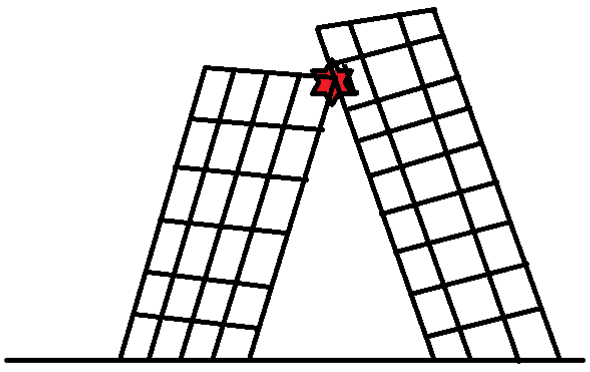

Figure 2.1: Pounding Effect in Structures

So if there are very small gaps or totally no gaps between two structures then it is possibly one of the big reasons for seismic vibrating of structures. And there are some causes which are described below of the effects on the surrounding buildings

to an outside force:
Whenever the gap between two structures is very less or totally nil.
During construction, they have a necessary gap, still they might be connected with some external elements.
It becomes quite impossible two construct two structures with exactly the same rules and same dynamic properties. For example, some of the properties can be design, geometry, height, mass and orientation. If we could built different structures with the same dynamic properties the pounding effect would be totally zero even if there were no gaps present between the structures .
When the center of gravity of neighboring buildings is not axial.
To reduce the impact of the earthquake, it is always wise to make pre-disaster investigation as much as possible and it should be the main focus rather than focusing on after disaster management. Thus to conduct different pre-earthquake management programs the aim should be structural assessment and evaluation of the weakness of the structure that may be inappropriately designed. Moreover anti seismic rules of improvement for previous generation structures is broadly presented which will confirm necessary resources. The pounding effect creates impacts in two buildings which are side by side and adjacent and they begin to shake violently in seismic activity period. So there are different types of options to minimize or to totally avoid pounding effects is structures which may also include to confirm the minimum gap between buildings which are adjacent. Still many research is needed on this matter though many of the structure rules has minimum requirements on the matter of separation gap. The Sap2000 is such a software which can model buildings which are adjacent and have different pattern and geometry. So pounding effect in structures can increase the risk of human lives and that is why I am considering to analyze if any structure has the minimum gap between them. And by using the Deep Learning process I am extracting the data from the uploaded image and then my system will automatically provide an output if the structure has this effect. Also to measure this effect, two buildings should be on the same ground level and if a building has two stories more than the other building, and the gap is very less, then it is also possible that pounding effect may occur during the violent shaking of the ground. Furthermore to measure this effect in the field level, the root which is square, maximum peak level and the shear of the columns can be studied and the results should be plotted in a graph. It can occur even if the lowest gap between two buildings are six inches. Less pounding occurs in the bottom of the building and the higher pounding occurs at the top of a structure. In UBC-97 the minimum gap requirement of structures can be found which is very necessary to follow to cope up with the pounding effect of structures.

2.3 Vertical Irregularities in Structures

If a structure is vertically irregular then that is the vertical irregularity of a structure. And there are some structural rules which defines this irregularity. Also if the top of a Structure has more beams and if it is more wider than the bottom then that structure may be vertically irregular. So if the graphical shape of a building does not follow any structural rules then that structure may be vertically irregular. Soft Palate or the irregularity of stiffness is if the stiffness level of a palate is below 70 percent then that is called a soft palate. And if the level of stiffness is above 80

percent then that is called an average palate. So it should be taken into consideration.
The next thing that we should consider is the bulk irregularity. When judging the vertical irregularity, bulk irregularity is an important thing. Bulk irregularity is found where the total mass of a floor crosses the percentage of 150 efficiency of the floor adjacent. Also if the roof of a structure is light weight then then floor of that structure, we need to consider that as bulk irregularity.

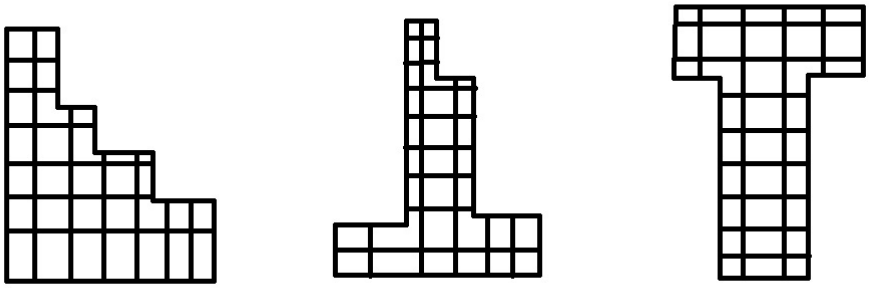

Figure 2.2: Vertical Irregularities in Structures

Geometrically irregular structure is such a structure in which the horizontal force of lateral resistance dimension technique is above the percentage of 130 on the floor which is adjacent.
The discontinuity of the in plane resistance force element of the vertical lateral:
If the in plane resistance force element of the vertical lateral is above than the total length of these elements than this should be considered to be present.
If the total area of the current floor is below the percent of 80 from the floor above then it is considered to be a weak floor. The sum of all seismic resistance element is the total force which share the floor shear in a direction.

2.4 Plan Irregularities in Structures

A structure is considered to be plan irregular if it is irregularly shaped and planned during construction which does not follow any building construction rule. The non parallel system irregularity is considered to be present if it is wedge shaped or triangularly planned.
We will say that this type of irregularity is present in a structure if the transverse of the construction, lateral torsion and the maximum displacement of floor to the axis is higher than 1.2 times of the floor drift average of two buildings. Also torsional irregularity will be considered in a structure if any window is kept open in a ground floor of a structure which is manually determined.

Reentrant corners will be considered present in a structure if the long wings are E,U,L,T or plus shaped. In our web application it will be determined using the

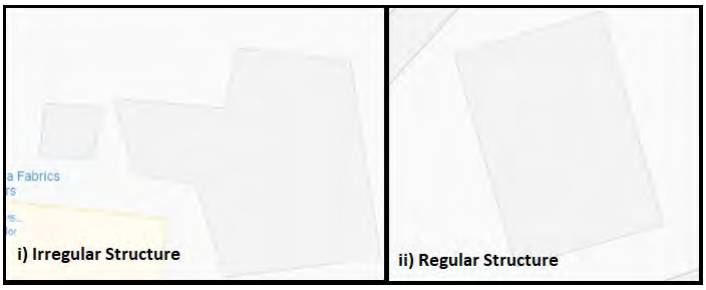

Figure 2.3: Plan Irregularities in Structures

deep learning approach under the machine learning technique. Also there are some other ways to determine that it is present if two of the projections following a reentrant horn are more than the percentage of 1.5 in any direction of the plan of the floor dimension.

2.5 Existing Artificial Intelligence Approaches to Structural Evaluation

Artificial Intelligence or AI is currently a hot topic in the field of all kinds of technology. It is very much sure that in the near future, AI will rule the world and make vast changes in the field of technology. It will automate many technological tasks which is currently very time consuming. And also AI is considered to be a blessing in the field of structural evaluation also. With the help of artificial intelligence, structural assessment and structural evaluation has also been blessed. We can now do the structural flaws identification and any security measurements very easily and in a less time consuming way. It has been possible to make many structural tasks automated with the help of AI. It can learn from the real world and then with the help of it's learning it can make automated decisions and complete the task without any outside interference. So it makes the process automated as well as it increases productivity because of making less time consuming decisions. Thus AI can solve complex problems and can make advance decisions in no time.
So in structural engineering, AI can create 3D models of different types of structures so that any irregularities can be tracked automatically. These 3D models of structures can be used to train the system and we can compare it to the original model to detect any types of flaws in the structure. Current approaches to evaluate any structure is to create a 3D model of the structure itself or use high quality structural images and train the data-set. Currently this type of model based approaches are being used to make appropriate predictions and output is generated from the trained data-set using necessary algorithms. AI is also used to generate automated structural designs according to different structural conditions and logic. So with the help of AI, our understanding of complex structural designs and and behaviour is enhancing by different approaches. So among all other approaches, the 3D model approach is currently the most popular AI approach in structural evaluation and assessment.

