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Disaster Damage Detection

Bachelor of Science in Computer Science

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Certificate

We accept the work contained in the report titled ‘Disaster Damage Detection’, written by Mr. Awais Tariq AND Mr. Sana Ullah Shah as a confirmation to the required standard for the partial fulfillment of the degree of Bachelor of Science in Computer Science.

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Abstract

Disaster Damage Detection System is a desktop based application which will use machine learning algorithm to perform classification on the given inputs i.e. (Latitude, Longitude, Magnitude, and Intensity) and will predict the damage that can be caused due to disaster. The system is first trained using training data sets. The system predicts the area damaged due to earthquake and flood, deaths due to earthquake, flood and financial-loss due to earthquake and displacement of houses due to flood.Disaster Damage Detection System also tells the difference between two satellite images. The system will analyze both images and will find the similarity index between the images. Image will be pre-disaster and post-disaster which will be analyzed to tell how much area is damaged.Disaster Damage Detection System can be used by the disaster management authorities. It can play important role in the recovery of damage caused by disaster and can help authorities to react properly to the disaster.

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Awais Tariq and Sana Ullah Shah
Islamabad, Pakistan

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“We think someone else, someone smarter than us,
someone more capable, someone with more resources will solve that problem.
But there isn’t anyone else.”

Regina Dugan

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Acronyms and Abbreviations

DSA	Data Structure and Algorithms
OOP	Object Oriented Programming
PF	Programming Fundamentals
SE	Software Engineering
SQL	Structured Query Language
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICODE	Unique, Universal, and Uniform Character enCoding
XML	Extensible Markup Language

Chapter 1

Introduction

In case, when there is a natural disaster happens, best emergency administration is required, including making data accessible by detecting the information regarding the disaster. For instance, the disaster management organization who is working in the city should gather all the information and tell the citizens about the damage in the result of the disaster like flood and earthquake. Disaster management organization have to arrange the best possible circumstances to minimize the effect of disaster. They also have to make the emergency repairs.

Disaster Damage Detection is a desktop based application that detects the difference between two satellite images to tell the similarity index and show us how much change occurs after the disaster.When system tell us the change we give different inputs of the changing areas i.e magnitude,latitude,longitude etc then system predicts the area damage that can be caused in case of earthquake or flood, deaths due to earthquake and flood, house displacement due to flood and financial-loss that can be caused due to earthquake.

To achieve these phases, we implemented image processing and machine learning algorithm using the help of different articles and the system is trained on data sets and shows the result. Results are evaluated to find out the accuracy and run time performance.

1.1 Problem Description

Infrastructure Damage Detection System is based on the ability to detect the damages in the region caused by natural disaster by the help of image processing and machine learning technique to predicting the area damaged, deaths and financial-loss that disaster can cause. When there is a natural disaster at that time it is very difficult for the authorities and different organizations to estimate the level of the disaster and the damages it can cause and how much area is effected because of different latitude and longitude and the authorities do not know what to do and how to handle the situation.In this situation there should be remote sensing technology by the help of which we can quickly get the desired results about the damages more efficiently as compared to human eyes. Our system will tell the regions affected by the disaster by the help of image processing. It will analyze two images pre-disaster and post-disaster and will calculate the similarity index between them. Further system will predict the area damaged financial-loss and deaths disaster can cause.

1.2 Objective

The main objective of the system is to:

- To respond more proper way and quickly.
- To detect the damage caused by disaster by analyzing satellite images.
- To locate the original area damages because of disaster.
- To predict the area affected by disaster.
- To predict the financial-loss caused by disaster.
- To predict the number of deaths due to disaster.
- To tell authorities which type of disaster it is.

1.3 Project scope

The system will differentiate the changes between two images using image processing technique and tell the similarity index and tell the damages done by disaster through machine learning technique.Our scope lies on same size, resolution and stable image.In near future we can check the similarity index on moving satellite images. The scope lies in the increasing trends towards human-computer interaction in more natural way to communicate with computer without traditional interface devices. Disaster Damage Detection System has application like:

- Research and education
- Disaster management Organization

1.4 Tools

We have used the following tools and technology in the development of Disaster Management System.

- Microsoft Windows 10.
- Microsoft office.
- Python Shell 3.6.0.
- Tkinter use for GUI.
- Spyder
- Latex

Chapter 2

Literature Review

In this chapter we will discuss the literature review of the disaster management system.

2.1 Related Work

As we are familiar that natural disasters are part of human life and thousands of people die on yearly basis because of natural disasters like earthquake, flood or storms. As well in is bizarre climate or any disaster happens, best emergency administration is required, including making data accessible by detecting the information regarding the disaster. For instance, the disaster management organization who is working in the city should gather all the information. In this case it takes a lot of time to by patrolling department of disaster management organization to gather information and realize the damage, even if we consider just serious damages by the disaster like flood or earthquake. In this situation there should be remote sensing technology by the help of which we can quickly get the desired results about the damage more efficiently as compared to human eye.

In the old systems they are just use to detect the damage of the disaster by the comparing the two images. One of the image is the before the disaster and the other image is after the disaster. System will just find the differences between the images, which is not a good system as a performance because it is not efficient, the reason behind this is it doesn't tell any forecasting of damage in the result of disaster.

The basic ideas of the previous research [3] was:

- The system shall be not only highly-functional but also inexpensive and robust.
- The system shall be linked seamlessly with daily operations of municipal governments.
- The system shall realize the individual and high-precision damage estimation of structures.
- The system has to predict progression of a disaster and response efficacy faster than the real-time progress.
- The system shall assist municipal governments not only in emergency operation but also in recovery and reconstruction operations. The system shall also be utilized in the preparedness phase, such as the emergency professionals training, the evacuation plan verification, etc.

