“BrainFight”

Dementia Prediction App

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CERTIFICATE

It is certified that the contents and form of thesis entitled **"BrainFight"** submitted by **Sitwat Atiq (NUST201200949BSECS60512F), Muhammad Waseem Khan (NUST201201043BSECS60512F)** and **Muhammad Faizan (NUST201200367BSECS60512F)** have been found satisfactory for the requirement of the degree.

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DEDICATION

To Allah the Almighty

&

To my Parents and Faculty

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The word dementia describes a set of symptoms that may include memory loss and difficulties with thinking, problem-solving or language. Dementia is caused when the brain is damaged by diseases, such as Alzheimer's disease or a series of strokes. Recent statistics show people suffering from this disease are increasing every year. The disease is prevailing very fast and death rate due to this disease is touching the sky. According to a recent study "An estimated 5.4 million Americans of all ages will have Alzheimer's disease in 2016**."** Improving our ability to recognize dementia is a key first step toward improving this widespread situation. If this disease goes out of hand then a person may suffer from memory loss, loss of mobility, eating and weight loss, unusual behavior and many more. But dementia if diagnosed at an early stage, can be treated and slowed but cannot be cured or stopped.

The challenge for us was early diagnosis of dementia, so in order to cater this we bring you an android based gaming application that incorporates standard tests that are used by neuropsychiatrists in order to diagnose dementia. Tests like MMSE, Mini-cog, TYM, clock draw tests along with analytical reasoning tests are included in the game. The concept of this gaming application is to provide mobile users with an at hand application that can predict the chances of dementia based on user interaction and inputs during the whole course of game.

BrainFight includes few levels based on different tests which evaluate a person's personality traits, cognitive strengths, analytical reasoning capabilities etc. At the end of each level, test's scores are calculated and sent to Amazon server. At the server side, a machine learning algorithm "Naïve Bayes Classifier" is run on the data. The algorithm predicts the chances of a person having dementia in future.

Chapter 1

INTRODUCTION

Dementia is one of the unsolved mysteries of human race. The main issue is diagnosing the dementia's disease, as symptoms are usually mistook for aging behavioral changes, slow reflexes, remembering routine matters daily etc. and then not only cure but managing the disease becomes a big challenge. Clues to the presence of dementia may be subtle and nonspecific. As dementia grows its treatment becomes impossible. Worldwide, nearly 46.8 million people have Alzheimer's or a related dementia. If this disease goes out of hand then a person may suffer from memory loss, loss of mobility, eating and weight loss, unusual behavior and many more.

Dementia in order to be controlled needs to be diagnosed at an early stage. But in most cases symptoms of this disease is mistaken as old age problems.

1.1 ABOUT DEMENTIA

Dementia is not a specific disease. It's an overall term that describes a wide range of symptoms associated with a decline in memory or other thinking skills severe enough to reduce a person's ability to perform everyday activities. Alzheimer's disease accounts for 60 to 80 percent of cases. Vascular dementia, which occurs after a stroke, is the second most common dementia type. But there are many other conditions that can cause symptoms of dementia, including some that are reversible, such as thyroid problems and vitamin deficiencies.

Dementia is often incorrectly referred to as "senility" or "senile dementia," which reflects the formerly widespread but incorrect belief that serious mental decline is a normal part of aging.

While symptoms of dementia can vary greatly, at least two of the following core mental functions must be significantly impaired to be considered dementia:

- Memory
- Communication and language
- Ability to focus and pay attention
- Reasoning and judgment
- Visual perception

People with dementia may have problems with short-term memory, keeping track of a purse or wallet, paying bills, planning and preparing meals, remembering appointments or traveling out of the neighborhood.

1.2 CAUSES

Dementia is caused by damage to brain cells. This damage interferes with the ability of brain cells to communicate with each other. When brain cells cannot communicate normally, thinking, behavior and feelings can be affected.

The brain has many distinct regions, each of which is responsible for different functions (for example, memory, judgment and movement). When cells in a particular region are damaged, that region cannot carry out its functions normally.

Different types of dementia are associated with particular types of brain cell damage in particular regions of the brain. For example, in Alzheimer's disease, high levels of certain proteins inside and outside brain cells make it hard for brain cells to stay healthy and to communicate with each other. The brain region called the hippocampus is the center of learning and memory in the brain, and the brain cells in this region are often the first to be damaged. That's why memory loss is often one of the earliest symptoms of Alzheimer's.

While most changes in the brain that cause dementia are permanent and worsen over time, thinking and memory problems caused by the following conditions may improve when the condition is treated or addressed:

- Depression
- Medication side effects
- Excess use of alcohol
- Thyroid problems
- Vitamin deficiencies

1.3 TYPES OF DEMENTIA

Following are some of the main types of Dementia:

- Alzheimer's disease
- Vascular dementia
- Dementia with Lewy bodies (DLB)
- Mixed dementia

- Parkinson's disease
- Frontotemporal dementia
- Creutzfeldt-Jakob disease
- Normal pressure hydrocephalus
- Huntington's disease
- Wernicke-Korsakoff Syndrome

1.4 DIAGNOSIS OF DEMENTIA

There is no one test to determine if someone has dementia. Doctors diagnose Alzheimer's and other types of dementia based on a careful medical history, a physical examination, laboratory tests, and the characteristic changes in thinking, day-to-day function and behavior associated with each type. Doctors can determine that a person has dementia with a high level of certainty. But it's harder to determine the exact type of dementia because the symptoms and brain changes of different dementias can overlap. In some cases, a doctor may diagnose "dementia" and not specify a type. If this occurs it may be necessary to see a specialist such as a neurologist or gero-psychologist.

1.5 DEMENTIA TREATMENT AND CARE

Treatment of dementia depends on its cause. In the case of most progressive dementias, including Alzheimer's disease, there is no cure and no treatment that slows or stops its progression. But there are drug treatments that may temporarily improve symptoms. The same medications used to treat Alzheimer's are among the drugs sometimes prescribed to help with symptoms of other types of dementias. Non-drug therapies can also alleviate some symptoms of dementia.

Ultimately, the path to effective new treatments for dementia is through increased research funding and increased participation in clinical studies. Right now, volunteers are urgently needed to participate in more than 180+actively enrolling clinical studies and trials about Alzheimer's and related dementias.

1.6 DEMENTIA RISK AND PREVENTION

Some risk factors for dementia, such as age and genetics, cannot be changed. But researchers continue to explore the impact of other risk factors on brain health and

prevention of dementia. Some of the most active areas of research in risk reduction and prevention include cardiovascular factors, physical fitness, and diet.

1.6.1 Cardiovascular Risk Factors

Your brain is nourished by one of your body's richest networks of blood vessels. Anything that damages blood vessels anywhere in your body can damage blood vessels in your brain, depriving brain cells of vital food and oxygen. Blood vessel changes in the brain are linked to vascular dementia. They often are present along with changes caused by other types of dementia, including Alzheimer's disease and dementia with Lewy bodies. These changes may interact to cause faster decline or make impairments more severe. You can help protect your brain with some of the same strategies that protect your heart – don't smoke; take steps to keep your blood pressure, cholesterol and blood sugar within recommended limits; and maintain a healthy weight.

1.6.2 Physical Exercise

Regular physical exercise may help lower the risk of some types of dementia. Evidence suggests exercise may directly benefit brain cells by increasing blood and oxygen flow to the brain.

1.6.3 Diet

What you eat may have its greatest impact on brain health through its effect on heart health. The best current evidence suggests that heart-healthy eating patterns, such as the Mediterranean diet, also may help protect the brain. A Mediterranean diet includes relatively little red meat and emphasizes whole grains, fruits and vegetables, fish and shellfish, and nuts, olive oil and other healthy fats.

1.7 MOTIVATION

Recently there have been many developments in healthcare and technology, though a lot of focus is towards gadgets and wearable. Big data and artificial intelligence has paved way for total software solutions too. The mentioned above two often make things possible which are beyond conventional methods. When we took up the challenge of finding a solution of early diagnosis for Dementia disease, we looked towards certain methods.

As Dementia disease has lesser physical abnormalities and more on the mental side so things like gadgets and a wearable were a no. So we were motivated to find different solutions and data is always helpful. Once a source of data was setup, we knew that big data techniques and machine learning could be potential candidate towards a solution to this problem.

We also wanted the technique of using game plays to be an answer to problems in healthcare. If we gamify the healthcare processes a user can be facilitated in a big way and we certainly wanted the similar goal to achieve in our project and set an example for future work as well.

1.8 MAIN OBJECTIVES:

Our application is to provide people with self-tests in form of an interesting gamified app based on their daily routines to evaluate their behavior, memory and personality traits to study if they have any symptoms of dementia and then suggest them whether they should visit a doctor or not.

Our main objectives include:

- To predict dementia using a smartphone app
- To make the prediction of Dementia accessible to a greater population
- To make the prediction available in an economic and time saving way
- We plan to provide a gaming environment to users which will be interesting to play for a dementia person and non-dementia person.
- It will be just one click away and no extensive search will be required to find a test online.
- To make an API available online to get Dementia prediction
- To setup a milestone in game based health diagnosis apps

1.9 SCOPE

The problem we are tackling is an open domain in research i.e. solving difficult medical related problems using computing. What we are trying to do is to predict dementia disease via using gamified version of standard dementia prediction questions and machine learning. The research that we will be doing in the project can be later used by professionals in tackling dementia. The end product will be a smartphone gamified application along with a cloud based dementia prediction learning algorithm. The smartphone game will be based on standard dementia prediction questionnaire and its main focus will be on gathering the data attributes required by the dementia prediction algorithm through an innovative and interactive game. The data gathering for the training of the machine learning models is also part of the scope. The data gathered will then have to be converted to suitable formats in order to apply the machine learning algorithm. The scope also includes the choice of the machine learning algorithm and its implementation.

