

Alzheimer's Diagnoser

ELEC4010i Course Project

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1 Introduction

1.1 Overview

Current Alzheimer’s tests are mostly paper-based, where elder test-takers have to answer questions on a piece of paper with a pen. For example, the SAGE test [1] given by the Ohio State University. However, the situation is that many elder people cannot even read the questions, nor write properly, making the testing process painful for many elder people, as shown in Figure 1. Consequently, many elder people refuse to take such tests and it also make it hard for test evaluators to obtain accurate evaluation results solely depend on the answers collected. Therefore, to ease the process of diagnosing Alzheimer disease and make the test more friendly to elder people, we hope to build a system that can diagnose Alzheimer simply by talking to the test-taker. Moreover, we hope that our product could help collect data from potential Alzheimer patients for other researches on Alzheimer disease.



Figure 1: An Elder Test-Taker Taking A Paper-Based Alzheimer’s Test

1.2 Objectives

The objective of this project is to build a interactive dialog system that can diagnose Alzheimer disease by analyzing the answers given by the test-takers during the conversation. With this system, Alzheimer test-takers no longer need to do a paper-based test where they have to right down answer on a piece paper. By simply chatting with the test-bot and answer all its questions orally, test-taker can receive feedback and evaluation result right after the conversation ends. Besides, with our system, test-taker now can take the test anywhere they want and get instant feedback after the test, which will greatly ease and shorten the testing process.

Here are some key features of our system:

- **Conversation-Based:** The whole process is conversation-based, which means that no writing will be necessary. Test-taker simply talks to the system and receive audio feedbacks, textual feedbacks are also available in case test-taker can’t here clearly. If the any question is not heard clearly, test-taker can ask the system to repeat the question. Also, if the test-takers

do not the answer to a question, he/she can simply say something like "*I don't know*". The conversation process is very natural and the system can be easily understood.

- **Instant Evaluation:** Evaluation result will be shown to the test-takers right after the test, no need to wait for the result.
- **Data Preservation:** Besides the test results, every thing the test-taker say during the conversation will be recorded and uploaded to the database, in case the test-taker want those data for further analysis in the future.

2 System Overview

For the sake of accomplishing such Alzheimer's test, a conversational system is built to fulfill such goal. The system is integrated from a set of different tool kits. It has a website front-end which is established with Javascript and HTML on the PC server, an API.AI agent as the back-end for data verification and switch of intents and a mongoDB database for data warehousing. Such system allows user to answer with speech utterance to make the test more interactive and intuitive. The result will be shown both in text and speech form which is also a key feature for the system. Besides the standard test, a more on Alzheimer's webpage is also implemented to help people get more idea on what Alzheimer's really is. This user initiated website extends the test by providing most updated health care suggestion which normal paper test could not achieve. The detailed design of each system component is given in the below methodology section.

3 Methodology

This section is for detailed introduction of block function, interface definition, logic implementation (FSM design), etc. for every single block.

3.1 Design

3.1.1 Front-End Design

The system's front-end consists of mainly three sites for different tasks of the system. These three sites are the test site, the result display site and the more on Alzheimer's site.

Test Site

The HTML file generally framed the user interface of this website. User can interact with the system in the way of both speech and text forms. There are two buttons implemented on the test site which allows user to initiate the action. One is the "Start" button, that will begin the test process when clicked and the other is the "Speak" button for user voice input recognition. An input text box is shown on these two buttons for user's text input whilst the response from the system will be displayed in a larger text area below the buttons. During the test, images will be displayed below the response text area for user's picture recognition question set while this block would be hidden in other time. A button named "Check My Result Now" will appear at the end of the test which

enable hyperlinking to the result display site.

In the separated javascript file, following methods are designed for integration of the test process.