2.2 Proposed Solution

The system we are thinking to develop will be able to predict the damage because of natural disaster. We have to enter the input values in the system for predicting the damage of the flood like the intensity, magnitude, longitude, and latitude. By the help of these input values our system will predict the damage of disaster by applying the machine learning technique of gradient boosting. Our system will help the disaster management organization to predict the damage of disaster like deaths of people, area damage and financial loss. These facilities are not available in the old systems used by the disaster management organization.

So, our system is very efficient in this regard that it can predict the damage in the result of the disaster like the flood and earthquake.

Chapter 3

Requirement Specifications

3.1 Proposed System

We propose a desktop application that will use machine learning technique and image processing technique to predict the damages caused by disaster. This will predict the damages caused by a disaster by analyzing the input values like latitude, longitude, magnitude. The results are given in the form of graphs which provide the predicted values of the damages that a disaster can cause.We hope that this application will be used by the Disaster Management Authorities to take a quick action in case on any bizarre situation. The purpose of the document is to describe the detail of disaster damage detection system using the image processing technique. This document is to explain the working, specification, functionalities, and constraints under which the system will operate and how it will behave with the external environment. This document describes all functional and non-functional requirements of the system.

3.2 System Overview and Scope

The scope lies in the increasing trend towards human-computer interaction in more natural way to communicate with computer without traditional interface devices. Disaster damage detection system has wide range of applications in fields like:

- Research and education.
- Disaster Management Department.
- Predict the damage due to Earthquake damage by disaster management organization.
- Predict the damage due to Flood damage by disaster management organization.

3.3 General Description

3.3.1 Product Functions

The primary perspective is to provide framework system which will be a new innovation because Disaster damage detection system is still in the phase of research and some works were done on MATLAB.
Using Image processing techniques, the image before and after the disaster is taken and compared and find the level of disaster remotely without human interference. At First, we take two images of good quality; these two images are before and after the disaster. Features are extracted from the first picture by famous feature extraction technique. Then features from the second picture are extracted and later on these features are compared with each other and we will find the difference between them by the help of gradient boosting. Then after extracting interested parts of picture, we can apply algorithm on them then we will compare them with sample features already stored in the database (sample database with predefined sample data which is predicted by the machine learning).

3.3.2 User Characteristics

The application does not require any special characteristics for the users. The users are expected to be familiar with windows based desktop computers. The application will provide a simple and easy to use interface which would not require any specialized knowledge or expertise.

3.4 Operating Environment

The following software and libraries needed to be installed.

- Windows XP or later
- Spyder (Python 3.6)

3.5 Constraints, Assumptions and Dependencies

- Visual Policies: Blur or Raster image can't give the proper/correct results.
- Criticality of system: In case of image is not clear by fog or smog or smoke, then the system will not detect the disaster effected area easily

- Input Values: The input values for predicting the damage in the result of disaster must be accurate.

3.6 Functional Requirements

The main function of our system is to detect the infrastructure damage due to disasters.

3.6.1 Login

The user will firstly login the system by the username and password.

3.6.2 Show Menu

After the sign in the user will see the menu of the system, which include the three modes

- Earthquake damage forecasting mode
- Flood damage forecasting mode
- Image processing

3.6.3 Earthquake Damage Forecasting

This is the first mode in which the user can forecast the damage due to earthquake by giving inputs.

3.6.4 Flood Damage Forecasting

This is the first mode in which the user can forecast the damage due to flood by giving inputs.

3.6.5 Image Processing

In this mode the user will upload the two images of good quality or resolution. The images were before and after the disaster. Our system will apply the algorithm and will find the differences.

3.7 Non Functional Requirements

3.7.1 Performance Requirements

The desktop computer should match with the minimum specification requirements that are required by the application. The processor, memory and the type of the windows should be compatible with the application.

3.8 Software Quality Requirements

3.8.1 SQR-01

The system will be able to recognize damage of disaster with 75

3.8.2 SQR-02

Our system should have availability to extended accordingly or be act as a module in other big system.

3.8.3 Performance

The system performs according to the Use Cases and flow diagrams.

3.8.4 Availability

The system will be available only to the disaster management organization.

3.8.5 Flexibility

The system will be flexible for enough for some later requirements change or features enhancement.

3.8.6 Usability

The interface and GUI design of the system will be user friendly with no training required to use the system.

