MASTER OF TECHNOLOGY INTELLIGENT SYSTEMS
2020

INTELLIGENT REASONING SYSTEMS

FINAL PROJECT REPORT

Your E-Diagnostics

Team members:

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Li Kaitong
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Content

1. Executive Summary

According to global consulting firm Towers Watson, Singapore has "one of the most successful healthcare systems in the world, in terms of both efficiency in financing and the results achieved in community health outcomes".[Ref1]

However, due to the high cost of private healthcare, most Singapore citizens and residents still will go to public medical facilities when they feel unwell, which contributed to a problem that the public medical facilities became more and more crowded.

With the rapid development of computer science and technology, many AI methods have been applied to the medical service industry, so that patients can enjoy safe, convenient, and high-quality medical services.

This project uses Python language to create an intelligent diagnosis web system, in order to let patients know what disease they have by simply entering their symptoms into the system.

2. Project Objective

This project covers three main objectives:

1) For individual users, the system can help them know what disease they have at home.
2) For private doctor users, the system can help them better make more accurate and efficient diagnosis of the diseases.
3) For hospital companies, the system can help quickly classify patients, shortens the time of patient consultation and waiting, and allocates and utilizes medical resources reasonably.

3. Background & Introduction & Business Process

3.1 Background & Introduction

When the number of people visiting the hospital increases, the limited space and resources of the hospital cannot meet the needs of medical services. The use of intelligent diagnosis system can better ensure the safety of patients

and improve the efficiency of the hospital:

1) The intelligent diagnosis system can help people know what disease they have at home, reduce the frequency and time of going to the hospital, and avoid the possibility of cross-infection in the hospital;

2) The intelligent diagnosis system can quickly classify patients, so that patients with serious illness can be given priority treatment, and help emergency department staff quickly identify patients who need immediate treatment;

3) The intelligent triage system can predict the possible infectious diseases in advance, in order to avoid the spread of infection in the hospital;

4) The intelligent diagnosis system enables patients to inquire about the diagnosis purposefully, shortens the time of patient consultation and waiting, and allocates and utilizes medical resources reasonably.

Therefore, the idea of designing and creating an e-diagnostic assistant came out.

Figure 1 shows that our intelligent diagnosis system consists of a selection page and a result page. On the selection page, users can select their symptoms from 6 main categories: internal, surgical, psychological, dermatological, ophthalmic, and reproductive. After entering the symptoms, the corresponding disease will be matched and found, and then displayed to the user through the result page.

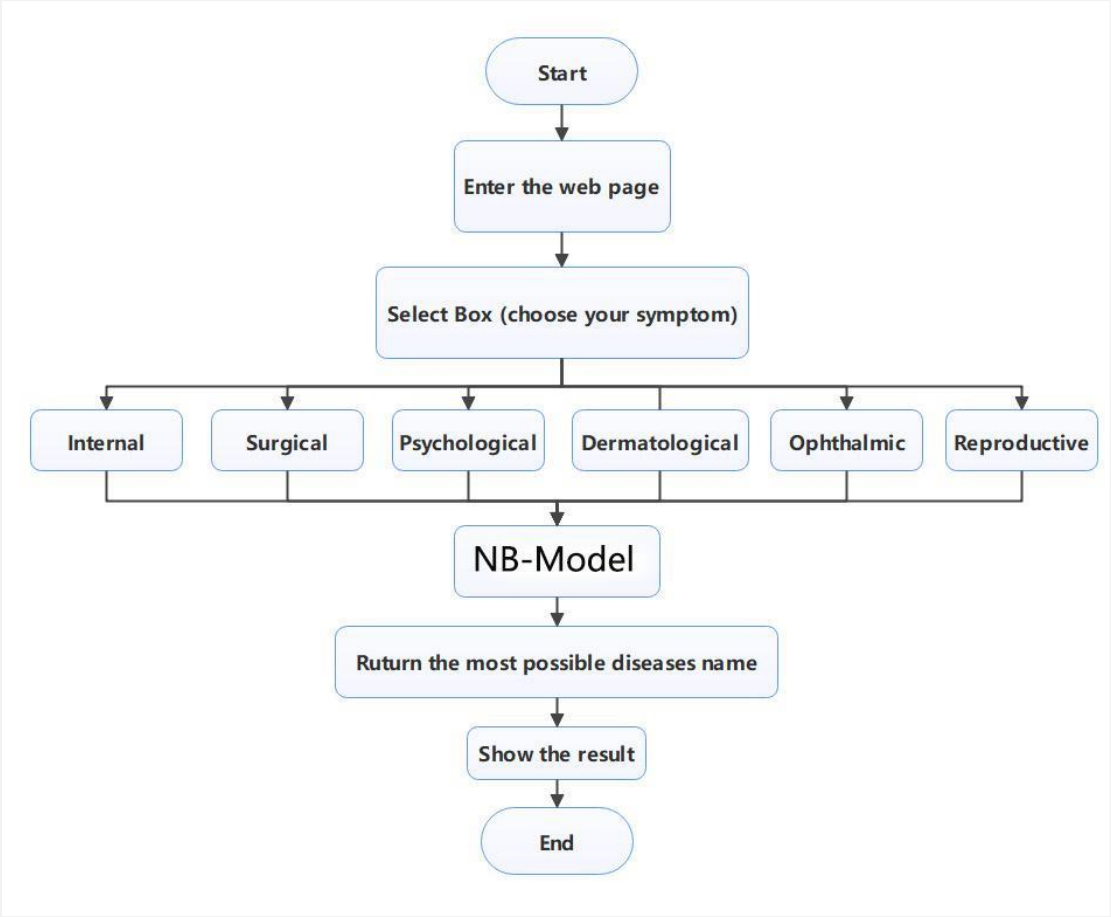

Figure 1: Main Process

3.2 Business Process

The Business Process is shown in the Figure 2 below.