- `startRecognition()`: This method is a software development kit provided by API.AI. It will be called when we press the "Speak" button so as to switch our input from text to voice. The language of the speech recognition will be English.
- `resetAPIai()`: This method will be called when we clicked on the "Start" button. It will clear all the contexts first and then reset it to the very beginning of the test by posting an asynchronous HTTP request to our API.AI agent.
- `sendTask(inputValue,someCont, TYPE)`: This method is the primary function to be called during the whole test. It contains the parameters of query text and context to trigger different intents at API.AI through the way of "User Say". There are three types of tasks we are sending, the pure text, the greeting task and the test task. The pure text task is the most fundamental one among these tasks where we post query text to API.AI and get the response from that. Upon the success of the query, the response will be set in the response text area by the `setResponse` method. The greeting task is for user data collection which mainly used the Greeting method mentioned below. The test task is for the conduct of test on the question set. It will verify user's answer and update the intent counter as well as score for different types of questions in our test. Moreover, `SetImg()` method is used during the test task for the Picture Recognition Problem.
- `sendData(data,key)`: This method is set for the connection of our test site and the mangoDB database. It basically create JSON object containing the data and put it to the mangoDB.
- `setResponse(val)`: This method will set the response from API.AI into the response text area. At the appearance of the test, the `SpeechSynthesisUtterance` method from API.AI library will also be called for text to speech translation.
- `Greeting(myResponse)`: This method is called when we collect the biographical data from the users. It is the starting intent of the whole test where user's gender, age and name will be asked for record via sending pure text task to the API.AI. When it finish the information collection, it will send data to the mangoDB database for later retrieval. The `start_flag` will also be set to true and the test's intent will be trigger once we leave the greeting intent.
- `updateCounter(answer)`: This method is called when we are in the test for answering the question set. After we post user's input to API.AI and get response from it, it will check whether the response is valid and update the test score. Four global are declared to hold the score of four question type, namely, `PICTURE_SCORE`, `MEMORY_SCORE`, `MATH_SCORE` and `OTHER_SCORE` for picture recognition test, memory test, math test and

common sense test, respectively. It will then update the intent counter for the test for triggering the next question shown. At the end of the test, it will send the test score to our result display test site for the analysis.

- `setImg()`: This method is used for the picture recognition problem during the test. It will show the pre-stored image right below the response text area and hide it when we are not in the intent of picture recognition test.

Result Display Site

The result display site consists of four main parts: personal information along with score and result interpretation, as well as three different charts showing test-taker's ability distribution. It will first display user's name, age and gender which we collected from the greeting intents. Below that, charts will be shown for result analysis. A bar chart is plotted for a general look of all question types. A radar chart will be shown to compare user's performance across different types of the question. The final chart to be displayed is the pie chart for the whole result analysis. These plots will be shown in the section of front-end evaluation later.

More on Alzheimer's Site

This site is designed for user to get more knowledge about the Alzheimer's disease after they visit the result display site. It generally looks similar to the test site introduced previously in the way of how it is developed. Yet a key difference between the test site and this site is that the test intent is initiated and switched automatically by the system while this site allows users to ask their own questions and switch intents by themselves. Questions like the possibility of getting Alzheimer's at the user's age are implemented for the response on this website.

3.1.2 Back-End Design

Software Architecture

The user's audio input will be post to the Webkit Speech Recognition API. The text sent back from the Webkit Speech Recognition API will be passed to the API.AI for further interpretation and processing. The result will be send to the analyzer, which will record the performance of the user in the test. The final interpretation will be made based on the raw scores, type based scores and the age of the user. The user's information and the test result will be recorded in the database for future training and study use. The final interpretation will be send back to the API.AI and the suggestion intents in API.AI will gives out some suggestion accordingly. This suggestion will be passed to the TTS API.

Data Flow

Details are shown in Figure 3.

3.1.3 Logic Design

- 1. User's personal information, including name, age and gender, will be collected at the main test web-page right before the test starts. And then, user's responses to test questions, whether correct or incorrect, will be collected and sent along with personal information to MongoDB.