2.6 Deep Learning Approaches in Structural Evaluation

To talk about Deep Learning in structural engineering specifically, it is also being used in an increasing amount today. Recently the use of Convolutional Neural Network(CNN) in DL is being the top interest among structural engineers. And the major use of DL in structural engineering today is the Structural Health Monitoring(SHM). Though the CNN approach in SHM is very new, but the result of it is proving to be perfect. It is used to first train the structural condition to the system as a learning process. Then the SHM system can obtain necessary features to classify structures using the learned parameters. It is currently being used for 2D signals only like video frames and images. So these can result in accurate image recognition. That is why they are using CNN in the SHM system as they are mainly vision based.
Moreover, to build the data-set different structural images are captured from different specific structures which are monitored to generate the structural condition and structural health report. The very first use of the CNN in structural engineering was to identify different types of cracks in structures. Following that, came the idea of using 1D CNN models to detect different types of structural damages. And it was proved that the system was much capable of training from the image data. So it provided satisfactory outputs to monitor the health of different structures. But it is true that a large number of image data needed to be collected to make the process accurate and to create the data-set consisting of only images and train the system with that image data. That was time consuming and troublesome. And to make it less time consuming, the engineers introduced the use of such a damage recognition model which is parameter less CNN model that only needed two calculations to create the training data-set. So the SHM system was a success in providing accurate and perfect damage detection in structures. Furthermore, the DL network was used to detect cracks in tunnels without considering any defected properties manually. So it was proven that the DL was more effective and accurate than any traditional image recognition approach in case of detecting any kind of cracks in concrete tunnels or structures. So DL is already a promising approach in the field of structural engineering. [4]

2.7 Smart cities with IOT

Smart cities is the concept where to gather and analyze different types of data of a city like traffic, waste, usage of energy, different kinds of IOT devices are used for example different sensors, meters, lights etc. So it can result in automated city management by providing efficient performance. The cost of the city is reduced as well as the life of the citizens are improved by having a great automated process and good time management in different kinds of city tasks. In smart cities, the city structures are connected with the smart grid system using the smart meter. Thus a great energy efficient city system can be introduced by analyzing the structures and make them connected to smart grids for automated energy efficient power system. It reduces cost as well as makes the whole process very time efficient. So without having to provide a manual energy flow system in a city, the entire process can be

done in a automated way by using smart sensors, smart meters and smart grids. So the standard of living of the citizens can be improved. And to do all of these process of course the structural evaluation is very much necessary. If we do not know the condition of the city structures then any of these process are not possible. At first the city structures are needed to be evaluated and they are needed to be built in a planned way. Also the existing structures are needed to be monitored time to time and make the process automated to detect any flaws and pre-evaluate them for any kinds of natural hazards. And to do them collecting high quality city images are necessary in a smart way. So the process is automated using different types of high quality cameras and high quality sensors. So the concept is the entire city structures will be monitored and ML is used to make the process further automated. The concept is that the city system is trained with DL by using different city structure images and then the entire city is monitored and whenever any irregularities of a structure is found the system automatically generates a structural evaluation report which presents the current condition of the structure. So DL plays a very vital role to make a city smart.

2.8 Improving the performance of structural engineering with AI

The vast progress in the AI is also improving the structural engineering in an automated way. And it all has happened in the past decade. With the advancement of technology, the advancement in structural engineering is visible now. To cope up with the latest technology, structural engineers are also updating them with the latest AI approaches. So in this section we will talk about how AI plays a vital rule to improve structural engineering. The use of AI in this area is not new but different types of automated approaches in this sector has been playing a game changer in the recent years. So at first to talk about the structural designs AI is playing a great role. AI is used to generate more accurate building designs and making the design generation process totally automated. Which means, currently there is no need to actually draw structural designs from scratch. Based on the structural requirements, the AI technology is capable of generating building designs automatically. So it saves a lot of effort as well as time. Because of the automated design process, the engineers can shift their concentration in different other areas which makes the entire process very balanced.

Moreover, previously structural flaws were needed to be identified manually. And because of that, many flaws could not be identified which resulted the structure to be vulnerable during any natural or man made disasters. But now with the help of the AI technology this entire structural flaw and damage detection process is now done in a fully automated way. That is why now any types of flaws on the structure can be identified and handled very smartly. So from the design process to identifying any building flaws to structural management the entire process can be now handled very smartly and in an automated way. To talk about different approaches, AI improves performance in Structural Health Monitoring(SHM) system by automatically monitor different types of health or condition of structures. It manages an automated monitoring system with the help of it's trained image data and checks for any types

of flaws in the structure. Whenever the flaw is detected, it automatically produces an output report which suggests if further building evaluation is required or not. Moreover, AI has changed the scenario in construction management also. From initial structural model to initiating different plans to improve structural quality, AI is now everywhere to make the entire structural engineering process fully automated. [5]

Chapter 3

Technologies Used

3.1 Back-end

I have used Microsoft software development environment which is the ASP.Net MVC Core to develop the back-end part of my application. Asp.Net version 6.0 is used in my web application. I have used the Visual Studio 2022 as the Integrated Development Environment. Visual Studio is most popular development environment for c sharp programming. As the programming language I have used sharp. It is a very popular and lightweight framework to develop different web application. It is also an open source web development framework which means that any developer can contribute to the framework. The full form off MVC is Model-View-Controller and the developer gets to work in this development architecture where the model, view and controller are connected to each other which makes a total work flow in the application. There are also different types of design patterns which can be used in this Microsoft development framework. In my web application I have used the repository pattern architecture. And in the repository pattern architecture, first I have created repositories for each and every database tables to connect with them through my project. Which means at the very beginning I have designed database tables according to my project planning.
Also I have created different types of relations between them. So after completing my database design, I switched to Visual Studio 2022 and created the repository pattern. After creating each repository against their database table, next I have created the services for all the repositories. And the services are used directly in the controller to inject the repositories which are necessary for each of the controller to manipulate the data in the database. And for each and every methods in the controller, I have created Views which holds the code for the front-end part. And also for each database table, I have created different Models in my project and defined all the properties which I have designed and created in the database table. So what we can understand is that the model-view-controller are the core part of this architecture and are internally connected to each other to create the data flow in the application.
Also I am using the appsettings.json file to define my database connection string to connect with the database. To store my code I have used the github which is the most popular version control and code management system. And for my project I have created a private separate repository in the github and to push and pull my coding changes I have used the gitbash console. I have also implemented the

gitignore file to ignore unnecessary changes in my project and it is very useful. I have used code first migration in my project. It is code first to interaction with the database. Which means I can create the code first to create, edit, update the database. It makes the entire process very easy. So inside the migration folder I can view all my migration history and if I need to revert any changes I can do it very easily from this migration folder. Inside the Dependencies section I can view all my project library dependencies. And last but not least, the wwwroot folder is the root folder of the application which holds different important things such as the project images, assets, libraries which includes Bootstrap, Javasript, Json, CSS, Fonts, Webfonts, jQuery Validation scripts etc.