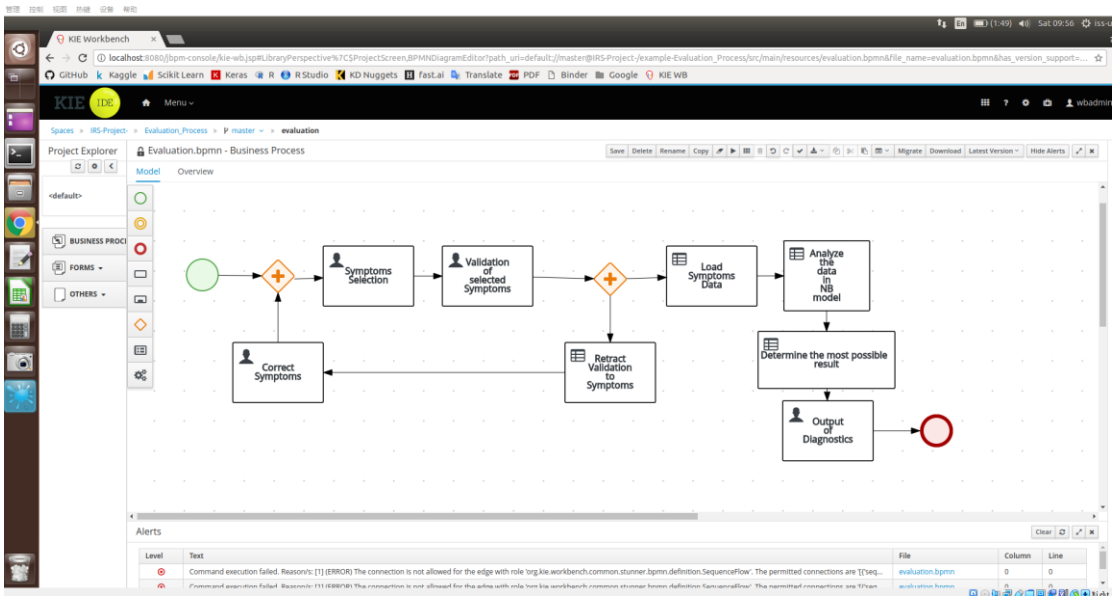

Figure 2: Business Process

Disease Data was used in the open source dataset collected from the Internet. After data cleaning and data preprocessing, we train and compare the model using Python. The predicted diagnostics is determined by the Native Bayes Model. The BPMN business process together with drools rules are applied in the KIE Workbench tool.

4. Methodology

The project was designed and created on a webpage for users to select their symptoms to predict the related disease when they feel uncomfortable. In this section, the knowledge and implementation will be introduced.

4.1 Data Training

In this project, the dataset obtained from the Internet was modified as the knowledge base. In this dataset, each disease has its corresponding symptoms. The symptoms in the dataset were categorized into the corresponding departments where the patient goes to the hospital, such as the Internal Medicine Department, Surgical Department, Psychological Department, etc.

After adjusting the dataset, it was trained and tested based on K-Nearest Neighbors (KNN), Decision Tree, and Naive Bayes (NB) models. Testing data and training data in the dataset were divided according to the ratio of 1/5.

4.2 User Interface

The webpage interface was designed based on HTML. It uses Flask in Python to implement the data interaction between the frontend and backend. When programming the system, each symptom was set with an index. When users choose their symptoms in each selection box on the webpage, the selections will be returned to one symptoms box in total. After clicking the “confirm” button below the box, the selections will be sent to the saved Naive Bayes model to match the most appropriate disease result. At last, the result will be posted to the webpage user interface to show the predicted disease result for the users.

	precision	recall	f1-score	support
(vertigo) Paroymsal Positional Vertigo	1.00	1.00	1.00	18
AIDS	1.00	1.00	1.00	22
Acne	1.00	1.00	1.00	31
Alcoholic hepatitis	1.00	1.00	1.00	24
Allergy	1.00	1.00	1.00	23
Arthritis	1.00	1.00	1.00	23
Bronchial Asthma	1.00	1.00	1.00	28
Cervical spondylosis	1.00	1.00	1.00	27
Chicken pox	1.00	1.00	1.00	21
Chronic cholestasis	1.00	1.00	1.00	21
Common Cold	1.00	1.00	1.00	34
Dengue	1.00	1.00	1.00	18
Diabetes	1.00	1.00	1.00	22
Dimorphic hemmorhoids(piles)	1.00	1.00	1.00	27
Drug Reaction	1.00	1.00	1.00	27
Fungal infection	1.00	1.00	1.00	24
GERD	1.00	1.00	1.00	27
Gastroenteritis	1.00	1.00	1.00	26
Heart attack	1.00	1.00	1.00	32
Hepatitis B	1.00	1.00	1.00	19
Hepatitis C	1.00	1.00	1.00	17
Hepatitis D	1.00	1.00	1.00	28
Hepatitis E	1.00	1.00	1.00	22
Hypertension	1.00	1.00	1.00	20
Hyperthyroidism	1.00	1.00	1.00	23
Hypoglycemia	1.00	1.00	1.00	13
Hypothyroidism	1.00	1.00	1.00	23
Impetigo	1.00	1.00	1.00	25
Jaundice	1.00	1.00	1.00	26
Malaria	1.00	1.00	1.00	25
Migraine	1.00	1.00	1.00	29
Osteoarthristis	1.00	1.00	1.00	23
Paralysis (brain hemorrhage)	1.00	1.00	1.00	30
Peptic ulcer diseae	1.00	1.00	1.00	24
Pneumonia	1.00	1.00	1.00	23
Psoriasis	1.00	1.00	1.00	18
Tuberculosis	1.00	1.00	1.00	24
Typhoid	1.00	1.00	1.00	25
Urinary tract infection	1.00	1.00	1.00	20
Varicose veins	1.00	1.00	1.00	28
hepatitis A	1.00	1.00	1.00	24
accuracy			1.00	984
macro avg	1.00	1.00	1.00	984
weighted avg	1.00	1.00	1.00	984

Figure 3: The classification Report of KNN model

5. Results & Analysis

5.1 Data Training

The dataset was trained with 3 models, K-Nearest Neighbors (KNN), Decision Tree, and Naive Bayes (NB) models, which are based on supervised learning. The accuracy of each model is 100% for both the training set and testing set.

Figure 3 above is an example of the KNN model which was trained and tested in for this project. The precision values show the accuracy of classification results, the recall values show the recall rate of classification results, and the f1-score shows the harmonic mean of precision and recall of classification results. It is clear that the precision, the recall and the f1-score are all equal to 1.00, which means the disease prediction is accurate for the related symptoms. The support value in this figure illustrates how many samples are in the corresponding category.

