

Intelligent Reasoning System

Project Report

Laptop For You

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1 BUSINESS PROPOSITION

Since the appearance of home computers in the 1970s, computers have become the basic configuration for more and more families, individuals and companies. The rapid development of semiconductor hardware with its smaller and smaller sizes and stronger computing power also promoted computers to become an indispensable part of personal work, life and entertainment. At present, laptops have become one of the most popular electronic devices because of their lightness and efficiency.

Because of the increasing demand for laptop computers, there are many products on the market, with various models and configurations, which makes choosing a laptop that suits you a little complicated. Even an expert of the laptop will find it is hard to give a recommendation to people, for it is a very customized question. Is there a way to make people who do not have professional knowledge choose a computer that suits them? This is exactly what we hope this system can solve, which will save people a lot of time and money.

This project brings to users a light, elegant and efficient laptop recommendation application on Android devices. It only requires the users to answer 3-5 simple questions like what they would use the laptop for to get users' preference. After inquiring about our rule based system, the app will feedback the users with many recommendations of laptops with details of model, specs, price and image. Users will get their recommendation in minutes, which meets people's demand perfectly and saves a lot of time from collecting all the knowledge and information by themselves.

2 PROJECT OBJECTIVE

In this project, our goal is to give users a laptop recommendation system with :

1. user-friendly interactive interface.
2. In order to facilitate daily use, it should be a mobile application.
3. Recommend laptops only through inquiries about the usage scenarios.
4. customized suggestion.

3 PROJECT SOLUTION

3.1 SYSTEM ARCHITECTURE

The diagram below shows an overview of our system architecture.

When we built the system, we used a crawler script to obtain laptop data from the brand's official websites. After we obtained these data, we performed standardization and clustering to the data and then saved the data to SQLite database.

In terms of the android part, we designed the user-interface and a rule-based system(RBS) inside the android application. The application would present the users with a survey to their preference and pass the users' preference to RBS. RBS would then provide a target to the

database to get the results similar to the target. These results would be shown to the users on their screen.

For Users who use our system, users only need to answer some simple questions in the application and will get feedback in seconds.

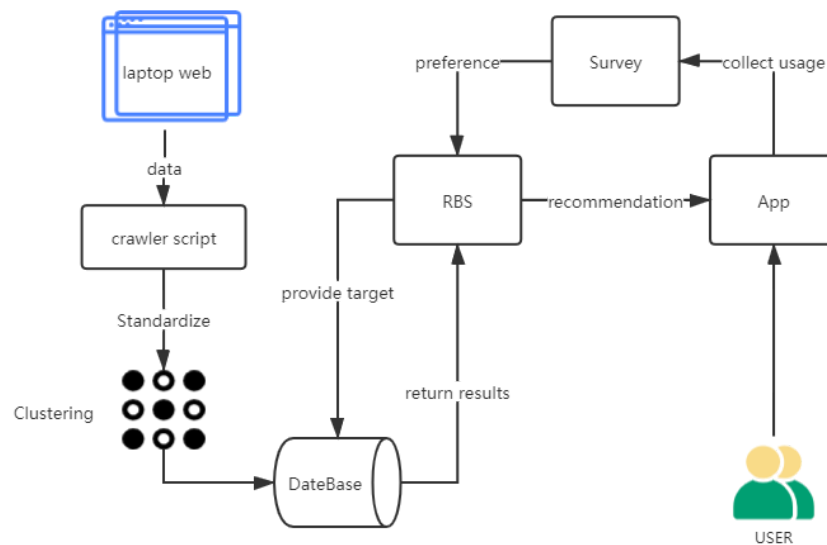


figure 1. System Architecture

3.2 DATA RESOURCES

For the purpose of recommendation of laptop, we firstly need to get the information about the laptops. So we built a web crawler to acquire the information about the laptops from the brand's official websites.

Next we take the steps to obtain laptop information of DELL as an example of our crawler script.

Firstly, entering the DELL laptop official website.