3.2 Front-end

To develop the front-end of this web application, firstly I have used the Hypertext Markup Language or shortly know as HTML. It works as the core skeleton of a web page. So to develop my web application pages, I have written HTML codes to create the basic structure. I have used ViewData to provide my page title. And I have also defined the Layout at the very top of my web page. This layout is necessary to inherit some fixed part of the page structure which we are willing to use repeatedly like the header, footer and different types of menu. I have coded the page structure using HTML and I have used all the major HTML tags and attributes in my web application and some of them are section tag, div tag, p tag, h tag, a tag, ul tag, li tag, i tag etc. HTML is important because it works as the backbone of web pages and different types of browsers understand this language and generates the structure of the web page accordingly.
And for the web page design, I have used necessary CSS properties in my project. It is used to style web pages and also create different types of pre-defined layouts. There are different versions of CSS and each of them is more improved and optimized than the previous version. With the help of this, we can add any types of styling and animations in our web page, define color codes and use them all over the application. There are different types of CSS like the in-line CSS, separate CSS and more. In my web application I have used the in-line CSS to code the CSS part. I have styled the header, footer, body and other related parts of my web application with the help of CSS. I have also defined several layouts for my web application pages.
Next I have incorporated Bootstrap in my system to extent my CSS features furthermore because it is a CSS framework. It works with different types of classes in the HTML tags. There are a lot of pre-defined Bootstrap classes which I have used in my project and to be more specific, I have written these Bootstrap classes in my HTML tags. It makes the web application responsive which means the web application will be perfect for any types of devices and any screen sizes. It is also an open source framework and reduces CSS codes in a great amount because of the introduction of CSS classes. In these classes there are different types of CSS codes which are pre-written by developers and that is why we can only use these classes to achieve the behaviour of CSS codes without writing the raw CSS codes. So Bootstrap makes our development and styling of front-end in a web application very time efficient and perfect.
Moreover, I have used the MVC razor engine which is actually a markup syntax to

generate the front-end Views of my web application. These Views are specific for every functions that are written in the controller. So there is an auto code generation framework in MVC which is known as Saffolding. At first I have written my necessary functions in my controller. After that I have generated the View using this MVC scaffolding framework to generate my MVC razor view which is actually a markup syntax. Then finally I coded with HTML, CSS, Bootstrap in this generated Razor View to build the front-end web pages of my web application.

3.3 Deep Learning for Image Processing

So as I have described earlier that I have used DL approach in my web application to build my data-set and train my data accordingly. The reason for choosing and using DL is for the accuracy. In today's world and in the aspect of structural engineering, DL is the approach which is producing the maximum accuracy and it is being used widely for image recognition. Because of the above circumstances I have choose DL to be my approach for the image recognition model in my web application. I have used total two types of data inputs in my web application. One is the manual user input and the second is the data that is extracted from the image by using the DL approach. So, for the DL approach to work, at first the data is taken from the user by some manual data inputs. For example, some of the non image data are the no. of floors, if the structure has glass wall, the area of the structure, the type of the building, the address of the building and if the structure is a smart structure. And for the DL approach I need a total of three types of images as my input parameter. The first type of image is the vertical view of the building which means the structure should be vertically visible in the first image. The second input image is the isometric view of the building. In this image, the 3D view or view from an angle of the structure should be present and also the neighbouring structures should be visible in this image. The last input image is the satellite view or the google map view of the building. So in this type of image, the satellite view or structural view of the google map should be present. This three types of image will be asked to the user to upload and these three images are the DL input images for the web application. The first image which is the vertical view is to detect the vertical irregularity of the structure. The second input image is the isometric view of the structure and this image is used as an input image to detect the pounding effect in a structure. The third image is the google map or satellite view of the building and it is taken as an input image to detect the plan irregularity of any structure.
Moreover my DL data-set is also image based which means I have used image only to train my DL model. Data has been collected from 12 different areas of Dhaka city such as: Badda, Banani, Baridhara, Dhanmondi, Jatrabari, Khilgaon, Lalmatia, Malibagh, Mirpur, Mohammedpur, Panthapath and Uttara. And after testing with the sample of 222 buildings from these 12 different areas I have managed to get an accuracy of 71 percent. The DL output is whether vertical irregularity, plan irregularity or pounding effect is present in a structure.

3.4 TensorFlow Inception Deep Learning Model

In my project I have used the ML.Net library from the Nuget package manager as the DL model. To be more specific, it is the TensorFlow Inception DL model. So it can be integrated into the project in two different ways. One is by using the package manager console and the other way is by using the Nuget package manager console from the Tools section. I have used the second way which means I have added the ML.Net library reference in my project by using the Nuget package manager. After that by right clicking the solution, there is an option named "Add". It can be used to add different libraries and classes into the project. So in the "Add" option there is a option named "Machine Learning Model". And by clicking on this option the ML model will be added into the project. Under the MlModel.mbconfig there comes three total files which are: MlModel.consumption.cs, MlModel.training.cs and the third one is the MlModel.zip. So after opening the MlModel.mbconfig file, at first the model will ask us to select which scenario I am willing to use. [6]
There are many types of scenarios. Under the Tabular scenario there are Data classification, Value prediction, Recommendation and Forecasting. Under the Computer Vision scenario there are Image classification and Object Detection. Also under the Natural Language Processing there is Text classification. So from all these scenarios I have selected Image classification to fulfil my goal. After selecting the scenario, the next step is the Environment selection. There are three types of Environment and they are: Local (CPU), Local(GPU) and Azure. I have selected Local (CPU) as my CPU is powerful enough to deal with the processing. The next step is the training data selection. This data will be used to train the ML model. The structure of the folder should be one parent folder and inside the parent folder there should be child folders and inside the child folders the training data should exist. In my case I put my structural images in these child folders as my training data-set is images. So after selecting the data parent folder, image data preview will be shown. The next step is the Training step. In this step there is only one option which is "Start Training". The ML data training will be immediately started by clicking this option and the ML system will be trained by this data-set. It may take several minutes for the training to be completed. [7]

3.5 Database

For the database development of my project I have used the Microsoft SQL Server 2018 and Microsoft SQL Server Management Studio 2018. And my database is relational database. After opening the Microsoft SQL Server Management Studio 2018, the first thing that will appear is a popup. It will ask for the credential to login to the SQL server. And after loging in, there will be an icon on the left side containing the local server name that I am connected to. It can be expanded by clicking on the "plus" icon. There will be several folders visible upon expansion such as: Databases, Security, Server Objects, Replication, PolyBase, Always On High Availability, Management, Integration Services Catalogs and XEvent Profiler. Each of these folders are expandable again. To create a new database I have right clicked on the "Database" folder and selected the "New Database" option. Doing so the system will ask for a database name. After providing the name I have clicked on the "OK" button to create my database successfully. Then we will be able to

show our newly created database under the "Databases" folder. This newly created database can also be expanded by clicking on the "plus" icon. After expanding this newly created database there will be again different sub folders such as: Database Diagrams, Tables, Views, External Resources, Synonyms, Programmability, Service Broker, Storage and Security. So to create new database table, I have right clicked on the Table folder and selected the "New Table" option. Then the system has redirected me to an table design mode. Here, necessary table property name and there data types should be defined and also the primary key and the foreign key and if null is allowed that should be defined. If the table is auto incremental, that should be defined too. If any table has any relationships with other tables that should be defined also from this table design mode. After designing the table successfully, one should save the table and upon saving another popup will ask for the table name. After providing an appropriate table name, the table will be created successfully.
For my project, I have created a total of 15 tables and relationships. The first table is the "MigrationsHistory" and the columns are MigrationId and ProductVersion. This table is used to store all the database code first migrations and it is an auto generated table. Then the next table is "Areas" and the columns are AreaId and Area. It is used to store all the area names of dhaka city which I have included in my project and their ids. Some other auto generated tables for user management and role management are AspNetRoleClaims, AspNetRoles, AspNetuserClaims, AspNetUserLogins, AspNetUserRoles, AspNetUsers and AspNetUserTokens. These are all system generated tables and are used for storing and managing user data and user role based data. The main table of my project is the "BuildingEvaluations" table. It holds all the building evaluation data and the columns of this table are: EvaluationId, NumberOfFloors, GlassWall, VerticalView, Latitude, Longitude, AreaId, BuildingTypeId, PlanIrregularity, Pounding, SoilType, StructuralEvaluation, VerticalIrregularity, Address, ConfidenceScore, HighRise, MidRise, SoilTypeScore, GoogleMapView, HorizontalView, IsSmartBuilding. So it is the main table of my project which holds all the structural information as well as building images information. The next table is the "BuildingTypes" and it's columns are BuildingTypeId and BuildingType. It is used to store different types of building names and their ids. The "ChangePasswordModel" table holds the password information of the users and it's colums are CurrentPassword, NewPassword and ConfirmNewPassword. Next comes the "SignInModel" table which I have used to store the user credentials for signing in to the system and the cloums of this table are Email, Password and RemenberMe. The "SignUpUserModel" table holds all the credential information related to a user to register to the system and the colums of this table are FirstName, LastName, Email, Password and ConfirmPassword. Lastly the "User" table is also a major table of this project which is used to store all the user information of the system and the columns of this table are FirstName, LastName, Email and Mobile. So this is the entire database design information of my project.