5.2 Disease Prediction

Although the training and testing accuracy results are 100%, the accuracy in real testing was not as accurate as expected. These 3 models all had some mistakes when predicting the disease, especially when the user chooses fewer symptoms. After many tests, the Naive Bayes model has the best performance among the 3 models, so that it was chosen to be used to make the disease prediction finally.

Figure 4: Example #1 – Select 3 Symptoms of Hypothyroidism

For example, the symptoms for Hypothyroidism includes fatigue, weight gain, cold hands and feet, mood swings, lethargy, dizziness, puffy face and eyes, enlarged thyroid, brittle nails, swollen extremities, depression, irritability, and abnormal menstruation according to the knowledge base.

From Figure 3, if users select 3 of the symptoms, it will return to a wrong result, which is shown in Figure 4 below.

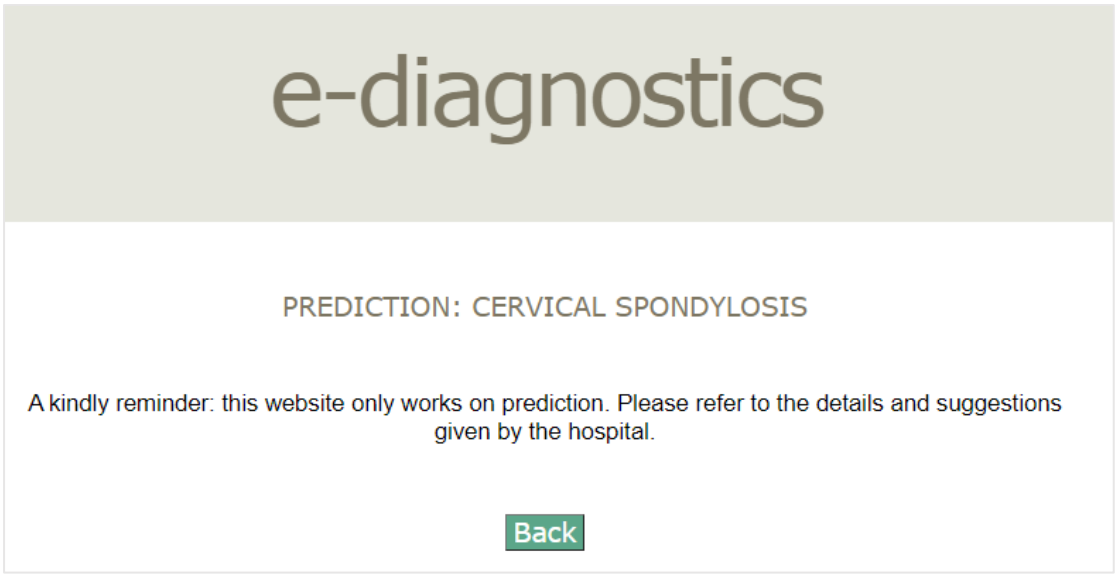

Figure 4: Example #1 – Wrong Prediction

Take another example. Select 7 symptoms, which is shown in figure 5 below.

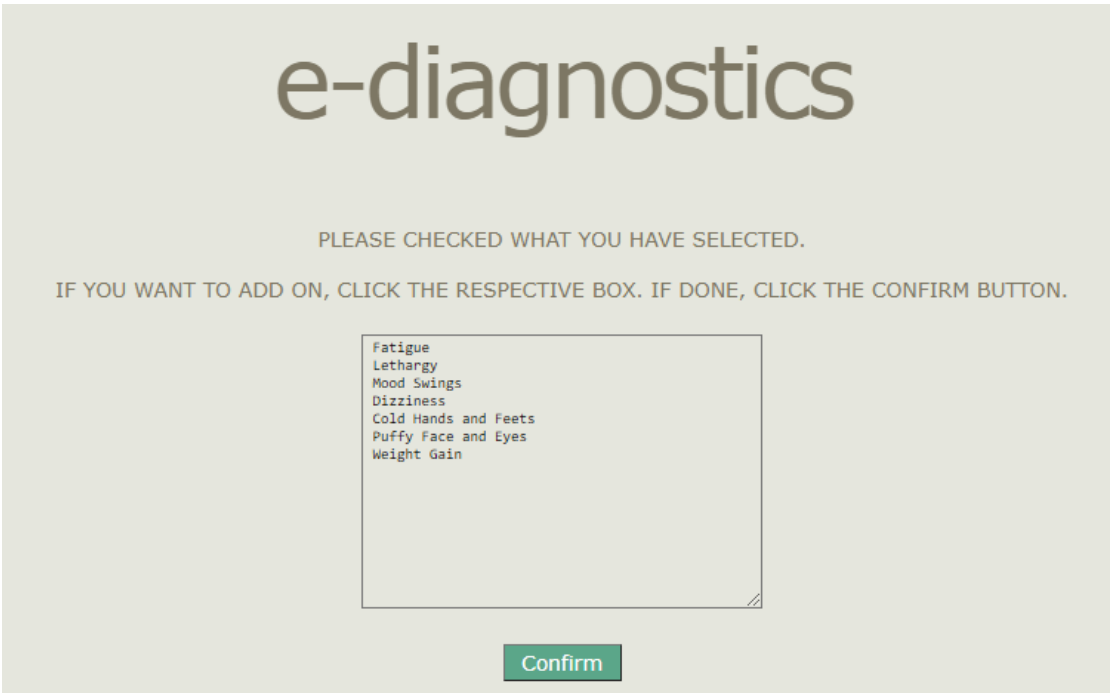

Figure 5: Example #2 – Select 7 Symptoms of Hypothyroidism

In this case, these symptom selections can make a more accurate prediction according to the knowledge base.

