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Developing a Recommendation System for Medical Healthcare

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Declaration of Authorship

This is to certify that the work presented in this project is the outcome of the analysis and experiments carried out by Al-Zami Rahman under the supervision of Hasan Mahmud, Assistant Professor, Department of Computer Science and Engineering (CSE), Islamic University of Technology (IUT), Dhaka, Bangladesh. It is also declared that neither of this thesis nor any part of this thesis has been submitted anywhere else for any degree or diploma. Information derived from the published and unpublished work of others has been acknowledged in the text and a list of references is given.

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Abstract

Doctor selection process for the treatment of a particular disease is the primary step of personal healthcare. Due to lack of information patients always seek doctor recommendation from others. The recommendation they get in return is also not based on any actual data. That recommendation is mostly based on personal experience of other people. Sometimes it may happen that, the person who is recommending also does not have any prior experience about the doctor. They may have heard about that doctor from someone else. Thus patients get misguided, which results in wastage of valuable time, money and effort. We address this issue and tried to come up with an online based recommendation system. This recommendation system takes into account all the key performance factor of a doctor. These performance factors can be patients treatment satisfaction, doctor's years of service experience, educational qualification, number of patients who recommended that doctor to other patients etc. We proposed a rating algorithm which generate rating for a doctor using those performance factors. Using the ratings, the system will recommend doctors to the patients. In our recommendation architecture we also included location and patients previous search history also. This system has the potential to assist people in doctor selection process.

Keywords: Healthcare, Recommendation System, Healthcare Sentiment Analysis, Healthcare Recommendation System, Feedback, Doctor Performance, Doctor rating, ranking, rating

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1. Introduction

A recommendation system or engine is an information filtering system that aims to offer assistance in decision making process based on “user rating” or “preference”. Now a days commercial application of recommendation system covers vast areas, such as e-commerce sector, online entertainment and also healthcare. The scope of this project is limited to developing a recommendation system for medical healthcare in the context of Bangladesh. We focused on developing such a system which will assist patients to find a suitable doctor for themselves. But the general concept behind this project will apply to anywhere else also.

The concept of recommendation plays a great role in healthcare. We humans always rely on recommendation when it comes down to selecting one option among many others. A recommendation from a trustworthy source gives us confidence to trust a person or institution. Any reliable recommendation will benefit us enormously. Generally, recommendation is a cluster of data points which we consider in order to make a decision. In healthcare this data points could be patient’s feedback, different performance factors of the doctor, doctor’s accumulated rating points and various patient metadata etc.

This system aims to award rating points to doctors based on different performance factors. These performance factors included doctor’s chamber environment, treatment quality, behavior towards patients. Also we will take into account the number of patients who wants to recommend the doctor to other patients as a measurement of excellence as well. These performance factors are measured based on patient feedback (comment, close ended questions). Patient will be able to search doctor from this system using different diseases specialization and sub-specialization criteria. Based on patient search query, system will recommend doctors according to the awarded rating point. Geographic location is also important in personal healthcare. Patients may not want to travel a long distance in order to make an appointment with a doctor. Sometimes patient may not be

able to travel a long distance due to severe illness or injury. It is also observed that, if patient's health related issue is not critical enough, they prefer to choose healthcare from a nearby convenient location from their home of residence. That is why this system will also accommodate location based doctor recommendation based on patient's previous search history.

1.1 Purpose of Recommendation System in Healthcare

Nature of healthcare recommendation system is different from other business related recommendation. Primary step for personal healthcare is to make decision regarding which doctor to select for the treatment of a particular disease. But making choices regarding personal healthcare is difficult and has profound impact on not only the persons who make the decision but also their entire family. Most important aspect of a healthcare recommendation system is to assist patients in this decision making process. So a healthcare recommendation must be responsible and fact driven. A healthcare recommendation system provides insights in order to guide patients for making a better decision. It is important to note that, huge healthcare data is being generated and it is very difficult to digest those data for decision making purpose. A recommendation system provides analytical insights in the form of various graphs and charts for easier data consumption. Overall a healthcare recommendation system should server the following purposes :

1. Assisting in decision making regarding personal. healthcare.
2. Enable patients to make a choice for themselves.
3. Make patients confident about their decision.
4. Recommend doctor based on patient's respective geographic location.
5. Recommend doctors based on patient's previous consultation history.
6. provide analytical insights, For easier data consumption.

1.2 Background of the problem

Healthcare is a very essential part of all human life. When a person is sick, he/she is looking for a good physician or goes to hospital for recovery. In Bangladesh, there is no proper method in place to match a patient with an appropriate physician. In our country, some doctors or hospitals are very well-known or popular among patients based on their own personal satisfaction or information from friends or close relatives. But there is no proper authentic information-based system available which will provide the fact-based classification of doctors to verify their competence and excellence in healthcare service. Therefore, most of the cases, patients are not able to identify or classify doctors based on performance, thus fail to get the proper medication and treatment. It results in wastage of both time and money. Recent study shows that More importantly, in most of the cases wrong treatment and improper health services experienced by patients remain unidentified or undisclosed since there is no such mechanism in place to disclose them. So, it has become very difficult to ensure healthcare professionals accountability. Hence, there is no competition among the health service providers to improve the quality of health services, especially in the context of Bangladesh.

1.3 Project Objectives

Making a choice in healthcare has always been a very difficult task. Our goal is to offer choices to patients and show them different insights which will enable them to make a decision on their own[14]. This project aims to assist patients to pick right doctor from a list of recommended doctors. Performance analytic of each recommended doctor will be provided by the system in the form of various graphs and charts. Patients will be able to pick right doctor using insight from those analytical charts. Thus patients will feel confident and empowered. Our system will also recommend doctor based on patient metadata, such as location and previous search history. Using location based filtering patient can easily find competent doctors in their locality. Patients will also be able to track past medical

history in the form of digital content which will help patients to learn from past experience. This system will also assist doctor to review their performance and make necessary amendments for better performance in the future.

1.4 Motivation behind the project

People rely mostly on recommendations from others when it comes to selecting a healthcare professional for his or her specific needs. Because it is not possible for a patients to recommend a doctor for themselves due to lack of prior experience. That is why patients seek assistance from others who have prior experience of a particular health issue. For recommendation, people tend to go to the people whom they know most. But opinions of only a few other people should not be enough for this purpose. If we can build a system which can collect the feedback from lots of different people and use those feedback to recommend doctors, people will now have lots of opinions from people of various background to consume and make a decision out of it. It will reduce mistakes in decision making and create a collaborative environment where feedback of the patients will help each other to get a considerable recommendation whenever they need it.

1.4.1 Case Study

We have conducted some interviews on some patients and listen to what they have to say. These patients shared their story with us. It helped us to understand where the problem lies. This study gave us clear idea where we should focus in order to solve this problem. We are describing some of the case study which we have conducted.

Case Study 1

Let's see a scenario of a patient called Mr. Assad. He had been suffering from severe ear pain. He sought recommendation from his circle of acquaintances. He received some recommendation from them. He went to a Ear specialist as per recommendation with a severe pain in his internal ear. The doctor proposed some medication to ease the pain and concluded that there was a tear found in

his ear drum. He as well as his family became very anxious and followed the doctor's procedure. Later the doctor confirmed that in order to fix the damaged ear drum, he must undergo a surgery immediately. Mr. Assad got surprised and nervous at the same time. Consulting with his family members, he sought out help from another prominent Ear specialist of the country. He then made appointment with his new doctor and he went to visit his doctor. The doctor performed some experiments and concluded that his ear drum is not damaged and will be fixed with proper medication. Eventually, Mr. Assad's ear got repaired in due course. But the suffering he went through all this time is really worth noticing. There is no way to hold the doctor accountable who performed wrong and misguided treatment. If he could get information through a system where doctors are being evaluated all the time by their patients, this type of situation can easily be avoided.