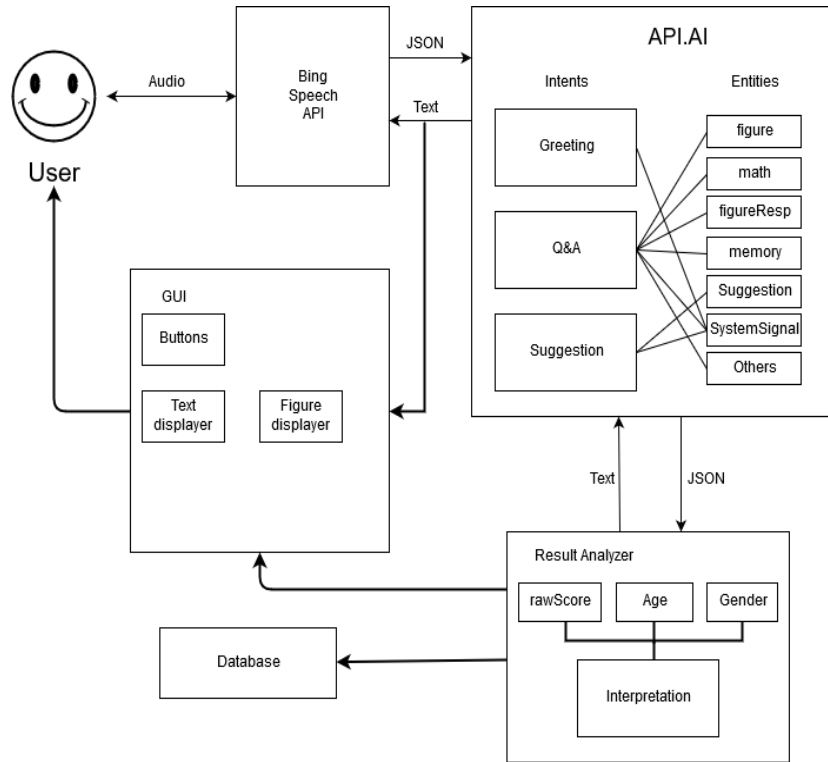


Figure 2: Software Architecture Diagram

- 2. When arriving at the second page, i.e. the result evaluation page, user's personal information will be downloaded from MongoDB for user to double check. Calculated scores will be downloaded as well and displayed to user in several charts for easier understanding on abilities distribution. On this same page, suggestion will be given by the system accordingly.
- 3. At the third page, some of user's personal information like age and gender will be downloaded from MongoDB so that Test-Bot will be able to answer questions according to user's actual situation when gender or age related questions are asked.

3.2 Implementation

3.2.1 API.AI

Agent Name: Test-Bot

1. Intentions:

(a) Intent 1: test-bot

- Description: Start of the test bot. Greet and collection of user's information.
- Context: test-bot

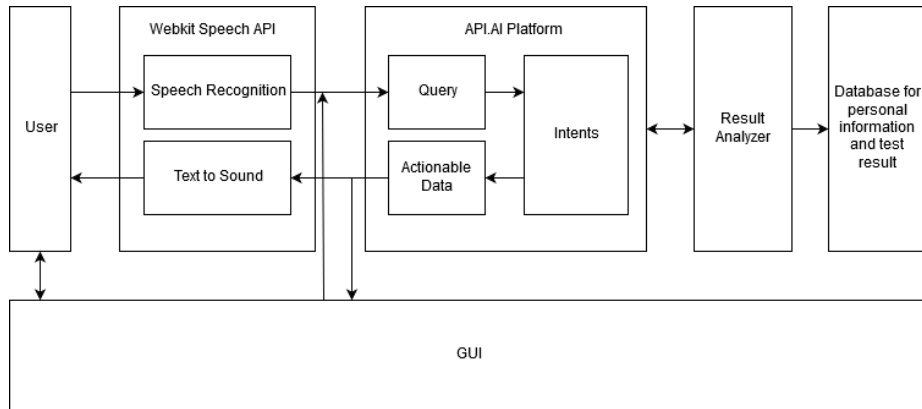


Figure 3: Data Flow Diagram

- Candidate Response: Welcome.....
- (b) Intent 2: Math(1-3), Picture_Recognition(1-3), Other_Type(1-3).
 - Description: Contain test problems and answers. Using filling the slot method.
 - Context: Math_X, Picture_Recognition_X, Other_Type_X (X 1,2,3)
 - Candidate Response: The corresponding problems
- (c) Intent 3: Memory_Test, Memory_Test_Ans
 - Description: Memory test problem. Memory_Test_Ans will be triggered 3 problems after the Memory_Test.
 - Context: Memory_Test, Memory_Test_Ans
 - Candidate Response: The corresponding memory test problems.
- (d) Intent 4: deny
 - Description: To detect if user says he or she doesn't know the answer.
 - Context: None
 - Candidate Response: OK no problem lets continue.
- (e) Intent 5: repeat
 - Description: To detect if user wants the problem to be repeated.
 - Context: None
 - Candidate Response: None
- 2. Entities:
 - Math(1-3), Picture_Recognition(1-3), Other_Type(1-3) Contain the answer to the problems.
- 3. System Entities Used:
 - @sys.number-integer

- @sys.color
- @sys.currency-name
- @sys.gender
- @sys.given-name

For detailed description of each entities, please go to <http://doc.api.ai>

Agent Name: Q&A

1. Intentions:

(a) Intent 1: Alz_Age_Gender

- Description: Provide the user with the Information about the age and gender situation of Alzheimer's disease
- Context: None
- Candidate Response: Alzheimer's disease is related with both age and gender. Here is what you may want to see.