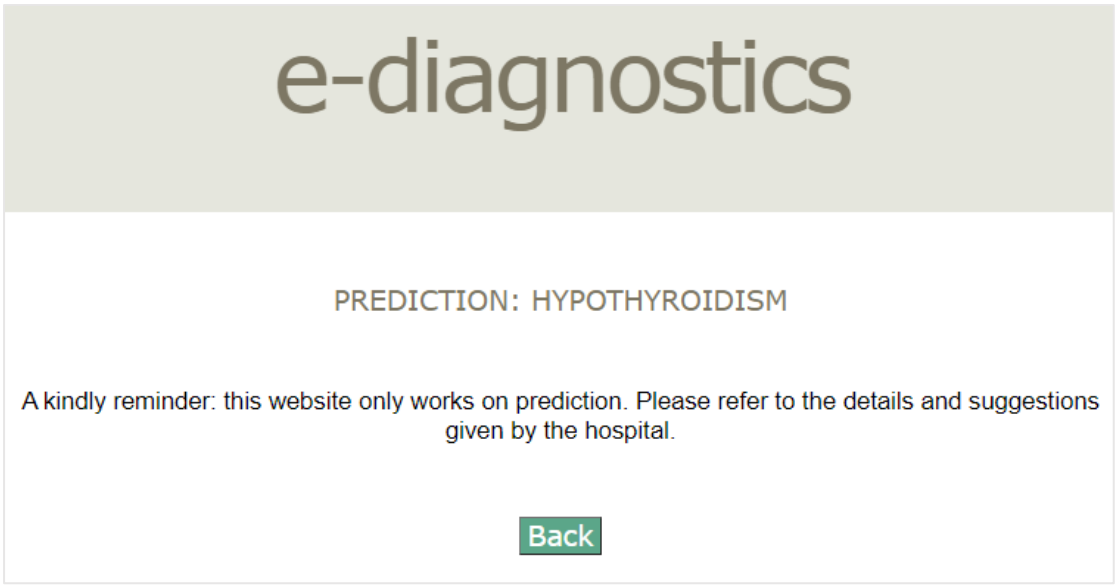

Figure 6: Example #2 – Accurate Prediction

From the example above, it is clear that in order to make more accurate disease prediction, users need to select the symptoms as detailed as possible.

6. Limitations & Future Work

Due to the shortage of time, some functions in this project should have been designed more intelligently and user-friendly, with details as follows.

1) At the early stage a chatbot was the plan to make it intelligent to communicate with users, and to filter out key information from the statements to predict diseases. However, due to time constraints, it is quite hard to delve into the functions of the chatbot so we gave up.

2) Since the four members of our team are all from China, we had planned to provide the contact information of relevant specialists to the user in the follow-up function after predicting the name of the disease. However, as we learned more about Singapore's healthcare system, we found that communicating directly with specialists was a way that could only be done in China, so we finally abandoned this function.

3) The data in the dataset (knowledge base) we obtained from the Internet is not enough, so that sometimes the trained models are not accurate enough to make the disease predictions.

Regarding the limitations of this project, future work includes the following aspects.

1) Design a chatbot using Dialogflow, where users can communicate with the chatbot on the symptoms they have and receive feedback on the estimated disease and corresponding suggestions.

2) Get more familiar with the healthcare system in Singapore. Then improving our system by doing the combination with the rules of the local healthcare system.

3) Improve the dataset by collecting more data on diseases and corresponding symptoms.

7. Conclusion

In the future, more medical intelligence projects like the one we're working on, E-diagnosis, will quickly fill every corner of our lives. The patient-centered service concept will be the development direction of the smart hospital, and the "wisdom" element will be deeply embedded in the whole diagnosis and treatment process of the hospital and the daily health management of residents, which will provide more convenient and smooth medical experience.

With the continuous improvement of living standards and quality of life, people will pay more attention to and invest more in their health. And more attention to human care and experience, miniaturization, convenience and other needs to stimulate and drive, the future of smart medicine will be ushered in a spurt of development. Our group project is just a simple attempt in the field of intelligent medicine. If we have more time, we will try to collect data sets by ourselves and try to develop more complex and intelligent diagnostic systems.

From this period, there is no doubt that we got the chance to exercise and put the knowledge of the reasoning system we have learnt into practice. In this project, we applied various techniques we learned from the IRS courses, such as KIE workbench, Decision Tree, Knowledge Base, and etc.

Overall, we spent more than ten days on this project. This is the first time we're going to apply cognitive systems to intelligent diagnosis areas, and it's very interesting.

References

[1] John Tucci, The Singapore Health System – Achieving Positive Health Outcomes with Low Expenditure, Watson Wyatt Healthcare Market Review, October 2004. Archived 19 April 2010 at the Wayback Machine.

[2] Li Ruiyang, Yang Yahan, Wu Shaolong, et al. Using Artificial Intelligence to Improve Medical Services in China.. 2020, 8(11):711.

[3] Ayedh abdulaziz Mohsen, Muneer Alsurori, Buthiena Aldobai, et al. New Approach to Medical Diagnosis Using Artificial Neural Network and Decision Tree Algorithm: Application to Dental Diseases. 2019, 11(4):52-60.

[4] Richard W. Jones, Andrew Lowe, Michael J. Harrison. A framework for intelligent medical diagnosis using the theory of evidence. 2002, 15(1):77-84.

[5] Kai Chen. Intelligent Pre-diagnosis Method and Experimental Research Based on Patient's Personal Information. 2018, 2(3).

Appendix A: Project Proposal

Date of Proposal:

July 11, 2020

Project Title:

ISS Project - Your E-Diagnostics

Sponsor/Client: *(Name, Address, Telephone No. and Contact Name)*

Institute of Systems Science (ISS) at 25 Heng Mui Keng Terrace, Singapore
NATIONAL UNIVERSITY OF SINGAPORE (NUS)
Contact: Mr. GU ZHAN / Lecturer & Consultant
Telephone No.: 65-6516 8021
Email: zhan.gu@nus.edu.sg

Background/Aims/Objectives:

When the number of people visiting the hospital increases, the limited space and resources of the hospital cannot meet the needs of medical services. Therefore, patients may face the problem of long waiting time after going to the hospital, and gathering together will increase the risk of cross infection. So the idea of designing and creating an e-diagnostic assistant came out.

Our aim is to create an intelligent diagnosis system which can better ensure the safety of patients and improve the efficiency of the hospital:

1. The intelligent diagnosis system can help individual patient users know what disease they have at home, reduce the frequency and time of going to the hospital, and avoid the possibility of cross-infection in the hospital;

2. The intelligent diagnosis system can help hospital company management quickly classify patients, so that patients with serious illness can be given priority treatment, and help emergency department staff quickly identify patients who need immediate treatment;

3. The intelligent triage system can help private doctors predict the possible infectious diseases in advance, in order to avoid the spread of infection in the hospital;

4. The intelligent diagnosis system enables patients to inquire about the diagnosis purposefully, shortens the time of patient consultation and waiting, and allocates and utilizes medical resources reasonably.