Case Study 2

Let's see another scenario of a patient called Mr. Abdul kashem. His mother had been suffering from urine infection. He made appointment with a prominent doctor who happens to see a lot of patients every single day. Due to this, the doctor can only give a few minutes to a single patients. When they visited the doctor, his mother could not properly disclose her condition due to lack of time. The doctor just listened and then prescribed some medicine without explanation. Then on the subsequent appointments, the same scenario continued. His mother eventually changed doctor and more or less experienced the same scenario. Sometimes doctor did not consider her prior treatment history before prescribing medicine. It made her fall victim to some harmful health condition. Mr. Abdul Kashem also feel the need of a centralized system where he could mention his experience with other patients. He appreciated the idea of patients being able to discuss and share their experience among themselves in a common platform.

1.4.2 Impact of Misguided Recommendation in Healthcare

It is not entirely possible for patients to clearly judge whether or not one doctor is better than the other. With minimum information a patient possess it is very

difficult to come to a decision. Patients may fall pray to misdiagnosis and ill-treatment due to wrong decision making. This contribute to search related cost increasing [6].

Year	Cost (USD)
2010	18
2012	23
2014	28
2016	32

Table 1.1: Yearly Increase of Cost in Healthcare Sector of Bangladesh

From the table : 1.1, it is evident that the healthcare cost in Bangladesh is on the rise [9]. Wrong decision generally stem from misguided recommendation procedure. Due to the wrong decision at the decision making step, extra expense are begin added to already rising healthcare expenditure. So, Impact of wrong decision in healthcare are the followings :

1. Patients fall victim to misdiagnosis.
2. Waste of time and money.
3. In worst case wrong decision in healthcare can cause permanent health damage or death.

1.4.3 Absence of Proper Healthcare Recommendation System in Bangladesh

A properly guided healthcare recommendation system can play a vital role for the society. Due to its absence, wrong decisions are always being made by patients which paves the way to many health related hazards. There is not enough reliable recommendation system in healthcare in Bangladesh. Most of the present solution rely on giving random results based on disease type a patient has searched for.

Sometimes they just give away random suggestions based on patient's location of interest. They are not reliable as they do not take into account the patient feedback which play a major role in doctor recommendation. Most of the time they suggest random doctor which may not be suitable for the specific needs of the patient. On the other hand, patients also feels confused while searching doctor as they don't know which criterion has been taken into account while recommending doctors for them.

1.4.4 Benefits Derived from an Online Based Recommendation System in Healthcare

An online based healthcare recommendation platform can reach out to everyone [2]. It has the potential to make people's life a lot easier by assisting them in searching personal healthcare. A recommendation system could assist us to make better decision. It enable patients to cross-validate their decision, which reduces the chance of making any serious mistake. This type of systems will help patients in planning their personalized therapy . It would be very helpful for the patients if there is a recommendation system which is transparent, reliable and reflect the opinion of the patients

Healthcare professionals will also be able to get their performance reviewed by their patients. It will help to to make amendments where they are lacking. As patients can now hold the doctors accountable, it will be very difficult for doctors to get away with severe performance lacking. It will possible to ensure better service in healthcare. Thus it will Establish a trusted relationship between patient and healthcare service providers.

2. Background study

We have conducted survey among patients with specific questionnaires in order to find meaningful insights. Purpose of background study was get a clear understanding about different recommendation strategy followed by the patients in Bangladesh. In order to develop a online based recommendation system we must ensure that it will reach out to each and every people of the country. So we have to find out whether or not the current internet infrastructure is capable enough to take our system from urban cities to remote corner of the country. We aims to study the existing online based recommendation system which are available for patients to use. And we tried to find out what are the basic requirement from patients which must be provided by those systems.

2.1 Scope of Background Study

Through this study, we tried to find out the traits of healthcare recommendation procedure being practiced in Bangladesh. We observed some of the online recommendation platforms. We have pointed out the key components, that are not currently implemented in those existing system. So scope of this study included :

1. Develop a clear understanding about the common healthcare recommendation practice in Bangladesh.
2. Figure out the prospect of online based healthcare recommendation.
3. What are the key characteristics of a recommendation system.
4. What is missing on existing online healthcare recommendation platforms.

2.2 Common Healthcare Recommendation Practices in Bangladesh

In Bangladesh it is a common practice to ask for external opinions when it comes to make a healthcare choice. It is generally know as word-of-mouth recommendation. As no data is available for patients to make a decision from, patients

do not feel confident enough to make a decision on their own. They are afraid of making mistakes which is very likely. So they tend to seek outside opinion regarding their health condition. People generally seek assistance from people they are acquainted with. In the age of digitization, online recommendation platforms are also emerging which offer assistance in decision making process. Another source of healthcare recommendation is the doctors themselves. Sometimes one doctor recommend another doctor. All these methodologies are commonly practiced in our country in order to get healthcare recommendation.

2.3 Prospect of Online Based Healthcare Recommendation in Bangladesh

Our country is a developing one and internet infrastructure is well established in urban areas. Healthcare can be one of the sectors which can be transformed through the proper use of internet. People are now well aware of internet and its benefits. Usage of internet is on the rise in different sectors. Nearly every major city of Bangladesh came under high speed broadband coverage. Also mobile broadband services covers the large part of the country. Mobile internet has the potential to take any online based services within the reach of rural population. Necessity for a reliable online based recommendation is in high demand throughout the world. It is high time to introduce the people of our country with the online based healthcare recommendation system.

2.4 Basic Characteristics of an Impactful Online Healthcare Recommendation System

Matching doctors with patients depends of multiple different factors. Any system can recommend doctors, but what is important here is to establish trust among patients. Most of the recommendation system available online are not following patient-centered approach. There is no participation of patients in the recommendation procedure. Patients opinion are neglected throughout [7]. Thus patients does not feel confident about the recommended doctors. If the system allows patients participation in the recommendation process, they will feel confident.

Thus a trusted relationship between the system and the user will be established which will eventually improve the performance of the system. More patient participation will generate more data. Larger amount of data opens up the possibility of better recommendation.

When patients seek word-of-mouth recommendation process, they ask for different performance related topics. Performance is the key ingredient of patient-doctor matchmaking. But it is not possible to take a correct decision from only a handful of opinions. Also doctor performance has various aspects which does not appear clearly during such word-of-mouth discussion about doctor performance. Medical data is huge and it is growing everyday. To to give an authentic recommendation, a system must serve the data in a detestable way so that user can easily consume them. For easier data consumption different analytical graphs and plots are being used worldwide. Healthcare data and doctor performance can be represent to patients using different data visualization techniques. It will make it easier for patients to observe and decide.

Patient participation is vital for a recommendation system. A recommendation system must make use of patient feedback in their recommendation procedure. If feedback is not collected from patients, it means the patients are being neglected from the process. But healthcare recommendation is all about helping patients to find their necessary personal healthcare. If patients feel neglected and their opinion are not valued, they may not feel confident about the process. They may decide to avoid the system altogether.

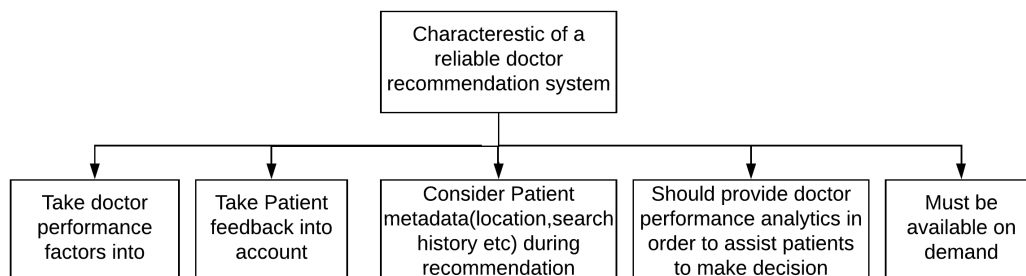


Figure 2.1: Basic characteristics of a reliable online healthcare recommendation system

Patient participation can be increased by allowing them to input their thoughts and experience about the treatment they receive. Patients experience can be obtained in the form of performance and experience related feedback and closed-ended questions. It will empower patients and enable them to take an active role in the healthcare recommendation process. If patients are allowed to provide feedback and share experience, the recommendation system itself will improve over time.

Patients may prefer doctor whose chamber is nearer from their home of residence. Some patients find it comfortable to visit to a doctor of specific gender [13]. Also doctor age is also important. More age generally means more years of service experience. As patients want to pick an experienced doctor, so years of service is also an important decision making factor [13]. So metadata such as patient's geographic location, doctor's years of service experience and gender must be considered by the recommendation procedure.