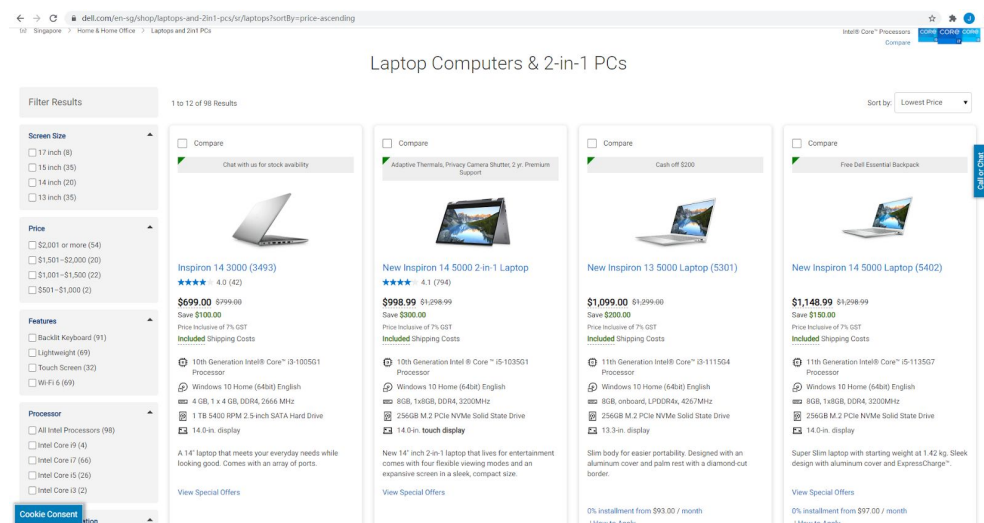


figure 2. DELL Laptop Website

Next, based on the red rectangular on the picture, we obtain the website for each individual product shown as below. In this page, we will obtain the required laptop information including model name, processor, graphics, ROM, RAM and price.

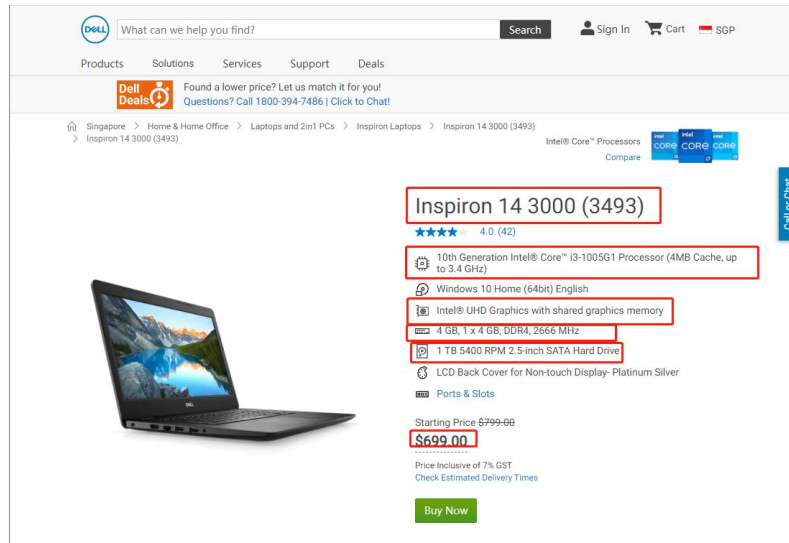


figure 3. Individual Product Website

We get these data through its Xpath and let crawler script to convert these data from the internet to a csv file. As a result, the raw data is in different kinds of format. So we use regular expression to perform a standardization to these data so that it will be in the format below. In this format the data can be used to form knowledge base and rules in the later chapters.

	name	price	processor	memory	hard_drive	graphics
0	Inspiron 15 3000 (3593)	\$1,198.99	Intel Core i7-1065G7	8.0	1TB_HDD	NVIDIA GeForce MX230 with 2GB GDDR5 graphics m...
1	New Inspiron 14 5000 Laptop (5401)	\$1,348.99	Intel Core i5-1035G1	8.0	512GB_SSD	NVIDIA GeForce MX330 with 2GB GDDR5 graphics m...
2	New Inspiron 14 5000 Laptop (5402)	\$1,248.99	Intel Core i5-1135G7	8.0	512GB_SSD	Intel Iris Xe Graphics with shared graphics m...
3	New Inspiron 13 5000 Laptop (5301)	\$1,249.00	Intel Core i5-1135G7	8.0	256GB_SSD	Intel Iris Xe Graphics with shared graphics m...
4	New Inspiron 14 5000 Laptop (5401)	\$1,348.99	Intel Core i5-1035G1	8.0	512GB_SSD	NVIDIA GeForce MX330 with 2GB GDDR5 graphics m...