1.10 STAKEHOLDERS

Some of the major stakeholders of our application are:

- Smartphone Users
- Dementia Patients
- Doctors
- Development Team

1.11 DEADLINE AND SCHEDULE

The timeline following in order to complete the project successfully is as following:

Table 1: Deliverables & Schedule

Deliverable	**Completion Date**
Proposal Defense Document	29th October, 2015
Software Requirements Document	30th November, 2015
Database Design	5th December, 2015
Game Interfaces Design/ Wireframes	15th December, 2015
2d/3d Models and Game Resources	20th December, 2016
Game Logic Implementation	18st February, 2015
Design Expo	8th February, 2016
Mid Defense Document	18th February, 2016
Learning Algorithm Implementation	15th April, 2016
Cloud Data gathering & integration	25th April, 2016
Software Testing Document	1st May, 2016
FD Project Report	4th May, 2016
Revised Version	4th May, 2016
Promotional Video	4th May, 2016
FD Presentation	6th May, 2016
Final Project Report Submission	9th May,2016
FD Demo	6th May, 2016
Open House	11th May, 2016

1.12 REPORT ORGANIZATION

The report is organized into five chapters.

Chapter 1 *consists of the introduction, scope and explains the major need of the project.*

Chapter 2 *consists of the Literature Review and explains the Background of dementia, various tests and work being done in this domain.*

Chapter 3 *gives insight into the functionality and design of BrainFight*

Chapter 4 *explains the implementation details and discusses the results*

Chapter 5 *discusses future recommendations and concludes the report*

Chapter 2

LITERATURE REVIEW/ BACKGROUND INFORMATION

2.1 KEY CONCEPTS

Health apps are application programs that offer health-related services for smartphones and tablet PCs. Because they're accessible to patients both at home and on-the-go, health apps are a part of the movement towards mobile health (mHealth) programs in health care. There are many varieties of health apps available for purchase from app stores. Some are designed to help consumers make healthier choices in their everyday life by offering advice about fitness or nutrition. Others help doctors and patients communicate from afar, like apps for diabetics that automatically sent glucose readings to their primary care physicians. Some apps are aimed at physicians themselves—many apps combine mHealth with electronic medical records (EMR), allowing doctors to keep accurate records that are easily accessible.

2.1.1 Concept of Health applications

Public health professionals have another source to turn to when looking for data, information and motivational materials that will help them promote and protect the health of the public.

The domain of games and social media, smartphone and tablet applications, or apps for short, have come a long way in recent years, particularly in the field of public health.

There are apps for an array of public health issues and audiences, and the value of apps has been recognized by authorities such as the Centers for Disease Control and Prevention and the United Nations.

Apps, which can be purchased and downloaded, often for free, by those with smartphones and tablet devices, allow users to access information and personalized data without searching for information on the Internet. They can serve as a direct window into a company or organization's product that users can reach quickly and with a minimum of clicking and searching. The product we are working on is also a health application.

2.1.2 Dementia Prediction

As mentioned before dementia is one of the most rapidly growing disease? The main issue is diagnosing the dementia's disease, as symptoms are usually mistaking for aging behavioral changes, slow reflexes, remembering routine matters daily etc. and then not only cure but managing the disease becomes a big challenge. Clues to the presence

of dementia may be subtle and nonspecific. Unrecognized dementia may lead to iatrogenic illness, unnecessary workups driven by vague symptoms, inappropriate and costly utilization of hospital and emergency room care, and poor out-comes. As dementia grows its treatment becomes impossible. Worldwide, nearly 44 million people have Alzheimer's or a related dementia. Improving our ability to recognize dementia is a key first step towards improving this widespread situation. Some types of dementias are treatable if detected at early stage while others aren't. So for a treatment to become possible or even to manage the disease, diagnosis is a must. If this disease goes out of hand then a person may suffer from memory loss, loss of mobility, eating and weight loss, unusual behavior and many more.

If we diagnose this disease at an early stage it is possible to treat it and slow it down. BrainFight has been the first application in its kind to deal with early prediction of this disease. It uses standard tests used to test user's cognitive impairment.

Our application provides people with self-tests in form of an interesting game based on their daily routines to evaluate their behavior, memory and personality traits to study if they have any symptoms of dementia and then suggest them whether they should visit a therapist or not.

2.1.3 Standard Tests

BrainFight incorporates tests that are internationally recognized and used by neuropsychiatrists and psychiatrists all over the world in order to diagnose dementia, Alzheimer's disease and other memory diseases. The tests that are part of the game are mentioned and explained below:

Mini-Cog Test

The Mini-Cog is a simple three-minute test that is useful in detecting mild cognitive impairment, dementia, or an early stage of Alzheimer's. The research study, included below, showed that the test has a high degree of accuracy (83 percent).

Clock Draw Test

Drawing a clock by hand is one of several useful screening tools that can help to detect mild cognitive impairment, dementia, or Dementia's.

While the clock-drawing test is generally quite effective at identifying cognitive concerns, there is not a consensus in the research community that it can consistently identify mild cognitive impairment or help distinguish between different forms of dementia (such as Alzheimer's disease and vascular dementia).

Mini-Mental State Test

This test is conducted to assess a number of different mental abilities. The mini–mental state examination (MMSE) or Folstein test is a 30-point questionnaire that is used

extensively in clinical and research settings to measure cognitive impairment commonly used in medicine and allied health to screen for dementia. Administration of the test takes between 5–10 minutes and examines functions including registration, attention and calculation, recall, language, ability to follow simple commands and orientation.

MMSE does not require specialized equipment or training for administration, and has both validity and reliability for the diagnosis and longitudinal assessment of Alzheimer's disease.

Test Your Memory (TYM)

The TYM test is a new cognitive test comprising of 10 tasks presented on 2 sides of a single sheet of soft card. Most people take about 5 minutes to complete the TYM. The test can be completed under supervision from a health professional. The maximum score is 50/50.

The average TYM score for normal individuals is 47/50 up until the age of 70 years and then there is a small decline.

The TYM tests 10 different cognitive domains including anterograde memory, semantic knowledge and visuospatial skills which are typically affected early in Alzheimer's disease. There is a very clear distinction between the scores of normal controls (average 47/50) and patients with mild AD (average 33/50). A cut off of 42 has a sensitivity of 93% and specificity of 86% in the diagnosis of AD in our study. The accuracy of this test to detect Alzheimer's disease is almost 93%.

Geriatric Depression Scale Test

The GDS questions are answered "yes" or "no", instead of a five-category response set. This simplicity enables the scale to be used with ill or moderately cognitively impaired individuals. The scale is commonly used as a routine part of a comprehensive geriatric assessment. One point is assigned to each answer and the cumulative score is rated on a scoring grid. Our game uses shorter version of this test which consists of 15 questions. The scoring is done as following

A score between 0-5 is ranked as normal whereas a score greater than 5 is marked depressive.

Analytical Reasoning / Abstract Thinking Test

The abstract reasoning test is also called the conceptual reasoning test. It measures your lateral thinking skills or fluid intelligence, which is your ability to quickly identify patterns, logical rules and trends in new data, integrate this information, and apply it to solve problems. It measures what most people would refer to as 'street smarts' and the ability to 'think on your feet'.

2.2 Other Solutions

As we researched as a part of our project, we have looked for other solutions that already exist in this context. There are no existing applications, portals, games or websites that are exclusively addressing this problem, but work is being done in this domain.

2.2.1 AKILI Interactive Labs

At Akili, work is being done to build clinically-validated cognitive therapeutics, assessments, and diagnostics that look and feel like **high-quality video games**. They aim to develop a new type of Digital Medicine that can be deployed remotely directly to any patient anywhere, prescribed and tracked by physicians.

Recently they have been working on a game project that monitors each player's progress over time. Studying gamer performance will allow researchers to identify patients experiencing cognitive decline indicative of Alzheimer's disease. They say, the best way to discover early on whether a patient has Alzheimer's might be analysis of video game scores.

Their project EVO is basically to detect mental illness through games and they believe In the not-too-distant future, doctors will give a different type of prescription to patients who are potentially suffering from early stages of Alzheimer's: a note to download a mobile game.

Other efforts done in this domain include blood tests, MRIs; CT-SCANS have proved to be of great help to diagnose. Apart from this many self-tests are available online which help one to take test at home, the test asks you daily routine questions, memory tests, depression and expression questions etc. At the end user is suggested either to visit a doctor or not.

2.3 BRIDGING THE GAP

In order to understand the problem before starting this project we met a neuropsychiatrist in order to get directions from him on our project. He walked us through whole process of first diagnosing a patient with dementia and then treating that patient.

According to him people in Pakistan are not fully aware of this disease and they don't pay special attention to it. A society where we live in, people usually take the symptoms of this disease as a part of aging. A lot of research is being done in this domain internationally, but people in this country need to know about this disease.

The main concept of our project is to develop an application that can be deployed remotely directly to any patient anywhere, prescribed and tracked by physicians. We

wanted to address Alzheimer's disease and use our knowledge and expertise in order find a solution for early prediction of dementia and also to provide a platform that spreads awareness about this deadly disease in our own country.

The neuropsychiatrist told us, the percentage of dementia is very high and he has treated many dementia patients. He assured us that he will provide us with patients to test our application at end once it is completed. He already had many patients and on our request he will help us to test our application on all those patients.

Looking from another point of view, we are also bridging the gap between technology and medicine. The problem we are tackling is an open domain in research i.e. solving difficulty medical related problems using computing. What we are trying to do is to predict dementia disease via using gamified version of standard dementia prediction questions and machine learning. The research that we will be doing in the project can be later used by professionals in tackling dementia. The end product will be smartphone game application along with a cloud based dementia prediction learning algorithm. The smartphone game will be based on standard dementia prediction questionnaire and it's mainly focus will be on gathering the data attributes required by the dementia prediction algorithm through an innovative and interactive game.