2.5 Existing Online Healthcare Recommendation platforms in Bangladesh

We have studied some online based healthcare recommendation platforms currently operation in Bangladesh. They are Platform-med, Doctorola, DoctorsBD, HelloDoctor. Short observation on each of the platforms are listed below.

Platform-med :

It is a platform which suggest doctor to patients. It provides doctor information randomly on their homepage and provide some information on that particular doctor, like his degree, chamber location,name and age etc. It does not allow user to search under different search criteria.

Doctorola:

It is also a doctor-patient matchmaking platform which allows to search doctor on different search criteria like location, specialization and symptoms. But most of the time it is unresponsive and not showing the parameters based on which the doctor recommendation is being generated

DoctorsBD :

It is also a doctor seeking platform which allows to search doctor on different search criteria like location, specialization and symptoms. But most of the time the site is down and not showing the parameters based on which the doctor recommendation is being generated.

Hello Doctor BD :

It is a platform to search doctor. But it is only allow user to operate through a mobile app, It is mostly an advertising platform which shows ads to its users on different medical products. It claims it allows user to connect with doctor through video conferencing

2.6 Limitation of the Existing Recommendation Platforms

Currently operating online healthcare recommendation platforms suffer from various reasons. Primary reason is they do not engage patients in recommendation process. They do not allow patients to provide feedback of any sort. Recommendation process is not transparent about the factors considered to recommend doctors to patients. The list of recommended doctors doesn't reflect the opinion and feedback of the other patients who have visited them previously. In many of the platforms the recommendation list mostly rely on search criteria. Limitations of the existing online healthcare recommendation platforms are mentioned in tabular form in the table 2.1.

Platform	Allow feedback from patients	Guided doctor search	Show doctor performance analytics	Data driven doctor recommendation	Location based doctor recommendation
Doctorola	no	yes	no	no	yes
DoctorBD	no	no	no	no	yes
Hello DoctorBD	no	no	no	no	yes

Table 2.1: Accuracy on Different Scaling Values

These platforms do not allow further filtering on the recommended doctors list. Patients are not allowed to search for specific gender or service year experience. Also it is not clear how they ranked the doctor. It could be random list of recommendation without considering any performance criteria. Patient may feel discomfort as no clear idea can be obtained from this systems

3. Proposed Methodology

By studying the existing platforms, we can observe that most of the platform which provide doctor recommendations are not based on the performance of healthcare practitioner. We wanted to build a system which will take into account doctor performance factors while recommending doctors to patients. On the other hand, all the other recommendation platforms does not include user feedback in doctor recommendation. We think patient feedback should play a key role in doctor performance evaluation and recommendation. .

A recommendation system evolves around some specific data points. In healthcare, these data points could be doctor's experience, doctor's performance in healthcare service, Patients satisfaction about the treatment they have received from their doctor, Whether or not a patient want to recommend a doctor to others etc. The main challenge is to collect and measure all those performance factors about a doctor and blend them together in order to make a recommendation procedure which people can relate with their real life experience.

3.1 Requirement Analysis of the Project

Requirements Analysis is the process of defining the expectations of the users for an application that is to be built or modified. Requirements analysis involves all the tasks that are conducted to identify the needs of different stakeholders. Requirements analysis in software development involves analyze data, documentation, validation and refactor a software or system. High-quality requirements are documented, actionable, measurable, testable, traceable, helps to identify business opportunities. Figure 3.1 is use case diagram of the bigger picture of a proposed healthcare management application. This healthcare management application has lots of different features. One specific feature is doctor searching facility for the patients. This is where recommendation system comes into play. When patients search for doctors, the system will provide them a list of recommended doctors.

Doctor recommendation system and doctor searching facility is the scope of this particular project.

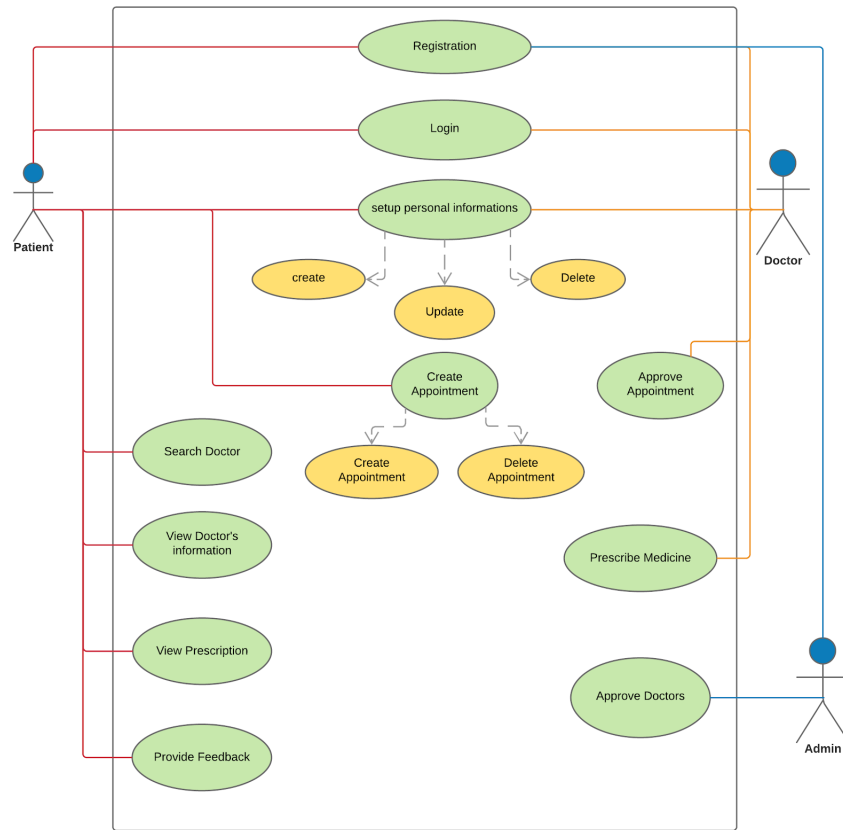


Figure 3.1: Use Case Diagram

From the use-case diagram in figure 3.1, we can easily identify who are the major users of the system. We have found that this system will mostly used by doctors and patients. And there will be an admin panel to regulate the system.

In this project we worked from patients point of view. We have conducted a survey on a group of 20 patients. The survey contains some precise close-ended questions. We tried to clearly identify the requirements of the patients regarding a healthcare recommendation system. The participants of the survey were asked the following questions during the survey.

Serial No.	Question
01	Do you feel the need of an online healthcare recommendation system?
02	Are you satisfied with the systems that are already available?
03	Do you prefer performance-based doctor recommendation?
04	Do you prefer location-based doctor recommendation?
05	Do you agree that providing feedback about your doctor will ensure accountability?
06	What are the important performance factors of a doctor?

Figure 3.2: Survey Questionnaires

3.2 Functional Goal of the Project

Functional requirement analysis of this project are completely based on the requirement of the project. We limited the scope of this project to implement the recommendation system and facilitate doctors search. We have to implement two different systems. One is to build a recommendation system module and the other is web user interface. Recommendation system module will be responsible for rating doctors. And web user interface will act as a graphical interface where users can use different features, such as doctor searching, view and manage profile and tract past medical records.

We will collect patient's experience and feedback. Feedback can be obtained in the form of user comment and from answer to close-ended question on different performance criteria of doctors. If the feedback is in the form of textual data, we will feed these feedback to a sentiment classification algorithm which will generate a numerical representation of those feedback. If feedback is generated from closed ended question, we will use the predefined numerical weight for the chosen answer. Based on the numeric representation of the feedback data, we will run a ranking algorithm which will produce a rating for each doctors.

3.2.1 Develop a Doctor Recommendation Architecture

We developed an architectural framework for the recommendation system. Patients will get doctor recommendation through this recommendation architecture. We proposed a rating generation algorithm. This algorithm takes into account

different performance factors of a doctor. Doctor will be awarded rating points using this algorithm [12]. Our doctor recommendation architecture possess the following characteristics :

1. Recommendation will be given based on doctor ranking
2. Ranking will be generated using a rating algorithm.
3. Rating algorithm should take all the key performance factor into account
4. It should be as close as possible how people generally rank while choosing personal healthcare .
5. Recommendation must be based on patient metadata, such as patient location, previous search history.
6. Doctor metadata such as, doctor experience and qualification must be considered so that recommendations can be more realistic.