3.9 Use cases

- Log-in
- Main Menu

- Earthquake Damage Prediction
- Flood Damage Prediction
- Image Processing

3.9.1 Main Use case

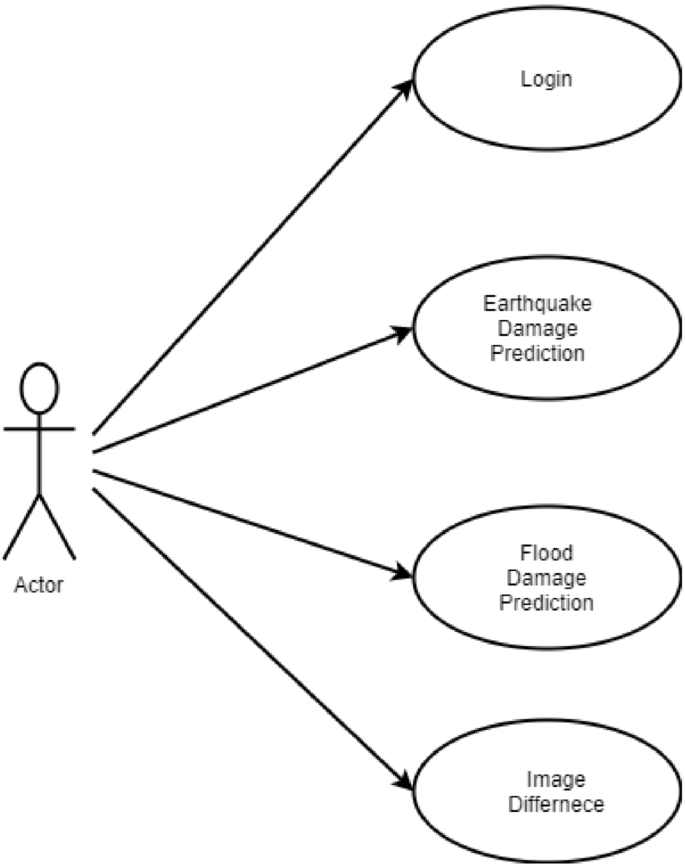


Figure 3.1: Main Use Case

Use Case ID	UC-1
Title	Main Use case
Description	User will be able to access the system and use it's functionality
Primary Actor	User.
Pre-Condition	System must be in running condition.

Table 3.1: Main Use case

3.9.2 Login Use case

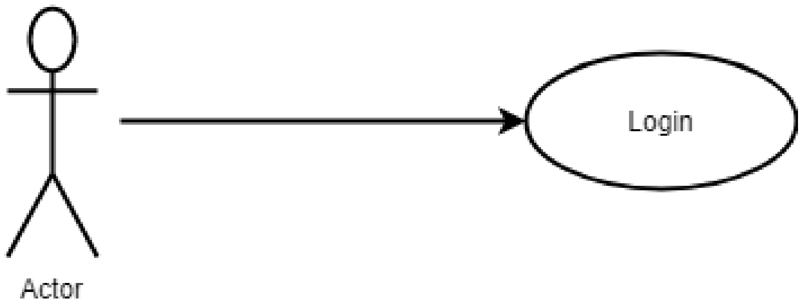


Figure 3.2: Login Use Case

Use Case ID	UC-2
Title	Login
Description	User will provide Username and password to login the system.
Primary Actor	User.
Pre-Condition	System Should be in running condition.
Post Condition	User will be logged in and main menu will be displayed.
Basic flow	1.User will run the system. 2. Provide username and password 3. Press “Login” button
Alternate steps	If user will not provide the username and password error message will be displayed.

Table 3.2: Login Use case

3.9.3 Earthquake Damage Prediction Use case

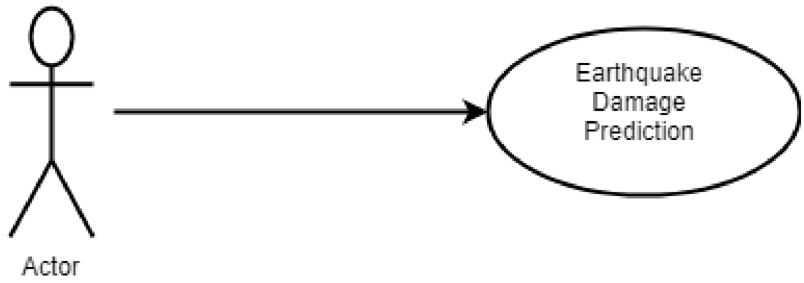


Figure 3.3: Earthquake Use Case

Use Case ID	UC-3
Title	Earthquake Damage Prediction
Description	User will provide the intensity, magnitude, latitude, and longitude to predict the results.
Primary Actor	User.
Pre-Condition	User must be logged-in.
Post Condition	Results will be displayed.
Basic flow	1. Press “earthquake Damage Prediction” button. 2. Provide earthquake information. 3. Press “Submit” button.
Alternate steps	If user will not provide the information or will provide wrong information error message will be displayed.

Table 3.3: Earthquake Damage Prediction Use case

3.9.4 Flood Damage Prediction Use case

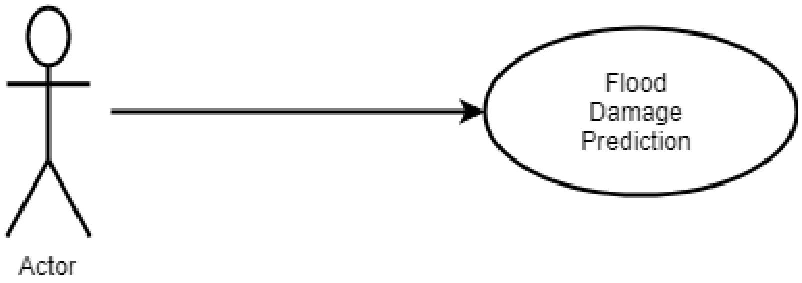
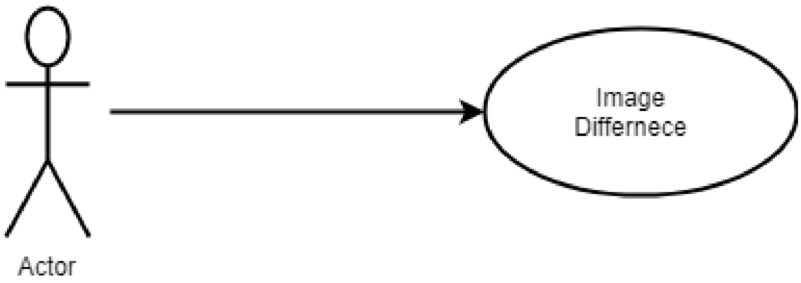


Figure 3.4: Flood Use Case

Use Case ID	UC-4
Title	Flood Damage Prediction.
Description	User will provide the severity and magnitude to predict the results
Primary Actor	User.
Pre-Condition	User must be logged-in to the system.
Post Condition	User will be prompted to select two images.
Basic flow	1. Press “flood Damage Prediction” button. 2. Provide flood information. 3. Press “Submit” button.
Alternate steps	If user will not provide the information or will provide wrong information error message will be displayed.

