Smart Pollen Monitoring and Prediction Service

By

Name	Reg number	Email
Abdus Samad	175735	abdus.samad46.as@gmail.com
Saqib Farooq	176323	saqib363849@gmail.com

Supervisor
Asst. Prof. Dr. Saddaf Rubab

Co-supervisor
Asst. Prof. Dr. Malik Muhammad Zaki Murtaza Khan

Submitted to Faculty of Department of Computer Software Engineering National University of Sciences and Technology, Islamabad in partial fulfilment for the requirements of a B.E Degree in Computer Software Engineering, July 20

DECLARATION OF ORIGINALITY

We hereby declare that the work contained in this report and the intellectual content of this report are the product of our work. This thesis report has not been formerly published in any structure nor does it include any verbalism of the published resources which could be treated as violations of the international copyright decree. We also recognize the term ‘plagiarism’ and ‘copyright’ and that in case of infringement or plagiarism established in this thesis, we will be held fully accountable of the consequences of any such violation.

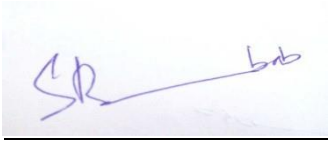
CERTIFICATE OF CORRECTIONS & APPROVAL

Certified that work contained in this thesis titled" **Smart Pollen Monitoring and Prediction Service**", carried out by **Abdus Samad** and **Saqib Farooq** under the supervision of **Dr. Saddaf Rubab** for partial fulfillment of Degree of Bachelors of Software Engineering, in Military College of Signals, National University of Sciences and Technology, Islamabad during the academic year 2019-2020 is correct and approved. The material that has been used from other sources it has been properly acknowledged / referred.

Approved by

(Supervisor)

Asst. Prof. Dr. Saddaf Rubab



Date: 11th July 2020

DECLARATION

No portion of work presented in this thesis has been submitted in support of another award or qualification in either this institute or anywhere else.

Plagiarism Certificate (Turnitin Report)

This thesis has been checked for Plagiarism. Turnitin report endorsed by Supervisor is attached.

(Signature of Student)

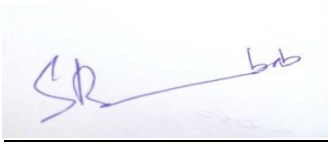
Abdus Samad

Saqib Farooq

Registration Number

00000175735

00000176323



(Signature of Supervisor)

Asst. Prof. Dr. Saddaf Rubab

ACKNOWLEDGEMENTS

There is no success without the will of ALLAH Almighty. We are grateful to ALLAH, who has given us guidance, strength and enabled us to accomplish this task. Whatever we have achieved, we owe it to Him, in totality. We are also grateful to our parents and family and well-wishers for their admirable support and their critical reviews. We would like to thank our supervisor. Asst Prof. Dr. Saddaf Rubab, for her continuous guidance and motivation throughout the course of our project. Without their help, we would have not been able to accomplish anything.

Dedicated to my exceptional parents and adored siblings whose tremendous support and cooperation led me to this wonderful accomplishment.

ABSTRACT

Rehabilitation Approach for Pollen Monitoring

Technological developments have revolutionized how we deal with many problems in our lives. We can find out about a lot of things before they happen thanks to technologies like Artificial Intelligence and Machine Learning.

Many types of allergies can be avoided by taking some precautionary measures like avoiding a specific food or drug. Pollen allergy is hard to deal with because its windborne as well. This is what we are trying to solve. We want to make pollen patients aware of any outbreak or spike of pollen density before it even happens so they can take precautionary measures. But is it possible?

What if we can look into the future and tell exactly how severe is the pollen going to be tomorrow? or the day after that? Or next week? However impossible it may sound, Thanks to Machine Learning we did just that. Using a huge dataset that contains data for different attributes like the count of pollen, humidity and temperature of every single day for the past 10 years, we built multiple ML models on which we trained this dataset. The models when trained were able to detect patterns in the data. These patterns could now be used to predict the density of pollen in future based on the training data set. We used three Machine Learning models of which Logistic Regression gave us the best accuracy of 99%. Being this accurate isn't very likely when dealing with other real world problems but because our dataset was very linear and the patterns were fairly visible, i.e the spike in pollen count in spring season specifically, we could get the accuracy as high as 99%.

The statistics we get from the Machine Learning algorithm will be displayed on an android application that we built from scratch. The user will have to install the android application and select the type of pollen allergy and his area. The application will show him if the pollen density is low, high, severe or critical for the next few days. The user can also set the notifications for when the density of pollen is alarming. This will help him take precautionary measures and stay inside in case there's an outbreak.

Table of Contents

List of Figures

List of Tables

Chapter 1. Introduction

1.1. Overview

The suspended pollen grains in the air reach the human respiratory track through inhalation, triggering a type of seasonal allergy called pollen allergy. Pollen is one of the most widespread of all the things that can cause allergies in humans. So our project is to prepare a system with the help of which users will be able to get predictions for the density of pollen, pollen patients can have awareness about the pollen density in a particular area and likewise the pollen density in at least the near future, with a given confidence level, so they can take proper precautionary measures to avoid pollen allergy and remain healthy.

1.2. Problem Statement

Watery red eyes, runny nose, sneezing, coughing, these familiar symptoms mean spring is in the air. Millions of people suffer from seasonal allergies triggered by airborne pollen not just in spring but in summer and fall, too and now evidence suggests their numbers will rise in a changing climate. When plants exposed to warmer temperatures and higher levels of CO_2, plants grow more vigorously and produce more pollen than they otherwise would. In a statement published last year, the World Allergy Organization, comprising 97 medical societies from around the world, opined that climate change will affect the start, duration, and intensity of the pollen season and exacerbate the synergistic effects of pollutants and respiratory infections on asthma.

1.3. Approach

Our solution will completely change the game of allergy sufferers. Our Machine Learning approach to pollen forecasting will completely transform how governments, corporations and individuals interact with pollen data. With up-to-date, location-based pollen data, those with severe sensitivities for whom pollen can be dangerous, such as people with asthma, will enjoy outdoor activities when they know pollen levels are low. There are some application available on playstore that predicts the density of pollen but they are for a particular area (i.e. Europe, America).It would be worth mentioning here that there is no app available for Islamabad .Our solution will help the people of Islamabad to have awareness of density of pollen in a particular area so they can take proper precautionary measures to avoid pollen and remain healthy.

1.4. Scope

The project will help the pollen patients by making the predictions about the density of pollens in a defined geographical area. The initial data provided to us by the PMD mainly cover the four sectors of Islamabad F-10, G-7, E-8, and H-8. This project mainly consist of three modules. In the first module we will be analyzing and pre-processing our data to transform the raw data into a format that is appropriate for further analysis through machine learning techniques. Raw data is usually incomplete or inconsistent and not ready for the techniques to be applied. In the second phase the model will be trained and tested to make predictions. Finally in the third phase we will develop an app and accompanied by a web portal that will show the estimation of the density of plant and give predictions of overall pollen count for each selected area or sector.

1.5. Objectives

Our Primary objective is to ensure the completion of our project along with the fulfillment of pre requisites of the final year project. This will include building individual scientific and AI skills and presenting the perfect details of the project. This project shall aid to build the necessary skills that would allow our group members to become capable of penetrating into the industry without confronting unnecessary hurdles. Project tasks will include a brief survey of the known techniques to create such application which may include open source libraries and platforms like scikit-learn and Tensor flow and pick the techniques and technology which helps the students map to the requirements in the best way. To understand and implement the end-to-end software development and deployment process in the context of AI-based software, keeping in view the practices and concerns of the industry.

1.6. Overview of the Document

This document shows the complete working process of our application SPM. It starts off with the literature review which shows past work done in similar field, requirement analysis of the system, system architecture which highlights the modules of the software and represents the system in the form of component diagram, Use Case Diagram, Sequence Diagram and general design of the system. Then it will move on to discuss the detailed Description of all the components involved. Further the dependencies of the system and its relationship with other products and the capacity of it to be reused will be discussed. At the end test cases and any future work proposal has been presented.

1.7. Document Conventions

Heading are prioritized in a numbered fashion, the highest priority heading having a single digit and subsequent headings having more numbers, according to their level. Font used is Times New Roman. All the main headings are of size 18 and bold. All the second level sub-headings are of size 16 and bold. All the further sub-headings are of size 14 and bold. All references in this document are provided where necessary, however where not present, the meaning is self-explanatory. All ambiguous terms have been clarified in the glossary at the end of this document.

1.8. Intended Audience

This document is intended for:

1. **Developers:** (Project Group)

   In order to be sure that they are developing the right project that fulfills the requirements provided in this document.

2. **Testers:** (Project Group, Supervisor)

   In order to have an exact list of the features and functions that must respond according to requirements.

3. **Users:**

   In order to get familiar with the idea of the project and how to use/respond in failure situations and suggest other features that would make it even more functional.

4. **Documentation writers:** (Project Group)

   To know what features and in what way they have to explain. What technologies are required, how the model is trained for making the prediction of pollen allergy and how is android application designed in order to facilitate the user to see the forecast..

5. **Project Supervisor:** (Assistant Professor Dr. Saddaf Rubab)

   This document will be used by the project supervisor to check whether all the requirements have been understood and in the end whether the requirements have been implemented properly and completely.

6. **Project Evaluators:** (CSE Dept. MCS)

   In order to know the scope of the project and evaluate the project throughout the development for grading.

Chapter 2. Literature Review

There is a growing global public health concern on the increasing and dynamic rates of asthma and allergies all over the world. Causes explaining the epidemic of (allergic) diseases are unclear. The prediction of allergy and preventive strategies are currently insufficient to abate the epidemic. A wide variety of mechanisms are associated with allergic diseases.[1]

Pollen allergies affect a significant proportion of Islamabad residents. Many patients with pollen allergy are hospitalized in Islamabad in spring (February to April), fall seasons (July to September) and after monsoons. To determine the type and concentration of airborne pollens causing allergic diseases in the susceptible patients in Islamabad. The study was conducted from January 2005 to December 2006 and Burkard Volumetric Spore Trap' provided by the World Allergy Organization was used. This spore trap was placed in the F-10 area of Islamabad and samples were collected on weekly basis during the whole study period. To obtain the sample, the spore trap drum was loaded with a strip of sticky tape every week. The sampled sticky tape was then collected each week at a specified time and replaced with a fresh strip of sticky tape, which was then collected next week. This cycle , continued for whole study period. From each sample seven permanent slides were made and mounted with gelevitol mounting media; The slides were then examined microscopically. A total of 702 individuals irrespective of age or gender were included in the study. Skin prick tests were performed for pollens using allergen extracts of Hollister-Steir, USA and the results were recorded. The two flowering seasons in Islamabad i.e., spring and fall caused maximum pollen allergies. The Broussonetia papyrifera (paper mulberry) tree in spring, and the Cannabis sativa (bhang) weed in the fall season, Produced the highest seasonal pollen counts. In the spring season of 2005, Broussonetia papyrifera produced the highest pollen count, (73%) of the total pollen count, with a maximum count of 1390 pollen/cu meter of air/hour on 20th of March, while in 2006, it accounted for 75% of the total pollen-count with a maximum count of 1430 pollen/cu meter of air/hour on 10th of March. in fall Season of 2005, Cannabis sativa produced maximum pollen counts of 85 pollens/cu meter of air/hr on 18th of August, while in 2006, it achieved maximum counts of only 40 pollens/cu meter of air/ hr on 27th of August. Skin prick tests demonstrated that out of 702 individuals selected irrespective of age or gender, 3 38 (48%) exhibited positive results in response to Broussonetia papyrifera pollen extracts, 207 (29%) were positive to grass pollen extracts and 137 (20%)w ere positive to Cannabis sativa pollen extracts. The Broussonetia papyrifera has the highest pollen count in the spring, (February to April), and is the main cause of allergic diseases like allergic rhinitis and asthma among the residents of Islamabad while the Cannabis sativa pollen count peaks in the fall season, causing allergic symptoms from July to

September. Skin prick tests confirmed the findings. Regular awareness campaigns for seasonal pollen allergy should be launched before the beginning of the seasons.
This study showed that 2 main types of plants (ie, B. papyrifera and C. sativa) producing allergenic pollen and causing seasonal allergic diseases in Islamabad. Grass pollen and mold spore allergies are manifested perennially in susceptible individuals. These results are specific to the city of Islamabad, Pakistan. Further surveys need to be undertaken before generalization to a wider geographical region could be possible. These data are supported by another study in Chicago from 1985 to 1989, which showed that death caused by asthma in 67 asthmatic patients aged 5 to 34 years was 2 times higher on days when fungal spore concentrations were at or above 1000 spores/m3 versus the days when below 1000 spores/m3. In our study, the Alternaria spores are below 1000, whereas Cladosporium spores rise to above 1000 in spring season when the pollen count for B. papyrifera is very high, reaching to above 30, 000/m3 air in a single day. There are deaths due to asthma in spring, and the pollen of B. papyrifera is regarded as the main cause, but above studies indicate that molds like Alternaria and Cladosporium may be the cause in aggravating asthma and even deaths. Research clearly shows that immunotherapy for the molds is effective, so if the mold immunotherapy is included in the immunotherapy schedule in Islamabad, many complications and even deaths can be prevented.[3]

Within the limitations of this study, it may be concluded that the 2 main types of plants producing pollen and playing a role in the genesis of seasonal pollen allergies are B. papyrifera and C. sativa during March/April and July to September, respectively. Grass pollen and mold spores are manifested perennially in susceptible individuals. These results are specific to the city of Islamabad, Pakistan. Further surveys would have to be undertaken before generalization is possible to a wider geographical region.[2]

References

[1] The soft computing-based approach to investigate allergic diseases: a systematic review, Gennaro Tartarisco, Alessandro Tonacci, Paola Lucia Minciullo,Lucia Billeci,Giovanni Pioggia,Cristoforo Incorvaia,corresponding author and Sebastiano Gangemi, April 13, 2017

[2] How AI and Weather Data Can Help You Plan for Allergy Season, Rachel Chukura, Misha Sulpovar, April 13, 2020

[3] Pollen allergies prediction through historical data in mobile devices, Daniel H. De la Iglesia1, Juan F. De Paz1, Gabriel Villarubia1,Ana de Luis1, Sigeru Omatu

Chapter 3. Software Req. Specification (SRS)

3.1. Introduction

The introduction of the Software Requirements Specification (SRS) provides an overview of the entire SRS with purpose, scope, definitions, acronyms, abbreviations, references and overview of the SRS. The aim of this document is to present detailed description of the project (Smart Pollen Monitoring & Prediction Service) which uses data provided by Pollen Monitoring Department (PMD) to make prediction about the density of pollens in a particular area for a specified time with certain confidence level. The detailed requirements of the Pollen Monitoring are provided in this document.