figure 4. Standard Format of Product Parameter

The image below shows the head of the data file, which contains the laptop data that was acquired from the internet. It has 8 columns, which are uuid(automatically generated by obtaining time), model name, processor, graphics, ROM, RAM, price and laptop image Hyperlink.

	A	B	C	D	E	F	G	H	I
1	uuid	name	price	processor	memory	hard_drive	graphics	img	
2	ee58b3e8-1443-	Inspiron 14 3000	\$699.00	Intel Core i3-1005G1		4 1TB_HDD	Intel UHD Graph	https://i.dell.com/is/image/DellCo	
3	ee638a70-1443-	New Inspiron 13	\$1,099.00	Intel Core i3-1115G4		8 256GB_SSD	Intel UHD Graph	https://i.dell.com/is/image/DellCo	
4	ee6d5fdc-1443-	New Inspiron 14	\$1,148.99	Intel Core i5-1135G7		8 256GB_SSD	Intel Iris Xe Grap	https://i.dell.com/is/image/DellCo	
5	ee785c5c-1443-	Inspiron 15 3000	\$1,198.99	Intel Core i7-1065G7		8 1TB_HDD	NVIDIA GeForce	https://i.dell.com/is/image/DellCo	
6	ee8291a4-1443-	New Inspiron 14	\$1,248.99	Intel Core i5-1135G7		8 512GB_SSD	Intel Iris Xe Grap	https://i.dell.com/is/image/DellCo	
7	ee8c7bd8-1443-	New Inspiron 13	\$1,249.00	Intel Core i5-1135G7		8 256GB_SSD	Intel Iris Xe Grap	https://i.dell.com/is/image/DellCo	

figure 5. head of laptop data

Since acquiring the data from the laptop's brand official website is very time consuming, we initially get 116 laptops' information from DELL.

3.3 KNOWLEDGE REPRESENTATION

3.3.1 LAPTOP CONFIGURATION

Combining the information about laptops on the internet with our own experience for the purpose of selecting a laptop, we define a laptop with 5 parameters: processor(CPU), graphics(GPU), hard drive(ROM), memoryRAM, price.

3.3.2 USER PREFERENCE

To get the relation of user' preference and laptop configuration, we firstly need to collect users' preference. So we put out a survey to laptop users to collect their preference. We design the survey as below.

The survey form consists of four sections, each with a title, a list of radio button options, and a text input field for '其他:' (Others):

- Section 1:** Title: "If you are going to buy a laptop, what will you use your laptop for? *". Options: ☐ For work, ☐ At home, ☐ For game, ☐ 其他: _____.
- Section 2:** Title: "Do you play game? What game do you play? *". Options: ☐ MOBA, ☐ MMO, ☐ Small game, ☐ 其他: _____.
- Section 3:** Title: "What is your work content? *". Options: ☐ Design, ☐ Code, ☐ only use office software, ☐ 其他: _____.
- Section 4:** Title: "What will you use your laptop at home? *". Options: ☐ music, ☐ movie/video, ☐ news, ☐ 其他: _____.

figure 6. survey

Seldom is there a user who fills the other, as a result, we ignore the other option. The result shows that for the purpose of game, users have more interest in MOBA, MMO, Small

games. For the purpose of work, users gather on office software, coding and design. And for the users who use laptop at home, they both listen to music and watch movies/videos. After acquiring the users' preference, we begin to match the preference with the laptop configuration. We investigate the most popular video games recommended system requirements, shown as below.