Table 3.4: Flood Damage Prediction Use case

3.9.5 Image Difference Use case



Use Case ID	UC-5
Title	Image Difference
Description	User will give two images to get similarity index between them.
Primary Actor	User.
Pre-Condition	User Must be logged-in.
Post Condition	The image difference and similarity index will be shown.
Basic flow	1. Press “Image Difference” button. 2. Browse first image by pressing “Before image” button. 3. Browse second image by pressing “After image” button. 4. Press “submit” button.
Alternate steps	Error message will be displayed.

Table 3.5: Image Difference Use case

Chapter 4

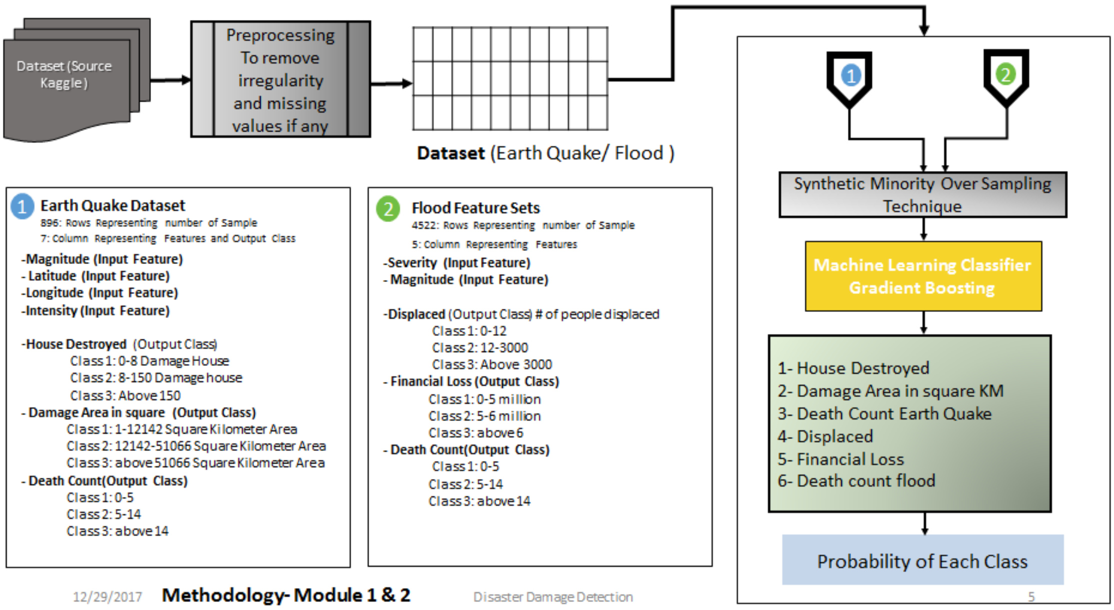
Design

In this chapter we are going to discuss the design and architecture of the project that is to be developed. This chapter will also give the overview of how different processes will carry out.

4.1 System Architecture

In this chapter architecture of the system and flow will be discussed

4.2 Methodology



Dataset (Source Kaggle)
Preprocessing To remove irregularity and missing values if any
Dataset (Earth Quake/ Flood)
1
2
Synthetic Minority Over Sampling Technique
Machine Learning Classifier Gradient Boosting
Probability of Each Class

1 **Earth Quake Dataset**
896: Rows Representing number of Sample
7: Column Representing Features and Output Class

-Magnitude (Input Feature)
- Latitude (Input Feature)
-Longitude (Input Feature)
-Intensity (Input Feature)

-House Destroyed (Output Class)
Class 1: 0-8 Damage House
Class 2: 8-150 Damage house
Class 3: Above 150
- Damage Area in square (Output Class)
Class 1: 1-12142 Square Kilometer Area
Class 2: 12142-51066 Square Kilometer Area
Class 3: above 51066 Square Kilometer Area
- Death Count(Output Class)
Class 1: 0-5
Class 2: 5-14
Class 3: above 14

2 **Flood Feature Sets**
4522: Rows Representing number of Sample
5: Column Representing Features

-Severity (Input Feature)
- Magnitude (Input Feature)

-Displaced (Output Class) # of people displaced
Class 1: 0-12
Class 2: 12-3000
Class 3: Above 3000
- Financial Loss (Output Class)
Class 1: 0-5 million
Class 2: 5-6 million
Class 3: above 6
- Death Count(Output Class)
Class 1: 0-5
Class 2: 5-14
Class 3: above 14

1- House Destroyed
2- Damage Area in square KM
3- Death Count Earth Quake
4- Displaced
5- Financial Loss
6- Death count flood