3.1.1. Purpose

This document covers the software requirement specifications for project. The idea of the project is to take relevant and available data followed by training and testing model on it to give predictions about the frequency of occurrences (density of pollen) for a particular area. The idea behind this project is to layout the prediction about density of pollen, so that pollen patients can take proper precautionary measures to avoid pollen allergy and remain healthy. The predictions will be uploaded to both web and android app in future weekly. This document is meant to outline the features and requirements of the Pollen Monitoring Software, to serve as a guide to the developers on one hand and a software validation document for the prospective client on the other.

3.1.2. Project Scope

The project will help the pollen patients by making the predictions about the density of pollens in a defined geographical area. The initial data provided to us by the PMD mainly cover the four sectors of Islamabad F-10, G-7, E-8, and H-8. This project mainly consist of three modules. In

the first module we will be analyzing and pre-processing our data to transform the raw data into a format that is appropriate for further analysis through machine learning techniques. Raw data is usually incomplete or inconsistent and not ready for the techniques to be applied. In the second phase the model will be trained and tested to make predictions. Finally in the third phase we will develop an app and accompanied by a web portal that will show the estimation of the density of plant and give predictions of overall pollen count for each selected area or sector.

3.2. Overall Description

3.2.1. Product Perspective

Main idea behind the project is to predict the density of pollen in selected areas of Islamabad. The Pollen usually start in first week of March in Islamabad and Rawalpindi and expected to ~~attain~~ peak during second fortnight of March. Pollen season is expected to end by mid-April. Our goal is to develop an app supported by web portal that predict the overall pollen count for each sector.

The predictions of the density of pollen will be done by applying machine learning algorithm on data provided to us by Pakistan Meteorological Department Department(This data can be seen from Pakistan Meteorological website http://www.pmd.gov.pk/rnd/rndweb/rnd_new/) .

3.2.2. Product Features:

The main features of Smart Pollen Monitoring & Prediction Service/ app are highlighted below:

1. Allows for the user to input the area of Islamabad which user wants to analyzes.
2. Show the users when pollen levels are expected to be high.
3. Notify the user when they might be exposed to risky pollen levels.

3.2.3. User Classes and Characteristics

Allergic Patients

Pollen Monitoring will help the allergic patients to keep track their allergies with pollen forecast, tracker and an index based on local pollen for more than 10 different plant types

Industries Leveraging Pollen Monitoring

Health Care: Protect the most sensitive population groups by keeping them aware of what's in the air, in real time wherever they are.

Tester (occasional user)

The testers of the system can check user requirements from this SRS and develop test scenarios accordingly.

Developers

The developers will use this at the developing time and at the time of any defect occurred in the product during maintenance.

Documentation Writers

The document can serve as a future reference for other versions of the SRS.

3.2.4. Design and Implementation Constraints

- GPU processing power may be required for running classification algorithm, thus necessitating the use of cloud platform or any available local machine with capability.
- Stable and fast Internet connection will be needed for serving the users over the web.
- For predictions to achieve accuracy, huge data set will be needed.

3.2.5. User Documentation

We will provide adequate user documentation in the app and through a separate web page for the users to understand the system and its use, better.

3.2.6. Assumptions and Dependencies

Assumption

The basic assumption is that the relevant government department will be able to provide us data, as promised, and structured in the way, with relevant attributes like variations in weather, pollen count, type etc., that we have specified and they have confirmed. We would also desire for the data to be in a cleaner form, however, we do understand that we might need to employ significant time to clean and pre-process the data before employing machine learning over it.

Dependencies

- Scikit-Learn
- Tensor Flow
- Nodejs
- Android
- Web (Html,CSS ,JavaScript)

3.3. External Interfaces Requirements

Android interface

1. User is provided an interface where he/she can monitor the density of different pollen plants and over all count of pollen in each sector.

2. User can set push notification for specific type of allergens by turning it on. Also Users will be prompted to set the certain level for that allergen in order to get notification alarms.

Hardware Interfaces

- RTX based or equivalent NVDIA GPU based system for training and interference.

Software Interfaces

- Scikit Learn and Tensor Flow will be used to apply the machine leaning to the data in order to train prediction models.
- Pandas and Sea-born will be used in visualization and analysis of the data set.

Communication Interfaces

The only communication is between the client (web & android) and the server. GET Request will be
used to receive data. HTTP will be used as the protocol

3.4. System Features

This section describes in detail the system features of the RAD.

3.4.1. User Location

Description and priority

User Location would help the system in determining the user geographical location hence resulting in accurate predictions of the density of pollen plants. Thus, It is the most important functionality because all other functionality have dependency on this functionality.

Stimulus/Response Sequences

The system will get access to user location by getting permission from the user on startup. After the permission is granted, the system can get the location from GPS module of the device.

Functional Requirements

FR-1: The system shall be able to get user current location.
FR-2: The system shall be able to show location on map view.
FR-3: The system shall ask user permission to access the device location.

3.4.2 Forecasting

Description

Forecasting will help the user in knowing the status of pollen allergy around his/her selected area. User needs this functionality because after finding the density of pollen plants around , he/she can take proper precautionary measures to avoid pollen allergy and remain healthy.

Stimulus/Request Sequence

Users will be provided an interface where he/she can monitor the density of different pollen plants and over all count of pollen in each sector. User can navigate through heat maps of pollen plants for the specific sector.

Functional Requirements

FR-5: The system shall be able to see prediction of the density of different pollen plants for area relative to user's location.
FR-6: The system shall also estimate the overall count of pollen for each sector.
FR-7: The system shall be able to create heat maps of different type of pollen plant for the specific sector.
FR-8: The system shall handle the internet connectivity issues in getting the forecasting information from server (repeated inquiry from server automatically).
FR-9: The system shall use the data in making predictions provided by Pakistan Meteorological Department in specified format.

3.4.3 Alert Notifications

Description

The system will generate allergy alerts when pollen count is high or allergens reaches the certain level. This functionality will be useful in a sense that if a certain user is allergic to certain allergens he/she can turn on the notifications for that allergens.

Stimulus/Response Sequence

User will set push notification for specific type of allergens by turning it on. Also Users will be prompted to set the certain level for that allergen in order to get notification alarms.

Functional Requirements

FR-10: The system shall notify the users if allergens reaches the certain level.
FR-11: The system shall provide the interface to the users to set certain levels for certain allergens.
FR-12: The system shall also notify the users when it finds the amount of pollen in an area is exceedingly high.
FR-13: The system shall ask the permission of users for pushing notifications.

3.4.4 Guide

Description

Guide will provide all the information to the user related to the different classes of pollen. This information include name of plant, images, concentration near user's location, pesky symptoms user faces from that plant, precautionary measures that users should take to remain safe.

Stimulus/Response Sequences

User will be provided with interface where they can read the guide of different pollen plants by sliding sideways.

Functional Requirements

FR-14: The system shall provide accurate information regarding each plant.

FR-15: The system shall handle the internet connectivity loss during getting the information from the APIS.

FR-16: The system shall show error message when internet connection is not available.

3.5 Other Nonfunctional Requirements

Performance Requirements

NFR-1: The response time of the system should not be more than 20 seconds while fetching the information from online database.

NFR-2: The system shall be able to process concurrent requests at the same time.

NFR-3: The system shall be able to maintain multiple sessions concurrently.

NFR-4: The performance of the system should be consistent for all users who use the system at the same time.

Security Requirements:

NFR-5: The database services that system is using shall be reliable and secured.

Software Quality Attributes:

NFR-6: The system shall be available 24/7 for use.

NFR-7: The application shall not crash if large number of simultaneous users access the system at same time.

NFR-8: The system shall not have a downtime of more than 20 minutes.

NFR-9: The system shall not exceed 20 events in a week that causes failure.

NFR-10: The database servers shall not take more than 30 min to restart in case of failure.

NFR-11: The application shall run on android supported devices.

Safety Requirements:

NFR-12: The application shall display the accurately predicted data about pollen.

Chapter 4. Design and Development

4.1 Introduction

(SPM) is the act of trying to determine the future density of different pollen plant in a defined geographical area. The successful prediction of pollen's density of different pollen plants will help the pollen patients in taking precautionary measures to avoid pollen allergy and remain healthy. The first phase of project involves the collection of (pollen) data from Pakistan Meteorological Department (pmd).The next phase of project aimed at using the Machine Learning algorithms for the task of predicting future density of pollen with a given confidence level. In order to help the patients in monitoring the predictions, we will develop an android app supported by web portal. This app will be able to show the density of different pollen plant and over all pollen count for the sector relative to user's location. It will also allow the user to set a certain allergic level for allergen in order to get notifications and as a result user will get notifications if the amount of pollen in an area is high. We will be uploading the predictions about certain range in future in weeks to our web portal.

4.1.1 Purpose:

This software design specification (SDS) document describes the architecture and system design of SPM. It mostly contains different design diagrams and their explanation. The document is intended to inform stakeholders of the details of the design and the design process. This document will help the developer(s) in implementation and maintenance of the Application (app).

4.1.2 Scope:

SPM will completely change the game of allergy sufferers. Our Machine Learning approach to pollen forecasting will completely transform how governments, corporations and individuals interact with pollen data. With up-to-date, location-based pollen data, those with severe sensitivities for whom pollen can be dangerous, such as people with asthma, will enjoy outdoor activities when they know pollen levels are low. Through our application pollen patients can constantly monitor the real time location-based pollen data and will also be able to get the alert if the amount of pollen in an area is high.

4.1.3 Definitions, Acronyms, Abbreviations:

- **APP:** Application
- **PMD:** Pakistan Meteorological Department
- **GUI:** Graphical User Interface
- **SPM:** Smart Pollen Monitoring & Prediction Service
- **SDS**: Software Design Specification
- **UML**: The Unified Modeling Language (UML) is a general-purpose modeling language in the field of software engineering, which is designed to provide a standard way to visualize the design of a system
- **ML:** Machine Learning
- **WBS:** The project management Work Breakdown Structure

4.1.4 References:

- **Use Case Modeling Guidelines**, which documents the guidelines used to develop the use case model specifying the functional requirements in this specification. http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=787548
- http://en.wikipedia.org/wiki/Sequence_diagram
- http://en.wikipedia.org/wiki/Component_diagram

4.1.5 Document Overview:

This document shows the design and working of SPM. It starts from higher level details for a non-technical reader to understand just by seeing the diagrams to the lower level details that aid the developer to code and understand other technical details of the application. Section 2 the **System Architecture Description** gives a detailed overview of the application. Section 2.1 **Structure and Relationships** shows the higher level details system working by the means of System Block, Activity, State Transition, and Use Case diagrams. Lower level details are described using the Class, Sequence diagrams and Structure Chart. Section 2.2 describes how the application is designed to curb the tendency of **User Interface Issues** and problems during User Interaction.

In Section 3, **Detailed Description of Component** is given to show the working of modules with low level details. It shows the purpose, function, subordinates, dependencies, interfaces, resources, processing and data of the components and their relationships with each other.

Section 4 shows the **Reuse and Relationship to other Products** i.e.; information about work done in the same project before and any reuse of the same work. The section also provides a key to reuse this system for further upgrade

Section 5, **Design Decisions and Tradeoffs** shows the architecture style and design pattern of the application, while in the Section 6 the **Pseudo Code** of the components is given in for human reading rather than machine reading.

4.2 Work Breakdown Structure:

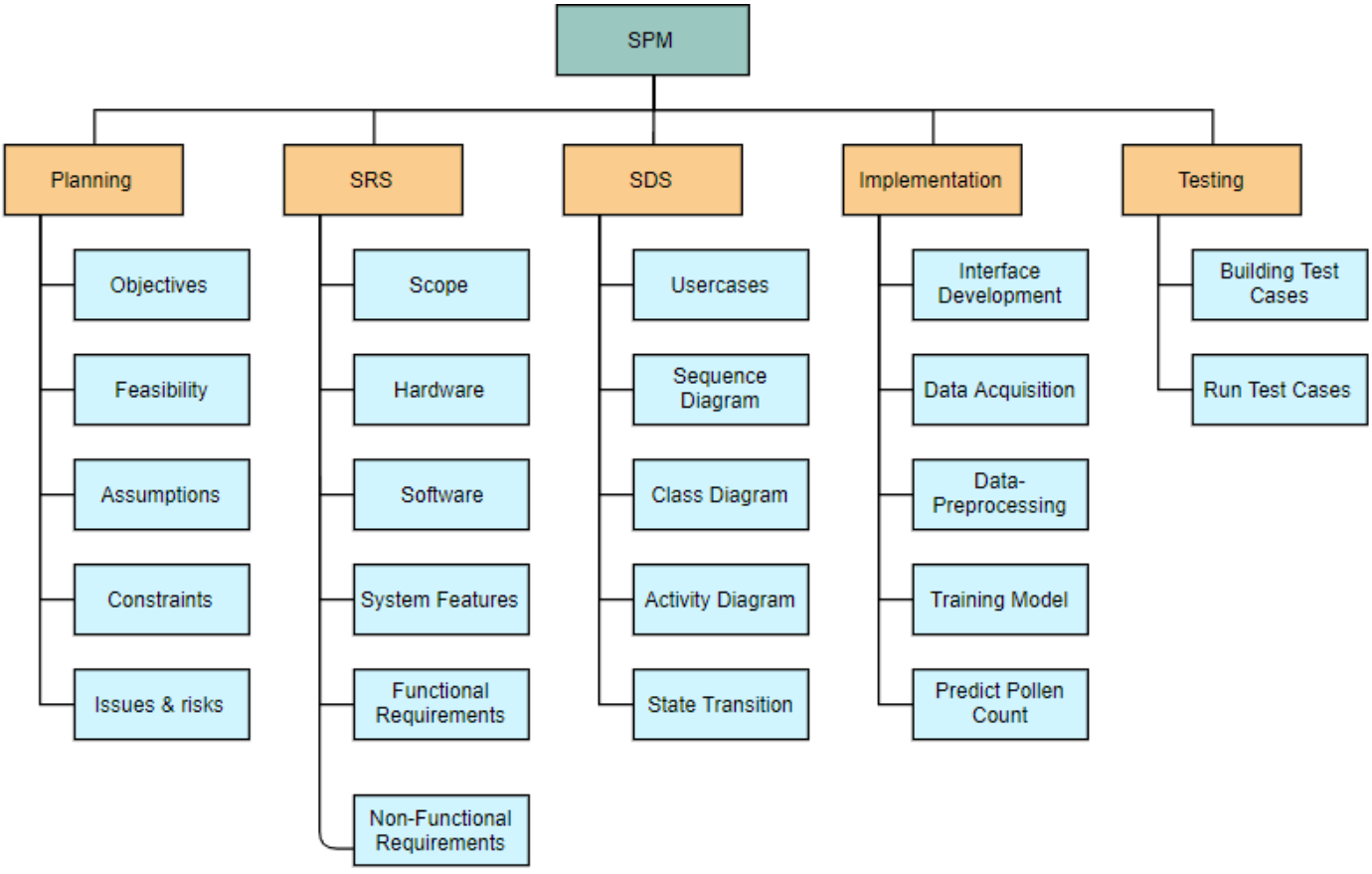


Fig 4.1.1: Work Breakdown Structure

4.2 System Overview

Give a general description of the functionality, context and design of our project.