Requirements Overview:

- Research ability – Requirements gathering and data gathering to understand the current flow of the process for diagnosis and treatment. Search the feedback on the internet.
- Programming ability – Rule based and knowledge-based systems
- System integration ability – Integration of JavaScript, HTML, CSS with the backend programs using Python Flask.

Resource Requirements: *(please list Hardware, Software and any other resources)*

Hardware: Any typical CPU.

Software:

- Eclipse IDE for HTML programming
- PyCharm IDE for Python programming
- KIE Drools Workbench for easy programming of KIE logic

Other resources:

- Google Colab for training and testing machine learning models e.g. Decision Tree, KNN, and Naïve Bayers.

Number of Learner required: *(Please specify their tasks if possible)*

A team of four project members.
The tasks completed are specified in their individual contribution reports.

Methods and Standards:

Procedures	**Objective**	**Key Activities**
Requirement gathering and analysis	The team should meet with ISS to scope the details of the project and ensure the achievement of business objectives.	1. Gather & analyze requirements 2. Define internal and external design 3. Prioritize & consolidate requirements 4. Establish functional baseline

Technical Construction	To develop the source code in accordance to the design. To perform unit testing to ensure the quality before the components are integrated as a whole project.	1. Setup development environment 2. Understanding of system context and design 3. Coding
Integration & Testing	To ensure interface compatibility and confirm that the integrated system hardware and system software meets requirements and is ready for acceptance testing.	1. Prepare system test document 2. Conduct system integration testing 3. Log exceptions
Acceptance Testing	To obtain ISS user acceptance that the system meets the requirements.	1. Plan for Acceptance Testing 2. Conduct Training for Acceptance Testing 3. Prepare for Acceptance Test Execution 4. ISS Evaluate Testing 5. Obtain Customer Acceptance Sign-off
Delivery	To deploy the system into production (ISS standalone server) environment.	1. Software packing and documentation as per ISS guidelines. 2. Submission of user manual for execution of the system

Appendix B: Business Value Analysis

In some countries with a large population base, due to the continuous population growth, compared with the economic and social development and the increasing demand for services from the people, the total amount of medical and health resources is relatively insufficient.

For public or private hospitals with good reputations, patients have to face the problem of long waiting times, which is the pain point of patients. The long queues of patients cause the waste of hospital configuration and resources, and therefore cannot maximize the use of these resources and configurations to help and serve patients. Especially during the recent COVID-19 period, long waiting time in the hospital will increase the risk of infection.

The E-Diagnostics project has disease prediction functions for patients based on their selected symptoms. It can be sold both for medical institutions, for individual users, and the Internet companies.

For medical institutions, the E-Diagnostics system can be an assistant to help doctors know which symptoms the patients have and get the disease prediction from the system. It can shorten the waiting time for the patients and improves the efficiency of patient consultation. At the same time, patients can be more reasonably allocated to departments of corresponding diseases. The allocation of medical resources in the hospital can be utilized to the maximum, allowing more patients to receive corresponding guidance and treatment from doctors in a limited time.

For individual users, the E-Diagnostics system is used to help them conduct self-tests of diseases no matter where they are. For some people with mobility impairments, they can predict which department of the hospital they should go to for help based on their symptoms, reducing the distance of movement. If some less serious diseases are predicted by selecting the symptoms, such as a cold, the patient can recover through treatment at home or go to the pharmacies to buy medicines. It avoids spending time going to the hospital for a consultation, saving their time and energy. In addition, through the understanding of the symptoms corresponding to the disease, the user can increase the corresponding medical knowledge and carry out better disease prevention.

For Internet companies, the E-Diagnostics system can be sold to form an online consultation platform, which can combine real doctors in hospitals all over the world. The platform can recommend a doctor with relevant background based on the patient’s symptoms and disease predictions. The advantage is that patients can get replies from excellent doctors in hospitals across the world in time, and get preliminary opinions on the disease soon.

We believe that the E-Diagnostics system can be applied to our daily life, to

improve the quality of life, and add more business value to the society.

Appendix C: Mapped System Functionalities

Below is the table summarizing the system functionalities or features of our system, as well as the course modules and corresponding knowledge, techniques and skills we have applied.

Table 1. Mapped System Functionalities

Function	Knowledge, Techniques and Skills
Knowledge Base	Data Mining through web crawling
Disease Prediction Model: Decision Tree, KNN, Naive Bayes	Knowledge Discovery by Machine Learning, Knowledge Modelling
Knowledge Based Reasoning	KIE Business Rule
Web Version System	Cognitive Systems

Appendix D: Installation & User Guide

Python 3.7.7 is used in this system running. Below is the chart illustrating the libraries needed in installation along with the version we are using.

Table 2. Libraries Needed

Library	Version
flask	1.1.2
joblib	0.16.0
pandas	1.0.5
numpy	1.17.0

Install the required libraries. Go to the folder “E-Diagnostics”. Run the main.py. Then you will see an address http://127.0.0.1:2020/ shown on the prompt. Copy it and running in Browser (only supported by Chrome, Firefox, Opera). You will be directed to the home page as shown in Figure 7.