(b) Intent 2: More_About_Alz

- Description: Provide the user with some general information about Alzheimer's disease.
- Context: None
- Candidate Response: Here is some additional information about Alzheimer's disease.

(c) Intent 3: Possibility

- Description: Provide the user with information about the Alzheimer's disease at his or her age.
- Context: None
- Candidate Response: Here is some information about the Alzheimer's at your age.

2. Entities: No entity is used in this agent.

3.2.2 User Interface

In this section, we are going to show the result of our front end design via screenshots of the three websites. Explanations are also included for further evaluations.



• Test Site

As you can see in Figure 4, in the main test UI, we mainly have the following components: user input box, speak/stop recording button, start button, test-bot's emoji, text response as well as a picture (for picture recognition questions). In this UI, user may need to talk about their names, ages, as well as their gender, before entering the test and start answering test questions. When the user is ready, he/she can press the "Start" button and start the dialog. later, whenever test-bot finishes a sentence, the speech recognition will start automatically. In case the speech recognition ends accidentally, user can feel free to press the "Speak" button to resume recording.

Your Input

Stop

Start

Great! Let's start the test now! Please name the object in the picture above.

Figure 4: Main Test UI

• Result Display Site

As you can see from Figure 5, in the result evaluation UI, there are some personal information that we collected from the previous page for user to double-check, followed by a diagnose conclusion and three different charts (Figure 6, 7, 8) analyzing user's situation from different aspects of the answers given. The plots below show example of how we make these charts.

Test taker's information:
 Name: Tom Age: 21 Gender: Male

Your Overall Score is: 80

My suggestion: You are a potential Alzheimer patient, please be aware and consult a doctor.

Figure 5: Personal Information & Diagnose Conclusions

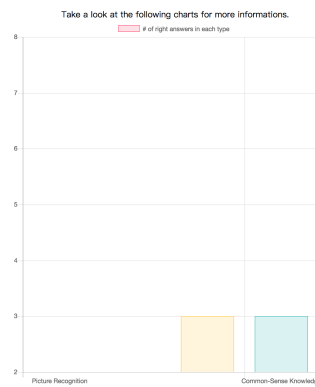


Figure 6: Bar Chart

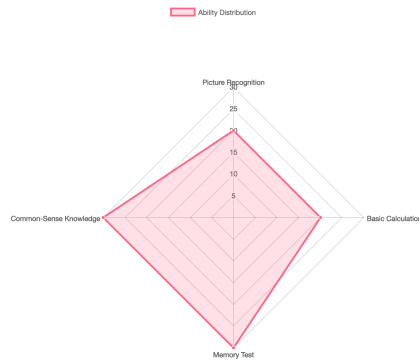


Figure 7: Radar Chart

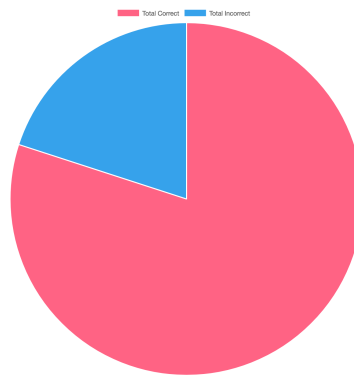


Figure 8: Pie Chart

- **More on Alzheimer's Site**

In this UI, as shown in Figure 9, there are mainly a user input box, a speak/stop button as well as a test-bot's emoji, which is quite similar to the main test UI. Here you can ask anything you would like to know about Alzheimer. Test-bot will try his best to answer your questions!

3.2.3 Database

For our project, we use MongoDB as our database. To be specific, here are some of the collections we created in mlab for the data we need: name, age, gender, score, raw, com, mem, math, pic, total_correct and total_wrong. Details can be seen from Figure 10.