Game	CPU	GPU	RAM	ROM
League of Legends	3 GHz processor	Nvidia GeForce 8800/AMD Radeon HD 5670	2GB	12 GB
FORTNITE	Core i5-7300U 3.5 GHz	Nvidia GTX 660 or AMD Radeon HD 7870	8GB	
PlayerUnknown's BattleGround(PUBG)	Intel i5-6600K / AMD Ryzen 5 1600	Nvidia GTX 1060 3G/AMD Radeon RX580 4G	16 GB	30GB
FALLGUY	Intel Core i5 or AMD	NVIDIA GTX 660 or AMD Radeon HD 7950	8GB	2GB

table 1. Recommended System Requirements of Games

Besides, we also investigate recommended system requirements of common office software and entertainment, shown as below.

Activity	CPU	GPU	RAM	ROM
OFFICE	/	/	4GB	4 GB
Auto CAD	3+ GHz	Nvidia GTX 660 or AMD Radeon HD 7870	8GB	6 GB
Photoshop/Pr	Intel 7th CPU	4 GB of GPU VRAM	16GB	8 GB
Movie/Video/Muic	1.5 GHz	/	0.5 GB	2GB

table 2. Recommended System Requirements of Common Activity

3.3.3 RELATION OF CONFIGURATION AND PREFERENCE

Acquiring all the raw information from the internet, a new problem came out: how can we relate the laptop configuration with all the complicated parameters with users preference. To solve this problem, we initially divide the system requirements into 3 groups based on users preference, which can be interpreted as low, medium, high according to its rank in the related field.

laptop parameters order	processor	graphics	hard_drive	memory
quality range (from low to high)	[0-2]	[0-2]	[0-2]	[0-2]

table 3. laptop quality score range chart

After that, we make a classification for independent laptop parameters according to the information given by experts in the related field. The rank of specs are shown as below.

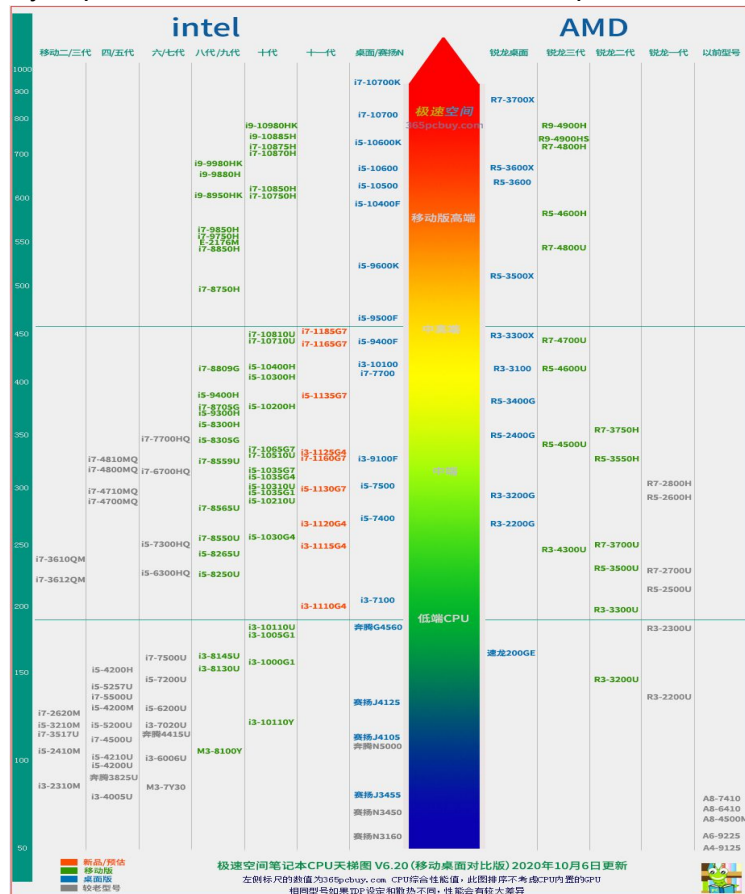


figure 7. Rank of Processor

Class	ROM	RAM
entry	4 GB	128 GB SSD or 1TB HDD
mainstream high	8 GB	256 GB SSD or 128GB SSD+1TB HDD
high	16 GB	512 GB SSD or 256GB SSD+2TB HDD
high plus	32 GB	1TB GB SSD or 512 GB SSD+4TB HDD
top-end	64 GB	2 TB SSD or above