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Figure 4.1: Methodology

4.3 Flow Chart

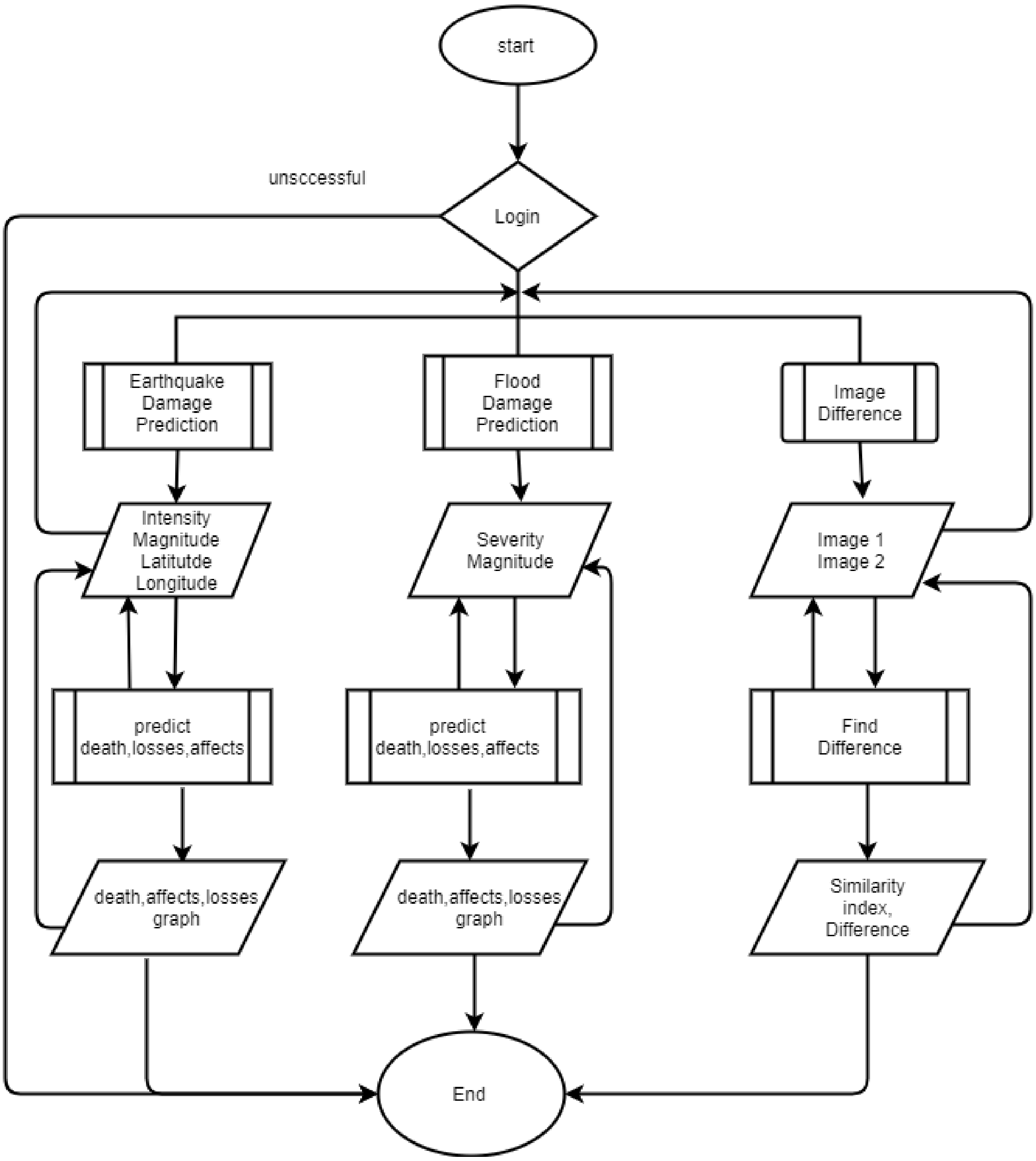
start
unsccessful
Login
Earthquake Damage Prediction
Flood Damage Prediction
Image Difference
Intensity Magnitude Latitutde Longitude
Severity Magnitude
Image 1 Image 2
predict death,losses,affects
predict death,losses,affects
Find Difference
death,affects,losses graph
death,affects,losses graph
Similarity index, Difference
End