3.2.2 Develop an Online User Interface

The purpose of the web based user interface is to provide a platform for the users so that they can easily use different features of the system. Users can navigate around different features of the project through this graphical interface. There is a set of features, such as doctor search, patient dashboard, managing profile, view medical records etc. Every feature will come under its respective menu item. For example, if patients wants to search doctor, they can find search related functionality under "Find Doctor" menu item. User can click to open the menu and can get recommendation based on their respective search criteria. This online based platform can be used from anywhere and anytime through internet.

3.2.3 Functionality Development Tools and Technologies

Back-end Development Tools

C-sharp (C#) Programming Language has been used for back-end implementation of the project. C-sharp is a general-purpose, multi-paradigm programming

language encompassing. It is strongly typed, lexically scoped, imperative, declarative, functional, generic, object-oriented, and component-oriented programming language.

ASP.NET technology has been used as back-end MVC (Model-View-Controller) framework for web development . We used the fifth version. ASP.NET MVC 5 is the latest version of the popular ASP.NET MVC technology that enables you to build dynamic websites using the Model-View-Controller technology, with an emphasis on a clean architecture, test-driven development and extensibility. C-sharp (C#) was the language of choice for web development.

Front-end Development Tools

For front-end implementation, we used the JavaScript programming language. It is well developed and general purpose programming language which have lots of community support.

Sentiment Analysis Platform Development Tools

ASP.NET CORE framework has been used for the development of sentiment analysis platform. ASP.NET CORE is a cross-platform variant of ASP.NET technology. Reason for choosing ASP.NET CORE over traditional ASP.NET was to take advantage of different machine learning library provided by the Microsoft. Machine learning library that we have used in our project are compatible only with ASP.NET CORE platform.

Machine Learning Model Development Library

ML.NET is a machine learning tool from Microsoft. We used this library in order to perform sentiment analysis of patient feedback. ML.NET is a free software machine learning library for the C-sharp (C#) programming language.

Database Development Tools

We are going to use Microsoft-SQL-Server (MSSql) 2014 version as our primary database development tool. Microsoft SQL Server is a relational database management system developed by Microsoft. It allows to separate the database into multiple separate schema. It has fast query mechanism and encompasses all the modern database development technologies. For database query we used the Dapper ORM (Object Relational Mapper). Dapper is developed by the popular programming platform stack-overflow. It is lightweight and community support is excellent. We have to write raw query in dapper. So, response time is very fast.

3.3 Usability Analysis and Prototype Design

Ensure easier and smooth user experience is an important part of usability analysis. We need to constantly evaluate our design by the user group and listen to their feedback. If user's feedback is reflected in the design, user will show eagerness to use the system. Usability analysis involved the following procedure :

1. Basic Requirement Identification.
2. Developing the initial Prototype.
3. Review of the Prototype by a user group.
4. Revise and Enhance the Prototype.

3.3.1 Advantage of Prototype Development

The Software Prototyping refers to building software application prototypes which displays the functionality of the product under development, but may not actually hold the exact logic of the original software. Software prototyping is becoming very popular as a software development model, as it enables to understand customer requirements at an early stage of development. It helps get valuable feedback from the customer and helps software designers and developers understand about what exactly is expected from the product under development. We needed to find

out how users may want to interact with the system. That is the key motivation factor for developing the prototype. We can show the users our prototype and get important feedback to enhance the user-friendliness of our system. Advantages of software prototyping are the followings :

1. Increased user involvement in the product even before its implementation.
2. Since a working model of the system is displayed, the users get a better understanding of the system being developed.
3. Reduces time and cost as the defects can be detected much earlier.
4. Quicker user feedback is available leading to better solutions.
5. Missing functionality can be identified easily.
6. Confusing or difficult functions can be identified.

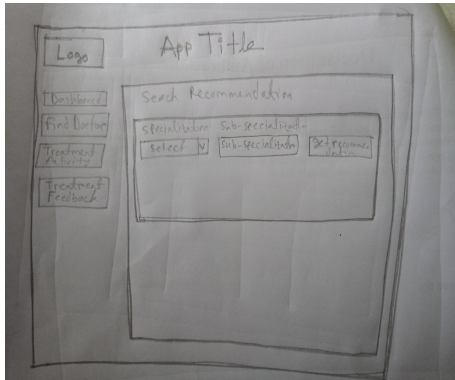
3.3.2 Prototype Development Strategy

Reason for Developing Software Prototype

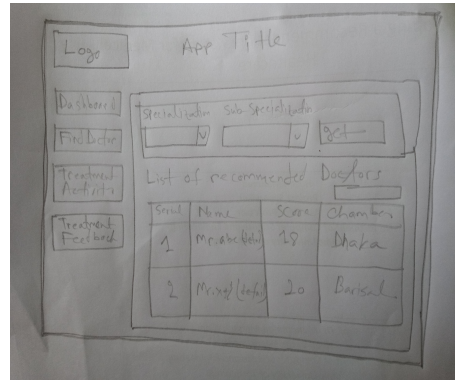
Prototyping is a vital part of web and application development. It consists of various different phases of development with their respective set of functionalities. The software prototyping approach let the users experience phases of the product with limited functionalities during the development process. The prototype development process appears to be a useful strategy for efficiently delivering effective application systems. In our study, the initial prototype encouraged the development of an effective system by emphasizing the building of a user needs framework. We used both low fidelity and high fidelity prototype for the project. Low fidelity prototype had been created first. It was used a base of the high fidelity prototype. For low fidelity prototype we used hand sketch and for high fidelity prototype we used some prototype development tools. After that we are going to use wire-framing on the high fidelity version of the prototype.

Low-Fidelity Prototype Development by Paper Sketching

Low-fidelity prototype is sketchy and incomplete. It has some characteristics of the target product. It is used to quickly produce the prototype and test broad concepts. Paper sketches are validated by the people involved in the software development process.



(a) Recommendation Search Page

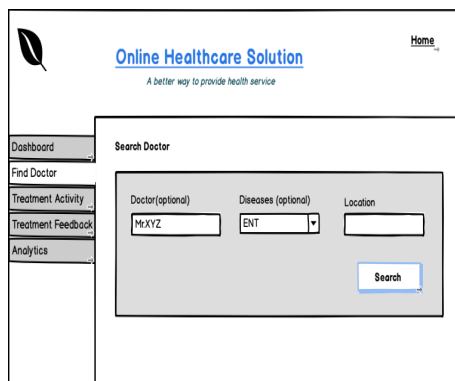


(b) Recommended Doctor List Page

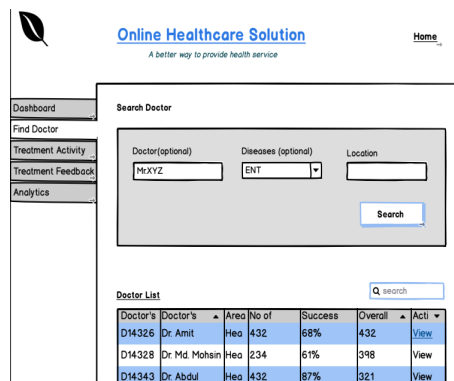
Figure 3.3: Sketch Prototype 1, Sketch Prototype 2

Construction of Wire-frame using Balsamic web tool

The process of linking all the prototypes is called wire-framing. Wire-frame help us to take the conceptual prototype to user. User can navigate this prototype and provide valuable feedback which gave us insight about what the user really wanted.



(a) Recommendation Search Page



(b) Recommended Doctor List Page

Figure 3.4: Prototype Wire-frame

3.3.3 Prototype Evaluation and Modification

User feedback helps to improve the user-friendliness of the system. Users can offer insights regarding their expectations. Taking user feedback into account helps to enhance customer satisfaction. We continuously sought user feedback and thus continuously updating and modifying the project prototype. User feedback plays a big role in software development. The key stakeholder of the project are both doctors and patients. As we are dealing with patient section, we evaluated the prototype by a group of user and thus provide valuable feedback which will help us to improve the system.