4.2.1 Context

This section describe the context in which (Smart Pollen Monitoring & Prediction Service) SPM can assist it users. It explains the abstract, unmet need of the society that SPM will be able to fulfill and how many would benefit from SPM.

4.2.2 Abstract

Pollen Monitoring is the act of trying to determine the future density of different pollen plant in a defined geographical area. The successful prediction of pollen's density of different pollen plants will help the pollen patients in taking precautionary measures to avoid pollen allergy and remain healthy. The first phase of project involves the collection of (pollen) data from Pakistan Meteorological Department (pmd).The next phase of project is task of Feature Extraction / Dimensionality Reduction. The final phase of project aimed at using the Machine Learning algorithms for the task of predicting future density of pollen with a given confidence level. In order to help the patients in monitoring the predictions, we will develop an android app supported by web portal. This app will be able to show the density of different pollen plant and over all pollen count for the sector relative to user's location. It will also allow the user to set a certain allergic level for allergen in order to get notifications and as a result user will get notifications if the amount of pollen in an area is high. We will be uploading the predictions about certain range in future in weeks to our web portal.

4.2.3 Unmet need of the Society

Watery red eyes, runny nose, sneezing, coughing, these familiar symptoms mean spring is in the air. Millions of people suffer from seasonal allergies triggered by airborne pollen not just in spring but in summer and fall, too and now evidence suggests their numbers will rise in a changing climate.

- An investigative research was carried out in 6 villages within 20 kilometers of central Islamabad to determine the incidence and prevalence of pollen allergy and factors associated with it. Using a cluster sampling method, a survey of 347 households was conducted. Results show that 33% of the total study population was suffering from more than one type of pollen allergy. The highest number of casualties occurred during the months of February and March and the most affected persons were those aged 40 years or above followed by children in the age category of 7-19 years. The symptoms of allergies for more than 39% of the patients last for a minimum of 60 days or more.

- There are some application available on playstore that predicts the density of pollen but they are for a particular area (i.e. Europe, America).It would be worth mentioning here that there is no app available for Islamabad .Our solution will help the people of Islamabad to have awareness of density of pollen in a particular area so they can take proper precautionary measures to avoid pollen and remain healthy.

4.2.4 Functionality

This section illustrates working for the project Smart Pollen Monitoring and Prediction Service by system features:

User Location

User Location would help the system in determining the user geographical location hence resulting in accurate predictions of the density of pollen plants. Thus, It is the most important functionality because all other functionality have dependency on this functionality. The system will get access to user location by getting permission from the user on startup. After the permission is granted, the system can get the location from GPS module of the device. User will also be provided an option to manually enter a location of his choice.

Forecast

Forecasting will help the user in knowing the status of pollen allergy around his/her selected area. User needs this functionality because after finding the density of pollen plants around, he/she can take proper precautionary measures to avoid pollen allergy and remain healthy. The system shall be able to see prediction of the density of different pollen plants for area relative to user's location. Users will be provided an interface where he/she can monitor the density of different pollen plants and over all count of pollen in each sector. User can navigate through heat maps of pollen plants for the specific sector. These predictions, estimation, heat maps will be based on the model trained using pollen data provided by Pakistan Meteorological Department.

Alert Notification

The system will generate allergy alerts when pollen count is high or allergens reaches the certain level. This functionality will be useful in a sense that if a certain user is allergic to certain allergens he/she can turn on the notifications for that allergens. The system shall ask the permission of users for pushing notifications. User will set push notification for specific type of allergens by turning it on. Also Users will be prompted to set the certain level for that allergen in order to get notification alarms. The system will also notify the users when it finds the amount of pollen in an area is exceedingly high.

Guide

Guide will provide all the information to the user related to the different classes of pollen. This information include name of plant, images, concentration near user's location, pesky symptoms user faces from that plant, precautionary measures that users should take to remain safe. The system will provide accurate information regarding each plant. The system will handle the internet connectivity loss during getting the information from the APIS. User will be provided with interface where they can read the guide of different pollen plants by sliding sideways.

4.2.5 Design

Design of Machine Learning Prediction Model

Following are the five modules/ components of how our prototype (Machine Learning Model) will be designed.

- **Acquisition of Data set**

  PMD will be providing us the required data.

- **Analyzing Dataset**

  We will analyze the dataset using our specific ML techniques.

- **Predicting the missing values**

  Prediction of lost data or noisy data so that we can visualize dataset.

- **Visualizing the Dataset**

  We can visualize datasets using Scatter plot, Box plot and Scree plot. It will help us to classify/group the data, which will produce better and meaningful results.

- **Deliverables**

  Prediction model and software prototype will be implemented for predicting pollen count upon completion.

4.3 System Architecture Description

This Section gives overview of application, its higher and lower levels details and user interfaces. Detailed description of system architecture and design pattern which this system is going to use is discussed in this section.

4.3.1 Architectural Design:

This section covers the overall technical description of SPM. It shows the working of application in perspective of different point-of-views and also shows relationships between different components.

4.3.2 System Block Diagram (Machine Learning Model)

After acquiring the data, we will visualize it in following formats. (Appendix A)

- Scree Plot
- Box Plot
- Scatter Plot

These visualizations give us better idea of our data and it further help us in choosing a technique. The techniques that we are working on are following. (Appendix B)

a. Regression (Simple linear, Multiple linear, Polynomial, Support Vector Regression)
b. Classification (K-Nearest Neighbor , Support Vector Machine)
c. Clustering (K-Means)
d. Kalman Filter
e. Principle Component Analysis (Non Linear Principle Component Analysis)

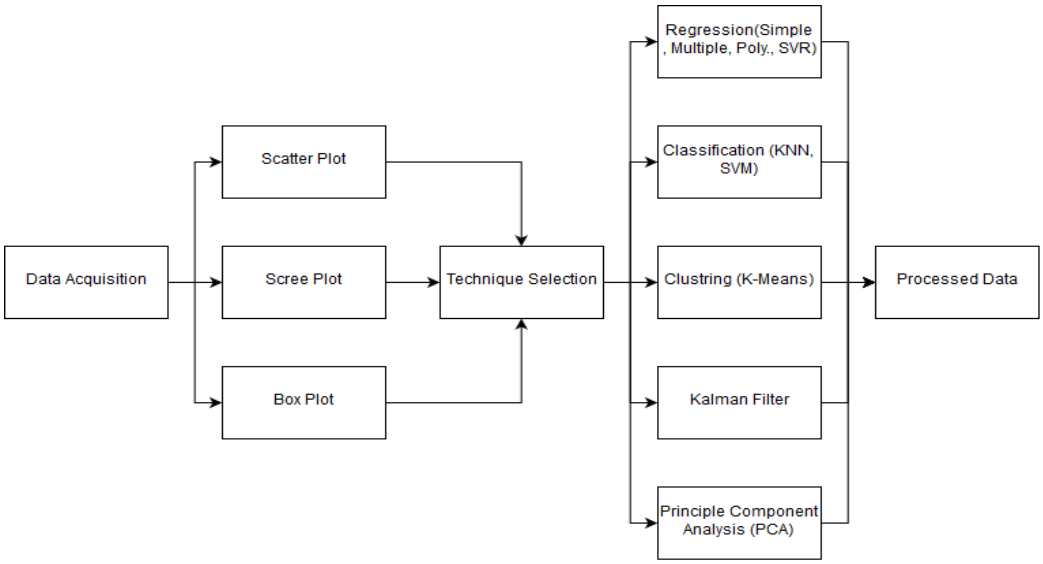


Figure 4.1. Structure and relationships

4.3.2 System Block Diagram (Application)

The diagram(s) show the higher level description of the application(s), generic working of the application(s) and interaction with the user.

User interacts with the application by selecting the location (which he desires to know the pollen status of that area). Database fetches the information particularly (pollen forecast) to user and display it to user. User can also set push notification for the specific type of allergen he is allergic to. In order to send notification to user in real time, Cloud Function is deployed on the firebase database environment. This function will send notification to user if amount of pollen in an area is high.

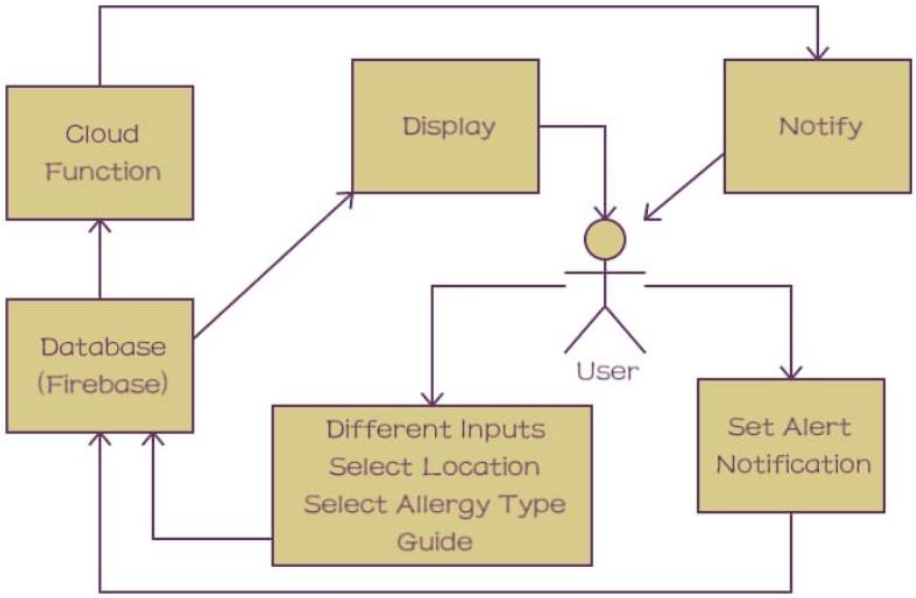


Figure 4.2. Block Diagram

The main components are:

- User Input
- GUI
- App Logic
- Database

4.4 Decomposition Description:

4.4.1 Component Diagram

This section describe the decomposition of subsystems in architectural design

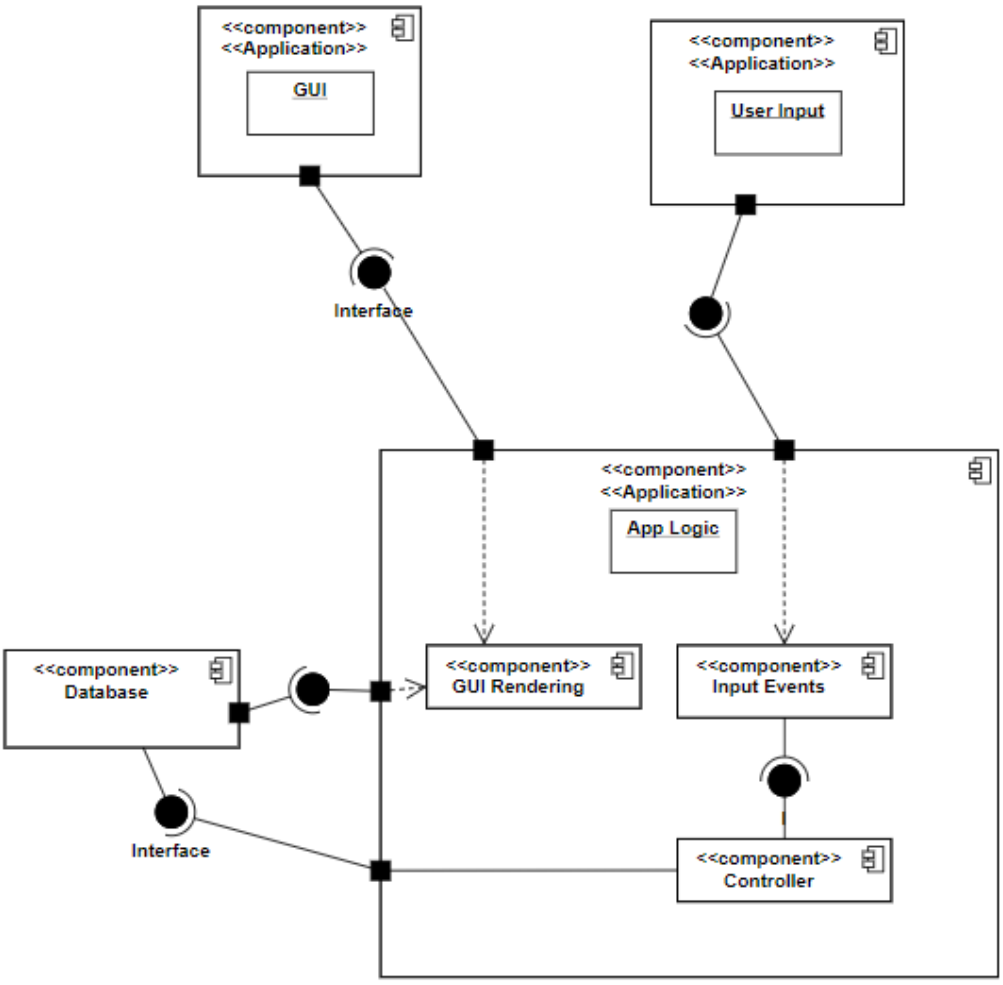


Figure 4.3. Component Diagram

4.4.2 Sequence Diagram

The sequence diagram(s) of the Snap Assistant is given below:

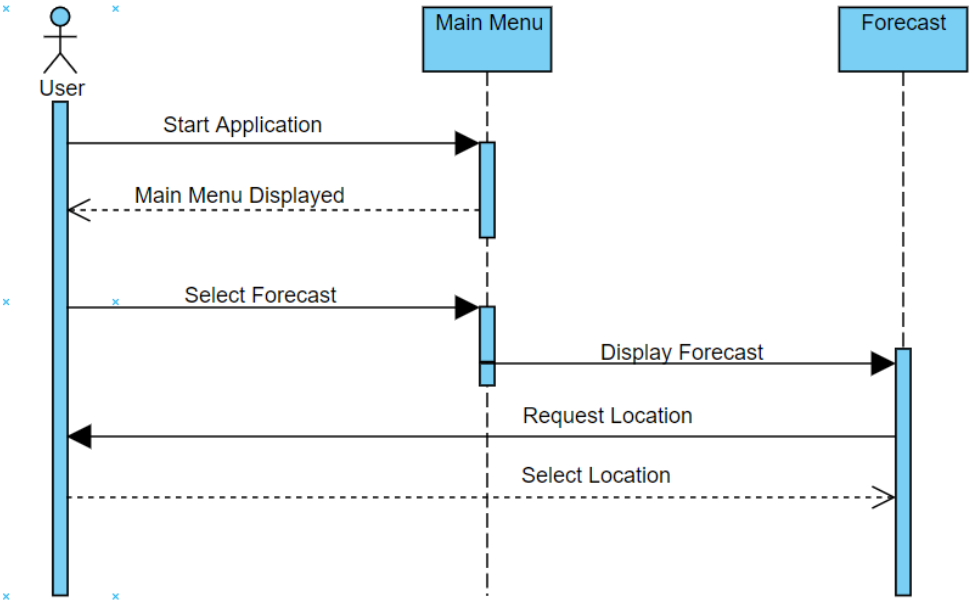


Figure 4.4. Sequence Diagram(1)

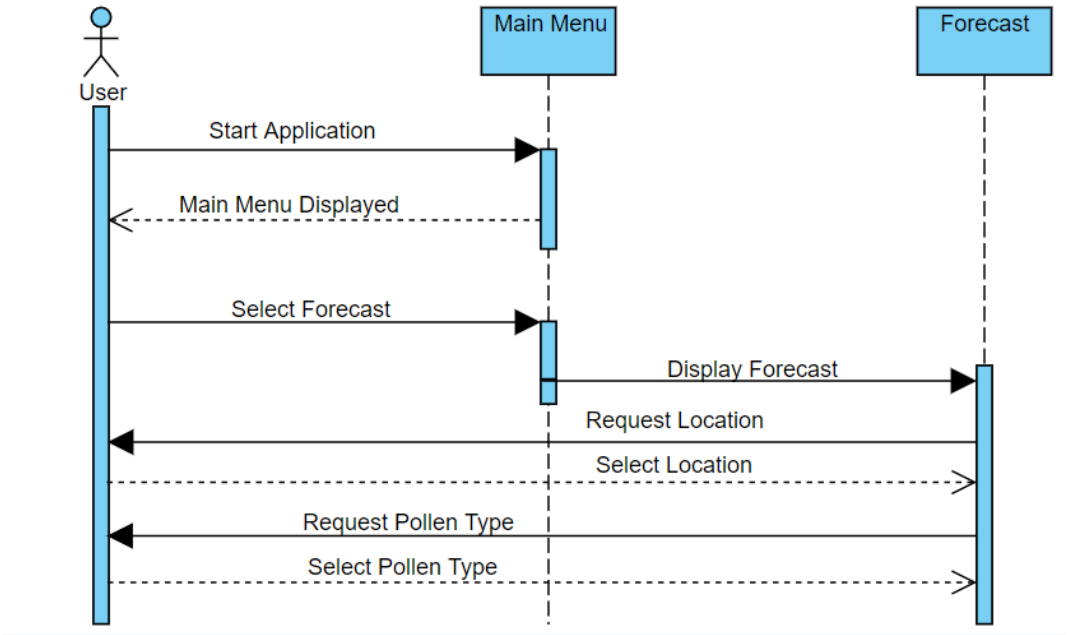


Figure 4.5. Sequence Diagram(2)

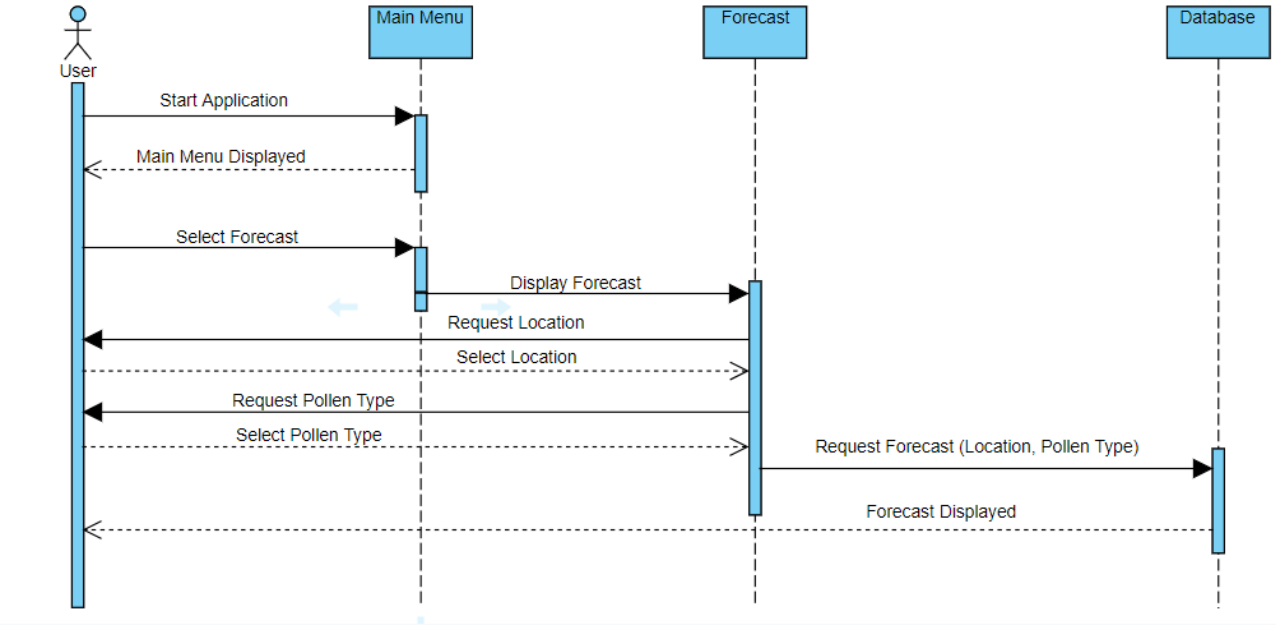


Figure 4.6. Sequence Diagram(3)

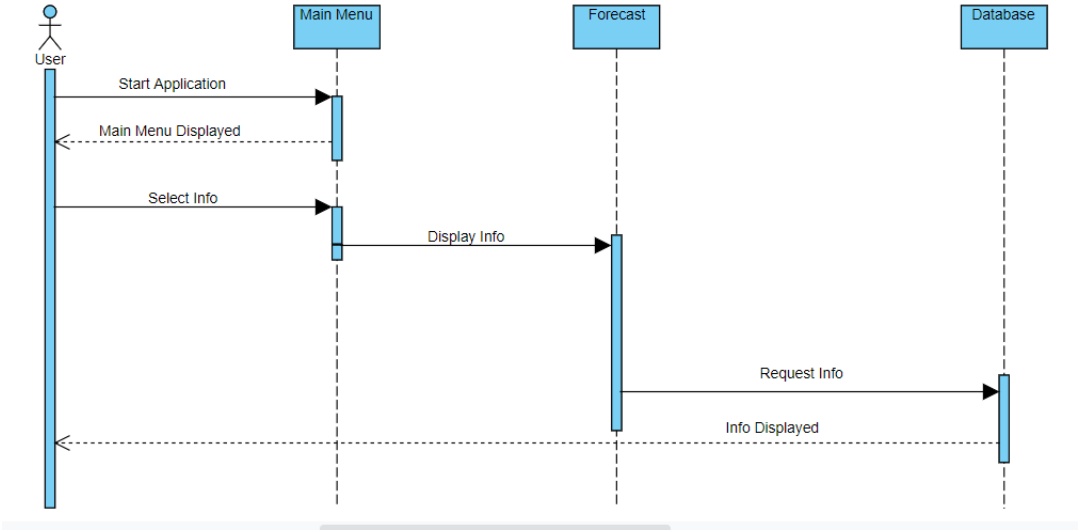


Figure 4.7. Sequence Diagram(4)

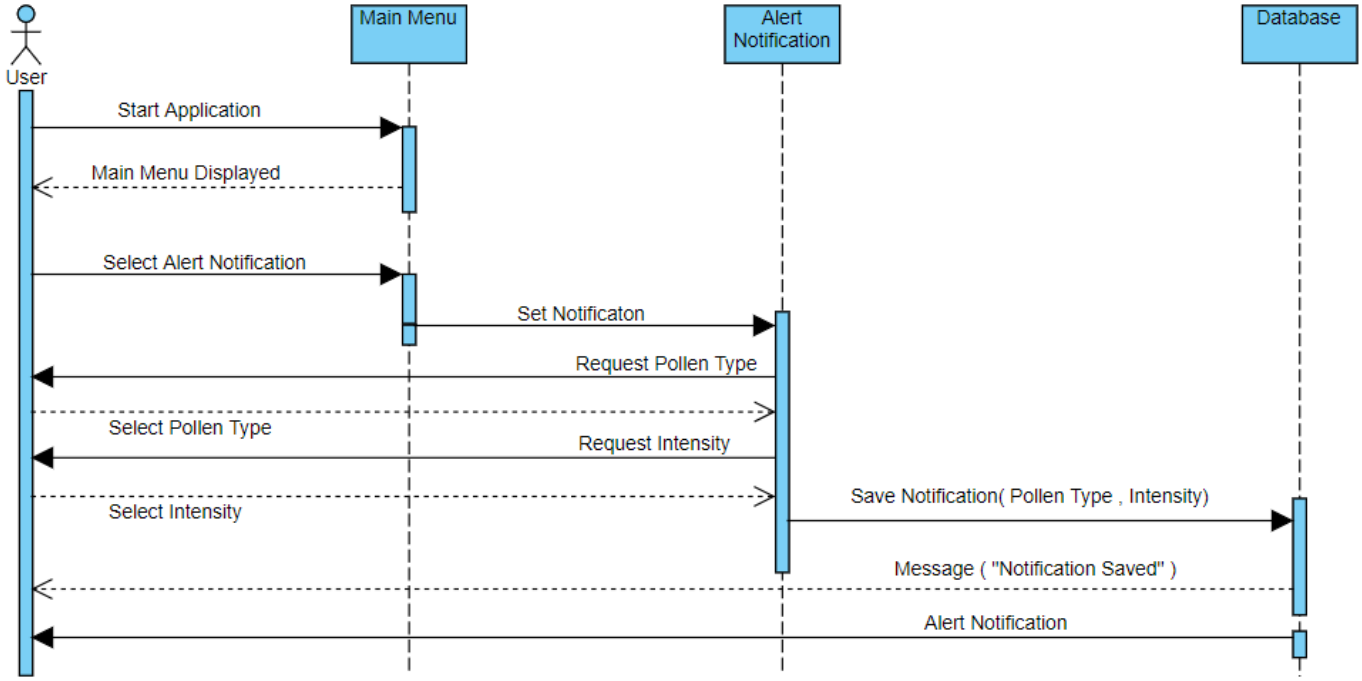


Figure 4.8. Sequence Diagram(5)