table 4. Table of class of ROM and RAM

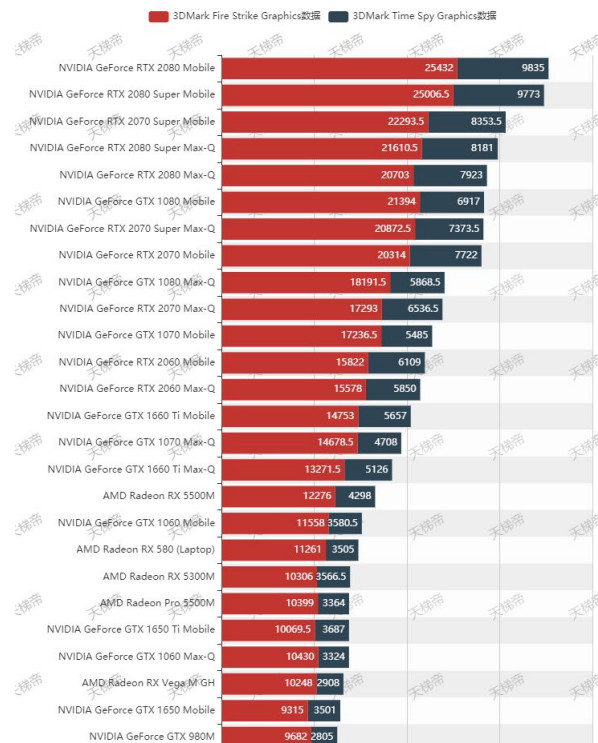


figure 8. Schematic Diagram of Rank of GPU

Based on the information above, the classification plot is shown as below.

	A	B	C	D	E	F	G	H	I	J
1	CPU	CPU	CPU	CPU	RAM	ROM	GPU	GPU	GPU	GPU
2	brand						brand	model	brand	model
3	Intel	i9-10	AMD	r9-4900			NVIDIA GEFORCE RTX	3080		
4	Intel	i7-10	AMD	r7-4800	32GB	1 TB SSD	NVIDIA GEFORCE RTX	3080		
5	Intel	i7-9	AMD	r5-4600	16GB	512G SSD+1TB HDD	NVIDIA GEFORCE RTX	3070		
6	Intel	i7-8	AMD		8GB	256GB SSD	NVIDIA GEFORCE RTX	2080		
7	Intel	i5-10	AMD	r7-4700	4GB	128GB SSD + 1TB HDD	NVIDIA GEFORCE RTX	2070		
8	Intel	i5-9	AMD	r5-4500			NVIDIA GEFORCE RTX	2060		
9	Intel	i5-8	AMD	r3-4300			NVIDIA GEFORCE RTX	1660	AMD Radeon RX	5500M
10	Intel	i3-10	AMD	r3-3300	2GB		NVIDIA GEFORCE RTX	1650	AMD Radeon RX	580
11	Intel	i3-8	AMD	r3-3200	1GB	1TB HDD	NVIDIA GEFORCE GTX	1050		
12			AMD	AG-3150		128G SSD	NVIDIA GEFORCE MX	450	AMD Radeon RX	560
13							NVIDIA GEFORCE MX	350		
14							NVIDIA GEFORCE MX	150		
15										
16							INTEL IRIS PLUS		VEGA 10 9 8 7	
17							INTEL HD Graphics			
18		https://www.365pcbuy.com/article.php?id=409			https://zhuanlan.zhihu.com/p/41215988		http://www.tiantidi.com/computer/notebook-gpu-benchmark-list/			
19										
20										
21	color	class	marks							
22	high			2						
23	median			1						
24	low			0						

figure 9. Classification of Laptop Parameters

After getting the classification of laptop parameters, we can manually match them with the laptop configuration we obtained. The table below shows the rule we obtain from the above charts and picture.

type	name	grade
processor	Intel Core i9-10 Intel Core i7-11 Intel Core i7-10 Intel Core i7-9	2
processor	Intel Core i7-8	1