2.4 DELIVERABLES

The final deliverables of our project include the following:

2.4.1 An Android Gaming Application

The main deliverable of our project is the gaming application. The game can be played by any person having a smartphone. It has been developed for people of all ages. The application includes a game that is based on user's daily routine and throughout the course of game users' mental strength, memory, depression rate etc. is being tested. At the end of the game, the score is sent to server for further processing. A machine learning algorithm is run on the data and prediction is made. The user is displayed a little report card, displaying his percentage of having dementia in future.

2.4.2 Machine Learning Models

These will be intermediary deliverables leading towards final product. Basically there will be machine learning models trained on our dataset to predict memory, depression, analytical thinking and dementia in the final product.

2.4.3 API

This will be a part of the final product, an online API from which one can get a prediction at any time via a post specified format post request.

2.4.4 Story Line

As first step, the story of the game was developed. The storyline was developed keeping the given standard tests in mind, interest of player and how to make prediction possible. There were two to three versions of story developed which were discussed with the co – advisor time to time. Memory test was developed at first around January 2016 and then personality and analytical reasoning tests were developed around April. As the stories were developed they were approved by the co-advisor.

2.4.5 User Interface Mockups

The next deliverable after defining the story line was to design the User Interface. The user interface after a lot of thought and processing were developed. The tools used to develop mockups are as follows

- Fluid.io (online tool)
- Adobe Photoshop
- Adobe Illustrator

2.4.6 Documentation

Project proposal

The basic purpose of this document was to introduce our idea, talk about its novelty, feasibility and tell about the need of the hour of such a project. This document consists of all costs associated with the project, targeted audience, time to implement this project, other work done in this domain, literature review and much more.

Software requirement specifications

The basic purpose of this document is to identify the detailed requirements of the Brain Fight including its functional and non-functional domain requirements, so the software designing team can produce an efficient, reliable and secure application. This will not only help to reduce the communication gap between the client and the project manager but also help during software development and maintenance phase in future.

This document covers all parts of our system including hardware and software interaction, functional & non-functional requirements, domain requirements and database requirements etc.

Chapter 3

FUNCTIONALITY AND DESIGN

The application is to provide people with self-tests in form of an interesting game based on their daily routines to evaluate their behavior, memory and personality traits to study if they have any symptoms of dementia and then suggest them whether they should visit a therapist or not.

The application will be able to predict dementia disease in all smartphones in an economical and time saving way. It will provide a gaming environment to so that a non-dementia patient and a dementia patient can play it.

3.1 Features of the Game

3.1.1 Gameplay

Level 1: Getting to know you

The first level of the game is where user enters his information. We get to know user. The profile of the user is built here. It asks a few basic questions from user like name, location, age, feelings etc.

Level 2: Challenge your memory 1

This level includes all the memory based tests like MMSE, Min-Cog, Clock Draw Test and TYM. These tests basically evaluate the cognitive impairment of a user. The storyline of this level is designed on the daily routine of a person which includes activities like shopping, carrying out daily routine, participating in lucky draws etc. Each input of the user carries score and contributes to the final scoring in prediction. At the end of the level score calculated on basis of level 1 is sent to server for further processing.

Level 3: Challenge your memory 2

This level is the extension of "Challenge your Memory 1", it also focuses on memory of the user. Some of the questions and tasks are performed in this level.

Level 4: Checking your liveliness!

This level focuses on the personality traits. Tests like SAGE, Geriatric Depression Rating Scale etc. are included in this level. The storyline of this level is also based on the daily routine of a person which includes activities like doing GYM, visiting hospital, driving, having family conversation etc. The input to questions carries score and at the end of level total score calculated is sent to server for further processing.

Level 5: Can you think?

This level consists of analytical reasoning questions. It evaluates the abstract thinking capabilities of the user.

Server-side prediction algorithm

The server side is where the actual classification is done. The server has the models to classify the instances according to their respective classes. A machine learning algorithm- Naïve Byes Classifier is trained on $2/3^{rd}$ of dataset to get our machine learning models and then. The user data from the game is sent to the server and then server applies the Naïve Bayes Classifier on them and predicts to which class they belong according to probability.

3.1.2 Report Display

The algorithm mentioned above analyzes the data and based on the analyses makes a prediction for dementia. The result is displayed back to the user in the form of a report that mentions the percentage of chances having dementia along with the type of dementia. At the end, user is either recommended to visit the related doctor if the percentage is pass a certain level

3.1.3 API

There will be an API using which an online prediction about dementia can be made. Someone just has to send a request to our server with the appropriate data format and a prediction based on that will be made.

3.2 REQUIREMENTS ENGINEERING

3.2.1 Functional Requirements

User registration

User needs to login using Facebook, in case he doesn't own a Facebook account he will have to register manually.

Level completion

User will complete each level. After completing each level user will be advanced to next level.

Dementia standard tests

The application will incorporate dementia prediction standard tests in the game main storyline.

Machine learning algorithm

At the end of each stage user's score is sent to server where a machine learning algorithm is run over data.

Report display

Server computes the result and sends back to user. The user is recommended to visit doctor on basis of the result**.**

Email report

The application displays a report at the end of the game. User can request to email the report to his/her specified email address for further consultation and confirmation from a doctor.

User fitness

Users can view the strength of their brains. User fitness board calculates total marks of user on basis of his performances and displays results based on his/her last test results. This will motivate user to play a healthier game.

3.2.2 Non Functional Requirements

Performance requirements

This software should be extremely efficient, secure and reliable because the use of this software is a matter of health of a person.

- The software should always ensure data being sent to the server is sent in an encrypted form.
- The machine learning algorithm is properly trained so that it does not make wrong prediction for a player.
- The software should ensure that communication with the server is never lost.

Safety and security requirements

The software should not only transmit confidential data gathered as fast as possible but also ensure that the data is transmitted in the encrypted form so confidentiality of the data is maintained.

Software Quality Attributes

- ***Reliability***

The software needs to be reliable as already stated before. The prediction is correct.

- ***User Friendly***

The game will be user friendly. A novice player will not find it difficult to understand how to play game. The game will incorporate on-screen instructional overlays to make easy for a user to play.

3.2.3 Other Requirements

Database management

For the better performance and smooth operations, one of the important requirements is to maintain the record of every player, his scores, mental capabilities etc. It is also important for the security point of view. It will help the easy management and retrieval of data when required.

3.3 DESIGN

3.3.1 Architecture

The project has a simple architecture that includes a smartphone, Amazon server and a database. There are two main components of the project, first one is a unity game then there is backend server on amazon web services.

The Gamified App

This is basically a unity app and follows the general architecture that any unity project does. This contains all the game assets and coding logic for game. Unity basically has event based architecture, so whenever an event occurs the appropriate action is called to handle that. The app consists of different scenes which are basically levels of our game too. There are other support scenes like menus, scoreboard etc.

Backend Server

The backend is where the actual machine learning is implemented. So we had a database of over 0.1 million patients so we firstly trained four models on that for classification. Those models are memory impairment prediction, depression impairment prediction, abstract thinking impairment prediction and dementia prediction. The models were trained on $2/3^{rd}$ dataset whereas $1/3^{rd}$ was used as test set.

After the training part the backend has a live running API for prediction. The API is integrated with application so prediction in application is made through that. The API can also be called independently to get prediction about anyone via sending the data in a specified format.