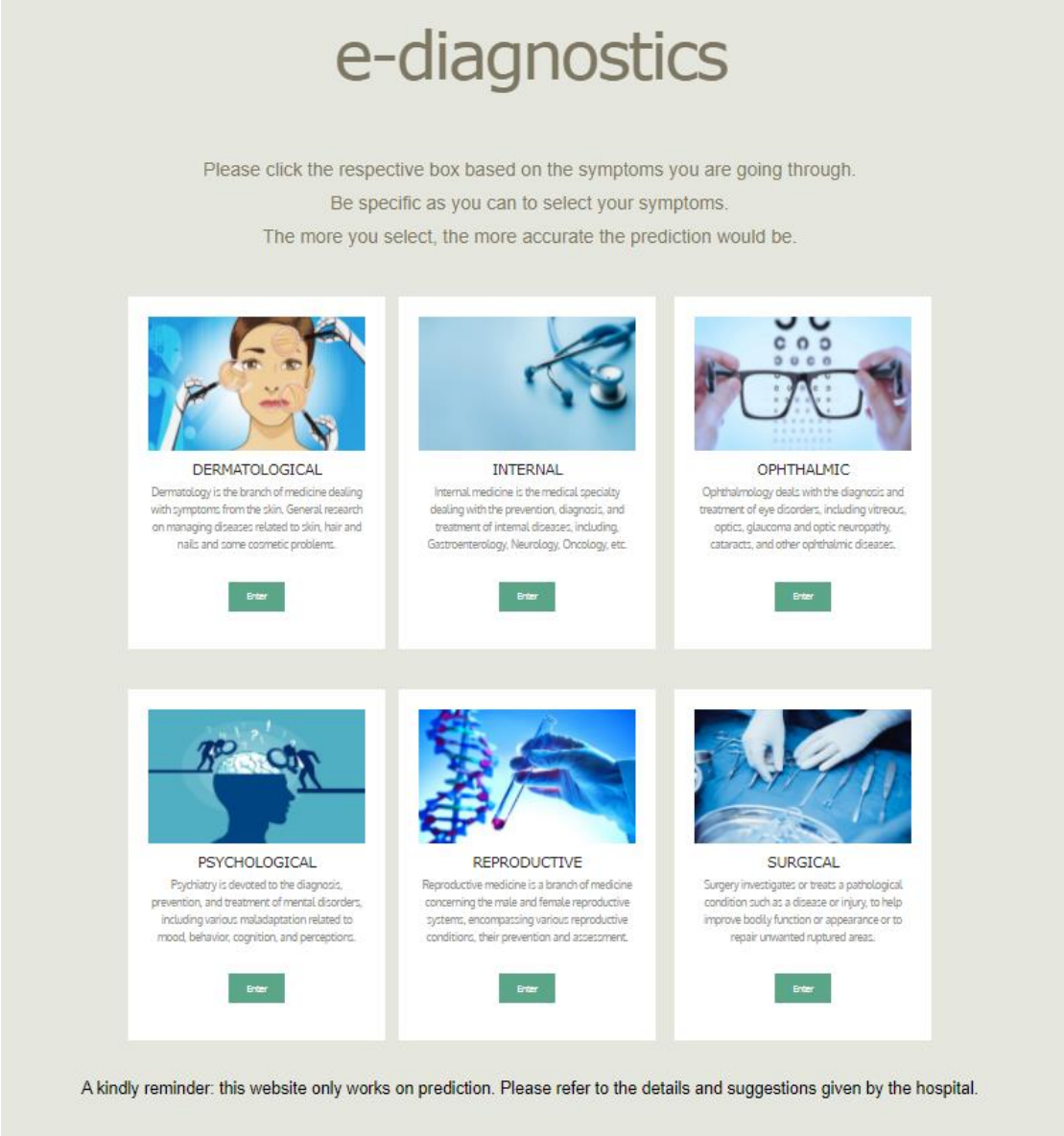

Figure 7: Home Page

Click the respective box based on the symptoms you are going through. Click the checkbox as shown in Figure 8 to select the symptoms you have and click the "Confirm" button". The more you select, the more accurate the prediction would be.

If you do not find any symptoms you have in the list, click "Back" button to return to the index page.

If you click the "Confirm" button without any selection, an alert will show up, as shown in Figure 9.

If you have done the selection, click "Confirm" to return to the home page.