3.6 Structural Evaluation Database Table

After saving structural data, the structural evaluation table including all it's columns are given below:

ID	Address	Storey	Mid Rise	High Rise	Vertical Irregularity	Plan Irregularity	D Type	Pounding	Final Score	Beam Status	Detailed Evaluation
1	H#27, UD Road, Bakshi bazar	9	0	0.4	0	-0.5	-1	0	2.1	1	0
2	H#32 UD Road, Bakshi Bazar	7	0.2	0	-2	0	-1	0	0.4	0	1
3	31 Girdda Urdu Road, Bakshi Bazar	8	0	0.4	0	-0.5	-1	0	2.1	1	0
4	H#33A, Giridi Urdu, Bakhshi Bazar	5	0.2	0	0	0	-1	-0.5	1.9	1	1
5	H#7, Bakshi Bazar Lane	6	0.2	0	0	0	-1	0	2.4	1	0
6	4A, BakshiBazar Lane, Chalk Bazar	6	0.2	0	0	0	-1	0	2.4	1	0
7	4\K BakshiBazar Lane, Chalk Bazar	7	0.2	0	-2	0	-1	0	0.4	1	1

Figure 3.1: Generated Database Table

Chapter 4

Development Process and Application Features

4.1 System Login and Signup Feature

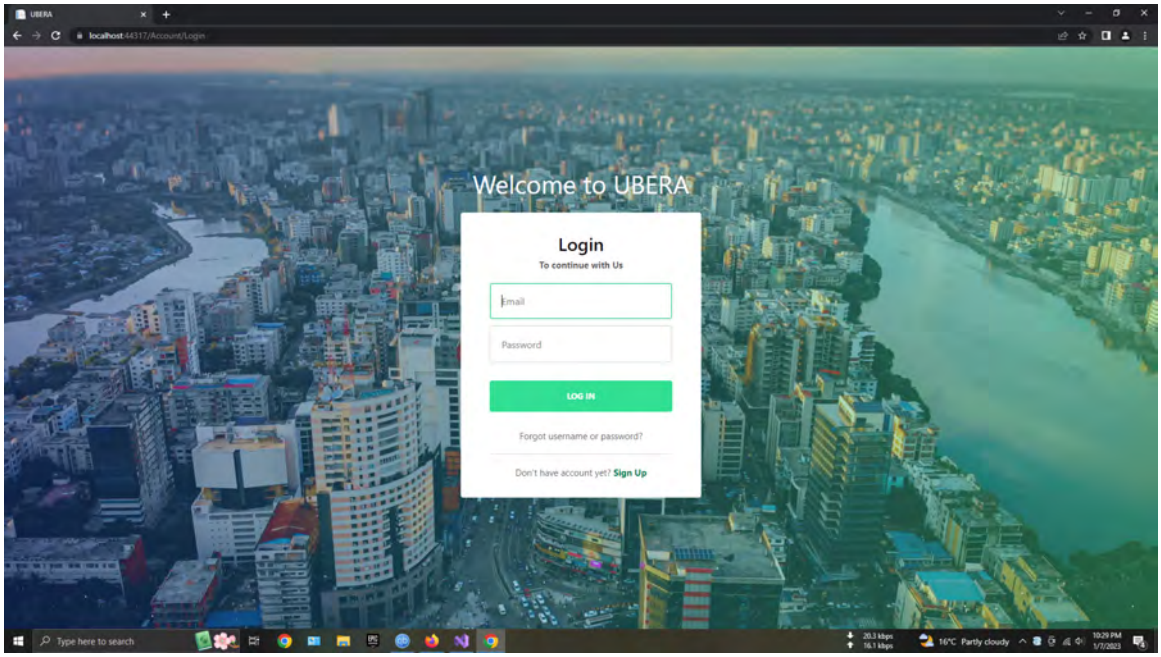

Figure 4.1: System Login and Signup Feature

The system has sign-up and login feature just like any other professional web application. After the system loads the Login page is the first page which appears. The user must be registered into the system to login to the web application. If it is a new user then he/she needs to first register by providing some basic user information like the first name, last name, email, password, mobile, confirm password. And to do that a user should click on the Sign-up link in the Login page. Doing so the system will redirect the user to the user sign-up page. In the registration page, the user will have to enter required information as mentioned and click on the Sign-up button to register as a new user into the system. Then after registering into the system, the user will be redirected to the login page. Then the user will be able to login into the system with the newly created credentials. If the user has already completed the

registration process earlier, he/she can skip the registration process and can login directly to the system with their credentials from the Login page of the application.

4.2 Home Page and Menus

Figure 4.2: Home Page

After Login into the system, the system will redirect the user to the Home page of the application. After accessing the Home page, the user can find that there is a navigation menu from which different pages of the system can be accessed. Home, Building Evaluation List, Evaluate Your Building are some of them. Also there is a drop-down item where the logged in user will see his/her full name. It is a drop-down menu and by clicking this item two drop-down options will appear one is the logout option and the other one is the change password option. By clicking logout option the user will be logged out of the system and the system will again take the user back to the Login page from which the user will be able to login again. The "Change Password" option will redirect the user into the change password page. This page will ask the user to enter the existing password, also the new password that the user wishes to be changed to and confirming the new password again. After inputting all of these properly the user needs to click on the "Change" button will change the password of the user successfully and the "Back" button will take the user back to the Home page again. There is also a custom logo of the system at the top and at the left side of the home page in the navigation bar. The navigation bar is transparent and has a big slider in the home page which makes the application very attractive. In the navigation bar, by clicking the Home option will take the user back to the Home page, Building Evaluation List will take the user back to the List page of the Building Evaluation and the Evaluate Your Building option will take the user into the Building Evaluation page. The Home page also has some other sections like Best Features, Blogs, Why choose us, Statistics, Quotes, News and the

footer section. The footer section has different navigation links, contact information and copyright information.