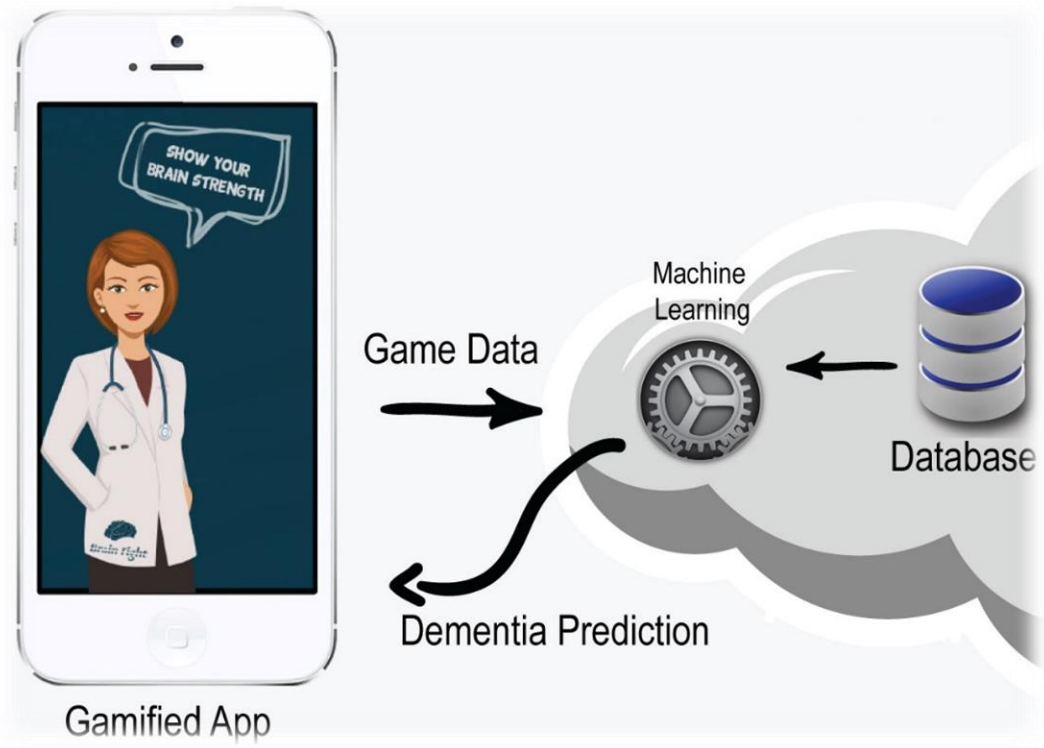


Figure 1 - Architecture Overview

3.3.2 Data Flow

The data flows through the whole architecture as shown in the figure below

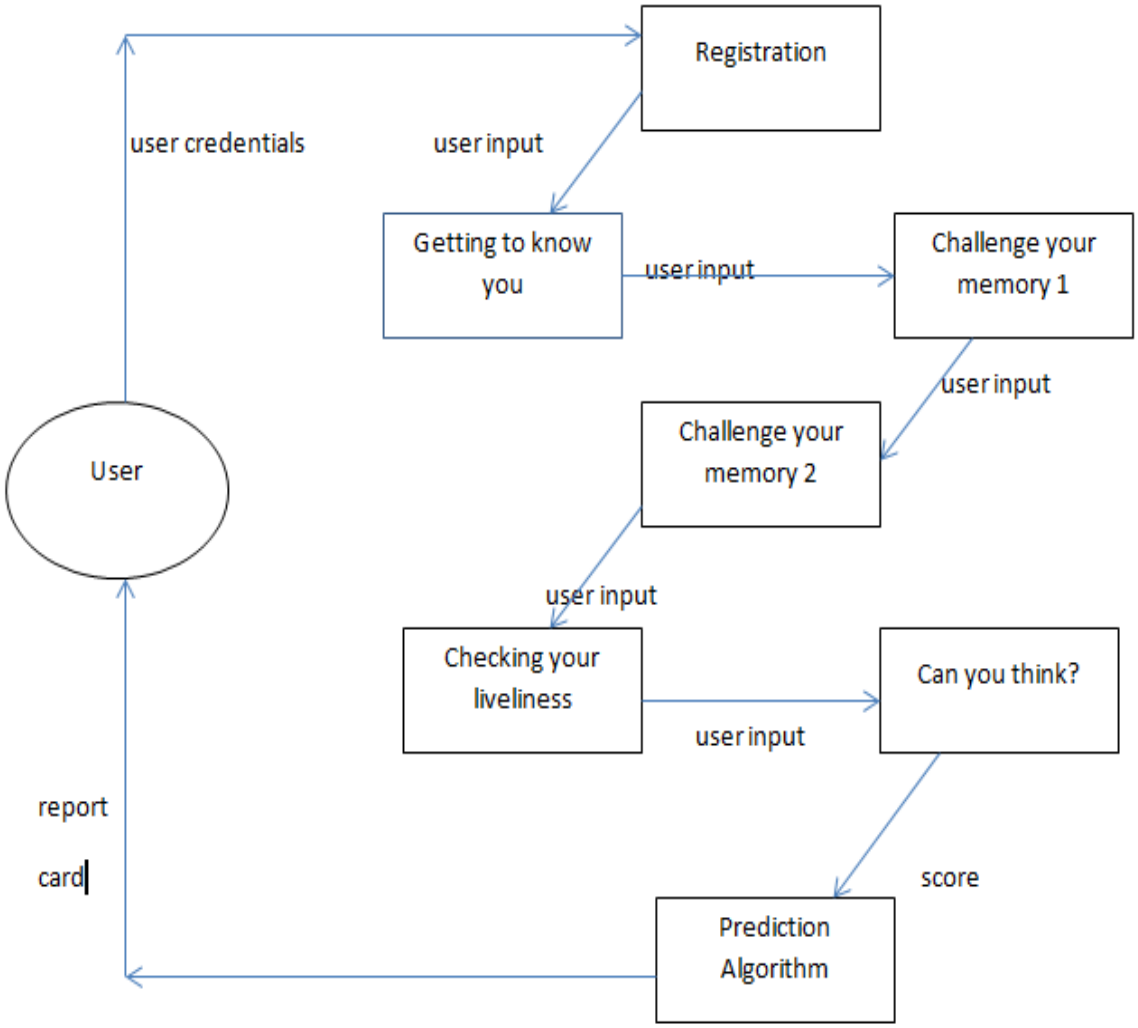


Figure 2 - Data flow Diagram

3.3.1 Database Schema

Table 2 - Database Schema

	Uniform Data Set (UDS) (LONGITUDINAL)		**Neuropathology Data Set (NP)**		**Minimum Data Set (MDS)**
	UDS	**FTLD Module**	**Data with associated UDS visit(s)**	**Data with no associated UDS visit (MDS only)**	
Years covered	Sep 2005 – present	Feb 2012 – present	2005 – present	1984 – 2005	1984 – 2005
Study subjects	Enrollees followed at ADCs (with or without dementia)		UDS subjects who died and underwent autopsy	MDS-only subjects who died and underwent autopsy	Enrollees followed at ADCs (with or without dementia)
Approx # subjects	32,938	1047	3,920	11,003	74,397
Approx # variables	725	379	85		67
Method of data collection	Collected prospectively by clinicians, neuro-psychologists, and other ADC research personnel, using up to 18 standardized forms at each visit. Some forms also have Spanish-language and telephone versions.	Collected prospectively by clinicians, neuro-psychologists, and other ADC research personnel, using up to 13 standardized forms at each FTLD Module visit.	Standardized neuropathology form, completed by neuropathologist		Mainly abstracted retroactively from ADC medical records
Time period covered	Initial visit and each annual follow-up visit, plus milestones such as death or dropout	Initial FTLD Module visit and annual follow-up visit	Status of brain at autopsy		Mainly status on last ADC visit; some variables also capture initial-visit status
Topics covered (brief list)	• Sociodemographics on subject and co-participant • Family history • Dementia history • Neurological exam findings • Functional status • Neuropsychological test results • Clinical diagnosis	• Neurological and motor exam findings • Clinical bv FTD and PPA findings • Neuropsychological test results • Social norms • Social behavior • Co-participant questionnaires	• Demographics • Date of death • Presence or absence of neuropathological features of most major dementias • Imaging availability • Vital status • Imaging availability • APOE genotype		• Demographics • Cognitive status • Clinical diagnosis • Selected clinical manifestations • Comorbid conditions • MMSE score

3.3.2 Use Case Scenarios

Table 3 - User Registration Use Case

Description	The system will ask user to first register in order to play game. For which user will provide the application with his basic information.
Data	User data
Stimulus	User basic information
Response	Will grant access to user
Pre- condition	User is not registered before.
Post – condition	User is allowed access to game.

Table 4 - Level Completion Use Case

Description	The user will play multiple levels of game
Data	User data
Stimulus	Level completion
Response	Advanced to next level
Pre- condition	User completed previous level
Post – condition	User plays next level

Table 5 - Report Card Display Use Case

Description	The user will play all levels of game
Data	User data
Stimulus	User Input
Response	User is displayed his report card
Pre- condition	User is logged in
Post – condition	User can view report card

3.3.3 Use Case Diagram

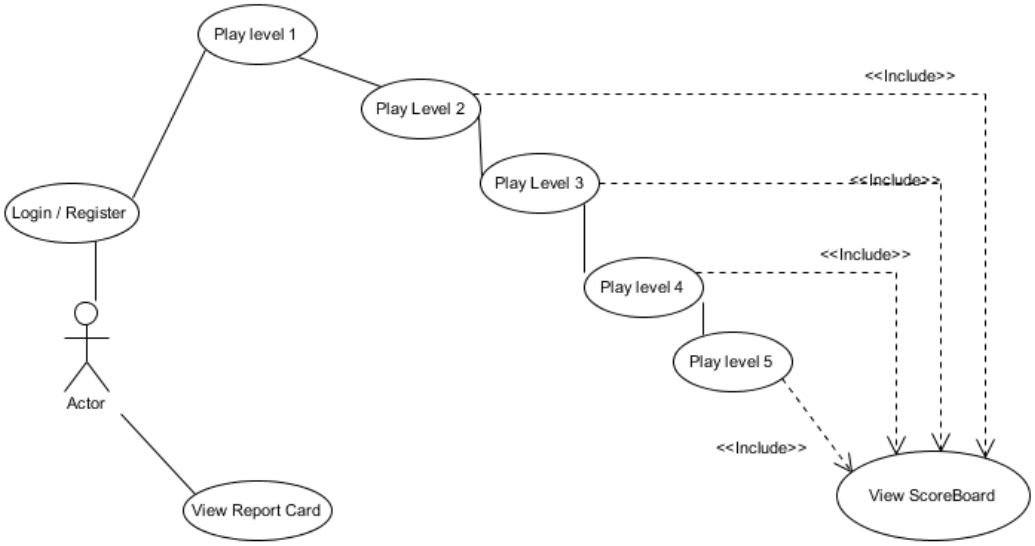


Figure 3 - Use Case Diagram

Chapter 4

IMPLEMENTATION AND RESULT DISCUSSION

BrainFight is developed using various tools, technologies and methods. The implementation of the application was planned as follows

4.1 STORY MAKING

As first step, the story of the game was developed. The storyline was developed keeping the given standard tests in mind, interest of player and how to make prediction possible. There were two to three versions of story developed which were discussed with the co – advisor time to time. Memory test was developed at first around January 2016 and then personality and analytical reasoning tests were developed around April. As the stories were developed they were approved by the co-advisor

4.2 USER INTERFACE

The next deliverable after defining the story line was to design the User Interface. The user interface after a lot of thought and processing were developed. The tools used to develop mockups are as follows

- Fluid.io (online tool)
- Adobe Photoshop
- Adobe Illustrator

Some of the developed mockups are:

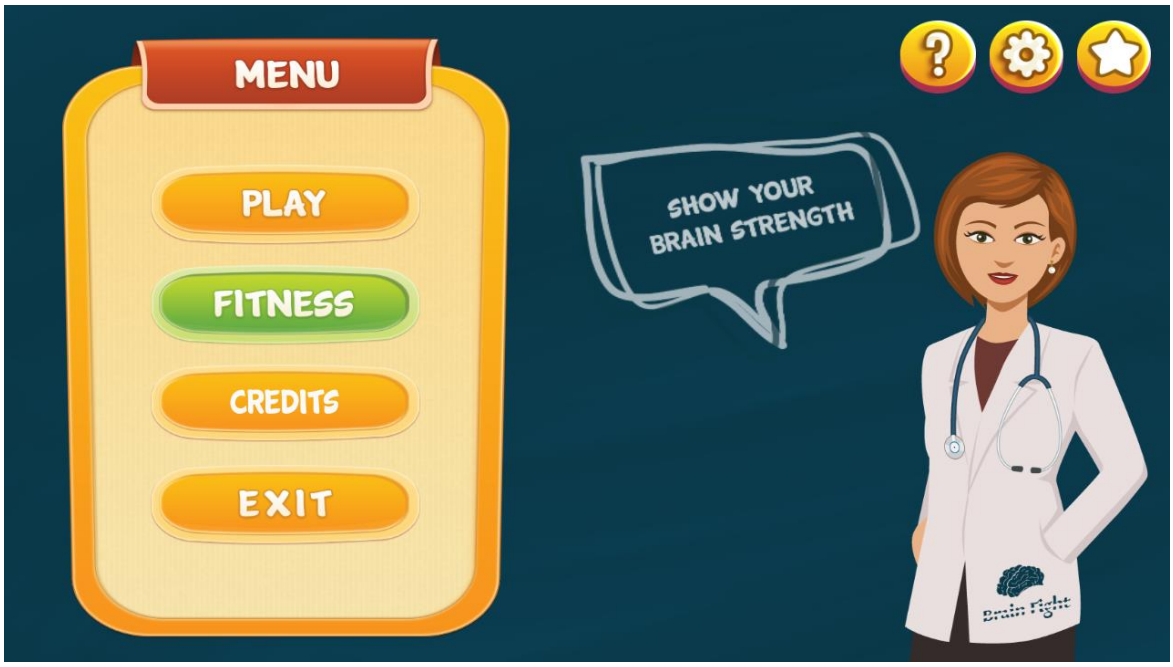


Figure 4 - User Interface Main Menu

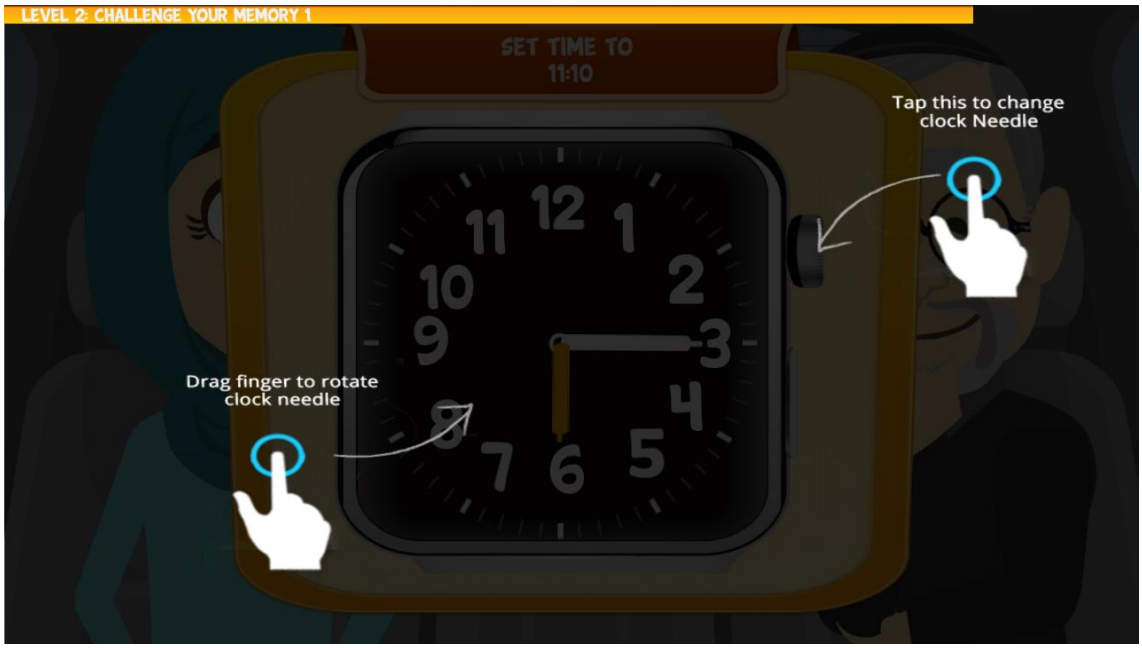


Figure 5 - User Interface Clock Draw Test Tutorial

Figure 6 - User Interface Clock Draw Test

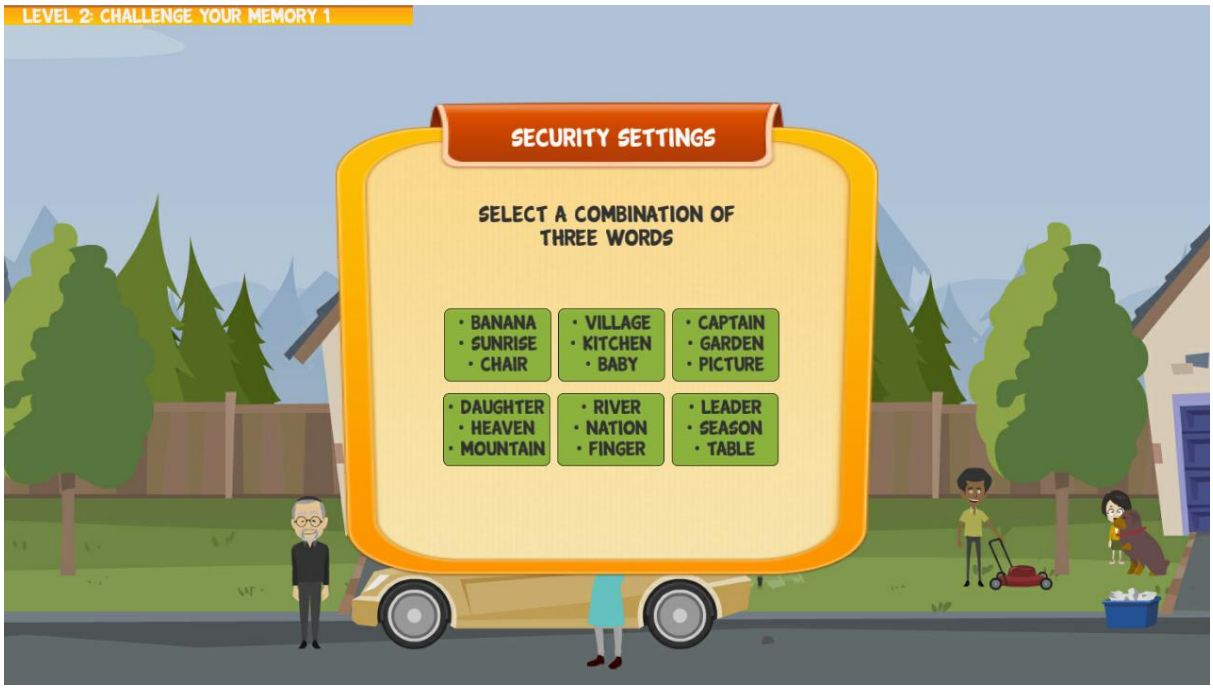


Figure 7 - User Interface Combination of Words

Figure 8 - User Interface Analytical Reasoning Test

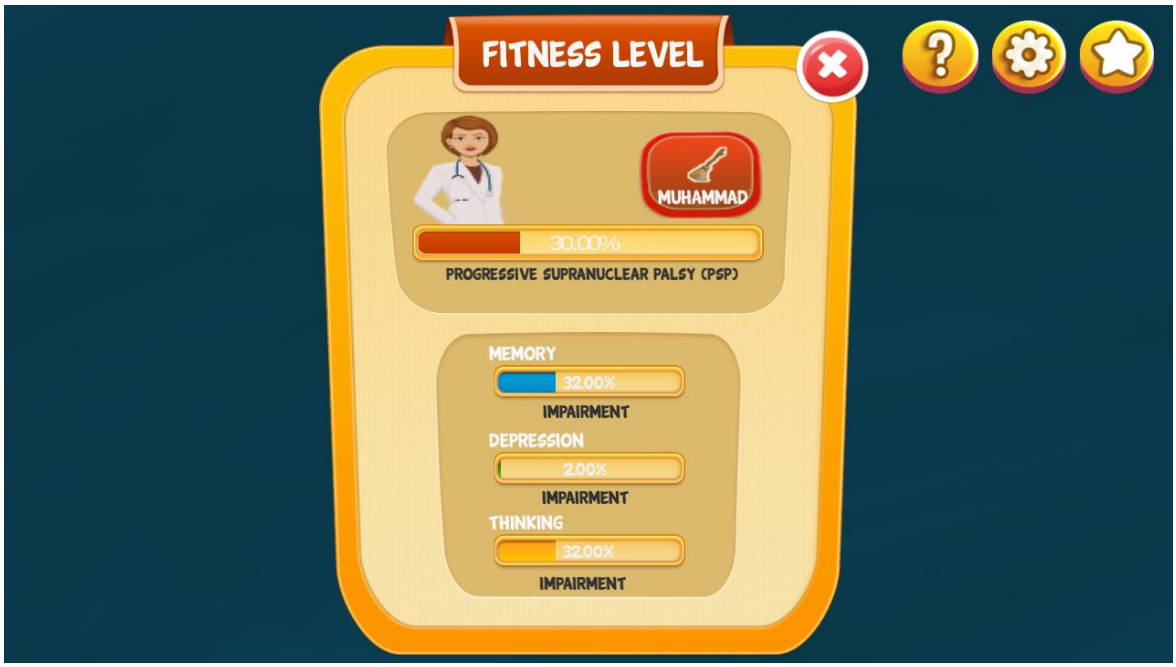


Figure 9 - User Interface Report Card

4.3 DESIGN AND ARCHITECTURE

Once the storyline and graphics were designed, the design and architecture of the application was designed. The application follows Model Viewer Controller architecture. The basic components of our application are as follows:

- User Smartphone
- Amazon Server
- Prediction Algorithm

4.4 COMPONENT'S IMPLEMENTATION

4.4.1 Code Snippets

Training Models: Dementia Model Training

```
import weka.core.converters.ConverterUtils.DataSource;
import weka.core.Instances;
import java.util.Random;
import weka.classifiers.bayes.NaiveBayes;
import weka.filters.Filter;
import weka.filters.supervised.instance.StratifiedRemoveFolds;
import weka.filters.unsupervised.attribute.StringToNominal;
import weka.classifiers.evaluation.*;


public class DementTraining {
	public static void main(String[] args) throws Exception {
		DataSource source = new DataSource("E:\\FYP\\a.arff");
		Instances data = source.getDataSet();
		// data.randomize(null);
		if (data.classIndex() == -1)
			data.setClassIndex(data.numAttributes() - 231);
		//String attributes to nominal values
		StringToNominal convert= new StringToNominal();
```

```
                convert.setInputFormat(data);
            String[] options= new String[2];
            options[0]="-R";
            options[1]="1-936";  //range of variables to make numeric
            convert.setOptions(options);
                Instances nomfilteredData=Filter.useFilter(data, convert);
               // use StratifiedRemoveFolds to randomly split the data
                StratifiedRemoveFolds filter = new StratifiedRemoveFolds();
                // set options for creating the subset of data
                String[] optionsdiv = new String[6];
                optionsdiv[0] = "-N";         // indicate we want to set the number of folds
                // split the data into three random folds
                optionsdiv[1] = Integer.toString(5);
                optionsdiv[2] = "-F";                 // indicate we want to select a specific
fold
                optionsdiv[3] = Integer.toString(1);  // select the first fold
                optionsdiv[4] = "-S";              // indicate we want to set the random seed
                optionsdiv[5] = Integer.toString(1);  // set the random seed to 1

                filter.setOptions(options);       // set the filter options
                filter.setInputFormat(nomfilteredData);       // prepare the filter for the
data format
                filter.setInvertSelection(false);  // do not invert the selection
                // apply filter for test data here
                Instances test = Filter.useFilter(nomfilteredData, filter);
                System.out.println("test length: "+test.numInstances());
                //  prepare and apply filter for training data here
                filter.setInvertSelection(true);     // invert the selection to get other data
                Instances train = Filter.useFilter(nomfilteredData, filter);
```

```
                    System.out.println("train length: "+train.numInstances());
                   // train classifier
                    NaiveBayes cls = new NaiveBayes();
                    cls.buildClassifier(train);
                    // serialize model

weka.core.SerializationHelper.write("E:\\FYP\\brainfightnaivebayes.model", cls);
                    // evaluate classifier and print some statistics
                    Evaluation eval = new Evaluation(train);
                    eval.evaluateModel(cls, test);
                    eval.errorRate();
                    double[][] results = eval.confusionMatrix();
                    for (int g=0; g<results.length; g++ ){
                                for (int h=0; h<results.length; h++ ){
                                }
                    }

                    Random rand = new Random(1);  // using seed = 1
                    int folds = 10;
                    eval.crossValidateModel(cls, nomfilteredData, folds, rand);
                    System.out.println(eval.toMatrixString());

                    System.out.println(eval.toSummaryString("\nResults\n======\n",
false));
                    System.out.println("Error Rate: "+eval.errorRate());
          }
}
```

4.4.2 Game Design

The game is developed on the story line that was developed at the start of the implementation phase. The implementation of game started in February 2016. The development of the game was a very time taking process. The game completed in April 2016.

The game was developed using the following tools:

Unity3D

Unity3d is a cross-platform game engine developed by Unity Technologies and used to develop video games for PC, consoles, mobile devices and websites. With an emphasis on portability, the engine targets the following APIs: Direct3D on Windows and Xbox 360; OpenGL on Mac and Windows. Unity is notable for its ability to target games to multiple platforms. Within a project, developers have control over delivery to mobile devices, web browsers, desktops, and consoles.

It was used for developing and linking user interface with the main application. Linking screens, adding functionality, buttons, text etc. was done using unity.

Visual Studio

Visual Studio implements the responsiveness in the game. It adds scripts behind buttons, text boxes, input fields etc. The main logic of the game, processing of data, calculation of score etc. was done using visual studio.

4.4.3 Backend Server

Dataset

Basically we got a data set for National Alzheimer's Center, USA of over 0.1 million instances and we used that in our application. As we were using Weka library so it required the format to be converted from CSV to ARFF format. We tried a lot of automatic tools but they all failed, we then had to go through the whole data dictionary and all 936 variables to convert it into ARFF format, to be used by the library.

Prediction Algorithm

Naïve Bayesian Classifier is run as machine learning algorithm. Naïve Bayesian was chosen as it has a good accuracy on medical diagnosis applications.

Naïve Bayes Classifier

To demonstrate the concept of Naïve Bayes Classification, consider the example given below:

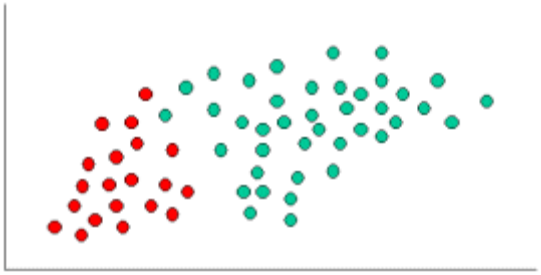


Figure 10 - Naïve Bayes Classifier

As indicated, the objects can be classified as either GREEN or RED. Our task is to classify new cases as they arrive, i.e., decide to which class label they belong, based on the currently existing objects.
Since there are twice as many GREEN objects as RED, it is reasonable to believe that a new case (which hasn't been observed yet) is twice as likely to have membership GREEN rather than RED. In the Bayesian analysis, this belief is known as the prior probability. Prior probabilities are based on previous experience, in this case the percentage of GREEN and RED objects, and often used to predict outcomes before they actually happen.
Thus, we can write:

Prior Probability of GREEN: number of GREEN objects / total number of objects
Prior Probability of RED: number of RED objects / total number of objects
Since there is a total of 60 objects, 40 of which are GREEN and 20 RED, our prior probabilities for class membership are:
Prior Probability for GREEN: 40 / 60
Prior Probability for RED: 20 / 60
Having formulated our prior probability, we are now ready to classify a new object (WHITE circle in the diagram below). Since the objects are well clustered, it is reasonable to assume that the more GREEN(or RED) objects in the vicinity of X, the more likely that the new cases belong to that particular color. To measure this likelihood, we draw a circle around X which encompasses a number (to be chosen a priori) of points irrespective of their class labels. Then we calculate the number of points in the circle belonging to each class label. From this we calculate the likelihood:

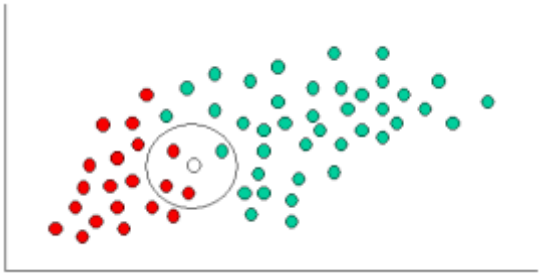


Figure 11 - Naïve Bayes Classifier

$$Likelihood\ of\ X\ given\ GREEN \propto \frac{Number\ of\ GREEN\ in\ the\ vicinity\ of\ X}{Total\ number\ of\ GREEN\ cases}$$

$$Likelihood\ of\ X\ given\ RED \propto \frac{Number\ of\ RED\ in\ the\ vicinity\ of\ X}{Total\ number\ of\ RED\ cases}$$

From the illustration above, it is clear that Likelihood of X given GREEN is smaller than Likelihood of X given RED, since the circle encompasses 1 GREEN object and 3 RED ones. Thus:

$$Probability\ of\ X\ given\ GREEN \propto \frac{1}{40}$$

$$Probability\ of\ X\ given\ RED \propto \frac{3}{20}$$

Although the prior probabilities indicate that X may belong to GREEN (given that there are twice as many GREEN compared to RED) the likelihood indicates otherwise; that the class membership of X isRED (given that there are more RED objects in the vicinity of X than GREEN). In the Bayesian analysis, the final classification is produced by combining both sources of information, i.e., the prior and the likelihood, to form a posterior probability using the so-called Bayes' rule (named after Rev. Thomas Bayes 1702-1761).

$$Posterior\ probability\ of\ X\ being\ GREEN \propto$$

$$Prior\ probability\ of\ GREEN \times Likelihood\ of\ X\ given\ GREEN$$

$$= \frac{4}{6} \times \frac{1}{40} = \frac{1}{60}$$

$$Posterior\ probability\ of\ X\ being\ RED \propto$$

$$Prior\ probability\ of\ RED \times Likelihood\ of\ X\ given\ RED$$

$$= \frac{2}{6} \times \frac{3}{20} = \frac{1}{20}$$

Finally, we classify X as RED since its class membership achieves the largest posterior probability.

Weka

To actually implement the above algorithm, we use the Weka library in java. Weka is a collection of machine learning algorithms for data mining tasks. The algorithms can either be applied directly to a dataset or called from your own Java code. Weka contains tools for data pre-processing, classification, regression, clustering, association rules, and visualization. It is also well-suited for developing new machine learning schemes. Weka is open source software issued under the GNU General Public License.