4. Implementation of the System

Software Implementation is a systematically structured approach where different components of a software are build separately or synchronously. And then these components are integrated together to make a finished product. Before going to the implementation phase, a clear goal and methodical approach should be established. The goal and requirements should be clear by now. Software quality largely depends on how well the implementation phase is managed. In the previous chapter we have discussed about the functional requirements of the system. Here we have provided a detailed explanation about the implementation of the functional requirements of this project.

4.1 Implementation of Recommendation Architecture

Implementation of the recommendation architecture is the most basic part of this project. We had a clear goal what a healthcare recommendation should incorporate. Based on that idea, we divided the whole work into multiple tasks. Upon completion of each task, our recommendation architecture will become fully functional.

4.1.1 Task list for developing a recommendation architecture

1. Find out the key performance factors of healthcare professionals [10].
2. Conduct a feasibility study on the existing rating algorithms.
3. Propose a customized rating generation algorithm model.
4. Create an application platform in order to make a machine learning model for sentiment analysis of patient feedback.
5. Turn patient's feedback into probabilistic sentiment using our sentiment analysis model, which is one of the performance factor.
6. Generate rating point for doctors by using our proposed rating algorithm.

7. Develop model in order to recommend physician for patients.

4.1.2 Identify key performance factors to rank a doctor

In healthcare, performance is a very broad term. How well a doctor will perform can not be measured through his or her academic excellence or experience only. Although qualification and experience play a vital role in performance. But we can not rely entirely on them. Doctors success is largely dependent on how well they are received by their patients. Following are the key performance measurement factor of a doctor [13].

1. Patient Feedback
2. Professional Experience in healthcare
3. Educational Qualification

the reason we needed to identify the performance factor in recommendation system development process is that when we developed a rating algorithm, these factors are used by the algorithm to generate doctor rating.

4.1.3 Feasibility Study on Existing Rating Algorithms

Among the worldwide popular ranking algorithms, Google's page-rank is one of the most popular. It ranks web pages based on different criteria. When a user searches a web page, recommended search results are shown to the users based on the rating generated by this page-rank algorithm. The page-rank algorithm calculate the web-page rating based on some criteria. These criteria included the number of views of each page, How many times the page has been recommended by another page using web-links. The uniqueness of contents.

We observed that a rating algorithm like page-rank considers different performance attributes of a web-page during rating process. We can not directly use this algorithm in our approach. But we observed that page-rank utilized the number of recommendation a web page received by another web-pages as a measurement of performance. We can use this attribute in our approach as well. How many patients recommended a doctor can be a measurement of performance of

that particular doctor. Keeping that in mind, when we proposed our rating algorithm we included "number of unique recommendation received by a doctor" as a performance enhancement factor.

4.1.4 Introduce a ranking algorithm to rate the doctors based on their performance factors

Performance factor we are considering for rating generation are patient's feedback, doctor qualification, doctor's service experience, and number of unique recommendation received by that particular doctor. For numeric calculation using those factor, we provided them specific weights. Total score a doctor can obtain from a particular is fifty (50). This score is distributed among the performance factors based on their specific weight. See Table 4.1.

Performance Factor	Weight (%)	Height Possible Score
Patient Feedback	60%	30
Educational Qualification	10%	5
Service Experience	10%	5
Unique Recommendation by Patients	20%	10

Table 4.1: Weight Provided to Performance Factors

We put more emphasize on patient feedback, because patient satisfaction is considered the effective performance measurement factor. We needed to put weight on the educational qualification and years of service experience also. Higher the educational qualification, higher the rating point a doctor will receive. Educational qualification is also weighted according to the table 4.2.

Educational Qualification	Highest Possible Score
Bachelor of Medicine (MBBS)	2.5
Fellow of College of Physicians and Surgeons (FCPS)	5

Table 4.2: Weight Provided to Educational Qualification

And for service year experience, higher the service experience, higher score the doctor will get. For the calculation purpose, we provided weight to service year experience according to table 4.3

Years of Experience	Height Possible Score
1-5 years	2
6-10 years	3
11-15 years	4
Above 15 years	5

Table 4.3: Weight Provided to Service Experience

We took proposed performance factors (feedback, qualifications and experience, number of unique recommendation by patients) into account and developed an algorithm which will be executed for each patient-doctor case. This algorithm will generate a cumulative score which will be used to rank doctors. A flow diagram of the proposed rating algorithm is provided in Fig : 4.1.

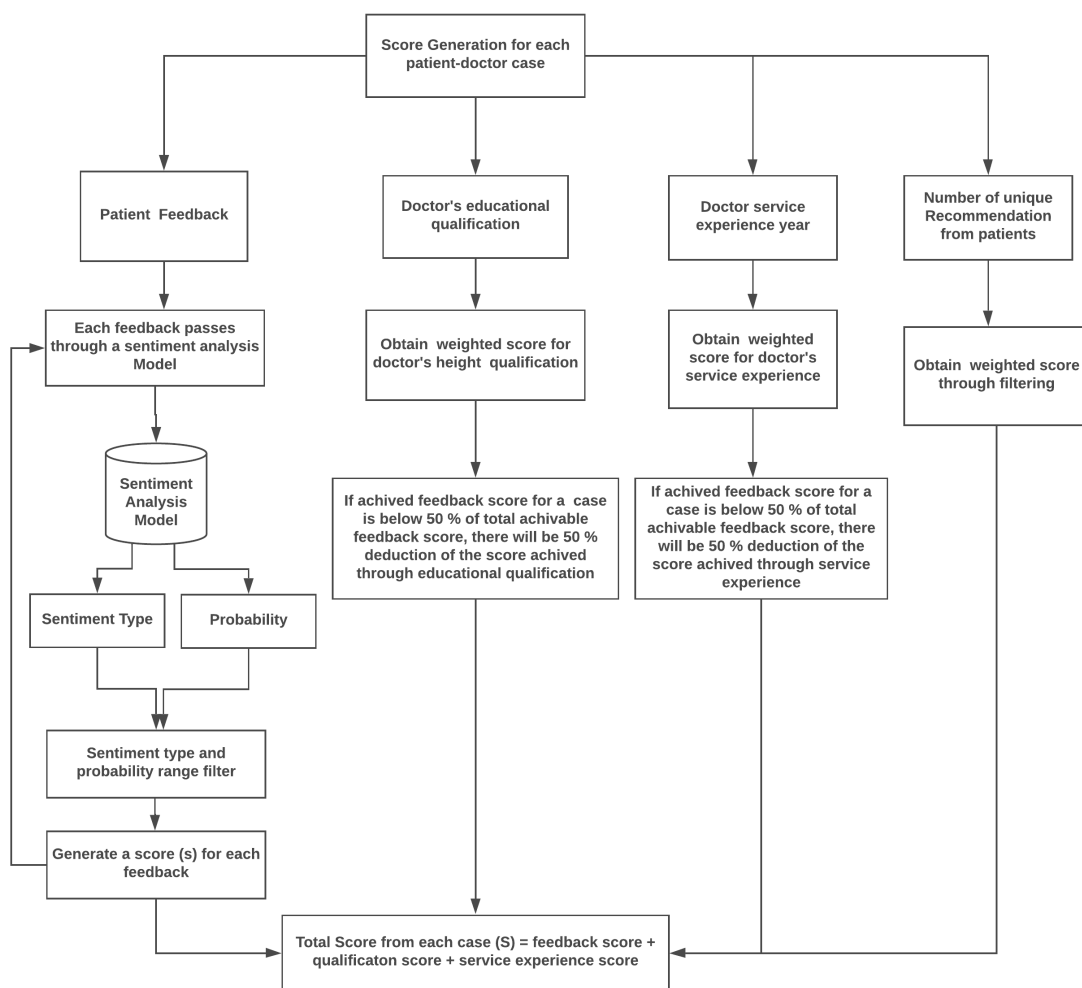


Figure 4.1: Proposed Rating Algorithm

4.1.5 Create a Sentiment Analysis Model to Transform Patient Textual Feedback into Neumaric Data

Sentiment analysis of healthcare data is useful to extract information [1]. We will transform patient feedback into sentiment using by using ML.Net machine learning framework, developed by microsoft [4] [3] . It is reliable and well tested. This process involves the following steps :

1. Create test-train dataset and labeling
2. Stemming the dataset
3. Featurization

4. Separate the dataset into test set & train set
5. Train sentiment analysis model using binary classifier
6. Test the model using test dataset
7. Evaluate the model

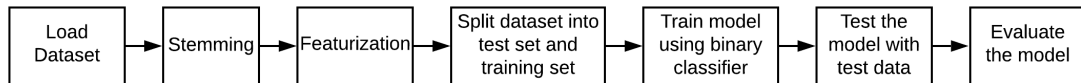


Figure 4.2: Sentimate Model Generation

Turn Patient Feedback into Sentiment

Each patient feedback has been transformed into numerical data by passing them through our sentiment analysis model. This model will translate each feedback into either positive or negative sentiment. Also the probability of being positive or negative will also be generated.