4.4.3 Dynamic View (Activity Diagram)

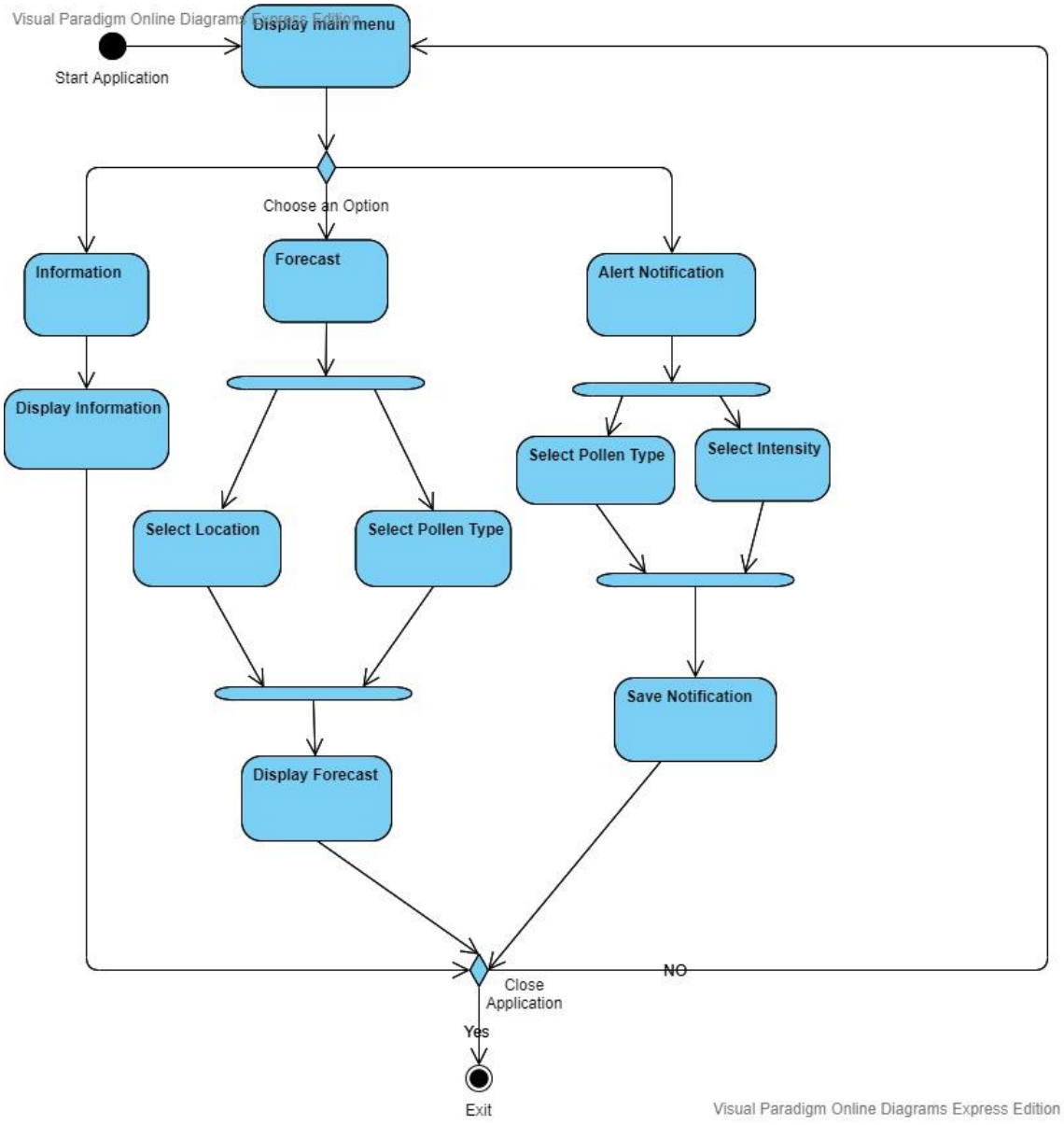


Figure 4.9. Activity Diagram of Mobile Application

4.4.3 State Diagram

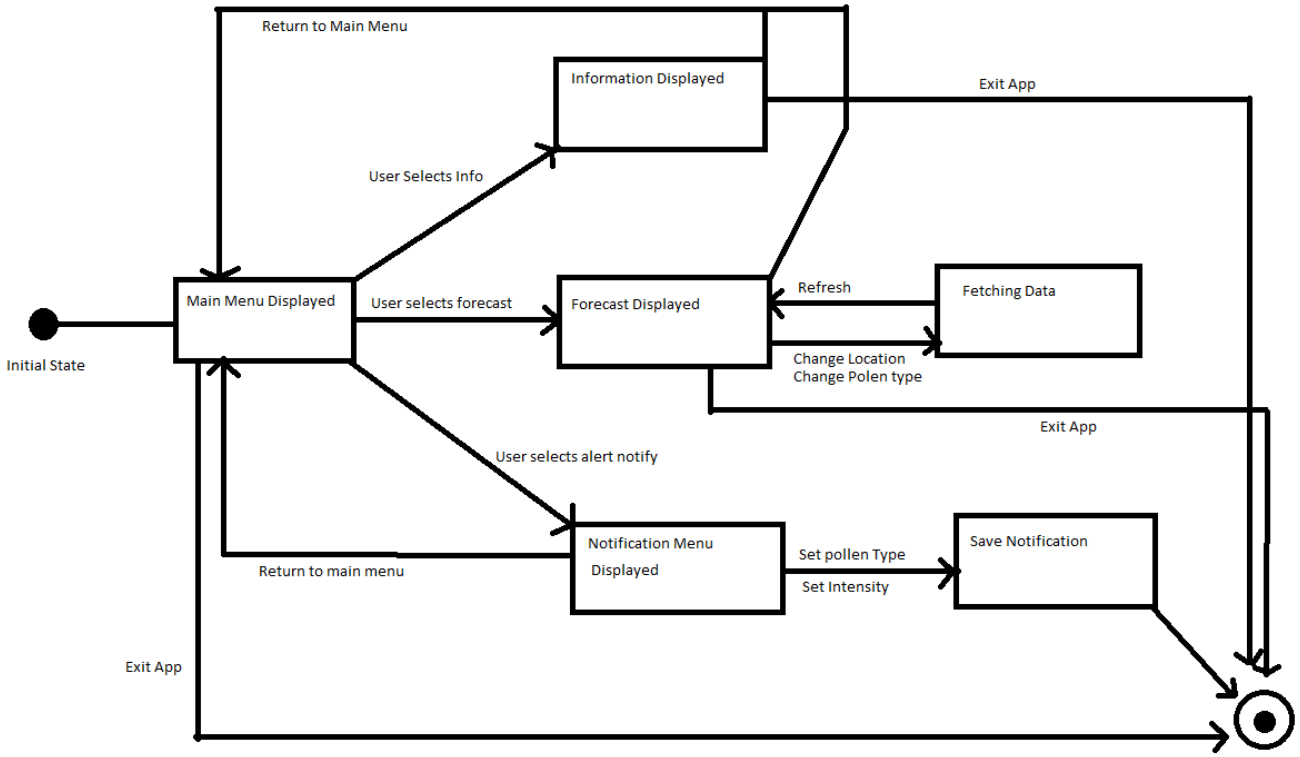


Figure 4.10. State Diagram of Mobile Application

4.4.4 Implementation View (Class Diagram)

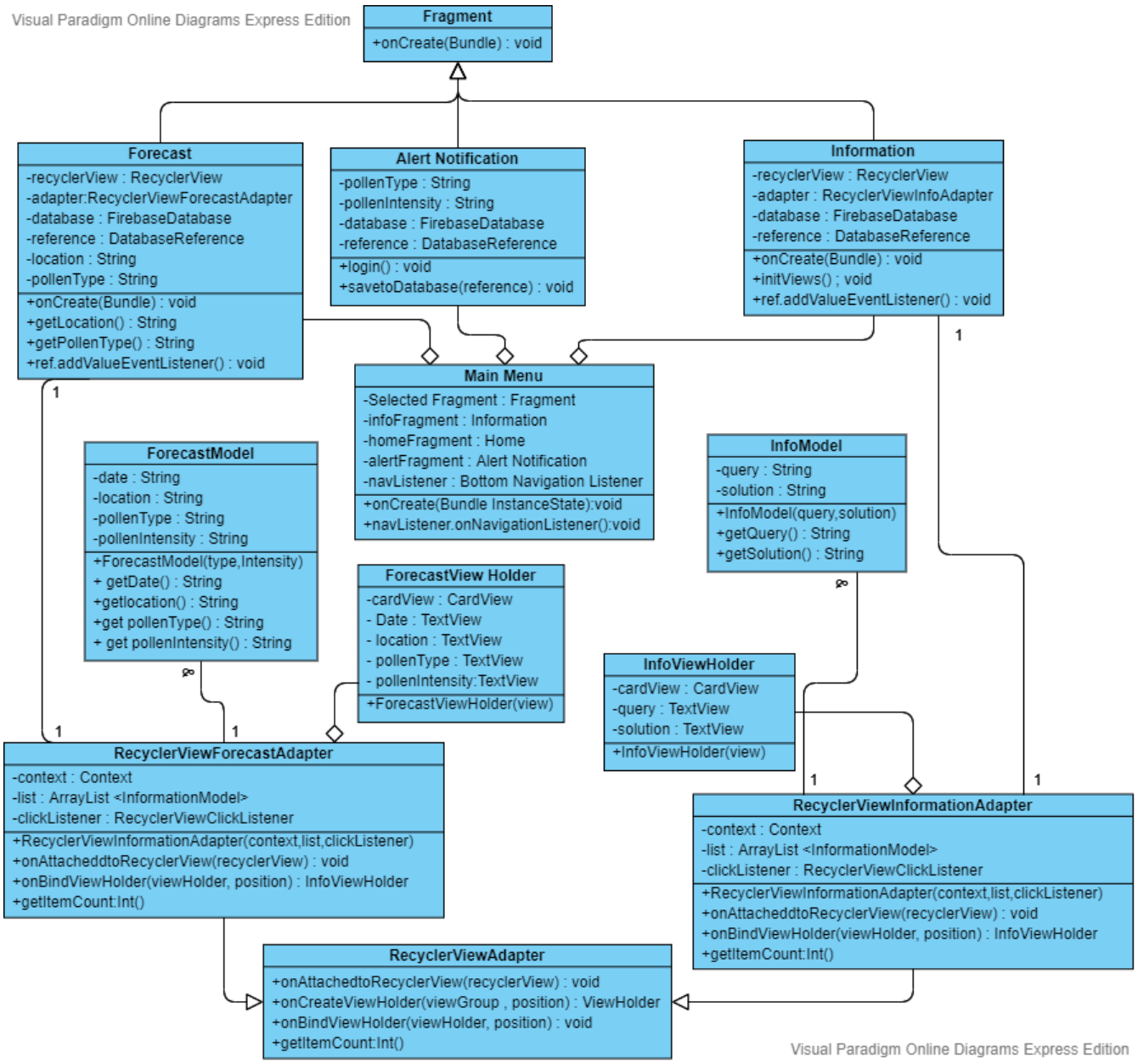


Figure 4.11. Class Diagram

4.4.5 Structure Chart

This chart shows the breakdown of the application to its lowest manageable levels. It shows the modules and their corresponding functions which this application will implement. This chart basically shows the structure breakdown of the application starting from main modules to specific functions.

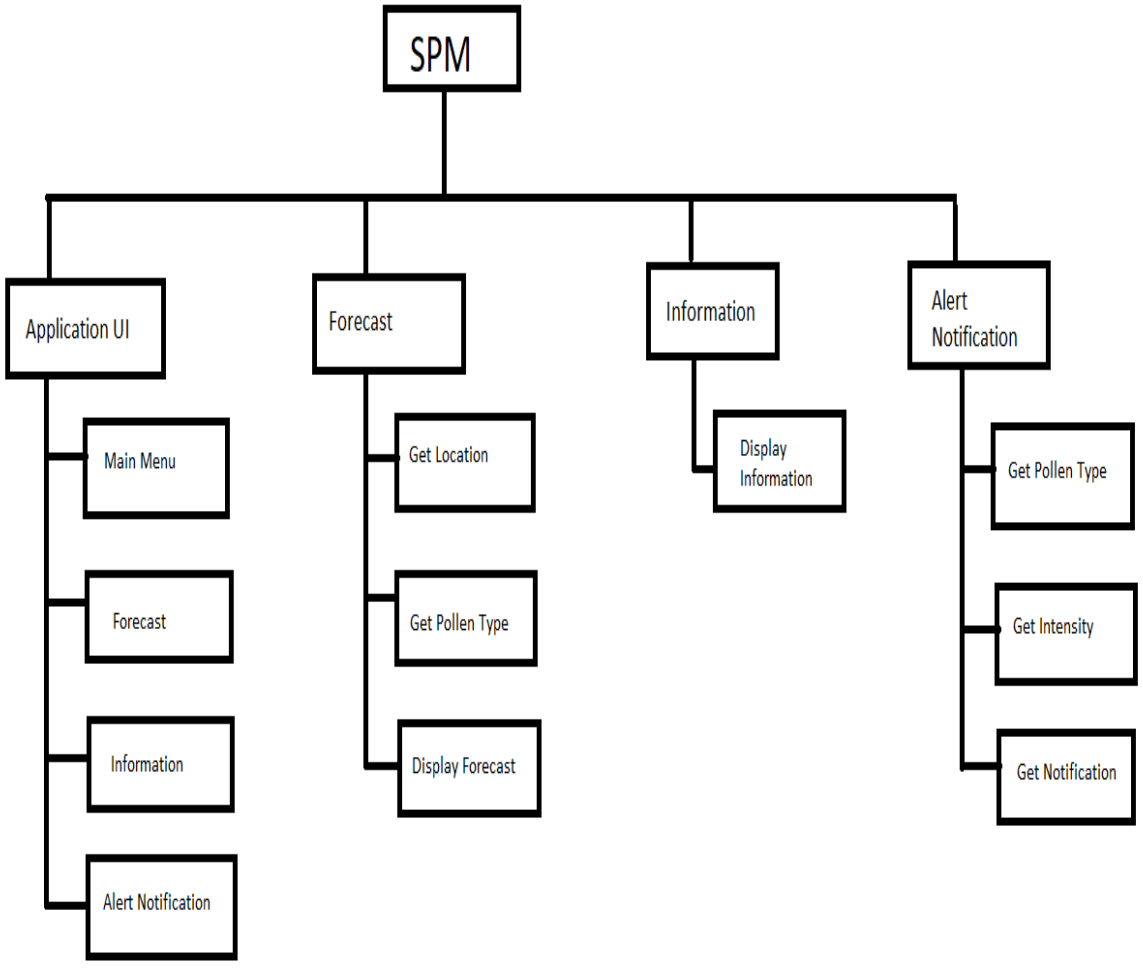
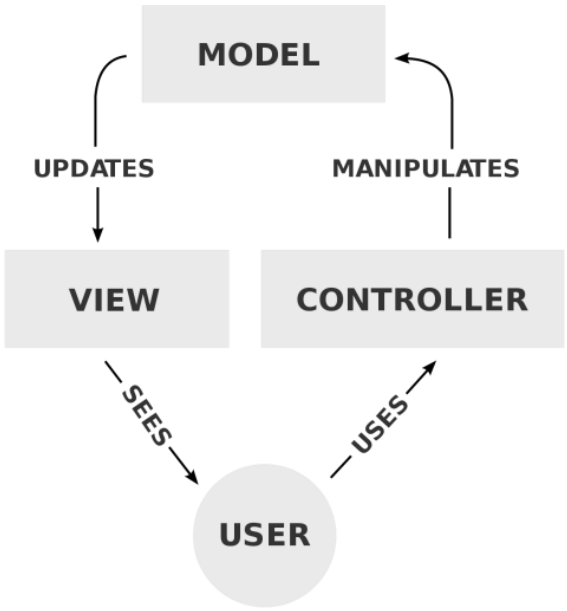


Figure 4.12. Structure Chart

4.4.6 Design Rationale:

SPM is an interactive application which requires multiple types of user interface. Developing such systems require thorough consideration on the design factors as it might result in complexity problem. A poorly-designed system results in a system consuming more resources with very little efficiency and a slower response time which directly affects the experience of the target user besides this, poor designs make testing and maintenance activities difficult.

MVC pattern will be used for the implementation of this application. General behavior of MVC is shown below.



4.5 Data Dictionary:

Name	Description
Main Menu	This is main class of the System. All the initial events are generated though it's function. It contain all the activities object to generate events.
Fragment	Fragment is a built-in android class that is a content controller and contain most views, layouts, and event logic including: • Layouts and views displaying relevant app content. • Event handling logic associated with relevant views. • View state management logic such as visibility or error handling. • Triggering of network request through a client object. • Retrieval and storage of data from persistence through model objects.
Alert Notification	This class is basically inheriting the fragment class. This is basically the fragment that is generated when user on main menu select Alert Notification. This fragment allows the user to login and set push notifications for a certain type of allergens he is allergic to.
Forecast	This class is also inheriting the fragment class. This class contain all the function and component listener that is necessary to get location and pollen type from the user and then request the data from the database based on user's selected location and pollen type
Information	This class is also inheriting the fragment class. This class is basically the view and the controller class that contain all the component and their necessary component listener for displaying the queries and solution. All the necessary logic to request the queries from the database is also implemented in this class.