4.3 Evaluate Your Building Feature

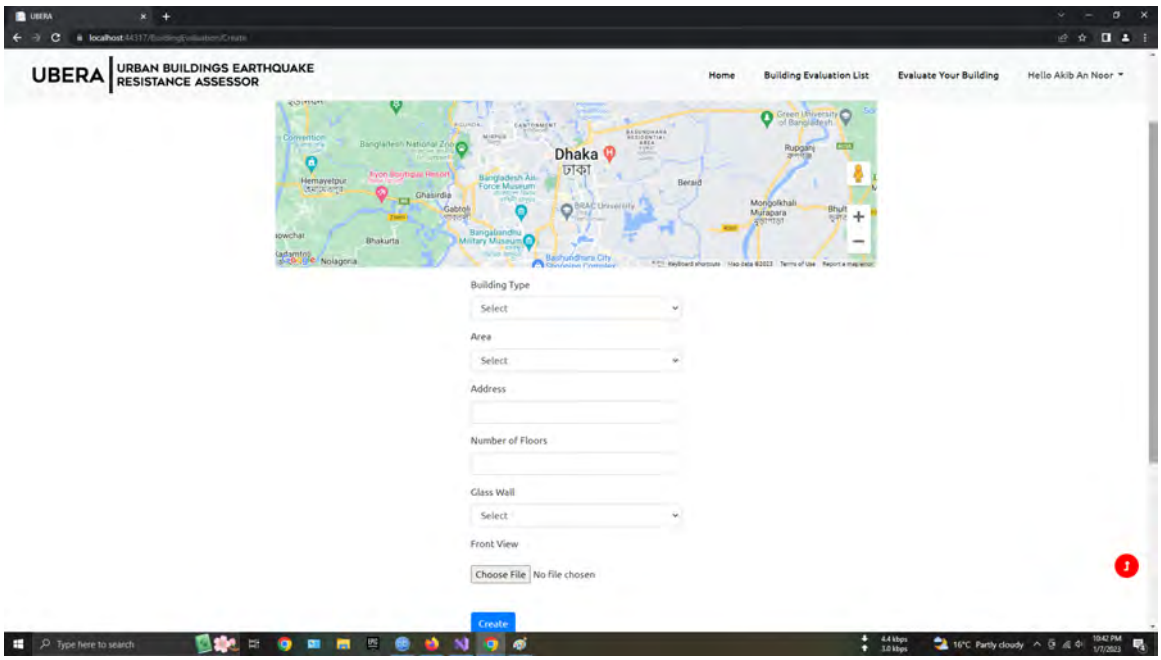

Figure 4.3: Building Evaluation Page

In the Evaluate Your Building page, the first thing anyone will notice is a Google Map section. There are also different input options in this page such as Building type, Area, Address, Number of Floors, Glass Wall and Image upload option. To enter the building evaluation information at first the user will have to select the building from the Google Map. The Google Map in this system is a API implemented from Google. This map is exactly the same as the Google Map we use everyday. The map can be zoomed in or zoomed out which makes the users easy to navigate any buildings. Also it has some other important features like switching to the map view and satellite view, full screen option, street view option etc. After selecting the building in the google map, the user will have to select which type of building is that by clicking the Building Type drop-down. The Types are: Commercial, Mixed, Residential, Industrial, Hospital, Other, N/A etc. Next the user will have to enter the Area in which the building is situated. There are almost all areas of Dhaka available in the Area dropdown such as: Badda, Banani, Baridhara, Dhanmondi, Jatrabari, Khilgaon, Lalmatia, Malibagh, Mirpur, Mohammedpur, Panthapath, Uttara etc. So the user will have to select the building Area from all these Areas. After that the next field is the building Address. In this field the user needs to type the exact address which should consist of the building street number, exact apartment number and building number. The next field is the Number of Floors. Here, the user needs to type the total floor number of the building. The next field is the Glass Wall. It is also a drop-down. The options are either yes or No. If the building has wall made of glass then the user will have to select Yes and if the building has no walls made

of glass then the user will have to select No. After that there are fields to upload the building image. By using these fields, the user can upload their building image from every angle. After uploading, there is also option to crop the uploaded image. This feature is exclusively included to make the image more perfect for the purpose of image processing accuracy using machine learning. After successfully providing all the required information, by clicking the create button will add the information into the Database and the user will be taken back to the Building Evaluation List page. Thus the user will be able to view the entry into the list page table. There is also data validation implemented in this page which means if anyone does not provide any information and just clicks the create button then the blank data will not be saved and the page will prevent the redirection to any other page and also validation error messages will be shown.

4.4 Building Evaluation List

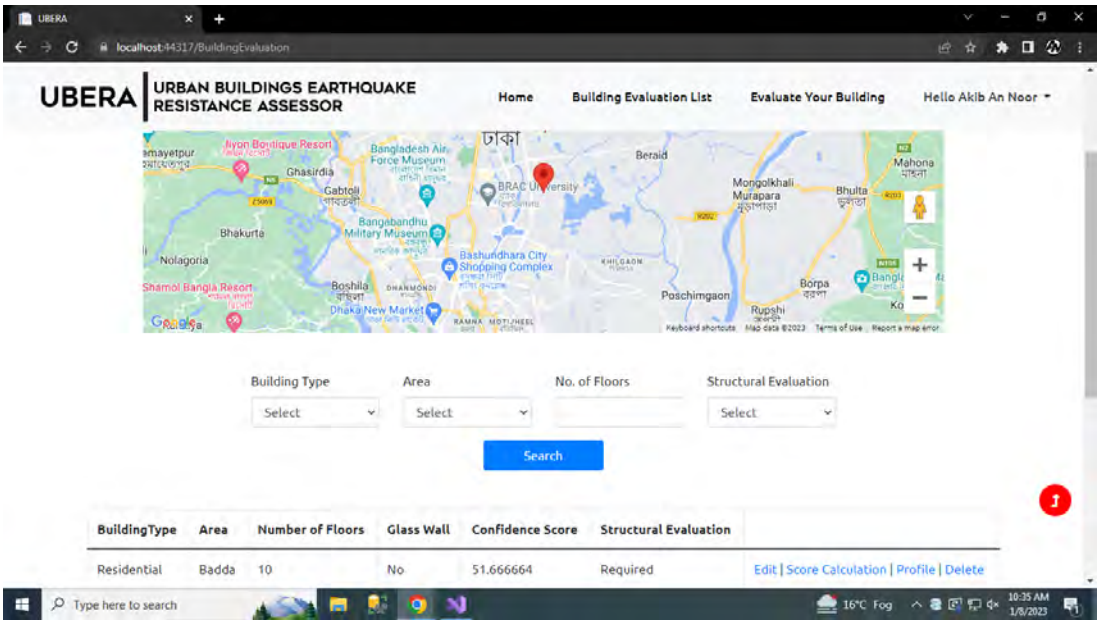

Figure 4.4: Building Evaluation List

The Building Evaluation List page contains all the created building information in all in one table. Also at the top of the table there is a Google Maps which shows all the created building location by a red colored pin in the map. The table data can be searched by a total of four filters and they are: Building type, Area, No of Floors and the Structural Evaluation. These search filter boxes are right above the table. There is also a search button. So to search any specific data in the table the user can enter their required info in any of these four boxes and by clicking on the search button the data filtered data will be shown in the table. The table has all important columns like Building Type, Area, Number of Floors, Glass Wall, Confidence Score, Structural Evaluation etc. There are also some actions which can be performed in the data table rows which are: Edit, Score calculation, Profile and Delete.