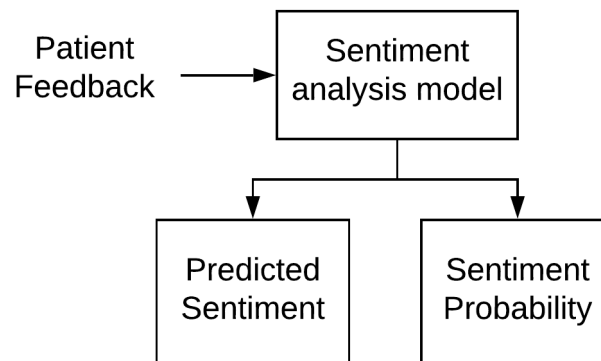


Figure 4.3: Turn Patient Feedback into Sentiment

4.1.6 Generate Rating Point for Doctors by Using Our Proposed Ranking Algorithm

We will generate rating point for each doctor in our system by running a database stored procedure. Pseudo code is given in Algorithm : 1

Algorithm 1: Pseudo code for rating generation

```
1 Function GenerateRating ()
2   for each doctor do
3     Declare score
4     Set score to zero;
5     for each case do
6       fetch all feedback;
7       for each feedback do
8         Get sentiment_type and sentiment_probability;
9         if sentiment_type is positive then
10        | Add to score;
11        end
12        else if sentiment_type is negative then
13        | Deduct from score;
14        end
15      end
16      Declare qualification_score, max_qualification_weight
17      Set qualification_score to zero;
18      Set max_qualification_weight = weight of max qualification
19      Set qualification_score = max_qualification_weight;
20      if Feedback score < 50 % then
21      | Set qualification_score = qualification_score / 2 ;
22      end
23      Set score = score + qualification_score;
24      Declare experience_score, max_experience_weight
25      Set experience_score to zero;
26      Get doctor maximum service year experience;
27      Set max_experience_weight = maximum experience weight
28      Set experience_score = max_experience_weight;
29      if Feedback score < 50 % then
30      | Set service_year_score = service_year_score / 2;
31      end
32      Set score = score + service_year_score;
33      Declare unique_recommendation = Percentage of
        recommendation
34      Set score_recommendation = weight of unique_recommendation
35      Set score = score + score_recommendation
36    end
37  end
38 end
```

4.1.7 Detail Walk-through of Rating Generation Process

When a patient comes to the system and provides feedback, this feedback is transformed into sentiment and sentiment probability using our sentiment analysis model.

We have considered the following performance factors to evaluate a doctor in our system. They are :

1. Patient feedback
2. Doctor's experience
3. Doctor's educational qualification
4. Number of unique patient recommendation

Above performance metrics are given weight according to their importance. A doctor can get at most 50 points from each case. Patient's feedback is given highest priority thus given 60 % of total points. And both doctor's experience and educational qualification metrics are given 10 % each. Number of unique patient recommendation gets 20 % of total score. When generating score for each doctor, all the patient feedback of that particular doctor run through our rating algorithm.

User feedback are also given weight. Probability of predicted sentiment plays a role here. Probability range are distributed among five categories.

If sentiment is positive and probability is 0.1 to 0.2 , add 1 point to score.

If sentiment is positive and probability is 0.3 to 0.4 , add 2 points to score.

If sentiment is positive and probability is 0.5 to 0.6 , add 3 points to score.

If sentiment is positive and probability is 0.7 to 0.8 , add 4 points to score.

If sentiment is positive and probability is 0.9 to 1.0 , add 5 points to score.

If the sentiment is negative, similar score will be deducted.

Though feedback is given highest priority, doctors can increase his score based on his educational qualification. For educational qualification, for simplicity we have used only MBBS and FCPS degree for evaluation. Doctor can get 10 % of total score of each case through educational qualification. That means educational

qualification can get a doctor 5 points. This point distributed according to qualification weight. We proposed to add 2.5 if the maximum qualification is MBBS. If the doctor has FCPS degree also, he will be awarded maximum 5 points to his or her rating. As feedback is given higher precedence, if feedback score falls below 50%, half of the score will be deducted.

Doctors can also increase his score based on their service experience. For educational qualification. Doctor can get 10 % of total score of each case through educational qualification. That means service experience can get a doctor 5 points. This point distributed according to weight given to service experience. We proposed to add 2 points to score if the maximum experience is 1 to 5 years.. If the doctor is 6 to 10 years experienced, he or she will be awarded maximum 3 points to his or her rating. On the other hand, 11 to 15 years experience will add 4 points to score. If the experience is above 15 years, doctor can have maximum 5 points. As feedback is given higher precedence, if feedback score falls below 50%, half of the score will be deducted.

Percentage of unique patient recommendation is very important. Maximum 10 rating points can be earned from each case. If a doctor treated 100 patients and 50 of them recommended him through our system, he will be awarded 5 rating points. If all 100 of them recommend him, he will awarded maximum 10 rating score. Weight for this rating factor is shown in table 4.4.

Recommendation Percentage	Height Possible Score
1-20 %	2
21-40 %	4
41-60 % years	6
61-80 %	8
81-100 %	10

Table 4.4: Weight Provided to Unique Patient Recommendation Count

4.1.8 Score Normalization

Purpose of normalization is prevent score difference between doctors from getting too large. In order to normalize our score we decided not to exceed maximum reputation above 20000. We then normalized the score using min-max normalization technique. Normalization range is selected from 0 to 1000. Let's assume three doctor's has 1000,5000 and 20000 rating each. Normalization process for these score is given below

First Step

Minimum value of new range is subtracted from each score. Our new minimum value is 1000. After subtraction score of respective doctors are 0,4000 and 19000. Now minimum score of a doctor is similar to our new range minimum

Second Step

Now our scores have a range of 0 to some positive number z . 2nd step is dividing all the numbers by z . Since the maximum number is z - when you divide it by z it will become 1. And your minimum number is 0 and when you divide 0 it will remain 0. So after this procedure all your numbers will be in a range of 0 to 1. In that case respective scores are 0, 0.21 and 1.

Third Step

Third step is to multiply the new transformed score by the result of subtracting new range max and new range min. In our case it will be 1000 subtracted by 0 which is equal to 1000. If we multiply 0, 0.21 and 1 by 1000 we will get 0, 210 and 1000. According to the normalized score we recommend doctor in descending order. That means the doctor with 1000 normalized score will be shown up in the order than the doctors with normalized score of 210 and 0.

4.1.9 Recommendation Architecture Model

1. Based on patient's diseases criteria search [5].
2. Based on patient's metadata.
 - Location : where a patient lives.
 - Patient's previous search history.