Forecast Model	This class is the model class for the card views that are populated dynamically on the recycler view component in the Forecast class.
InfoModel	This class is the model class for the card views that are populated dynamically on the recycler view component in the Information class.
ForecastView Holder	This ViewHolder class is the keystone to the Recycler View and the Adapter. ing a ViewHolder to the View, we store the cache of the View objects. So whenever we scroll up a list (RecyclerView), the data on the top most ViewHolder is shifted onto the ViewHolder kept above the screen (not visible to user) and the View is kept for recycling and if the user scrolls down, the ViewHolder already stores the cached data, and thus the Views and the data from ViewHolder can be presented again to the user. This process makes the lists efficient and provides smooth scrolling.
InfoView Holder	This class is similar to forecast View Holder class. The only difference is that it is the view Holder class for the recycler view in the Information class.
RecyclerView Adapter	The adapter prepares the layout of the items by inflating the correct layout for the individual data elements. This work is done in the onCreateViewHolder method. It returns an object of type ViewHolder per visual entry in the recycler view.
RecyclerView Information Adapter	This class manages the data (Infomodel) and adapts it to the individual entries in the widget. It extends the RecyclerView.Adapter class and is assigned to the recycler view via the RecyclerView.setAdapter method. The input to the adapter of an recycler view can be any arbitrary Java objects. Based on this input the adapter return the total number of items via its getItemCount() method.
RecyclerView Forecast Adapter	This class manages the data (Forecastmodel) and adapts it to the individual entries in the widget. It extends the RecyclerView.Adapter class and is assigned to the recycler view via the RecyclerView.setAdapter method. The input to the adapter of an recycler view can be any arbitrary Java objects. Based on this input the adapter return the total number of items via its getItemCount() method

4.6. Pseudo code of Components

4.6.1 Pseudo code of Android Application:

Main Menu

```
View();
Selected Fragment = Null
If (user .select("Forecast")){
        Selected Fragment = new ForecastFragment();}
else if ((user .select("Information")){
        Selected Fragment = new  InfoFragment();}
else if ((user .select("Alert Notification")){
        Selected Fragment = new  InfoFragment();}
```

Forecast

```
Database db = FirebaseDatabase();

String Location = Ask User to select location();

String Pollen Type = Ask User to select pollenType();

List[] myDataset = db.requestforecast(Location, PollenType);

mAdapter = new MyAdapter(myDataset);

recyclerView.setAdapter(mAdapter);

Display Forecast ();
```

Information

```
Database db = FirebaseDatabase();

List[] myDataset = db.requestInfo();

mAdapter = new MyAdapter(myDataset);

recyclerView.setAdapter(mAdapter);

DisplayInfo();
```

Alert Notification

```
Database db = FirebaseDatabase();

String PollenType = Ask User to selectPollenType();

String Intensity = Ask User to select Intensity();

List[] myDataset = db.savenotification (PollenType,
Intensity);

mAdapter = new MyAdapter(myDataset);

recyclerView.setAdapter(mAdapter);

Notify ();
```

Dataset (Model)

```
class Dataset{

String location;
String PollenType;
Dataset(location,pollenType){
        this.location = location;
        this.pollenType = pollenType;
}
getLocation(){
 return location;}

get pollenType(){
 return pollenType;}
}
```

Adapter

```
Class Adapter{
Dataset dataset;
Adapter(Dataset){
        this.dataset = Dataset;
}
V = View();


Item = V .getitem();
Item.setValue(dataset);
```

4.7 Human Interface Design

4.7.1 Overview of User Interface

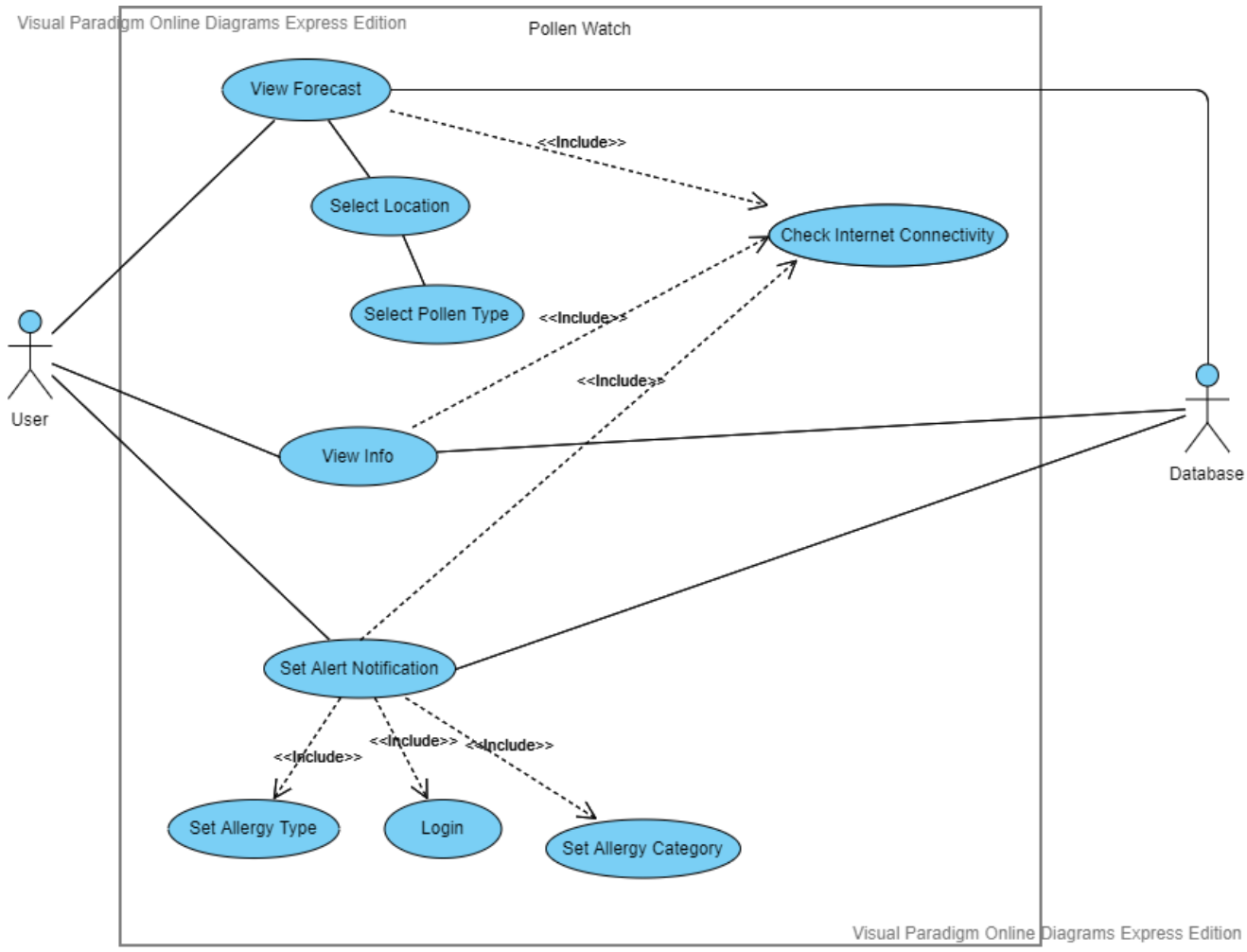


Figure 4.20. Use case Diagram

Actors:

Primary Actors:

User

Secondary Actors:

None

Use Case Description:

Use Case 1

Use Case	View Forecast
Actors	User , Database
Use Case Description	This use case will help the user to monitor pollen forecast of different pollen type in various location according to their own choice.
Normal Flow	View Forecast will contain two options for the user which enable them to monitor pollen according to their own choice. These two options are : (i) Select Location (ii) Select Pollen Type
Alternative Flow	Application may not be working properly. User has to reinstall the application or check his internet connectivity.
Pre-condition	1. App is installed and working properly on the phone. 2. The device should have a good Internet Connection.
Post Condition	The two options for setting the location and pollen type will be displayed and after user sets the location and pollen type, pollen forecast of that pollen type and location will be fetched from Database and display to user on screen to monitor it.
Includes	1. Check Internet Connectivity 2. Select Location 3. Select Pollen Type
Extends	N/A
Assumptions	Phone has a good Internet Connection.

Use Case 2

Use Case	Select Location
Actors	User
Use Case Description	This use case will help the user to select that location of which user wanted to monitor the pollen forecast.
Normal Flow	User taps on the set location text field and drop down list of different sectors will be displayed to the user. User choose the sector from the drop down list by clicking on it and as a result that particular location (sector) will be selected.
Alternative Flow	N/A
Pre-condition	The Pollen Watch App is installed and working properly on the phone.
Post Condition	Drop down list of different sectors will be displayed to user. User selects the location from the list.
Includes	N / A
Extends	N/A
Assumptions	N / A

Use Case 3

Use Case	Select Pollen Type
Actors	User
Use Case Description	This use case will help the user to select that pollen type of which user wanted to monitor the forecast.
Normal Flow	User taps on the set pollen type text field and drop down list of different pollen types will be displayed to the user. User choose the pollen type from the drop down list by clicking on it and as a result that particular pollen (type) will be selected.
Alternative Flow	N/A
Pre-condition	The Pollen Watch App is installed and working properly on the phone.
Post Condition	Drop down list of different pollen types will be displayed to user. User selects the pollen type from the list.
Includes	N/A
Extends	N/A
Assumptions	N/A

Use Case 4

Use Case	View Info
Actors	User, Database
Use Case Description	This use case "view Info" is like a guide that clear doubts of different user queries. This will provide the user with most doubted queries about pollen allergy with their solution.
Normal Flow	User clicks on the view Info tab. All the information will be fetched from the database and displayed too user on screen.
Alternative Flow	N/A
Pre-condition	Application is working properly and phone has a good Internet connection.
Post Condition	After fetching the information from database, the application will show the information
Includes	Check Internet Connectivity
Extends	N/A
Assumptions	Phone is having a good Internet Connection.

Use Case 5

Use Case	Set Alert Notification
Actors	User , Database
Use Case Description	This use case will generate allergy alerts when pollen count is high or allergens reaches the certain level. This functionality will be useful in a sense that if a certain user is allergic to certain allergens he/she can turn on the notifications for that allergens.
Normal Flow	User will set push notification for the allergens he is allergic to by doing these steps: 1. User will first login via email. 2. User will select the Allergy type of which he wanted the application to notify him. 3. User will then select the category (high, low, medium) of Allergy type selected in the previous step. 4. User will the click the “save” button to save the notification.
Alternative Flow	User may want to change some previous notification.
Pre-condition	Application is working properly and having a good Internet Connection.
Post Condition	The notification will be save in the database. Whenever that certain allergen cross the limit set by user, user will be notified.
Includes	1. Login 2. Set Allergy Category 3. Set Allergy Type
Extends	N/A
Assumptions	Phone is having a good Internet Connection.