Figure 4.2: Flow chart

4.4 Activity Diagram

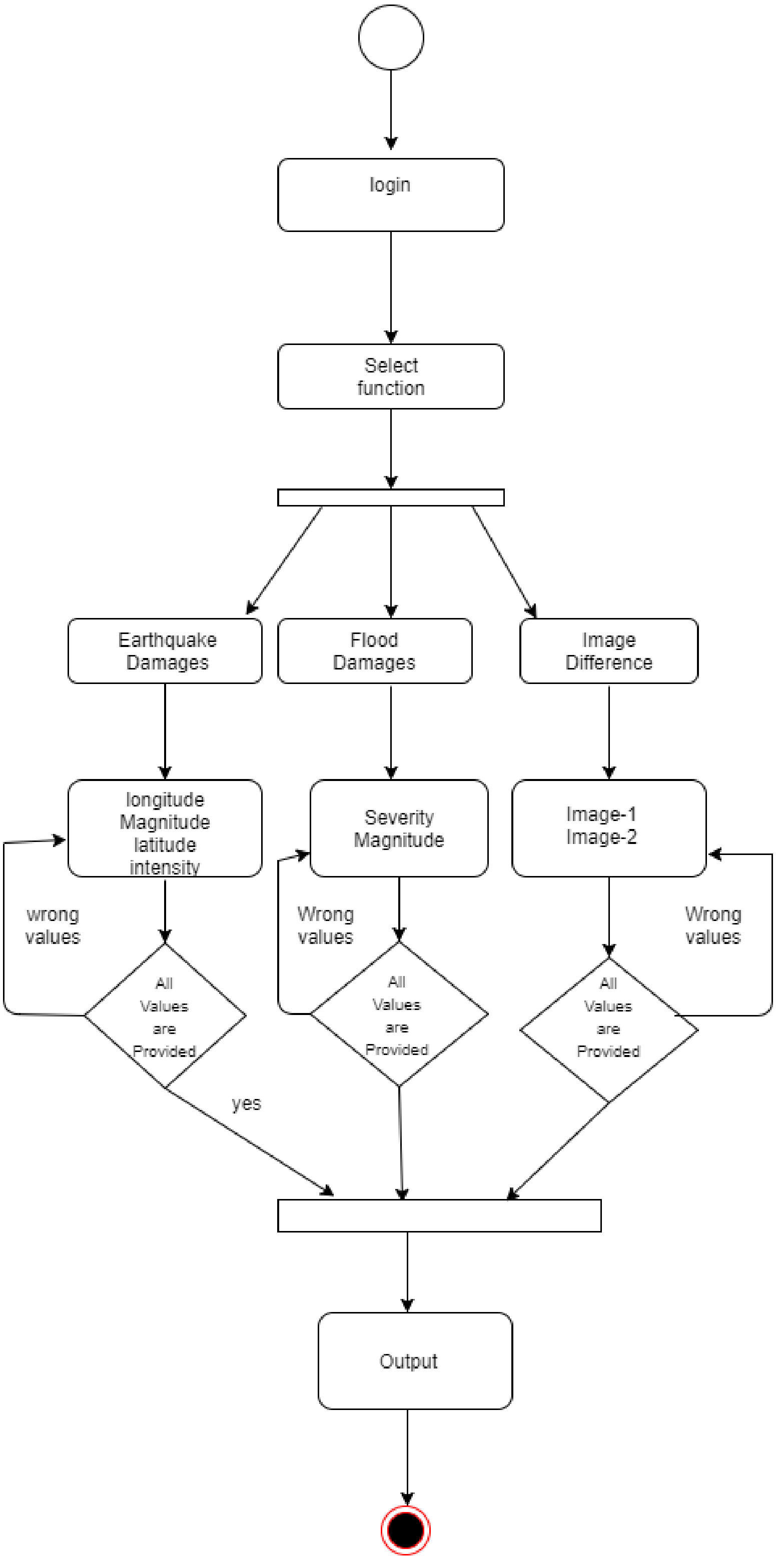

Figure 4.3: Activity Diagram

4.5 Sequence Diagram

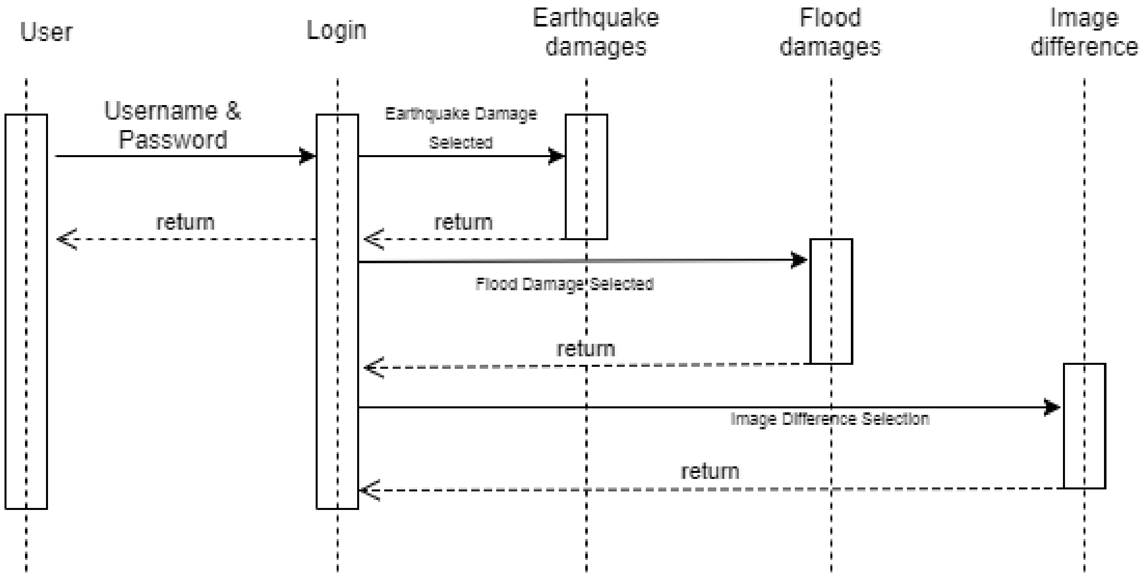

Figure 4.4: Sequence Diagram

Chapter 5

System Implementation

In this chapter we will discuss the details about how the Disaster Damage Detection system is developed. It will include the actual working and the algorithm used to get the best possible result. All the details about the working and algorithm of the DDDS is discussed in this chapter.

5.1 Design Overview

Disaster Damage Detection System is a desktop based application and a research based project in which images are analyzed to get their similarity index and input values are classified and using these values prediction is made about the damage that a disaster has caused. First of all we get the dataset and then purify our data after this we can do over sampling on data after getting a desired result we train our system on this dataset. when we train our system we create three classes low medium high these ranges are defined to get the best accuracy on result these all thing are done with machine learning algorithm that are defined below. Predictions are down using Gradient Boosting Algorithm.

5.1.1 Algoritham[Gradient Boosting]

Gradient boosting is a technique used for machine learning which helps in classification and overcome the regression problems. It produces prediction model in the form of an ensemble of weak prediction models.

Gradient Boosting Algorithm follows following steps:

- System is initialized.
- As the system is initialized learning process start.
- After initialization, initial fit stages are started to fit boosting stages.

- After each stage a decision tree is fitted to generate prediction. As predictions are made tree models are added to the model to generate accurate prediction.

5.1.2 Tools Used

Tools and technologies used during the implementation of this project are following:

- Developer Tools: Spyder (Python3.6).
- Programming Languages : Python.
- MS Office: For documentation.
- Spiral Team: For the project plan and schedule and tracking of requirements.