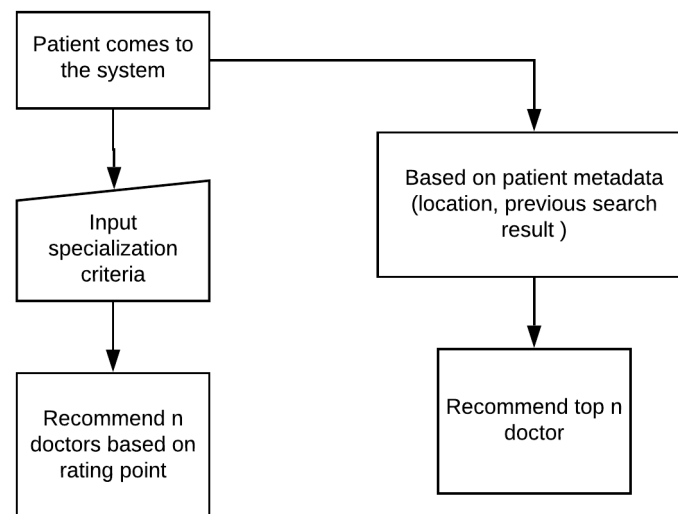


Figure 4.4: Recommendation Architecture

4.2 Development of Web User Interface

A web platform gives the user the ability of interacting with different features of our platform through a graphical interface.

1. Patients will be able to search different diseases criteria and get recommendation for doctor
2. Patients will see top rated doctors listed in descending order according to their respective rating points.
3. Patients will be able to see performance detail about a particular doctor
4. Patients can check the ranking generation process which is used by the system.

It will enable the system to get feedback from users about the system

5. Patients will be able to see the medical history timeline in dashboard

4.2.1 Software architecture

This web application is implemented by following MVC Repository design pattern.

Following is the diagram of MVC Repository pattern.

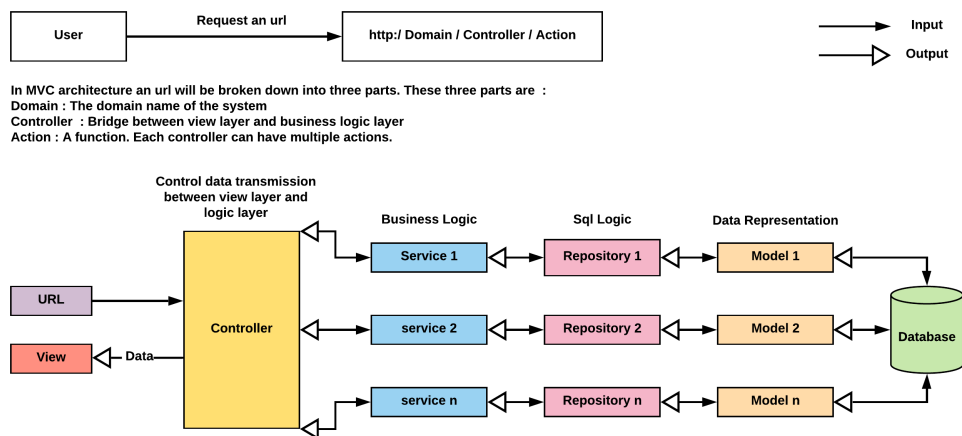


Figure 4.5: Repository Pattern

Advantages of the mvc-repository design pattern :

Followings are the advantages of mvc repository design pattern.

- 1.Clean code
- 2.Modularity
- 3.Scalability
- 4.Efficient memory management

4.2.2 Database Design

For implementation of the database for Relational Database has system been used . Microsoft SQL Server 2014 has been used as main database engine. Separate schema has been created doctors, patients, application and settings related data.

For faster query execution, extensive use of stored procedure has been performed. Dapper library was used object relational mapper (ORM)

Schema Separation

In order to separate the concerns, We structured the whole database into four schemas. They are doctor, patients, app and settings. App schema is used for application specific data Settings schema stores settings related data like educational information, area information etc. Both doctor and patient schema stores doctor and patient data respectively

ER Diagram :

Er diagram for app schema is given below :

App Schema :

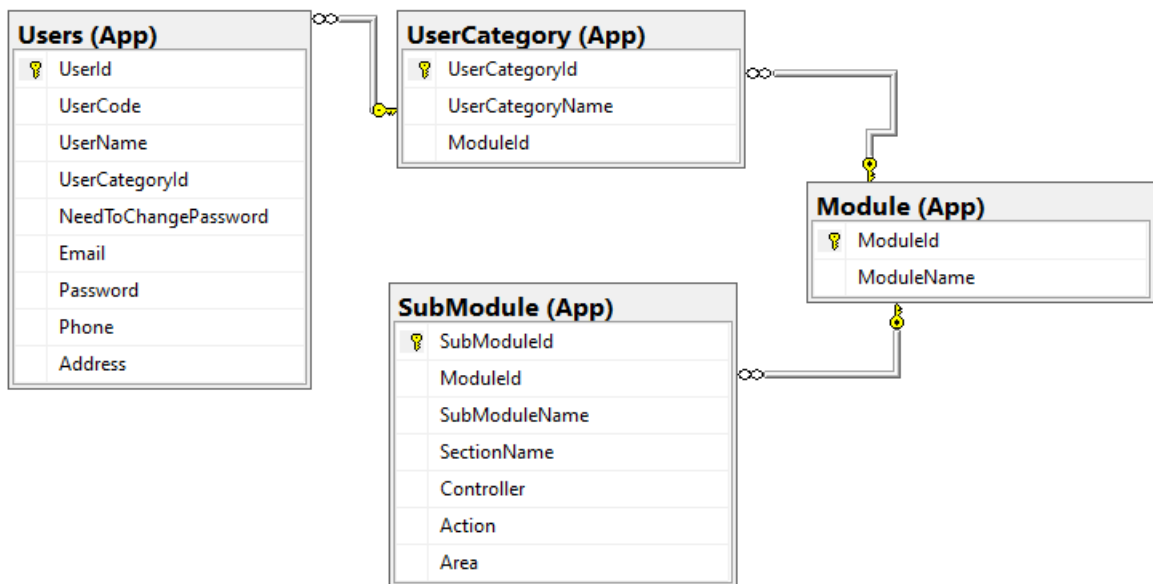


Figure 4.6: App Schema

4.2.3 Complete Graphical User Interface

The graphical user interface is a form of user interface that allows users to interact with electronic devices through graphical icons and audio indicator such as primary notation, instead of text-based user interfaces, typed command labels or text navigation. Major advantage of GUIs is that they make computer operation more intuitive, and thus easier to learn and use. GUIs generally provide users with immediate, visual feedback about the effect of each action. GUI allows multiple programs and/or instances to be displayed simultaneously. As per our prototype design, we developed the graphical user interface of the system. Following Fig 4.7 is the sample of some of the developed graphical user interface of our system

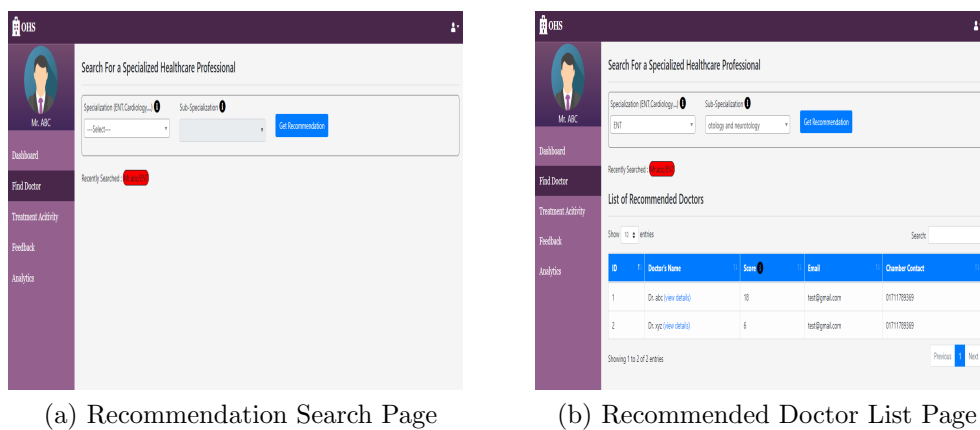


Figure 4.7: Graphical User Interface

5. Analytical Insights about Recommended Doctors

If a patient comes to the system and search a doctor under a particular specialization he/she will get a list of recommended doctor. Among those recommended doctor a patient can see each individual doctor's performance graph. These graphs are generated using data stored by the system through a doctor's interaction with his patients. A patient can gather useful insights and thus pick the right health-care professional who is best suited for his/her specific need. Some of the graphs are demonstrated here [11].