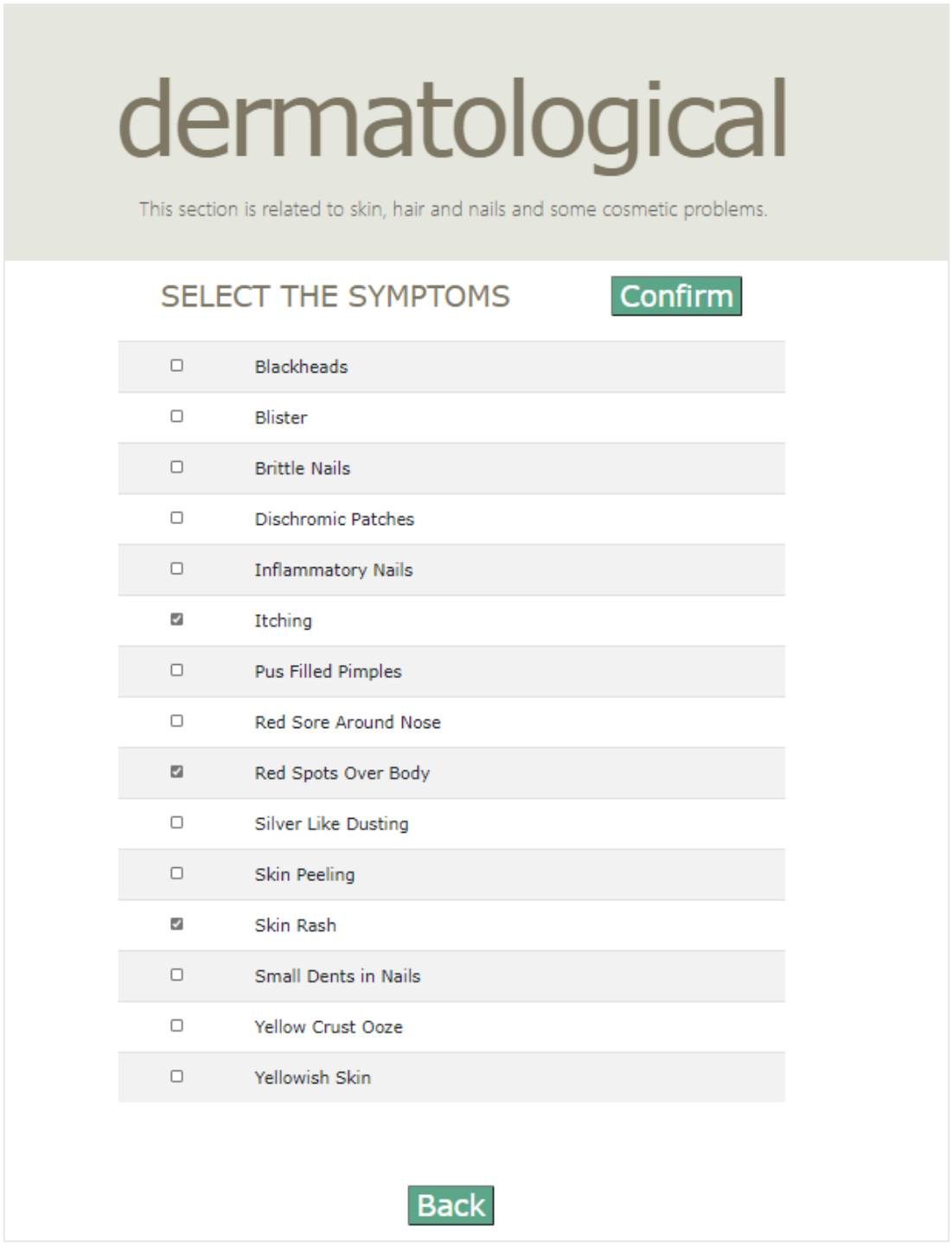

Figure 8: Select the Symptoms

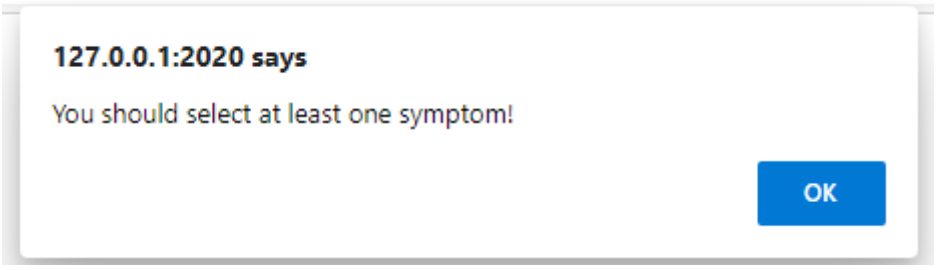

Figure 9: Alert of Empty Selection

After selecting the corresponding symptoms, this system will display a text box for you to check what you have selected, as shown in Figure 10. You can choose to add on more symptoms by clicking the respective boxes below.

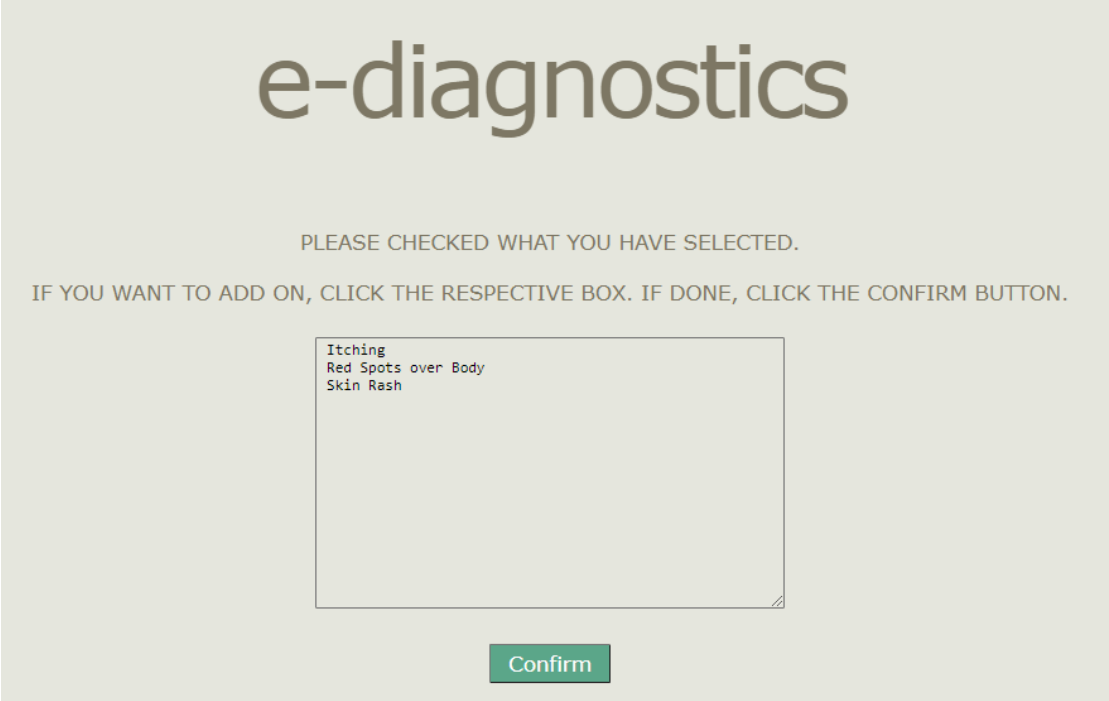

Figure 10: Selected Symptoms Displayed on the Text Box

If done, click the "Confirm" button to result page. You will be shown the prediction of the disease you might have based on the symptoms you have selected, as shown in Figure 11. Please be reminded that this page only works on prediction. For further details and suggestions, you should refer to the hospital.

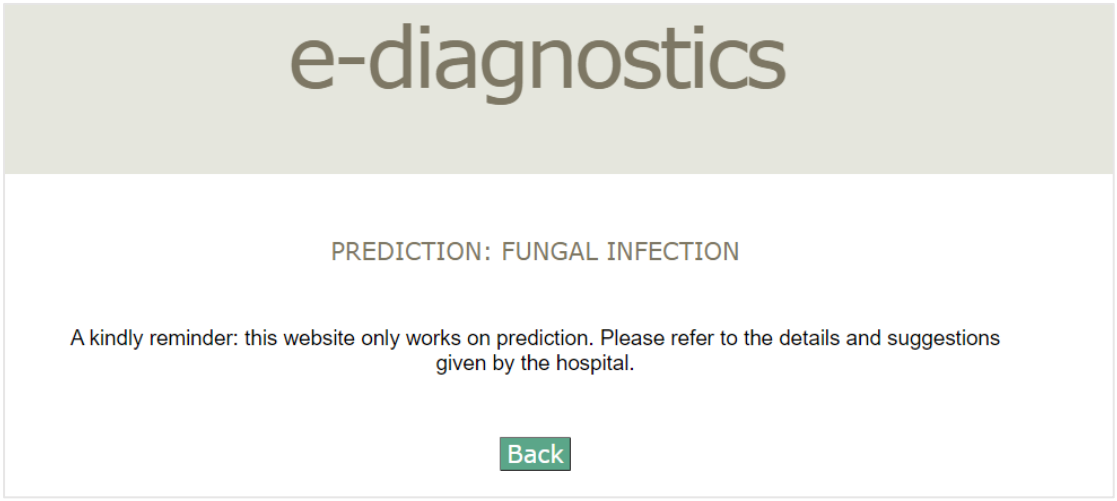

Figure 11: Result Page

Appendix E: Individual Project Reports

1. ZHAN SHENG – A0215253N

Personal Contribution to This Project

In this project, I participated in many aspects of project completion. Including formulating project directions and plans, source code compilation, dataset collection and cleaning, using KIE SUITE to model business processes, writing reports, and complete introduction video production.