Amazon Web Services

The API that we developed and training was done using amazon web services as we had a huge datasets and we need good hardware. We used amazon EC2 instance for our development purposes. Amazon Web Services offers reliable, scalable, and inexpensive cloud computing services.

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

Amazon EC2's simple web service interface allows you to obtain and configure capacity with minimal friction. It provides you with complete control of your computing resources and lets you run on Amazon's proven computing environment. Amazon EC2 reduces the time required to obtain and boot new server instances to minutes, allowing you to quickly scale capacity, both up and down, as your computing requirements change. Amazon EC2 changes the economics of computing by allowing you to pay only for capacity that you actually use. Amazon EC2 provides developers the tools to build failure resilient applications and isolate themselves from common failure scenarios.

4.5 DESIGN AND IMPLEMENTATION CONSTRAINTS

4.5.1 Security Constraint

Security is the main issue, as it is highly security sensitive, so all the credential must be kept safe and no outsider will be allowed to access the user data. Cyber security measures would be taken to avoid invaders in the system.

4.5.2 Updating database

Database had to be updated timely and if database is not up to date it will result in security constraints and other issues. It will affect the performance directly.

4.5.3 International humanitarian law

International humanitarian law had to be maintained and innocent people should not be affected in any situation.

4.5.4 Proper Messaging

Proper encryption should be used to avoid invaders.

4.5.5 Limited Research on the topic

Many people have been suffering with dementia and Alzheimer worldwide, but they are not timely informed which in most of the cases worsen the case. Researchers are still researching in this domain, many tests and temporary cures are introduced but

nothing has yet been launched that can permanently heal this disease. So scope of our application is limited to prediction of this disease only.

4.5.6 Limited Data for Learning Algorithm Training Set

Since we had to train our algorithm on users' datasets, these datasets are not available in large amounts and those available can only be accessed after a lot of effort and time.

4.6 TESTING TECHNIQUES

Some of the testing techniques used in BrainFight are as following:

4.6.1 Load Testing

Load testing is the process in which the system performance is tested by putting load on it that it approaches its limits. It is used to uncover bugs if any in the system and its result show that whether the system meets its specific in extreme load condition or not. Some of the examples for detect of which load testing are done

- Memory leaks, buffer overflows.
- To make sure that the functionality of the system is fulfilled under real-time conditions.
- To detect any problem

4.6.2 Stress Testing

Stress testing sometimes called torture testing is one of the important testing technique. It is mainly performed so that one could know how stable the system is. In it the load put on the system is more than its limits. Some of the reason for which stress testing was performed on BrainFight are as following

- To get to know which reasons can cause failure of the system
- To find break points
- To know whether the system meets specification successfully or not
- To know the extent of stability of system

4.6.3 Usability Testing

Usability testing is one of the significant testing technique and nearly used in every kind and nature of system. This technique gives bugs which can give rise to usability issues arises are detected. Usually usability testing is done by inviting few participants to conduct certain tasks related to the system. Its main purpose is to make system easily usable of any kind of user even for novice one.

A successful test means that the interface of the system is user friendly and any user can easily use it. It is mainly black box testing. Some of the reasons for which the usability testing was performed on BrainFight are as following

- To know whether the interface is easy to use or not
- To know how convenient is BrainFight

4.6.4 Functional Testing

In case of BrainFight functional testing was very important. As the scope of the project is large so each and every functionality much be tested. It is kind of quality assurance of the project. In it we basically test the features of the system in every way and make sure that it meets the specification of the system. Functional testing involves six steps:

- The creation of input data based on the function's specifications
- The determination of output based on the function's specifications
- The execution of the test case
- The comparison of actual and expected outputs
- To check whether the application works as per the customer need.

4.6.5. Test Cases

A few test cases are mentioned below

Table 6 - Test Case User Registration

Test Case ID: 1 A	**Test Designed By: Sitwat Atiq**
Test Priority (Low/Medium/High): High	**Test Designed Date:** March 15, 2016
Module Name: Game Play	**Test executed by: Sitwat Atiq**
Test Title: User logins using Facebook.	**Test Execution Date: April 20, 2016**
Test Description: Test the login page	
Preconditions:	
User is connected to the internet.	
Post conditions:	
The account session details are logged to database.	
Dependencies:	
Server is up.	

Step No.	Step	Test Data	Expected Result	Actual Result	Status (Pass/Fail)	Notes
1.	Navigate to login page.	User clicks log in button	User is navigated to homepage after successful login.	User logs in	**PASS**	
2.	Click on login button.					

Table 7 - Test Case Game Save

Test Case ID: 2	**Test Designed By: Sitwat Atiq**
Test Priority (Low/Medium/High): High	**Test Designed Date:** March 15, 2016
Module Name: Game Play	**Test executed by: Sitwat Atiq**
Test Title: Game Save	**Test Execution Date: April 20, 2016**

Test Description: Test whether game saves or not

Preconditions:

User has played a little part of the game

Post conditions:

Database is updated.

Dependencies:

Server is up.

Step No.	Step	Test Data	Expected Result	Actual Result	Status (Pass/Fail)	Notes
1.	User logs in	User clicks save button	Data is correctly updated in database	Data is saved	**PASS**	
2.	Plays game					
3.	Press SAVE button					

Table 8 - Test Case Clock Draw Test

Test Case ID: 3	**Test Designed By: Sitwat Atiq**
Test Priority (Low/Medium/High): High	**Test Designed Date:** March 15, 2016
Module Name: Game Play	**Test executed by: Sitwat Atiq**
Test Title: Clock Draw Test	**Test Execution Date: April 20, 2016**

Test Description: Clock draw test is performed correctly or not

Preconditions:

User has played level one of game and is now playing level two

Post conditions:

Database is updated.

Dependencies:

Server is up.

Step No.	Step	Test Data	Expected Result	Actual Result	Status (Pass/Fail)	Notes
1.	User logs in	User puts clock numbers and needles correctly.	Score is calculated on basis of placing of numbers and needles and sent to database	Database updated	**PASS**	
2.	Plays level 1					
3.	Plays level 2					
4.	Put clock numbers in place					
5.	Place needles correctly					

4.7 CHALLENGES

Some of the challenges faced during the whole course of the project are mentioned below

4.7.1 Medicine Background

As we are engineering students with very small medicine background, so coping with such adverse circumstances was a very difficult task. Proper research was to be done in order to come up with best solution. The primary part of the planning phase comprised of research in this domain. We visited a few doctors in different hospitals to get their feedback and analyze the feasibility of this project. At some stages, this project seemed infeasible but with research and faith we came up with solutions time to time. All statistics and figures, already worked done etc. had to be searched. All this literature work took the major part of our project planning phase.

4.7.2 Datasets

Once the facts and figures were straightened, the next task was to find datasets to train machine learning algorithm. Since, limited work has been done in this domain so finding datasets of Alzheimer's and dementia patients was one of the biggest challenges. We had to contact hospitals, doctors and online database centers for data. After a lot of paper work National Alzheimer's Coordinating Centre (NACC), USA provided us with a database of over one lac dementia patients in February. The dataset consisted of over nine hundred variables that were used to determine dementia probability in a person.

Getting data was one thing and then understanding that data was another. It took a few weeks in order to read and understand the data and its data dictionary. It consumed a lot of time. After a lot of hassle, when we learned the format of the dataset our next task was to find the variables that mapped to the variables in our game. All these tasks were very time consuming and frustrating. We had to work out each and every variable's value individually.

4.7.3 Algorithm Training

Reading the database and analyzing models and results was another tiring task. It took two to three months to read the file and generate results. The tool used for machine learning was Weka and for trial we ran algorithm on dataset of Diabetic patients.

As the work done in this domain is limited so it was very difficult to find large datasets. The algorithm hence was trained on a small set of data.

4.7.4 Lack of expertise

A few challenges were faced during the implementation of project. Some new tools had to be used which required a little training time. Tools like Unity 3D, Weka, Adobe Photoshop, Adobe Illustrator etc. required a little training. It took a few weeks to get to know these tools.

4.8 RESULTS

Here are some of the stats of our results:

Test length: 10850

Train length: 108498

Results

======

Correctly Classified Instances	95746	**80.2249 %**
Incorrectly Classified Instances	23601	19.7751 %
Kappa statistic	0.7244	
Mean absolute error	0.0124	
Root mean squared error	0.1092	
Relative absolute error	29.5761 %	
Root relative squared error	75.5494 %	
Total Number of Instances	119347	
Ignored Class Unknown Instances	1	

Error Rate: **0.19775109554492362 %**

Confusion Matrix

```
    a    b    c    d    e    f    g    h    i    j    k    l    m    n    o    p    q    r    s    t
u    v    w    x    y    z   aa   ab   ac   ad   ae   af  <-- classified as

 29501  665    0    8  415   77 1479  871    0    1    0  506   16   63    0    0    0
 1773 1316    0    0   25    0    0   30   30    0  321   17   54 6057    0 |    a = 1

   14 2852    0    9   59    9   86   57    0    0    0   27    0   14    0    0    0   95
   55    0    0    0    0    0    1    4    0   13   11   18  153    0 |    b = 2

    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
    0    0    0    0    0    0    0    0    0    0    0    0    0 |    c = 3

    1   30    0  223   15    3   20    3    0    0    0    5    0    0    0    0    0   22
    2    0    0    0    0    0    0    0    0    0    0    0   16    0 |    d = 4

    4   53    0   13  305    1   38    8    0    0    0    4    0    1    0    0    0   26
    3    0    0    0    0    0    2    0    0    1    0    7   42    0 |    e = 5

    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    8    0
    0    0    0    0    0    0    0    0    0    0    0    0    0 |    f = 6

    9   71    0   34   43   41 3657   35    0    0    0   43    1    0    0    0    0  196
   64    0    0    1    0    0   20    7    0    2    0    7  413    0 |    g = 7

   49   62    0    0   40    1   79 1546    0    0    0   15    0    6    0    0    0  138
   74    0    0    3    0    0    0    0    0   11    0    3  571    0 |    h = 8

    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
    0    0    0    0    0    0    0    0    0    0    0    0    0 |    i = 9

    0    0    0    0    0    0   11    0    0    1    0    1    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0 |    j = 10

    0    3    0    0    0    0    1    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    2    0 |    k = 11

    0    8    0    4    0    2    5    0    0    0    0  110    0    0    0    0    0    2    2
    0    0    0    0    0    7    0    0    0    0    2    9    0 |    l = 12

    4   12    0    0    1    0    4   14    0    0    0    2   30    0    0    0    0    6   23
    0    0    0    0    0    2    0    0    3    0    1   47    0 |    m = 13

    8   22    0    0    0    0    2   19    0    0    0    1    0   38    0    0    0    3    5
    0    0    0    0    0    0    0    0    1    0    1   32    0 |    n = 14
```