Test data will be collected and uploaded from the first web page where user will take the conversational test, and then downloaded to the second web page where test evaluations are shown to the test-taker in the form of charts. In the database, we have a special collection named "raw" where every thing said by the test-taker will be recorded and preserved. These data can be useful for further analysis.

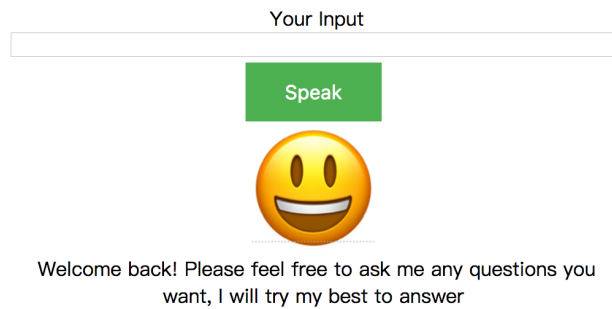


Figure 9: Q&A UI

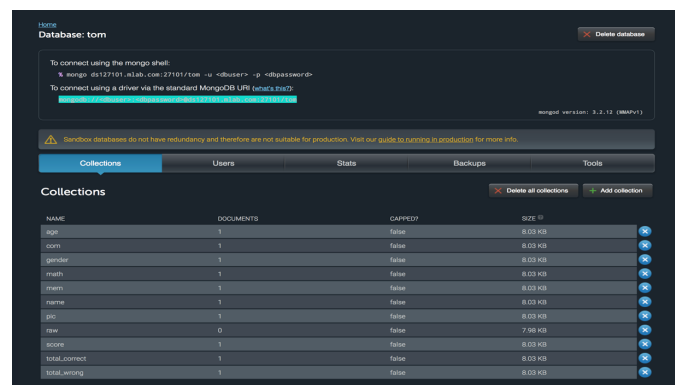


Figure 10: MongoDB Database and Data Collections

3.2.4 Result Interpretation

- **INTERPRETING THE TYM WHAT IS A NORMAL TYM SCORE?**
From age 18 years to age 60 years the normal score is 80/100. From age 60 years to age 80 years the normal score is 60/100. Over the age of 80 years the normal score is 50/100.
- **HOW WELL DO PATIENTS WITH MILD ALZHEIMER'S DISEASE (AD) OR MILD COGNITIVE IMPAIRMENT (MCI) DO THE TYM?**
The average score for patients with mild AD 60/50. The average score for patients with moderate AD on the TYM is 50/100. Patients with mild cognitive impairment (MCI) – organic memory problems which may or may not progress to Alzheimer's disease may score much better. An average score for the best MCIs is 80/100 with particular problems with recall of the learnt sentence.
- **HOW TO INTERPRET A SCORE BETWEEN 60 AND 80?**
This test is part of the assessment of a patient with memory problems and the test score alone cannot be used as a substitute for a clinical opinion but 93% of patients with AD score 60 or less.

- CAN PEOPLE USE THE TEST AS A SCREENING TEST?
Yes with some caution. A person in whom you have a low suspicion of organic memory problems who scores well on the test is highly unlikely to have AD.
- CAN PEOPLE USE THE TEST AS A DIAGNOSTIC TEST? No, a low test score is a sign that a patient needs further assessment but is not a diagnostic test for AD.
- HOW DO WE ALOCATE THE SCORE FOR EACH QUESTION?
There are totally 10 questions currently in our question set, including three picture recognition questions, three basic calculation questions, three common sense questions and one sentence memorization question. Using score calculation rules from some other online Alzheimer test as references, we give each picture recognition question, basic calculation question and common sense question 10 marks, and the sentence memorization question 30 marks.

3.3 Testing

3.3.1 Example User Case

TestBot: Hi, my name is test-bot. First of all, may I know your name please?

User: Hello! My name is Litao Hu.

TestBot: Great! May I know your gender as well?

User: Sure, I am a boy.

TestBot: Nice to know you Mr. Hu! Could you please tell me your age? this is very important for our test result evaluation.

User: Of course. I am 22.

TestBot: Great! Let's start the test now! Please name the object in the picture above.

User: Maybe a volcano.

TestBot: Who is the President of United States?

User: Could you give me some hints?

TestBot: OK, but to ensure a better result accuracy, I can only give you one. Here it is. Humm, the president is not Clinton. So, Who is the President of United States?