4.7.2 Screen Images

The user Interface of the Pollen Watch is as follow

When the user selects forecast / home

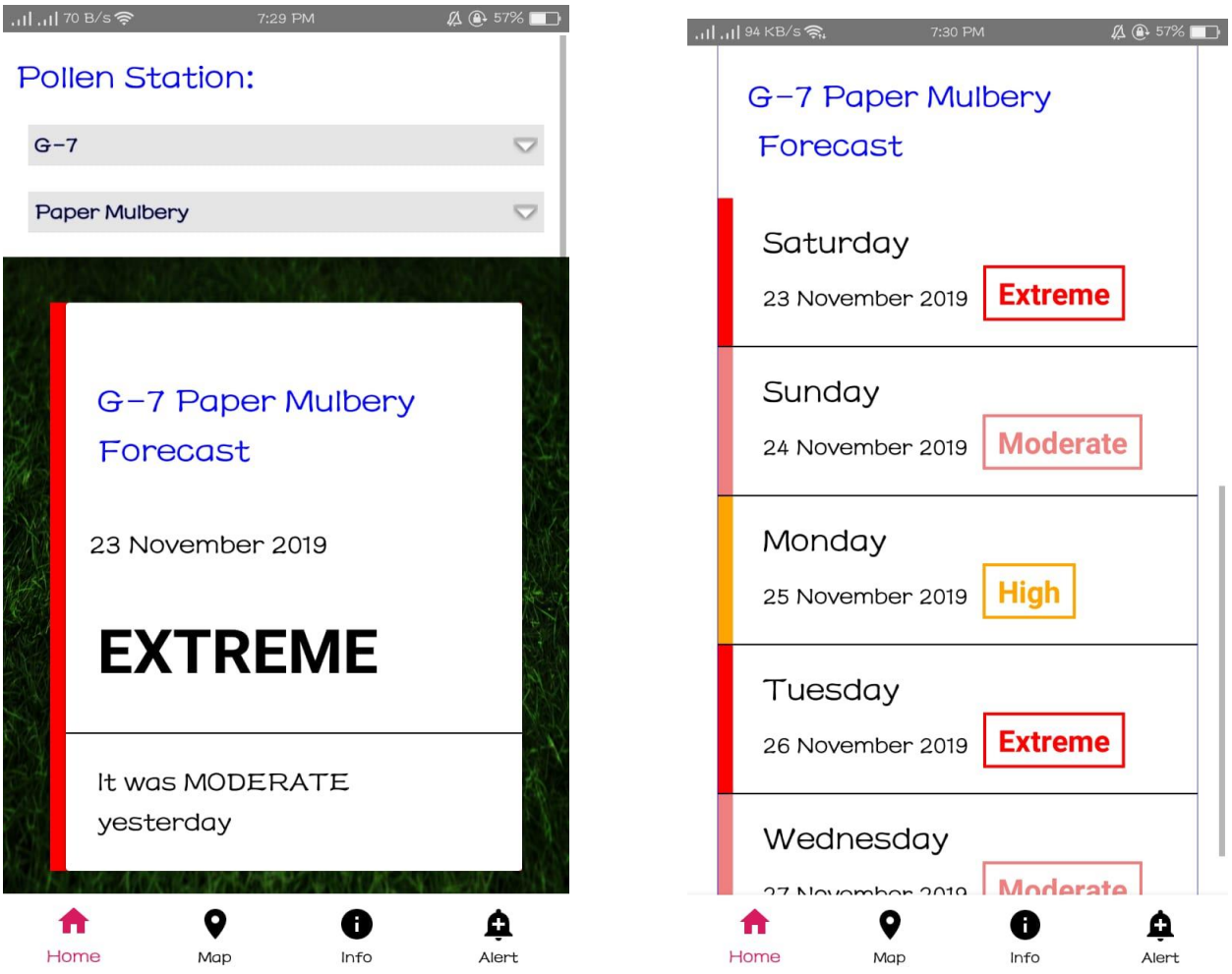


Figure 4.21. Forecast

When the user selects the information / info tab

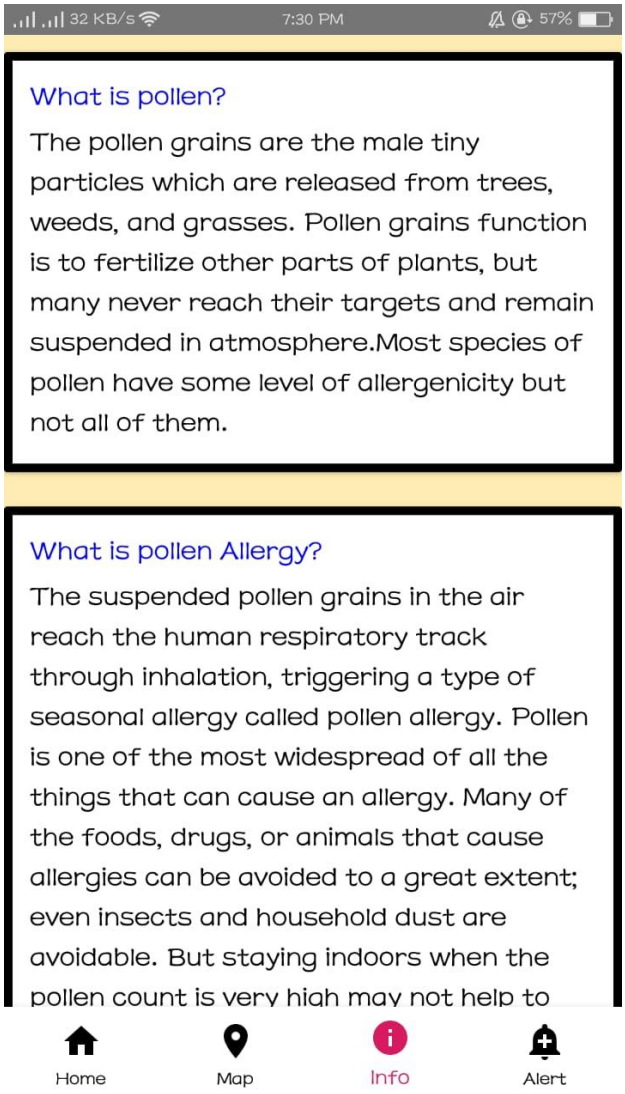


Figure 4.22. Information

When the user selects the Alert Notification tab

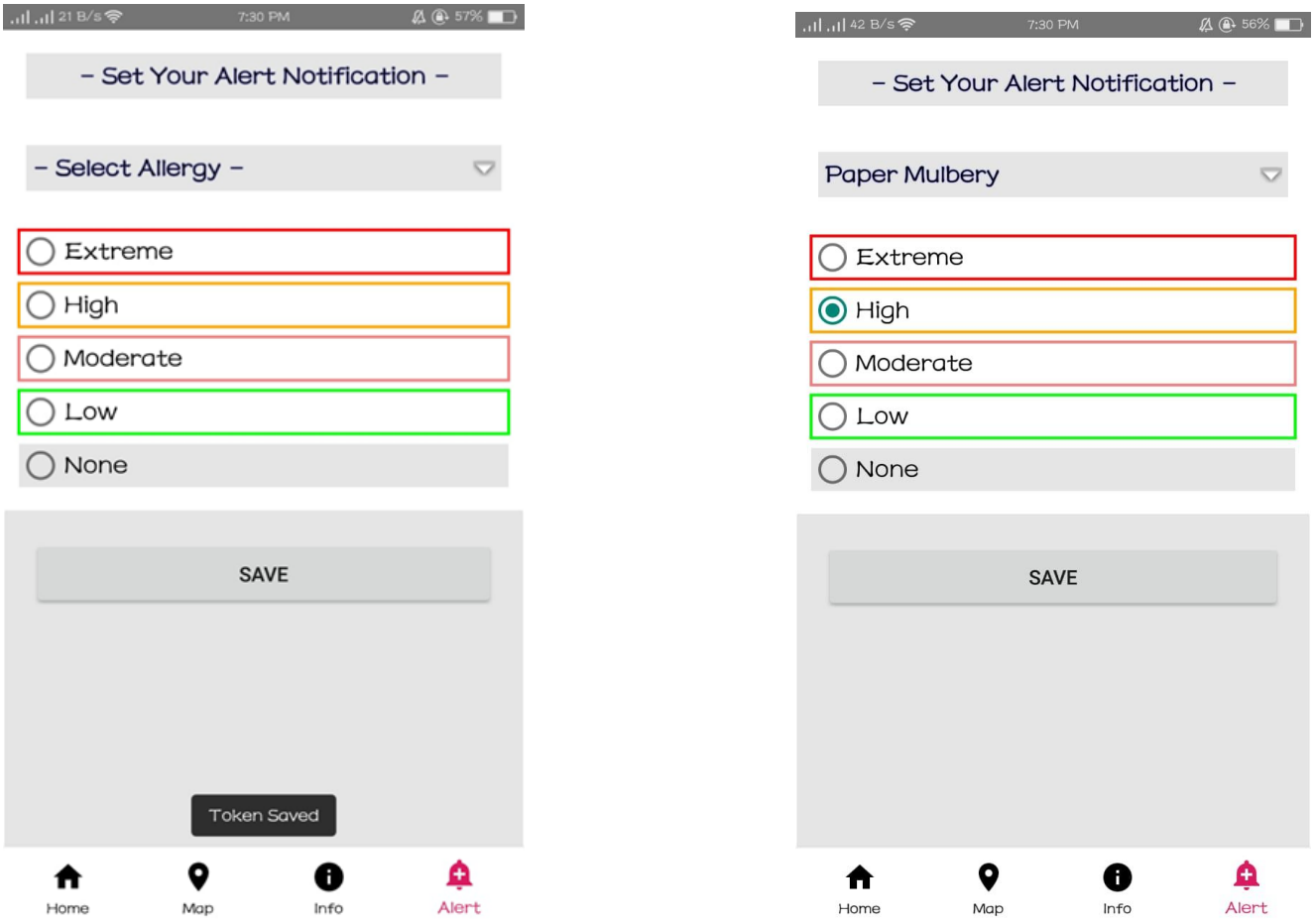
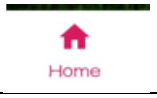


Figure 4.23. Alert Notification

4.7.3 Screen Objects and Actions

4.7.3.1 Home Icon

Object Name	Home icon
Image	
Present on Screen	Main Menu
Action	When user selects home option on main menu (screen) , he is navigated to forecast window.

4.7.3.2 Info Icon

Object Name	Info icon
Image	
Present on Screen	Main Menu
Action	When user selects info option on main menu (screen) , he is navigated to Information window

4.7.3.3 Alert Notification Icon

Object Name	Alert Notification icon
Image	
Present on Screen	Main Menu
Action	When user selects Alert option on main menu (screen) , he is navigated to Notification window.

4.7.3.4 Change Location(Drop Down)

Object Name	Drop Down(Change Location)
Image	
Present on Screen	Forecast
Action	When user clicks on change location (drop down), a drop down list of different sectors pops in front of user, from which user selects his desired location. eg Sector G-7

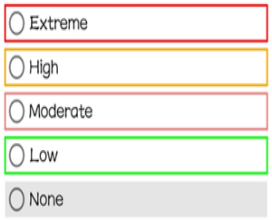
4.7.3.5 Change Pollen Type(Drop Down)

Object Name	Drop Down(Change Pollen type)
Image	
Present on Screen	Forecast
Action	When user clicks on change Pollen Type (drop down), a drop down list of different pollen types pops in front of user, from which user selects his desired pollen Type. eg Paper Mulbery

4.7.3.6 Recycler View

Object Name	Recycler View
Image	
Present on Screen	Allergy Notification
Action	When user clicks on Select Allergy (drop down), a drop down list of different allergies pops in front of user, from which user selects the one allergy (of which he wanted to receive notifications).

4.7.3.8 Radio Group (Select Intensity)

Object Name	Radio Group(Select Intensity)
Image	
Present on Screen	Allergy Notification
Action	User can select one of these radio buttons to select the intensity for receiving notifications. So if certain allergens crosses the limit user gets the notification.

4.7.3.9 Save Button

Object Name	Save Button
Image	
Present on Screen	Alert Notification
Action	When the user clicks on the save button, a notification alarm is saved in database for that user .So in the future user receives the notifications if certain allergen crosses the user selected intensity.

4.7.4 Requirement Matrix:

Functional Requirements	Component
4.1.3 The system shall be able to get user location.	 This component (text Field present on forecast window) allows the user to select location
4.2.3 The system shall be able to see prediction of the density of different pollen plants for area relative to user's location.	 This component (Recycler view) shows the user forecast of pollen relative to his location.

Chapter 5. Project Test and Evaluation

5.1. Introduction

This test plan section describes the appropriate strategies, process and methodologies used to plan, execute and manage testing of the "Smart Pollen Monitoring & Prediction Service(SPM)". The test plan will ensure that SPM meets the customer requirements at an accredited level.

Manual Testing will be followed which includes testing a software manually, i.e., without using any automated tool or any script. In this type, the tester takes over the role of an end-user and tests the software to identify any unexpected behavior or bug. Each Unit will be tested separately and then will be integrated with other units; therefore, Unit Testing and Integration testing will be followed. For each unit, Black box Testing is done and for combined units Acceptance Testing is done.

The test scope includes the Testing of all functional, application performance and use cases requirements listed in the *requirement document.*

Software testing, depending on the testing method employed, can be implemented at any time in the development process. However, most of the test effort occurs after the requirements have been defined and the coding process has been completed.

This document includes the plan, scope, approach and procedure of the testing of SPM. The pass/fail criteria of the test items are also defined. The document tracks the necessary information required to effectively define the approach to be used in the testing of the product.

5.2. Test Items

The test items selected for testing include the following

1. Performance / Accuracy
2. Interface
3. User Control

5.3. Features to Be Tested

The features of our game include the functionality mentioned in our design document. Following features are to be tested keeping in view the test items and system features aforementioned

- The application should be properly
- The Application shall be able to get user current location.
- The different options available on bottom navigation bar shall be

A. Forecast
B. Info
C. Alert Notification

- At any time user shall be able to exit the application when required.
- On selecting forecast**:** the user shall be able to see prediction of the density of different pollen plants for area relative to user's location.
- The application shall also estimate the overall count of pollen for each sector.
- The application shall handle the internet connectivity issues in getting the forecasting information from server (repeated inquiry from server automatically).
- The application shall notify the users if allergens reaches the certain level.
- The application shall provide the interface to the users to set certain levels for certain allergens.
- The application shall provide accurate information regarding each plant
- The application shall handle the internet connectivity loss during getting the information from the APIS

5.4. Test Approach

Functional Testing will focus on each use case that is included in the version currently being worked on. Testing will mainly consist of execution of test cases written to address the gap identified. It will focus on inputs, outputs and system changes due to the actions.The testing strategy for SPM will be Alpha testing (Black box and White box techniques). Black Box testing technique will be used for testing functionality of each module.

.

5.5. Item Pass/Fail Criteria

Details of the test cases are specified in section Test Deliverables. Following the principles outlined below, a test item would be judged as pass or fail.

1. Preconditions are met
2. Inputs are carried out as specified
3. The result works as what specified in output => Pass
4. The system doesn't work or not the same as output specification => Fail.

5.6. Suspension Criteria and Resumption Requirements

Testing procedure will be suspended whenever a defect is found that restricts further testing. A corrective measure will be applied depending upon the criticality of the defect and testing will be resumed.
Efforts have been made to remove all and every chance of failure but there are certain unpredictable factors such as network issues, corrupt input data, or system failure that may lead to some issues. Error handling is applied more deeply to cover all these issues but unforeseen circumstances may happen.

5.7. Test Deliverables

Testing tasks

1. Develop Test Cases.

2. Execute tests based on the test cases developed.

3. Report defects during tests if any.

4. Manage the changes made after testing.

Test cases

Following are the Test Cases:

5.7.1. Getting the User Location

Test Case ID	**TC 1**
TestCase Description	It shall display the user with the two options, i.e Use GPS, or Select Sector
Testing Technique used	Black Box Testing.
Preconditions	1.The application must be installed properly
	2. Mobile phone is connected to Internet .
Steps	1. Launch Application on mobile phone.
Expected output	User shall be able to see two option to select i.e Use GPS or Choose Location
Actual output	Application Screen is displayed having options 1.Use GPS 2.Select Location
Status	PASS

Table 5-1 TestCase1

5.7.2. User Selects Use GPS option

Test Case ID	**TC 2**
Description	This test case will check whether application be able to get the user location from GPS, when the user selects the GPS
Testing Technique used	Black Box testing
Preconditions	Application is launched and a Screen is displayed with the two options i.e Use GPS and Select Location and user selects the "**USE GPS**" option
Steps	1. Launch application. 2.Select "**USE GPS**" from the application screen
Expected output	Application shall be able to get coordinates of user location from GPS

Caution	Ask User Permisson before accesing GPS
Actual output	Application gets the coordinates of user location from GPS.
Status	PASS

Table 5-2 TestCase2

5.7.3. User Selects Choose Sector Feature

Test Case ID	**TC 3**
Description	This test case will check whether application be able to get the sector from google map api, when the user selects the particular sector
Testing Technique used	Black Box testing
Preconditions	Application is launched and a Screen is displayed with the two options i.e Use GPS and Select Location and user selects the "**Choose Sector**" option
Steps	1. Launch application. 2.Select "**Choose Sector**" from the application screen
Expected output	Application shall be able to get coordinates of user selected Location from the google map api.
Actual output	Application gets the coordinates of user location from GPS.
Status	PASS

Table 5-3 TestCase3

5.7.4. Displaying the options in bottom navigation bar

Test Case ID	**TC 4**
TestCase Description	The bottom navigation bar shall contain the three icons that can be Selected by the user: These three options should be: 1- Forecast 2- Info 3- Alert Notification
Testing Technique used	Black Box Testing.
Preconditions	1.The application must be installed properly
Steps	1. Launch Application on mobile phone.
Expected output	User shall be able to see a three icons in bottom navigation bar
Actual output	Bottom Navigation bar is displayed having options 1- Forecast 2- Information 3- Alert Notification
Status	PASS

Table 5-4 TestCase4

5.7.5. User selects the forecast icon

Test Case ID	**TC 5**
Description	This test case tests whether on clicking the forecast icon system shows the user the pollen's density forecast of different type of pollen based on their selected location
Testing Technique used	Black Box Testing
Preconditions	1- The system shall use the data in making predictions provided by Pakistan Meteorological Department in specified format. 2- The model on which system is relying on, will be trained and tested to make accurate predictions.
Steps	1- Launch Application on mobile phone. 2- Select "**Choose Sector**" from the application screen 3- Select "**Choose Pollen Type**" from the application screen 4- Select **"Forecast icon"** from the bottom navigation bar
Expected output	The user shall be able to see prediction of the density of different pollen plants for area relative to user's location
Caution	Good Internet Connection
Actual output	The user was able to see prediction of the density of different pollen plants for area relative to user's location
Status	PASS

Table 5-5 TestCase5

5.7.6. User selects the Information icon

Test Case ID	**TC 6**
Description	This test case will check whether on clicking information icon in the bottom navigation bar , a new window will open that will show the different queries of user with their location
Testing Technique used	Black Box testing
Preconditions	1- Application is launched and User selects the info icon. 2- The system shall handle the internet connectivity loss during getting the information from APIS.
Steps	1. Launch application. 2. Select **"Information icon"** from the bottom navigation bar
Expected output	The system shall provide accurate information related to queries asked by users related to pollen
Actual output	The system provided the accurate information related to the queries asked by user related to pollen
Status	PASS

Table 5-6 TestCase6

5.7.7. User selects the Alert Notification icon

Test Case ID	**TC 7**
Description	This test case will check whether on clicking Alert Notification icon in the bottom navigation bar , a new window will open that will allow the user to set the alert notification for the specific type of pollen
Testing Technique used	Black Box testing
Preconditions	1- Application is launched and User selects the Alert Notification icon. 2- The system shall handle the internet connectivity loss during getting the information from APIS.
Steps	1. Launch application. 2. Select **"Alert Notification icon"** from the bottom navigation bar
Expected output	The system shall allow the user to set the alert notification for the Specific type of pollen

Actual output	The user was able to set alert notification for specific set alert notification for specific type of pollen
Status	PASS

Table 5-7 TestCase7

5.8. Responsibilities, Staffing and Training Needs

5.8.1. Responsibilities:

All developers of the project are responsible for the completion of all components testing and integration testing tasks.