Chapter 6

System Testing and Evaluation

In this chapter we are going to discuss software testing techniques to evaluate the final result of the application that will be the accuracy of the constraints.

6.1 Testing Objective

The fundamental reason for testing is to assess the framework as indicated by prerequisites and approve whether the framework is working as per necessities or not.

6.1.1 GUI software testing

Infrastructure Damage Detection System is designed according to user requirements. The system GUI is interactive and simple.

6.1.2 Usability, Performance, Compatibility testing

Infrastructure Damage Detection System satisfies the usability testing as GUI of system is according to user Requirements.

6.1.3 Error handling testing

The system has proper checks for errors.

6.2 Test Strategy

Infrastructure Damage Detection System patients was divided into small parts and then tested.

6.2.1 Component testing

The overall system is divided into components according to processes and each component is tested separately. These components are as following.

- Browse to select and upload image.
- Compare both the images.
- Find the differences.
- Take the input from the user to predict the area damaged by flood.
- Take the input from the user to predict the deaths by flood.
- Take the input from the user to predict the displacements due to flood.
- Take the input from the user to predict the area damage by earthquake.
- Take the input from the user to predict the deaths due to earthquake.
- Take the input from the user to predict the financial loss due to earthquake

6.2.2 Unit testing

Each unit of system is tested and evaluated. The three main units of the system are listed in the following:

- Input Unit: Browse to select and upload image, input values for damage prediction of area, deaths financial loss.
- Main Processing: Compare two images, apply algorithm on the given inputs
- Output Unit: Result.

6.2.3 Integrated testing

Integration is carried out after completion of individual modules. These modules are integrated into a complete solution and the integrated modules are tested.

6.2.4 System testing

System testing is carried out once the complete project has been combined into a working system.

6.2.5 Methodology

Testing method used in our case is the image are of before and after the disaster so that module can be tested for the desired outputs.

6.2.6 Pass/fail criteria

Scenarios that determine whether an application passes or fails the test are determined. If a module passes a given test and no other error is found then the module is assigned a pass state, otherwise, the module is assigned the fail state.

6.2.7 Schedule

The time period of testing after which the application would be ready for use by the end user is determined and a schedule of testing is prepared.

6.3 Test Cases

6.3.1 Login Test Case

Test Case	01
Description	Try to login into the system using correct username and password.
Requirements	Systems run perfectly on Windows10.
Steps to be taken	User will enter username User will enter password Press the “Login” button.
Expected Result	Successful Login.
Actual Result	Successfully logged-in.
Status	Status Pass

Table 6.1: Login Test Case

6.3.2 Earthquake Damage Prediction Test Case

Test Case	02
Description	Try to predict the earthquake damages.
Requirements	Systems run perfectly on Windows10.
Steps to be taken	User will press the "Earthquake Damage" button. Provide the information about Earthquake. Press "Submit" button.
Expected Result	A new screen appears and result is shown in the form of graphs.
Actual Result	Up-to expectation.
Status	Status Pass

Table 6.2: Earthquake Damage Prediction Test Case

6.3.3 Flood Damage Prediction Test Case

Test Case	03
Description	Try to predict the result for flood damage prediction.
Requirements	Systems run perfectly on Windows10.
Steps to be taken	User will press the "Flood Damage" button. Provide the information about Flood. Press "Submit" button.
Expected Result	A new screen appears and result is shown in the form of graphs.
Actual Result	Up-to expectation.
Status	Status Pass

Table 6.3: Flood Damage Prediction Test case

6.3.4 Image Difference Test Case

Test Case	04
Description	Try to find difference between two images to find the affected region.
Requirements	Systems run perfectly on Windows10.
Steps to be taken	Press “Image Difference” button. Select image 1. Select image 2. Press “Submit” button.
Expected Result	A new screen appears and shows the results.
Actual Result	Similarity index not shown.
Status	Fail

Table 6.4: Image Difference Test case

6.3.5 Image Difference Test Case(2)

Test Case	04
Description	Try to find difference between two images to find the affected region.
Requirements	Systems run perfectly on Windows10.
Steps to be taken	Press “Image Difference” button. Select image 1. Select image 2. Press “Submit” button.
Expected Result	A new screen appears and shows the results.
Actual Result	Up-to expectation.
Status	Pass

Table 6.5: Image difference Test case(2)

Chapter 7

Conclusions

Disaster Management System is not only an application but an innovation in the new era.As the image processing and machine learning application are increasing in demand day by day,this system allowed us to learn a lot of new things about the emerging technology in the new technical era. Using different machine learning techniques we get the accuracy up to 70 percent on the given dataset.If can increase our dataset in the future the more accurate results we can get from this system.

The result were up-to our expectation and the final product came up with a spectacular design,efficient in performance and with accurate results.

7.1 Major accomplishment

Image processing was a troublesome for us. Our major accomplishment in this project is the implementation of machine learning algorithm and to purify our dataset through over sampling. Now we can predict area damage, deaths and financial-loss that can come with the disaster. Our system can also detect building, bridges etc from an image. After detecting features, we applied an algorithm and some further calculations to get required results. On the basis of which we predict the damage caused by disaster.

7.2 Limitation

There are some limitations in our project which are as follow

- Image should be clear
- Image should not be covered with anything
- Input values for earthquake forecasting should be correct.
- Input values for flood forecasting should be correct.