What is the Most Useful Learnt

1) The most important point is that I understand how difficult it is to develop a complete system. From the business value analysis of the project, feasibility verification, code writing, model debugging, and finally product promotion (video production and report). Every part needs me a lot of effort and time to attend. So I guess what I treasured most is the experience of the whole process of realizing a cognitive system, which is very helpful to participate in the actual development in the future.

2) Understand how to use the logic learned from the reasoning system in daily life. For example, the decision tree, knowledge base, reasoning system, cognitive model. When considering some problems, we can use them for deep reasoning and get wisdom.

3) It is the first time for me to learn how to use machine learning related knowledge and process. Next time I can analyze data, train and test , and then select the optimal solution through various models to tackle actual problems.

How to Apply the Knowledge and Skills in Other Situations or Workplaces

1) In my future work, I will be able to use the KIE SUITE tool in the LINUX system for business process modeling to improve efficiency. KIE is a software worthy of further study. Optaplanner, task assignment, schedule arrangement and other examples in it are all very significant problems in the field of ARTIFICIAL intelligence.

2) R language tools taught by Fan Zhenzhen are very suitable for data analysis, text mining and data visualization. I'm trying to learn more about it.

3) Aobo taught me how to use the dialogue robot. We tried to realize it in the project, but it was a pity that we failed to realize it. However, if we

work in the field related to NLP in the future, the dialogue robot is definitely a tool that can greatly improve efficiency and obtain information.

2. WU JINGXUAN – A0215262N

Personal Contribution to This Project

In this project, I helped my team members classify data with different categories. I trained and tested the dataset with supervised learning methods, including KNN, Decision Tree and Naive Bayes models. All the disease predictions are based on the trained models. Moreover, after my team member finished the HTML page, I tested the model and tried to improve its performance.
In addition, I wrote the contents in the Methodology and Result & Analysis sections in the report. I wrote the README.md file on GitHub as an instruction as well.

What is the Most Useful Learnt

For me, the most useful parts are:

1) How to apply the cognitive system in real life. The project has assistance function and decision ability, which can assist doctors to make disease predictions according to the symptoms.

2) How to use a knowledge base to solve problems. The dataset in this project is like a knowledge base from medical experts. All the predictions are made based on the knowledge base.

3) How to apply Decision Tree in real data training and testing. The model in this project needs to be trained and tested to get disease predictions.

4) The most important thing for business is to get the users' pain points. Only if the project satisfies users' needs can make more business value.

How to Apply the Knowledge and Skills in Other Situations or Workplaces

In future work-related projects, I know how to form a knowledge base, including basic facts, rules, and other relevant information, based on a specific field to solve problems. For example, in my coming internship which is related to the medical field, the knowledge base from medical experts can be formed to determine whether the patient has a certain disease from their symptoms.
In addition, cognitive knowledge can be used to design and create a robot assistant to decrease the workload of humans and the Decision Tree can be used to make predictions, such as weather prediction, fraud prediction and disease prediction, according to their knowledge bases.

3. LI KAITONG – A0215436J

It was a happy and fruitful experience working with my teammates Zhan Sheng, Wu Jingxuan and Lin Danmeng. This project did help me get enhanced on my coding abilities and other technical skillsets applied to convert coursework knowledge into practice.

In this project *Your E-Diagnostics*, I was mainly responsible for the user interface design. Flask Python web app framework was applied in the system programming, to implement the data interaction between front-end and back-end. I had no idea how to combine Python programs with HTML web system until I started working on Flask Python. It was quite interesting and did broaden my knowledge. And I became more sufficient in HTML programming, the field that I was not so familiar with.

Through this project, I got the chance to learn more about how to build a cognitive system, which is the most useful learnt for me, and have a better understanding on the knowledge I have learnt from class. Getting user requirement and pain points is a fundamental step for doing knowledge based reasoning, to better highlight the business value.

The knowledge and skills I have learnt from this project and also from class do contribute to my future plan. In future, I might come across a similar machine reasoning problem. I have got to know how to build a knowledge base by data mining techniques and further build a cognitive system. Nowadays, it has been used to mimic human intelligent capabilities in many field like a weather chatbot. It is quite important to apply the knowledge we know into practice. I strongly believe that knowledge we obtained from this Intelligent Reasoning certificate lays a solid foundation for my future plan in discovering the field in Artificial Intelligence.

4. LIN DANMENG – A0215493A

Personal Contribution to This Project

In the process of selecting the topic of the project, we choose a project that propose practical problem-solving application that demonstrates the advantage of computer-based reasoning technology, platforms, and tools. Since diagnose diseases assistance is quite useful for hospitals and convenient for patients, we chose diagnostics as our project topic.

In the process of completing the project, considering the need to combine the knowledge we learned in the course to solve practical problems, I am responsible for project objectives, project background and project proposal part. My views of combining various parts of the project have helped the successful implementation of the project.

What is the Most Useful Learnt

Through this project, I learned how to use html to build a website page. In the process of writing, I made many mistakes due to typesetting issues, and I also optimized the code and beautified the interface during the debugging process. This part is quite challenging since I have never touch html before, but at the same time it also brings me great gains.

From this project I did many outside research on the GitHub and other website resources. I checked information, existing code references to expand our functions, brought outside knowledge to group and discuss about the ideas.

This project also helps me a lot about group participation and leadership. Since we are conducting e-learning due to covid-19, we held many zoom meetings to discuss about the project, and everyone will be assigned the next stage of work.

How to Apply the Knowledge and Skills in Other Situations or Workplaces

Through the study and implementation of this project, I will be able to transform it flexibly in the future and apply it to other scenarios that require a recommend system.

The first example is the recommendation system for people who want to buy electronic products such as mobile phones or computers and build models to select the most suitable products according to the user's needs for various performance indicators.

The second example is that the recommendation system selects a suitable geographic location and apartment type for people who want to rent or buy a house in a certain area. If I do similar projects next time, I will make more progress.