	Intel Core i5-11 Intel Core i5-10 Intel Core i5-9	
processor	Intel Core i5-8 Intel Core i3-11 Intel Core i3-10	0
hard_drive	2TB_SSD 1TB_SSD 512GB_SSD+1TB_HDD 512GB_SSD	2
hard_drive	256GB_SSD 256GB_SSD+1TB_HDD 128GB_SSD+1TB_HDD	1
hard_drive	1TB_HDD and below	0
graphics	RTX	2
graphics	GTX MX	1
graphics	Intel	0
memory	16 GB and above	2
memory	8 GB	1
memory	4 GB and below	0

table 5. Score Table

3.4 TECHNICAL APPROACH

3.4.1 FRONT-END DEVELOPMENT

In terms of front-end, as our system design is for mobile use, we choose to deploy the project on Android. Android is a mobile operating system based on a modified version of the Linux kernel and other open source software, designed primarily for touchscreen mobile devices such as smartphones and tablets. For our system, we support Android System 6.0 and above.



Our system's layouts and their functions are shown as below:

Layout Name	Function
activity_main	Welcome page and brief introduction to the app
activity_query_use	User choose what will they use the laptop for and jump to related page according to the answer
activity_query_game	Collect users preference on game
activity_query_home	Collect users preference on what they would use at home
activity_query_work	Collect users' work content
activity_query_price	Collect users budget for laptop
activity_show_result	Show the recommendation results to users

The layout design is shown as below.

This is the welcome page when entering the system. The page contains the title of this app and a short introduction to this app. After viewing this, click the "LET'S START!" button to proceed to the next page.

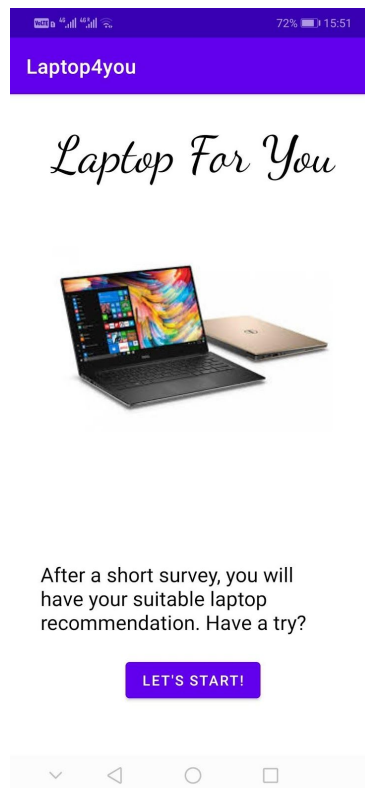


figure 10. Welcome Page

The query of use page contains a multi-choice question for the users. Users choose their own use scenario and the next few questions will be determined based on their choice. For instance, if a user only selects the Game option as the image shown, then he will only be asked about the query of game.



Your laptop is used for?

☒ Game

☐ Office

☐ Home

NEXT



figure 11. Query of Use

Next 3 pages are query pages for 4 aspects: game, work, home and budget. Each of them will collect the related users' preference and pass this information to the back-end model. The model will use the information to calculate the laptop configuration based on its knowledge base and rule-based system.



What type of game do you play?

☒ MOBA games(LOL,DOTA)

☐ Massively multiplayer online game(PUBG, CALL OF DUTY)

☐ Small games(web game)

NEXT



figure 12. Query of Game



What is your work content?

☒ Design(Photopshop, auto CAD)

☐ Coding(Software or algorithm development)

☐ Office(Word, Excel, Powerpoint)

NEXT



figure 13. Query of Work

Laptop4you

How will you use it at home?

☐ Surf the internet/Listen to music
 ☐ Watch movies/videos

NEXT

Laptop4you

What is your budget?

☐ Below 1000 SGD
 ☒ 1000 - 2000 SGD
 ☐ 2000 - 3000 SGD
 ☐ 3000 - 4000 SGD
 ☐ Above 4000 SGD

SUBMIT

figure 14. Query of Home

figure 15. Query of Budget

The final page shows the recommendations given by the system, which are all based on users' preference and suit users' requirements. This page lists the recommendation of laptops and their detailed information, including product image, laptop model, processor model, graphic card, ROM and RAM. Obtaining these recommendations, users can go to the official website to select their ideal laptops.