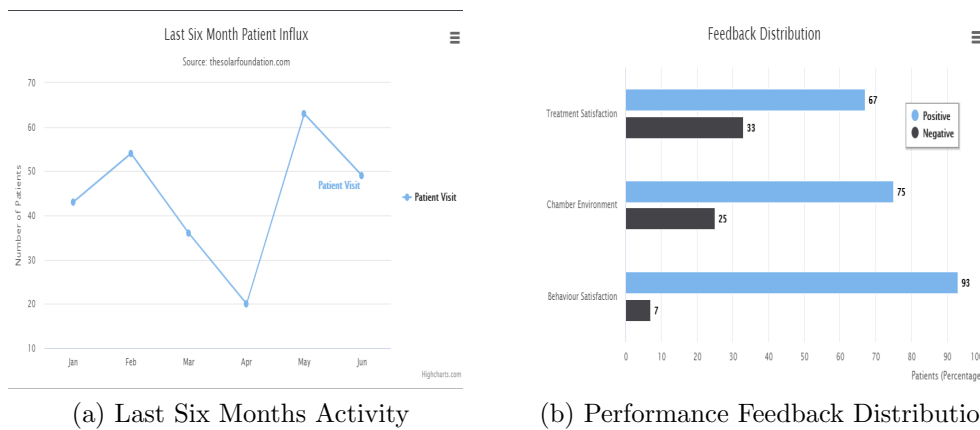


Figure 5.1: Last Six Months Activity , Performance Feedback Distribution

The graphs in figure 5.1 shows the patients the current activity of a doctor. The patients can visualize that the doctor has good number of patients visiting him or her. Also a patient can see how other patients evaluated the doctor from the performance feedback distribution graph. Through these graphs, a patients can decide whether or not this particular doctor is suitable for his or her particular need. These graphs are generated using data stored by the system through a doctor's interaction with his patients. This insight can be really helpful in the early stage of decision making process.

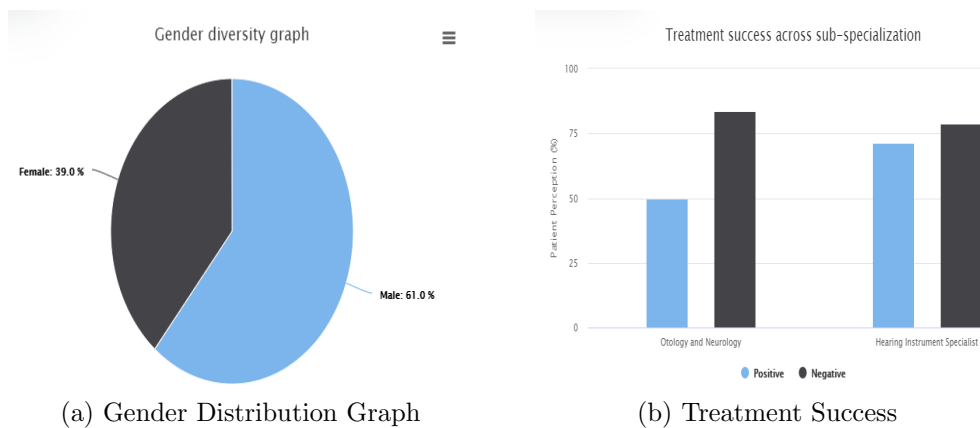


Figure 5.2: Gender Distribution Graph, Treatment Success Graph

Some patients may prefer a doctor of a similar gender distribution. Suppose female patients may want to visit a doctor to whom female patients normally visit. From the gender distribution graph a patient can visualize the gender distribution among all the patients of a particular doctor. Also from Treatment success graph, patients can gain knowledge about the success rate of the doctor in different disease specialization and sub-specialization. This data will also come from patient feedback.

Above four graphs have specific purposes. From here patients can see how many patients have been treated by a particular doctor. A patient can also see the feedback distribution around different important feedback criteria such as a doctor's behavior toward his patients, environment of the chamber and most importantly a patient can get an idea from other patients about the satisfaction they get regarding a doctor's treatment.

This system can help patients in many ways. Through this system a patient can get recommendation and also get valuable insights which will help to reduce error. Reducing error at the primary stage will save patients a lot of time, money and energy. It can earn patients valuable time during critical situations.

Benefit of the patients :

1. Patient will be able to find doctor based on reliable recommendation system.
2. Patient will be able to provide feedback which will impact doctor's rating, thus apply a check and balance in healthcare service
3. As patient feedback play a role in doctor rating, healthcare professionals will emphasize on providing better service to patients.

Advantage for the doctors :

1. This system can also help doctors to understand patients views and opinion regarding his treatment.
2. People can share their views on different performance factors which will help healthcare service providers to make amendments quickly and efficiently

6. Evaluation

Heuristic evaluation (Nielsen and Molich, 1990; Nielsen 1994) [8] is a usability engineering method for finding the usability problems in a user interface design so that they can be attended to as part of an iterative design process. Heuristic evaluation involves having a small set of evaluators examine the interface and judge its compliance with recognized usability principles (the "heuristics").

Typically, a heuristic evaluation session for an individual evaluator lasts one or two hours. Longer evaluation sessions might be necessary for larger or very complicated interfaces with a substantial number of dialogue elements, but it would be better to split up the evaluation into several smaller sessions, each concentrating on a part of the interface.

During the evaluation session, the tor goes through the interface several times and inspects the various dialogue elements and compares them with a list of recognized usability principles (the heuristics). These heuristics are general rules that seem to describe common properties of usable interfaces. In addition to the checklist of general heuristics to be considered for all dialogue elements, the evaluator obviously is also allowed to consider any additional usability principles or results that come to mind that may be relevant for any specific dialogue element. Furthermore, it is possible to develop category-specific heuristics that apply to a specific class of products as a supplement to the general heuristics. One way of building a supplementary list of category-specific heuristics is to perform competitive analysis and user testing of existing products in the given category and try to abstract principles to explain the usability problems that are found (Dykstra 1993).

We have followed heuristic evaluation process to evaluate the system workflow. It involves a small set of expert evaluators who examine the interface and assess its compliance with "heuristics," or recognized usability principles. The following principles will be followed:

1. Pleasurable and respectful interaction with the user.
2. User privacy. Flexibility and minimalist design.
3. Error prevention and Error handling. Consistency and standards.

Evaluation Analysis

The output from using the heuristic evaluation method is a list of usability problems in the interface with references to those usability principles that were violated by the design in each case in the opinion of the evaluator. It is not sufficient for evaluators to simply say that they do not like something; they should explain why they do not like it with reference to the heuristics or to other usability results. The evaluators should try to be as specific as possible and should list each usability problem separately. For example, if there are three things wrong with a certain dialogue element, all three should be listed with reference to the various usability principles that explain why each particular aspect of the interface element is a usability problem. There are two main reasons to note each problem separately: First, there is a risk of repeating some problematic aspect of a dialogue element, even if it were to be completely replaced with a new design, unless one is aware of all its problems. Second, it may not be possible to fix all usability problems in an interface element or to replace it with a new design, but it could still be possible to fix some of the problems if they are all known.

4. User control and freedom. Match between system and real world.

7. Conclusion and Future Works

Doctor selection process for the treatment of a particular disease is the primary step of personal healthcare. Due to lack of information patients always seek doctor recommendation from others. The recommendation they get in return is also not based on any actual data. That recommendation is mostly based on personal experience of other people. Sometimes it may happen that, the person who is recommending also does not have any prior experience about the doctor. They may have heard about that doctor from someone else. Thus patients get misguided, which results in wastage of valuable time, money and effort. We address this issue and tried to come up with an online based recommendation system. This recommendation system takes into account all the key performance factor of a doctor. These performance factors can be patients treatment satisfaction, doctor's years of service experience, educational qualification, number of patients who recommended that doctor to other patients etc. We proposed a rating algorithm which generate rating for a doctor using those performance factors. Using the ratings, the system will recommend doctors to the patients. In our recommendation architecture we also included location and patients previous search history also. This system has the potential to assist people in doctor selection process.

In the future we intend to work extensively on more data visualization. We would like to implement more graphs to further help patients. We planned to develop a patient analytic where patient can observe different health related analytic. We also want to work from doctor's point of view to help doctor to treat patients more efficiently

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