4.5 Building Evaluation Edit Feature

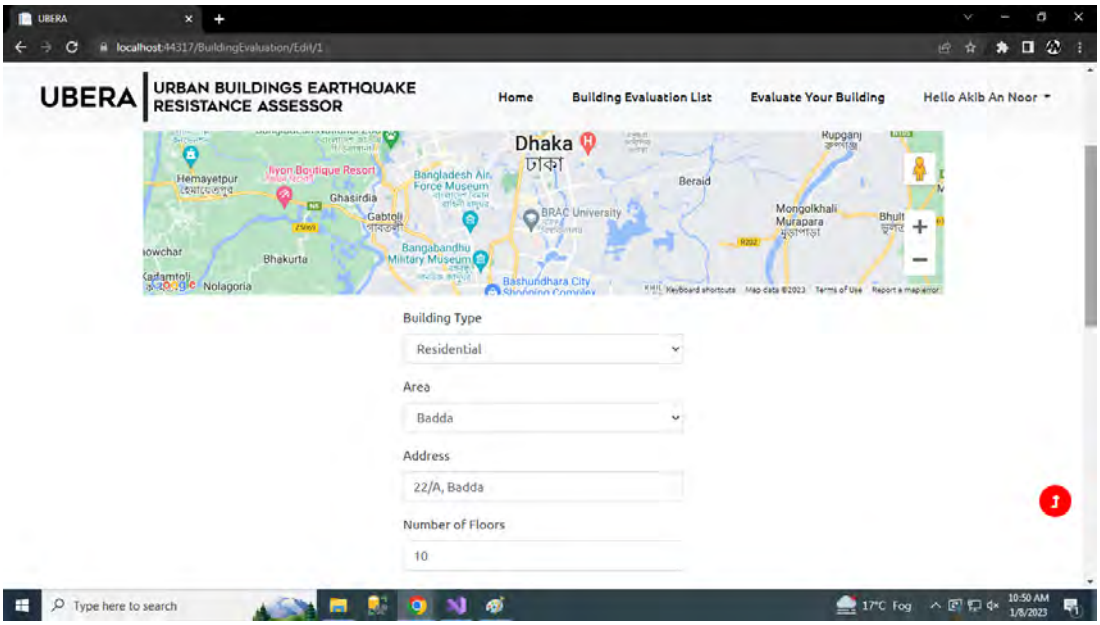

Figure 4.5: Building Evaluation Edit Page

From the Building Evaluation List page, by clicking the Edit link from the table row, the user will be taken to the Building Evaluation Edit page. The Edit page has all the same data fields as the Evaluate Your Building page but it the difference is that the data fields will show all the information regarding to that data table building information which you have clicked. Here is also a Google Map which will again show the exact building location by a red colored marker. Building type, Area, Address, Number of Floors, Glass Wall etc. all of these information will be shown in their specific fields. Also the uploaded building images will be shown here. So the user will have the authority to change any information form here and for that he/she just need to enter the new information in the data field he/she wishes to edit. Finally the user needs to click the Update button which will successfully update the information and will take the user back to the Building Evaluation List page. This page also has the data validation feature which means required data fields cannot be left empty or else the submission will be canceled automatically and validation error message will be shown. Page header and footer are also available in this page from which the user will be able to navigate to any other pages very fast.

4.6 Building Profile Feature

From the Building Evaluation List page, by clicking the Profile link from the table row, the system will take the user to the Building Profile page and this page is a details page of a specific building and contains all of it's information in details. It also has the building image shown to the user. The page contains all the information a building has and the fields are: Building Type, Area, Address, Number of Floors, Glass Wall, Plan Irregularity, Vertical Irregularity, Pounding, Soil Type, confidence Score, Structural Evaluation etc. So if a user wishes to know any specific building information in detail he/she can visit this Building Profile page to get each and

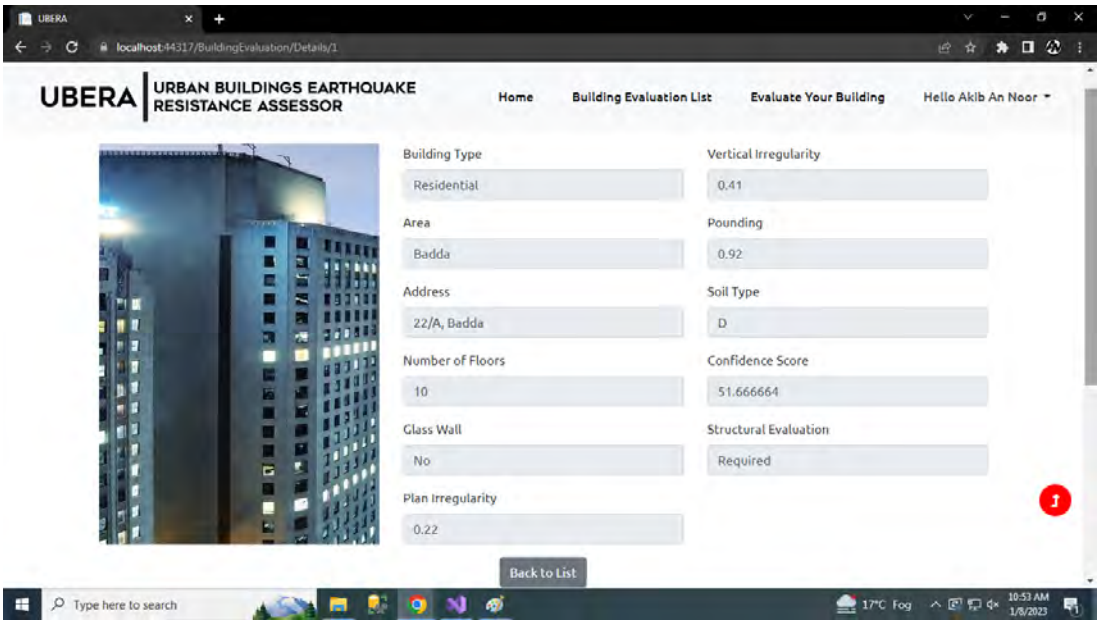

Figure 4.6: Building Evaluation Profile Page

every information a specific building has. There is a back to list button and if the user clicks this button then the system will take the user to the Building Evaluation List page and this page also has the header and footer included in it so the user will have the opportunity to navigate to any other page in a very fast way.

4.7 Building Evaluation Delete Feature

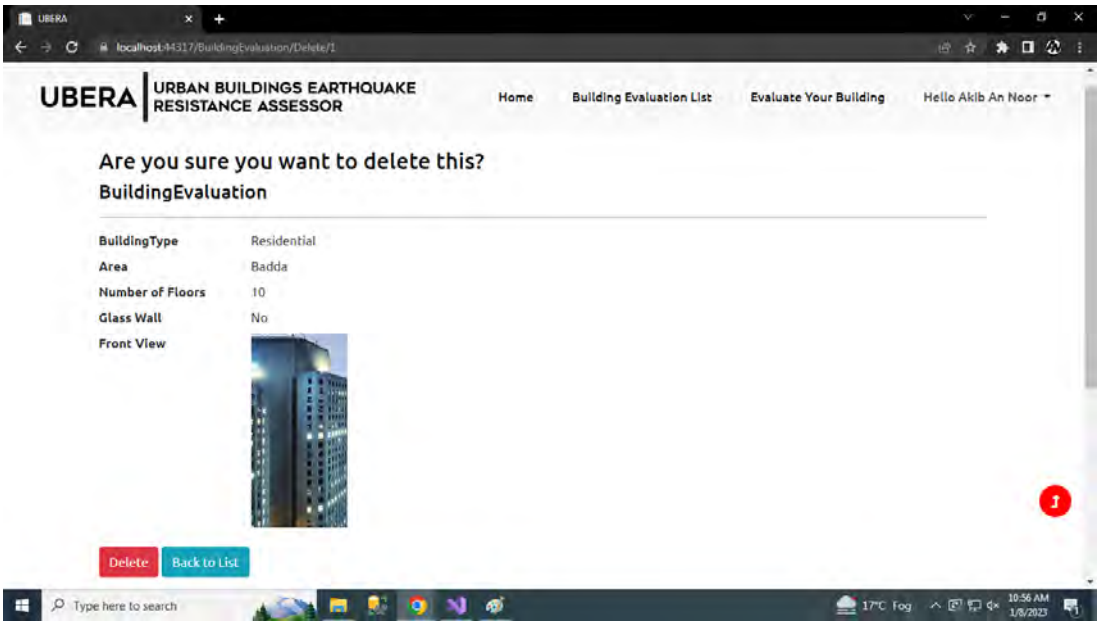

Figure 4.7: Building Evaluation Delete Page

Again from the Building Evaluation List page, by clicking the delete link from the table row, the system will take the user to the Building Evaluation Delete page and

this page is similar to other pages but the difference is it does not hold unnecessary or all the building information in it. Well it's understandable because it's a delete page and it should not contain all of that. After accessing the delete page the user will see some of the basic building information of that specific building he/she wants to delete. The building picture will be also shown in this page. Then at the bottom there is the delete button which is red colored. By clicking that button the building information will be deleted and the system will take the user back to the Building Evaluation Page again. Also beside the delete button there is another button named Back to list. It can be used to return back to the list page without deleting anything.