5.8.2. Staffing and Training Needs:

Basics knowledge of testing strategies and techniques is needed for the testing of the project. Techniques such as Black Box testing, integration testing should be known to developers.

All the developers will be testing each other's work and will be actively participating in the development and testing of the project simultaneously.

5.9. Risk and Contingencies

Efforts have been made to remove all and every chance of failure but there are certain unpredictable factors such as network issues, corrupt input data, or system failure that may lead to some issues. Error handling will be applied more deeply to cover all these issues but unforeseen circumstances may happen.

5.9.1. Schedule Risk:

The project might get behind schedule so in order to complete the project in time we will be needing to increase the hours/day that the project is being worked on.

5.9.2. Operational Risks:

Operational risks will be eliminated by Scheduling daily meetings and regular deadlines to meet the goals of the project as well as provide proper communication within the group.

5.9.3. Technical risks:

Technical risks will be eliminated by keeping the once defined requirements constant.

5.9.4 Programmatic Risks:

In case of a programmatic risk the scope of the project will be limited in order to stay inside the constraints of the project.

Chapter 6. Future Work

This project can be extended further in some of the ways that are going to overcome the limitations that we are facing. One most severe limitation right now that we are facing is that we have been given the data of only one sector of Islamabad by Pakistan Meteorological Department for the one type of pollen that is fluctuating and causing severe allergy in pollen allergic patients

So one way to overcome this is if we are predicting the pollen count of one city for example Islamabad then department which is collecting the data on these thing i.e pollen should provide multiple variables for multiple location. Along with that they should also some variable from which we can directly infer the amount of pollen in that specific sector or location.

There is one more way that can be done in future to predict the density of pollen if in future some one is facing the same limitations (mentioned above) as us, what they can do is that if they have the trend of of the sector they can correlate the trend of another sector based on some criteria and variables.It may not give us the exact prediction but it can be pretty close.

Another improvement that can be done in this project is that we can include services like weather forecast , rain prediction some thing like that in our application so that it can be like complete package for the weather, pollen, allergy, rain etc. In future we can also build an application programming interface that is going to provide json data related to the prediction to other organization who might want to utilize this kind of data. We have only build the interface of this application in android , In future this application can also be build on multi-platform like web , desktop, iphone apps etc.

A very most interesting thing can be done in future on this project is to collect the data from pollen patient or some other allergic patients using gadgets like apple watch of their daily activities and to utilize this data in an edge learning system that will perform the profound calculation at the edge of system i.e on the person’s phone or on his laptop to provide insights to the patients what they can do to improve their daily routine. It’s interesting because in this way the user's data will only be on their devices and they might feel secure that their daily life can only be seen by their devices and by no one else.

Chapter 7. Conclusion

What if we can look into the future and tell exactly how severe is the pollen going to be tomorrow? or the day after that? Or next week? However impossible it may sound, Thanks to Machine Learning we did just that. Using a huge dataset that contains data for different attributes like the count of pollen, humidity and temperature of every single day for the past 10 years, we built multiple ML models on which we trained this dataset. The models when trained were able to detect patterns in the data. These patterns could now be used to predict the density of pollen in future based on the training data set. We used three Machine Learning models of which Logistic Regression gave us the best accuracy of 99%. Being this accurate isn't very likely when dealing with other real world problems but because our dataset was very linear and the patterns were fairly visible, i.e the spike in pollen count in spring season specifically, we could get the accuracy as high as 99%.

The statistics we get from the Machine Learning algorithm will be displayed on an android application that we built from scratch. The user will have to install the android application and select the type of pollen allergy and his area. The application will show him if the pollen density is low, high, severe or critical for the next few days. The user can also set the notifications for when the density of pollen is alarming. This will help him take precautionary measures and stay inside in case there's an outbreak.

Appendices

Appendix A: Glossary

1. **APP:** Application
2. **GUI:** Graphical User Interface
3. **SPM:** Smart Pollen Monitoring and Prediction Service
4. **SDS**: Software Design Specification
5. **UML**: The Unified Modeling Language (UML) is a general-purpose modeling language in the field of software engineering, which is designed to provide a standard way to visualize the design of a system
7. **WBS:** The project management Work Breakdown Structure

Bibliography

Bibliography

[1] Allergy Insights with Watson uses AI to predict allergy symptom risk, KYLE WIGGERS, APRIL 20, 2020

[2] How AI* Can Help Patients Cope with Chronic Diseases like Allergies, doc.ai, Oct 27, 2018

[3] Deep learning for pollen allergy surveillance from twitter in Australia, Jia Rong, Sandra Michalska, Sudha Subramani, Jiahua du, Hua wang 08 November 2019

[4] How AI Is Finding Patterns And Anomalies In Your Data, Kathleen Walch, May 10, 2020

[5] Doc.ai launches blockchain-based conversational AI platform for health consumers, doc.ai, Oct 27, 2018

[6] The soft computing-based approach to investigate allergic diseases: a systematic review, Gennaro Tartarisco, Alessandro Tonacci, Paola Lucia Minciullo,Lucia Billeci,Giovanni Pioggia,Cristoforo Incorvaia,corresponding author and Sebastiano Gangemi, April 13, 2017

[7] How AI and Weather Data Can Help You Plan for Allergy Season, Rachel Chukura, Misha Sulpovar, April 13, 2020

[8] Pollen allergies prediction through historical data in mobile devices, Daniel H. De la Iglesia1, Juan F. De Paz1, Gabriel Villarubia1,Ana de Luis1, Sigeru Omatu

[9] Challenges in interpreting allergen microarrays in relation to clinical symptoms, Mattia C F Prosperi , Danielle Belgrave, Iain Buchan, Angela Simpson, Adnan Custovic

[10] Howard LE, Levetin E (2014) Ambrosia pollen in Tulsa, Oklahoma: aerobiology, trends, and forecasting model development. Ann Allergy Asthma Immunol 113: 641-

[11] CDC (2013) Asthma facts|cdc's national asthma control program grantees. Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention.

[12] Arbes SJ, Gergen PJ, Elliott L, Zeldin DC (2005) Prevalences of positive skin test responses to 10 common allergens in the us population: results from the third national

health and nutrition examination survey. J Allergy Clin Immunol 116: 377-83.

[13] Bacsi A, Choudhury BK, Dharajiya N, Sur S, Boldogh I (2006) Subpollen particles: carriers of allergenic proteins and oxidases. J Allergy Clin Immunol 118: 844-50.

[14] Thompson JL, Thompson JE (2003) The urban jungle and allergy. Immunol Allergy Clin North Am, 23: 371-87.

[15] Oswalt ML, Marshall GD (2008) Ragweed as an example of worldwide allergen expansion. Allergy Asthma Clin Immunol 4: 130-5.

[14] NIEHS (2010) A human health perspective on climate change: A report outlining the research needs on the human health effects of climate change. In A Human Health Perespective On Climate Change: A Report Outlining the Research Needs on the Human Health Effects of Climate Change. Environmental Health Perspectives (EHP); National Institute of Environmental Health Sciences.

[15] Astray G, Fernández-González M, Rodríguez-Rajo FJ, López D, Mejuto JC (2016) Airborne castanea pollen forecasting model for ecological and allergological implementation. Sci Total Environ 548: 110-21.

[16] Csépe Z, Makra L, Voukantsis D, Matyasovszky I, Tusnády G, et al. (2014). Predicting daily ragweed pollen concentrations using computational intelligence techniques over two heavily polluted areas in europe. Sci Total Environ 476: 542-52.

[17] Rodríguez-Rajo FJ, Astray G, Ferreiro-Lage JA, Aira MJ, Jato-Rodriguez MV, et al. (2010). Evaluation of atmospheric poaceae pollen concentration using a neural network applied to a coastal atlantic climate region. Neural Netw 23: 419-25.

[18] Voukantsis D, Niska H, Karatzas K, Riga M, Damialis A, et al. (2010) Forecasting daily pollen concentrations using data-driven modeling methods in thessaloniki, greece. Atmos Environ 44: 5101-11.

FYP thesis

ORIGINALITY REPORT

15%	5%	1%	13%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Higher Education Commission Pakistan Student Paper	2%
2	Submitted to RDI Distance Learning Student Paper	1%
3	Submitted to University of Mauritius Student Paper	1%
4	www.coursehero.com Internet Source	1%
5	breezometer.com Internet Source	<1%
6	manualzz.com Internet Source	<1%
7	Submitted to University of Bedfordshire Student Paper	<1%
8	Submitted to Mahidol University Student Paper	<1%
9	www.slideshare.net	

	Internet Source	<1%
10	Submitted to Pathfinder Enterprises Student Paper	<1%
11	Submitted to CSU, San Jose State University Student Paper	<1%
12	Submitted to Middlesex University Student Paper	<1%
13	Submitted to CTI Education Group Student Paper	<1%
14	Submitted to Study Group Australia Student Paper	<1%
15	Submitted to The University of Manchester Student Paper	<1%
16	Submitted to Laureate Higher Education Group Student Paper	<1%
17	Submitted to Colorado Technical University Online Student Paper	<1%
18	www.overtone.co.jp Internet Source	<1%
19	Submitted to Multimedia University Student Paper	<1%
	nation.com.pk	

20	Internet Source	<1%
21	Submitted to Coventry University Student Paper	<1%
22	Submitted to Asia Pacific University College of Technology and Innovation (UCTI) Student Paper	<1%
23	Submitted to University of Maryland, University College Student Paper	<1%
24	Submitted to Manipal University Student Paper	<1%
25	studentsrepo.um.edu.my Internet Source	<1%
26	Submitted to Regis University Student Paper	<1%
27	Submitted to University of Technology, Sydney Student Paper	<1%
28	Submitted to University of Westminster Student Paper	<1%
29	Submitted to (school name not available) Student Paper	<1%
30	Submitted to University of Queensland Student Paper	<1%

31	www.phasis.nl Internet Source	<1%
32	Submitted to UCSI University Student Paper	<1%
33	jwcn-eurasipjournals.springeropen.com Internet Source	<1%
34	hdl.handle.net Internet Source	<1%
35	arxiv.org Internet Source	<1%
36	Mandira Singh Shrestha, Muhammad Riaz Khan, Nisha Wagle, Zaheer Ahmad Babar, Vijay Ratan Khadgi, Shahzad Sultan. "Review of Hydrometeorological Monitoring and Forecasting System for Floods in the Indus Basin in Pakistan", Elsevier BV, 2019 Publication	<1%
37	Submitted to MENA College of Management Student Paper	<1%
38	link.springer.com Internet Source	<1%
39	Submitted to University of Lincoln Student Paper	<1%
40	Submitted to London School of Commerce Student Paper	<1%

41	Submitted to McMaster University Student Paper	<1%
42	Submitted to University of Reading Student Paper	<1%
43	Submitted to Universiti Teknikal Malaysia Melaka Student Paper	<1%
44	Submitted to The Hong Kong Polytechnic University Student Paper	<1%
45	Submitted to University of Malaya Student Paper	<1%
46	bitaacj.mozdev.org Internet Source	<1%
47	aoip.osa.org Internet Source	<1%
48	Submitted to Universiti Utara Malaysia Student Paper	<1%
49	Submitted to University of KwaZulu-Natal Student Paper	<1%
50	www.aut.upt.ro Internet Source	<1%
51	Submitted to Universiti Teknologi MARA Student Paper	<1%

52	Submitted to London School of Marketing Student Paper	<1%
53	Entregado a University of Essex el 2012-12-07 Student Paper	<1%
54	docplayer.net Internet Source	<1%
55	Submitted to University of East London Student Paper	<1%
56	Submitted to CSU, Dominguez Hills Student Paper	<1%
57	Submitted to Imam Muhammad Bin Saud Islamic University Student Paper	<1%
58	Submitted to Thapar University, Patiala Student Paper	<1%
59	Submitted to Prince Sultan University Student Paper	<1%
60	Submitted to The University of the South Pacific Student Paper	<1%
61	shareok.org Internet Source	<1%
62	Submitted to Universiti Tunku Abdul Rahman Student Paper	<1%

63	Submitted to American Public University System Student Paper	<1%
64	Submitted to Johns Hopkins Unversity Student Paper	<1%
65	D.G. Firesmith. "Use case modeling guidelines", Proceedings of Technology of Object-Oriented Languages and Systems - TOOLS 30 (Cat. No.PR00278), 1999 Publication	<1%
66	Submitted to International School of Management and Technology (ISMT), Nepal Student Paper	<1%

Exclude quotes	Off	Exclude matches	Off
Exclude Bibliography	On		

END