Laptop4you

Here are some recommendations

New Inspiron 13 5000 Laptop (5301)
\$1,399.00
 Intel Core i5-1135G7
 NVIDIA GeForce MX350
 8GB 512GB_SSD

New Inspiron 14 5000 2-in-1 Laptop (5406)
\$1,448.98
 Intel Core i5-1135G7
 NVIDIA GeForce MX330
 8GB 512GB_SSD

New Inspiron 15 7501 Laptop
\$1,498.98
 Intel Core i5-10300H
 NVIDIA GeForce GTX 1650 Ti
 8GB 512GB_SSD

New Inspiron 15 5000 Laptop (5502)

figure 16. Result Page

3.4.2 MODELS

3.4.2.1 Data preprocess

In the description of 3.1, we got the original data through the crawler. And in the chapter of 3.2.3, we acquire the relation of laptop configuration and user preference.

For the subsequent cluster analysis, the characteristics of the text type can be scored according to Classification of Laptop Parameters in chapter 3.2.3, and then the numerical characteristics that can be clustered will be obtained. Based on the classification rule above, the processor, memory, hard drive and graphics data can be classified and quantized. The classified data is shown below. The uuid and price data are retained the same, while the others data are converted to 0-2, which represents the quality from low to high.

	uuid	price	processor	memory	hard_drive	graphics
0	ee58b3e8-1443-11eb-9321-0242ac1c0002	\$699.00	0	1	0	0
1	ee638a70-1443-11eb-9321-0242ac1c0002	\$1,099.00	0	1	1	0
2	ee6d5fdc-1443-11eb-9321-0242ac1c0002	\$1,148.99	1	1	1	0
3	ee785c5c-1443-11eb-9321-0242ac1c0002	\$1,198.99	2	1	0	1
4	ee8291a4-1443-11eb-9321-0242ac1c0002	\$1,248.99	1	1	2	0

figure 17. Preprocessed Data Example

The final input to the clustering model will be the last four columns of the data set: processor, memory, hard_drive and graphics.

	processor	memory	hard_drive	graphics
0	0	1	0	0
1	0	1	1	0
2	1	1	1	0
3	2	1	0	1
4	1	1	2	0

figure 18. Final Input of Clustering Model

3.4.2.2 Cluster Model and Performance

After data preprocessing, we use the K-Means model in scikit-learn to the input dataset to perform data clustering. Scikit-learn (formerly scikits.learn and also known as sklearn) is a free software machine learning library for the Python programming language.



figure 19. Scikit-learnIcon

The image below shows the scree plot when performing k-means on the input dataset.



figure 20. Scree Plot

Based on the scree plot above, we choose to set the clusters to 5. And it has a silhouette score of 0.61, which is a good result for clustering.

```
clusters = 5
kmeans = KMeans(clusters,init="k-means++", n_init = 10, max_iter= 100)
kmeans.fit(kmeans_data)

temp = cluster_data
temp["Cluster"] = kmeans.predict(kmeans_data)

goodness = silhouette_score(kmeans_data,temp["Cluster"])
print("Clusters =", clusters," Silhouette = ",goodness)

Clusters = 5 Silhouette = 0.6163742370395876
```

figure 21. Process of K-means

After clustering, the laptops in the data set are divided into 5 categories. Then write the center of each category and the laptops under its category into the database.

	id	name	cord_1	cord_2	cord_3	cord_4
0	1	cluster_1	2.000	1.0	2.000000	0.588235
1	2	cluster_2	0.875	1.0	0.750000	0.312500
2	3	cluster_3	2.000	2.0	1.891892	0.972973
3	4	cluster_4	1.000	1.0	2.000000	1.000000
4	5	cluster_5	1.000	1.0	2.000000	0.000000

figure 22.Cluster Centers

3.4.2.3 Database

For the requirement of data storage of this project, we choose to use SQLite as our dataset.