4.8 Adding and Training ML.Net Machine Learning Model

This section describes how to work with the Microsoft Machine Learning model. At first, I have downloaded the ML.Net package for Microsoft visual Studio from their official website. After that, to add it in the project, I have right clicked on the main project file inside Microsoft Visual Studio. Then selected "Add" and after that I have selected "Machine Learning Model" option. Then from the options I have selected "Machine Learning Model(ML.Net)" and finally clicked on "Add" button to add. After that the system have asked me to choose actually which type of ML.Net Model I want from many of them. At first, the first the system will ask to choose for a scenario. Data Classification, Value Prediction, Recommendation, Forecasting, Image Classification, Object Detection, Text Classification are the total number of scenarios offered from the system. I selected Image Classification among them because my goal is to identify building conditions from their images. So after clicking on Image Classification, the next step is setting up the environment. In this section, there are a total of three options. The first one is the Local(CPU) and this means that the data will be trained on your local machine, the second one is the Local(GPU) and this means that the data will be trained locally on your machine with GPU and the last one is the Azure (Microsoft) and this means that the data will be scaled out to the cloud and trained in Azure. For my image data training, I have selected the Local(CPU) option. After going to the next step, the system will ask the user to add data to be trained. There is also an example data folder structure given in the right hand side and which tells that there should be one parent folder, and inside that parent folder there should be sub-folders containing the images to be trained as the data-set.

I have selected my data-set as required. The next step is the data training. In this step, the system will ask the user to train the data-set by clicking on the "Start Training" button. By clicking that button, the system will start to train the data. It will require some time which is based on the computer performance. In my system, it took about four to five minutes to finish the training of the data-set. The training results will be visible providing us the Best Accuracy which I got about 85 percent, Best Model which I got DNN + ResNet50, Training Time was 236.60 seconds, Models Explored(total) was 1 and Generated Code Behind was MlModel.consumption.cs, MLModel.training.cs. These were the training results for my image data-set. Then I have clicked on the "Next Step" and the next step is

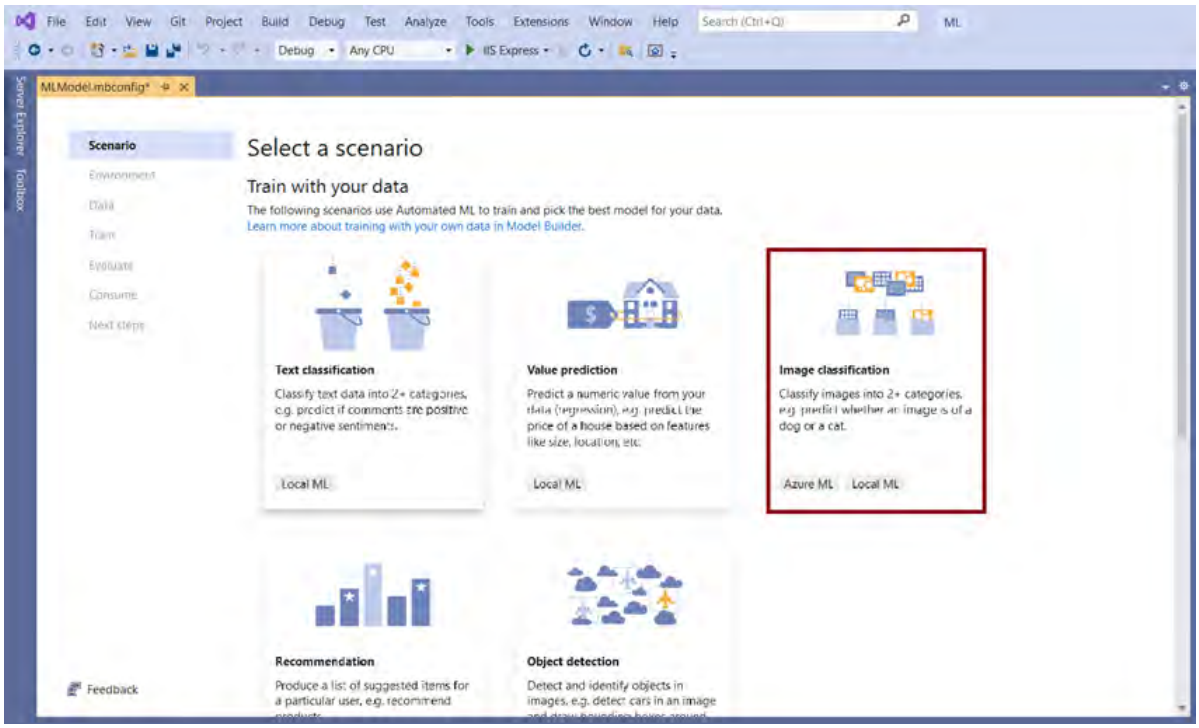

Figure 4.8: ML.Net Integration

"Evaluate". In this step, we can input any image and get machine learning output result based on the trained image data-set we have just trained. To do that, I have clicked on the "Browse and image" option and selected my image. After some time, the system will automatically show the machine learning results of that image based on our trained image data-set. Then after clicking on the "Next Step" again, the next step will appear and it is the Consume model. In this step we can consume this model to our project. If this model serves our purpose then we can consume this model in three ways into our project. The first step is we can copy a code section directly to implement this model in our project and this code can load sample data as well as load model and predict output. The other model is to add an Asp.Net Core console app which uses our model to predict results. The third way is to add an Asp.Net Core Web API that consumes our model. For the second and third step there is a "Add to solution" option which adds these into our system instantly. For my project, I have added the console app into my system. Now if we run the console app from our project, we can get our desired machine learning output score. [8]

Chapter 5

Assessment Result and Evaluation Report

5.1 FEMA Model

FEMA is a method to evaluate the strength of a building on the basis of various attributes such as high/medium stress,characteristics of soil, irregularity in ground plans , perpendicular indiscipline of structures and many more. If we follow 2002 FEMA model, we observe there exist various types of structures in Dhaka among what specialists consider to be immensely moderate urban constructions . Such type of building has a base count of 3.2 which predicted to be free of risk if the resulting collective count for all sectors in over 2. My work is followed by this FEMA model with respect to the soil type of Dhaka city,which are basically D and E type soils. Most buildings in Dhaka do not obey the rules set by the government. We also observe that distance between two buildings is not appropriately maintained . This distance which is also called pounding , plays a very vital role on the impact of earthquake . Following FEMA 154 tier1 model as we examine building hazard in Dhaka , we can address pounding to be one of the major issues.According to a research by a top public university in Bangladesh “pounding” is considered a building risk factor.