User: I don't want to say.

TestBot: OK, no problem. Let's continue. Do you know what is it in the picture? If yes, please tell me the name.

User: Pardon?

TestBot: What is the name of the object in the picture above?

User: Oh, I don't know.

TestBot: OK, no problem. Let's continue. Please read out and try to memorize the following sentence: Good citizens always wear stout shoes.

User: Repeat the sentence.

TestBot: The sentence you need to memorize is: Good citizens always wear stout shoes. Please read it out.

User: Good citizens wear shoes.

TestBot: How many nickels are there in 35 cents?

User: I think there are seven.

TestBot: Please name three colors.

User: Red, blue, and ... I don't know.

TestBot: You are buying 2.55 of groceries. How much change would you receive back from a 5 bill?

User: I want to go back to the previous question.

TestBot: OK, no problem. Please name three colors.

User: Red, blue, and Yellow!

TestBot: You are buying 2.55 of groceries. How much change would you receive back from a 5 bill?

User: I got this, 2.45.

TestBot: Please repeat the sentence you memorized previously. The sentence begins with: Good.

User: Good citizens I forgot.

TestBot: Please name the object in the picture above.

User: It is an apple.

TestBot: Do the following calculation: $5 + 6 = ?$

User: Eleven.

TestBot: Please name three types of currency currently in use.

User: RMB, HKD, USD.

TestBot: Congratulations! You have finished the test. Please click the orange button below to view your test report!

User: (action)Click Button.

TestBot: Hey Litao, your test report is ready, please double check you personal information below. Your overall score is 60, you are a potential Alzheimer patient, please be aware and consult a doctor. If you have further question, please click on the orange button located at the bottom of this page. Thank you for using the ultimate Alzheimer's test. Wish you a healthy and happy life!

User: (action)Click Button, after reading the test report.

TestBot: Welcome back! Please feel free to ask me any questions you want, I will try my best to answer.

User: Does Alzheimer's disease depend on gender?

TestBot: Alzheimer's disease is related to both age and gender, here is what you may want to see. +(Display paragraphs.)

User: What is Alzheimer's disease?

TestBot:Here are some additional information about Alzheimer's disease. +(Display paragraphs.)

User: How do I cure my Alzheimer?

TestBot: Good question! So sad I don't know the answer.

User: What is a normal test score?

TestBot: Here are some average scores of different age ranges. +(Display paragraphs.)

User: Will a pig have Alzheimer's disease?

TestBot: I think I need to study harder to understand your question.

User: Could you help me to improve my test score?

TestBot: I am sorry, this is beyond my ability.

User: Can I use the test as a diagnostic test?

TestBot: Unfortunately no, a low test score is a sign that a patient needs further assessment but is not a diagnostic test for AD.

User: What is the possibility of getting Alzheimer's disease at my age?

TestBot: Here are some information about Alzheimer at your age.

4 Work Distribution

Main tasks of our project can be classified as the following(One task may involve cooperations among multiple members):

- **Front-End Design:** Litao Hu, Zhiyuan Mao, Yuchen Liu
- **Back-End Design:** Litao Hu, Zhiyuan Mao, Yuchen Liu
- **Assignment 1:** Litao Hu, Zhiyuan Mao, Yuchen Liu, Zhiwei Cui
- **Assignment 2:** Litao Hu, Zhiyuan Mao, Yuchen Liu, Zhiwei Cui
- **Assignment 3:** Litao Hu, Zhiyuan Mao, Yuchen Liu
- **Presentation PPT:** Zhiwei Cui, Litao Hu, Zhiyuan Mao, Yuchen Liu

5 REFERENCES

References

- [1] <https://wexnermedical.osu.edu/brain-spine-neuro/memory-disorders/sage>
- [2] P. Erdős, *A selection of problems and results in combinatorics*, Recent trends in combinatorics (Matrahaza, 1995), Cambridge Univ. Press, Cambridge, 2001, pp. 1–6.

Appendix A Assignment 1

Uploaded on Gitlab master folder. File name is: "[elec4010i-assignment2.pdf](#)".

Appendix B Assignment 2

Uploaded on Gitlab master folder. File name is: "[elec4010i-assignment1.pdf](#)".

Appendix C Presentation PPT

Uploaded on Gitlab master folder. File name is: "[group_5.pptx](#)".