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
0 0 0 0 0 0 0 0 0 0 0 0 0 | o = 15

4 0 0 0 0 0 0 1 0 0 0 3 0 0 0 0 0 1 0
0 0 0 0 0 0 0 0 1 0 0 10 0 | p = 16

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 | q = 17

0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 78 0
0 0 0 0 0 0 0 0 0 0 0 0 0 | r = 18

4 21 0 0 1 0 24 42 0 0 0 0 0 2 0 0 0 59
1162 0 0 2 0 0 1 0 0 1 1 0 280 0 | s = 19

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 7 0
0 0 0 0 0 0 0 0 0 0 0 0 0 | t = 20

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 3 0
0 0 0 0 0 0 0 0 0 0 0 0 0 | u = 21

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 17 0
0 0 1 0 0 0 0 0 0 0 0 0 0 | v = 22

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 | w = 23

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2 0
0 0 0 0 0 0 0 0 0 0 0 0 0 | x = 24

2 6 0 1 0 0 6 11 0 0 0 0 0 1 0 0 0 4 26
0 0 0 0 0 97 0 0 1 0 2 81 0 | y = 25

3 5 0 0 1 0 10 7 0 0 0 0 0 0 0 0 0 5 11
0 0 1 0 0 5 1 0 0 0 1 27 0 | z = 26

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
0 0 0 0 0 0 0 0 0 0 0 0 0 | aa = 27

5 4 0 0 1 0 11 39 0 0 0 0 1 1 0 0 0 15 34
0 0 3 0 0 3 0 0 248 1 1 167 0 | ab = 28

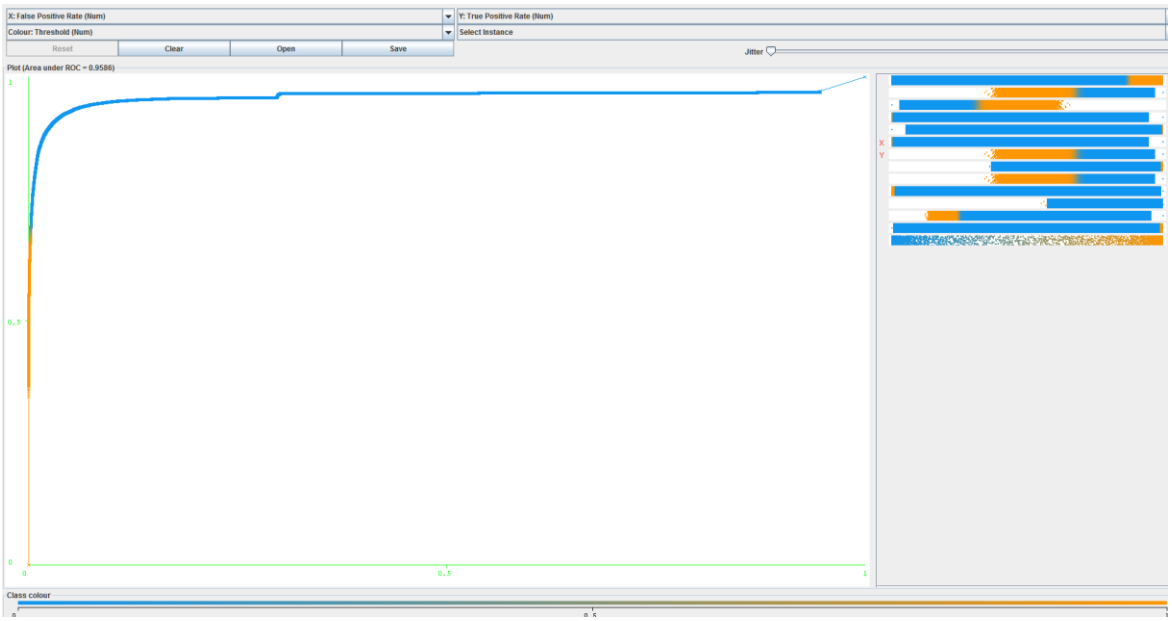
0 6 0 0 2 0 6 7 0 0 0 1 0 0 0 0 0 17 45
0 0 0 0 0 2 0 0 12 2 3 66 0 | ac = 29

```
   40   65    0   10   15    0  125   90    0    0    0   21    1    0    0    0    0  152
120    0    0    0    0    0    6    0    0   17    3  468  568    0 |   ad = 30

   57  138    0    5   21    0  183  161    0    0    0   56    1   15    0    0    0    0
143    0    0    0    0    0    7    1    0   12    6   10 6335    0 |   ae = 99

    0    0    0    0    1    0    0    0    0    7    0    1    1    0    0    0    0 2752    0
0    0  640    0    0    0    0    0    0    0    0    0 49091 |   af = 88
```

4.8.1 Receiver operating characteristic Curve



4.9 FUTURE ASPECTS

Brain Fight is well thought out and well processed application. It has been planned thoroughly and after all due diligence it was implemented. Due to time constraints a few features cannot be added. As for the future aspects, we plan to make this application more users friendly and interesting. We hope to take this application to a new level by testing it on large number of patients and will also try to incorporate some memory sharpen puzzles and questions.

Chapter 5

CONCLUSION AND FUTURE RECOMMENDATIONS

5.1 CONCLUSION

The major focus for now is on prediction part. In the longer run we will make an app that will not only predict dementia & improves mental activity but will also be used to assist a patient in daily activities.

5.2 RECOMMENDATIONS

5.2.1 Text to Voice Conversion

At the moment, the application displays dialogues of characters in the form of text. We plan to introduce speech in the later versions of this application which will make game more interesting for the user.

5.2.2 New Levels

We plan to introduce more features in this application in future. We will introduce new levels based on user daily routines that will ask user to perform daily tasks. Also we will include a level to check reflexes of a person, movement of limbs, movement etc.

We also plan make this application an assistant to a person who have been diagnosed with dementia. It would help the user to carry out all his daily routine work, will keep track of all the activities of the user etc.

5.2.3 Online Portal

In future we will introduce an online portal where user report will be saved against his profile. Doctors and users will be connected. A user may request a doctor to review his report and share his views with him.

5.2.4 Score Board

In future, we plan to include a scoring system of all people using this application. That will keep user motivated. It will help to compare brain strengths of every player with each other. The players will be ranked on the basis of their performance.

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APPENDIX A

Weka

Weka (pronounced to rhyme with Mecca) is a workbench that contains a collection of visualization tools and algorithms for data and predictive modeling, together with graphical user interfaces for easy access to these functions. The original non-Java version of Weka was a Tcl/Tk front-end to (mostly third-party) modeling algorithms implemented in other programming languages, plus data preprocessing utilities in C, and a Make file-based system for running machine learning experiments. This original version was primarily designed as a tool for analyzing data from agricultural domains,[2][3] but the more recent fully Java-based version (Weka 3), for which development started in 1997, is now used in many different application areas, in particular for educational purposes and research. Advantages of Weka include:

- Free availability under the GNU General Public License.
- Portability, since it is fully implemented in the Java programming language and thus runs on almost any modern computing platform.
- A comprehensive collection of data preprocessing and modeling techniques.
- Ease of use due to its graphical user interfaces.

Weka supports several standard data mining tasks, more specifically, data preprocessing, clustering, classification, regression, visualization, and feature selection. All of Weka's techniques are predicated on the assumption that the data is available as one flat file or relation, where each data point is described by a fixed number of attributes (normally, numeric or nominal attributes, but some other attribute types are also supported). Weka provides access to SQL databases using Java Database Connectivity and can process the result returned by a database query. It is not capable of multi-relational data mining, but there is separate software for converting a collection of linked database tables into a single table that is suitable for processing using Weka. Another important area that is currently not covered by the algorithms included in the Weka distribution is sequence modeling.

National Alzheimer’s Coordinating Center

The National Alzheimer's Coordinating Center was established by the National Institute on Aging/NIH (U01 AG016976) in 1999 to facilitate collaborative research. Using data collected from the 29 NIA-funded Alzheimer's disease Centers (ADCs) across the United States, NACC has developed and maintains a large relational database of standardized clinical and neuropathological research data. In partnership with the Alzheimer's Disease Genetics Consortium (ADGC) and the National Cell Repository for Alzheimer's Disease (NCRAD), NACC provides a valuable resource for both exploratory and explanatory Alzheimer's disease research. **NACC data are freely available to all researchers.**

The data are contributed by the 39 past and present Alzheimer’s Disease Centers (ADCs) supported by the U.S. National Institute on Aging/NIH, where all enrolled subjects undergo a standardized evaluation. The clinic-based population includes subjects with Alzheimer’s disease and related disorders, as well as cognitively normal subjects and those with MCI.

The NACC database comprises several standardized clinical and neuropathology data sets, all of which are freely available to the research community. **No password or account is required**, and no affiliation with the NIA Alzheimer's Disease Centers is needed.