Chapter 8

User Manual

8.1 User Manual

8.1.1 Login

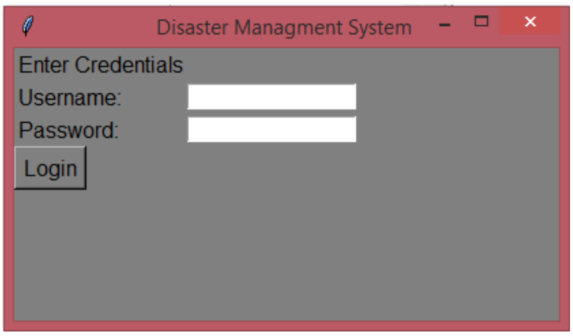

Figure 8.1: Login

8.1.2 Main Menu

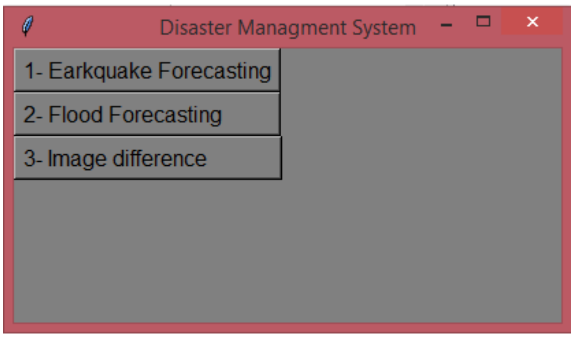

Figure 8.2: Main Menu

8.1.3 Earthquake Damage prediction form

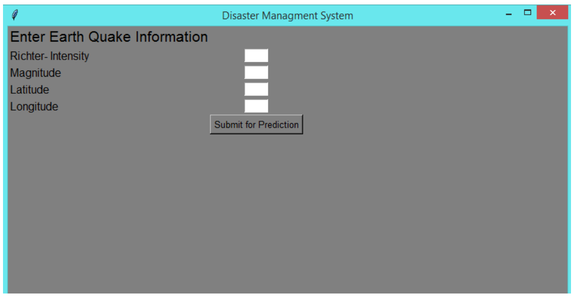

Figure 8.3: Earthquake Damage Prediction

8.1.4 Flood Damage Prediction Form

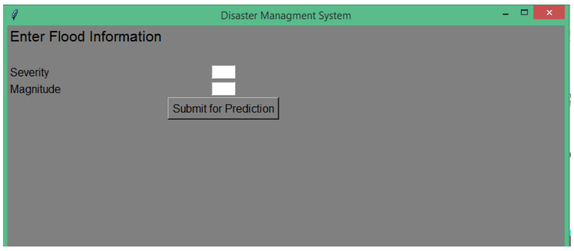

Figure 8.4: Flood Damage Prediction

8.1.5 Image Difference form

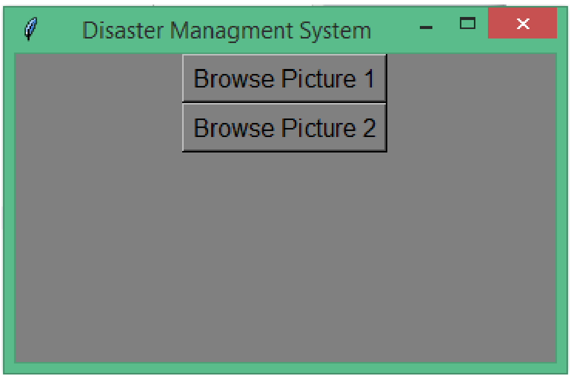

Figure 8.5: Image Difference

8.1.6 Results

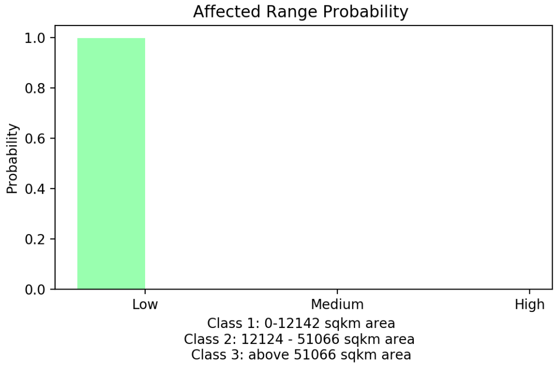

Figure 8.6: Affected Region

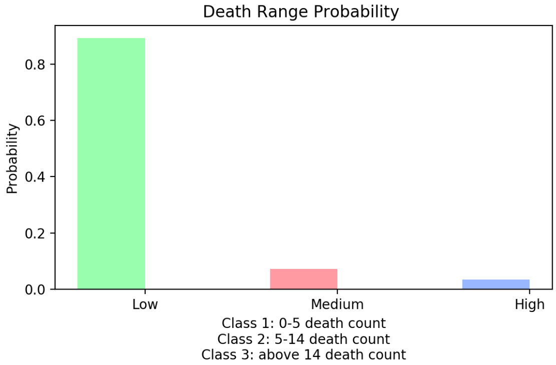

Figure 8.7: Deaths

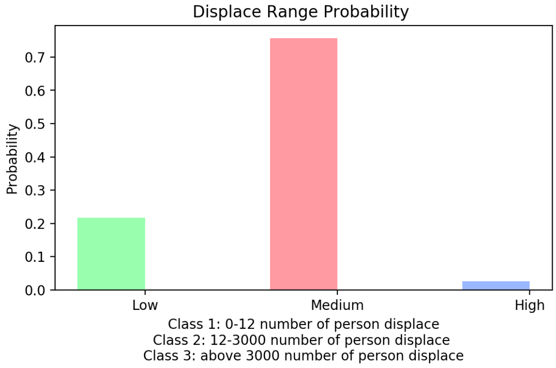

Figure 8.8: Displaced

References