5.2 FEMA Score Calculation

In this chapter, we will learn about the output result of this software system. I have implemented the FEMA standard in calculating the building score. And to calculate the FEMA score there is an equation. The goal is to determine if the structural evaluation is required for a building. Data is collected from 12 different areas of Dhaka. The known labels for training of model ascertained using FEMA P-154(3rd Edition). The total flow is first the data is collected manually and then the data is accumulated and sorted. Then the FEMA score is computed and manual validation is performed. Then it is saved to the Database. After that the data is trained and it is tested and analyzed. Finally it is deployed. And the data is actually given for image processing is the structure image, total no. of floors, occupancy and the soil type of the area. Thus from these input data the image is processed using the machine learning technique and also manual validation is performed. The output we

get is the vertical irregularity, plan irregularity, pounding. After calculating these using the FEMA calculation standard equation we get the final output which is the confidence score and with that score we can understand if a structural evaluation is required for that building or not. The seismicity region is also considered for image processing and Dhaka is classified as Moderate region based on MCE Spectral Acceleration Response table. If the Spectral Acceleration response is less than 0.25 than it is considered as low seismic region. if it is greater than or equal to 0.25g but less than 1.0g then it is considered as moderate seismicity region and so on the Moderately High, High and Very high seismicity region is divided. The building type equation is Concrete Moment - Resisting Frame.

$$E_{CS} = E_{BS} + E_{SH} + E_{VI} + E_{PI} + E_{ST} \text{.....} (i)$$

Here,

$$E_{CS} = ConfidenceScore = SUM$$

$$E_{BS} = BasicScore$$

$$E_{SH} = StructuralHeight$$

$$E_{VI} = VerticalIrregularity$$

$$E_{PI} = PlanIrregularity$$

$$E_{ST} = SoilType$$

Basic score and minimum score are 2.1 and 0.3 respectively.
If,

$$ConfidenceScore < MinimumScore$$

then, Final Score = Minimum Score
On the other hand if,

$$ConfidenceScore > MinimumScore$$

then, Final Score = Confidence Score
Structural Evaluation is required if Final Score is smaller than cut off value 2.0 . Also if it exists Pounding, Falling hazards or Significant structural damage.
Soil Type Distribution:
There are a total number of seven soil types which I have considered in my web application during the research of soil types. They are,

rock soil, soft rock soil, hard rock soil, poor soil, stiff soil, soft rock soil and soft clay soil.
These are categorized based on Shear Wave Velocity, Standard Blow Count and Undrained Shear Strength. So based on the collected data and research I have found that Mohakhali, Niketan and Gulshan - 1 are Soft Clay soils and all the other areas of Dhaka city are Stiff Soil. There will be no change in FEMA score for Very Dense Soil and Soft Rock soil and also for Stiff soil. For Hard Rock soil and Rock soil the score is 1.1 and the score will be -0.7 or -0.8 for Soft Clay soil.

5.3 Getting the Output

So practically to calculate the FEMA score and getting the output result we need to navigate to the Building Evaluation list page. There in out list table, at the right hand side of each and every row we can see that there is an option named "FEMA Score Calculation". We need to click that option and the system will redirect us to the FEMA Score Calculation page. This page will show us some of the basic building information such as the building type, area, number of floors, glass wall etc. and there will be three fields such as the vertical irregularity, plan irregularity, pounding.

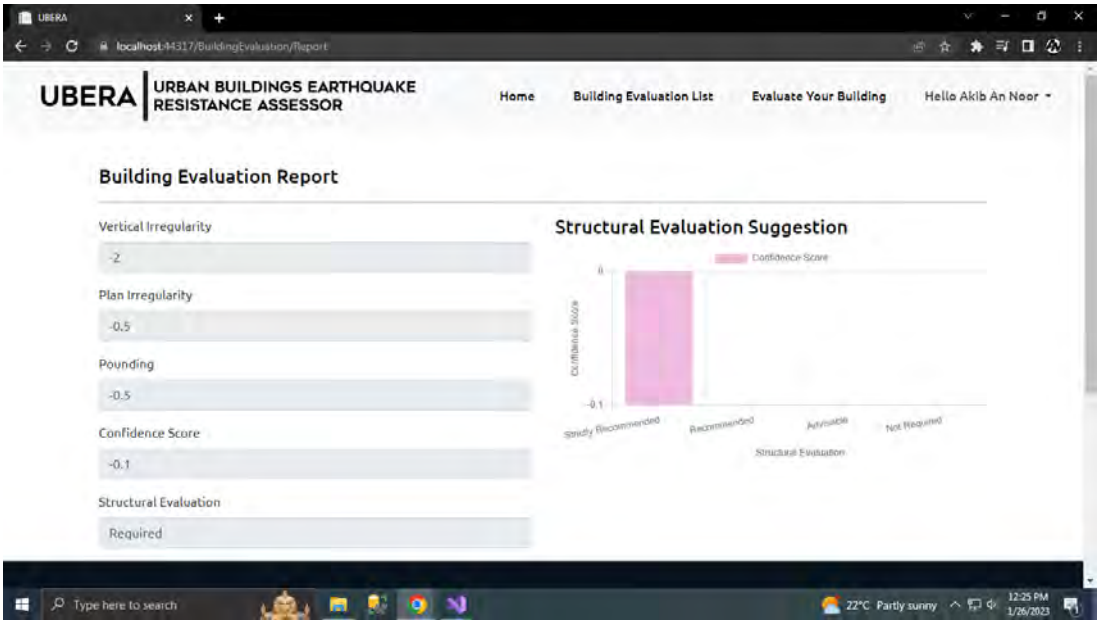

Figure 5.1: Output Result with Report

We need to put the values of these fields from our image processing result and we need to click on the "Calculate" button to calculate the FEMA score. After clicking on the "Calculate" button the system will automatically calculate out output score and will show us the building Confidence Score with a value. The system will also show us if structural evaluation is required or not which was our desired output. There will also be a graph showing us the output result for our better understanding.

Chapter 6

Conclusion

Neither we can Intercept the movement of earth plates nor their related earthquakes.The recent earthquake took place in Japan drew our attention to the fact that events of minimum probability and maximum impact may strike at any time.Such situation requires collective actions taken by nations,communities and individual families in order to develop resilience to risk in general.It's a procedure which requires effective measurements taken by not only the highest authority at every level but also non-profit associations,private sectors as well as personal individuals.
It's very important for the nation to understand the reasons and effects of earthquakes.With the growth of population,we notice that the expansion of modern development and structural work are gradually encroaching on earthquake-prone areas.We should gain proper understanding about the causes as well as the effects of earthquakes including clear knowledge about some facts as how earthquakes affect constructions,infrastructure and human social life itself in order to able to diminish the destruction and harm of life.Development of such knowledge and regarding actions will be slow ,sometimes really slow. But if we look at the benefits of them at a large scale,we shall say this development is worth pursuing.
In order to mitigate the effects of earthquakes,building code is a very essential factor.Surprisingly the earthquake hit Chile in April in a sale of 8.8 caused less causalities and fewer damage than the Haiti earthquake which hit in a scale of 7 in January.This miracle happened only because of the percipient investment into planning and infrastructure .
This system UBERA will not actually stop earthquakes which its not intended for, but it has the scope to cover the entire city and evaluate every buildings to expose their risks during earthquake and to motivate pre-assessment of different structures for a risk free living.

Bibliography

[1] Banglapedia: National Encyclopedia of Bangladesh,
https://en.banglapedia.org/index.php/Earthquake

[2] World Health Organization: Earthquakes,
https://www.who.int/health-topics/earthquakestab=tab$_1$

[3] Seismic Pounding,
https://www.sciencedirect.com/science/article/abs/pii/S0267726118313848

[4] IBM: What is Deep Learning,
https://www.ibm.com/topics/deep-learning

[5] Forbes: Predicting Earthquakes,
https://www.forbes.com/sites/davidbressan/2017/11/24/why
-cant-we-predict-earthquakes/?sh=31504dde6332

[6] Ml.Net: How does it work,
https://learn.microsoft.com/en-us/dotnet/machine
-learning/tutorials/image-classification

[7] Ml.Net: Model Builder,
https://devindeep.com/how-to-use-ml-net-model-builder-for-image-classification/

[8] Image Classification in Web Applications,
https://www.who.int/health-topics/earthquakestab=tab$_1$