SQLite is a relational database management system (RDBMS) contained in a C library. In contrast to many other database management systems, SQLite is not a client–server database engine. Rather, it is embedded into the end program.



figure 23.SQLite

The clustered dataset has been stored in a database using SQLite. As shown below, the dataset contains 8 tables, including BENCHMARK, CLUSTER_1-5, CLUSTERS, LAPTOPS. The data in cluster_1 is also shown below.

```
sqlite> .tables
BENCHMARK  CLUSTER_1  CLUSTER_3  CLUSTER_5
CLUSTERS    CLUSTER_2  CLUSTER_4  LAPTOPS
sqlite> select * from cluster_1;
uuid|price|processor|memory|hard_drive|graphics
ee58b3e8-1443-11eb-9321-0242ac1c0002|699.0|0|1|0|0
ee638a70-1443-11eb-9321-0242ac1c0002|1099.0|0|1|1|0
ee6d5fdc-1443-11eb-9321-0242ac1c0002|1148.99|1|1|1|0
ee785c5c-1443-11eb-9321-0242ac1c0002|1198.99|2|1|0|1
ee8c7bd8-1443-11eb-9321-0242ac1c0002|1249.0|1|1|1|0
0daa49aa-1444-11eb-9321-0242ac1c0002|699.0|0|1|0|0
0db3e0e6-1444-11eb-9321-0242ac1c0002|1099.0|0|1|1|0
0dc0cbda-1444-11eb-9321-0242ac1c0002|1148.99|1|1|1|0
0dcaa8d0-1444-11eb-9321-0242ac1c0002|1198.99|2|1|0|1
0ddea56a-1444-11eb-9321-0242ac1c0002|1249.0|1|1|1|0
117fb4de-1444-11eb-9321-0242ac1c0002|1499.0|1|1|1|1
14002a2c-1444-11eb-9321-0242ac1c0002|1499.0|1|1|1|1
14d7a2cc-1444-11eb-9321-0242ac1c0002|2298.99|1|1|1|0
159e8950-1444-11eb-9321-0242ac1c0002|1499.0|1|1|1|1
16694d3e-1444-11eb-9321-0242ac1c0002|1999.0|1|1|1|0
174105f8-1444-11eb-9321-0242ac1c0002|1999.0|1|1|1|0
```

figure 24. Tables and Cluster_1

The BENCHMARK table contains rules for giving grades to related laptop parameters. The benchmark table is shown as below.

```
sqlite> select * from BENCHMARK;
type      name                                grade
processor  Intel Core i9-10                    2
processor  Intel Core i7-11                    2
processor  Intel Core i7-10                    2
processor  Intel Core i7-9                     2
processor  Intel Core i7-8                     1
processor  Intel Core i5-11                    1
processor  Intel Core i5-10                    1
processor  Intel Core i5-9                     1
processor  Intel Core i5-8                     0
processor  Intel Core i3-11                    0
processor  Intel Core i3-10                    0
hard_drive 2TB_SSD                            2
hard_drive 1TB_SSD                            2
hard_drive 512GB_SSD+1TB_HDD                 2
hard_drive 512GB_SSD                         2
hard_drive 256GB_SSD                         1
hard_drive 256GB_SSD+1TB_HDD                 1
hard_drive 128GB_SSD+1TB_HDD                 1
hard_drive 1TB_HDD                          0
graphics   Intel                              0
graphics   RTX                               2
graphics   GTX                               1
graphics   MX                                1
```

figure 25. Benchmark

The LAPTOPS table contains all the laptop data that we obtain from the internet. The table will be accessed when the system needs to return recommendations to the users. The table content is shown as below. The web link of the laptop image is a little long, so it may not look neat.

```

mysql> select * from LAPTOPS limit 10;
+----+-----+-----+-----+-----+-----+-----+-----+
| uid | name | price | processor | memory | hard_drive | graphics | img |
+----+-----+-----+-----+-----+-----+-----+-----+
| ee58b3e8-1443-11eb-9321-0242ac1c0002 | Inspiron 14 3000 (3493) | $699.00 | Intel Core i3-100501 | 4 | 1TB_HDD | Intel UHD Graphics | https://i.dell.com/is/image/bellContent//cont
ent/dam/global-site-design/product_images/dell_client_products/notebooks/inspiron_notebooks/14_3490/global_api/notebook-inspiron-14-3490-black-campaign-hero-504x350-ng.pdf?format=jpg&wid=570&hei=400
| ee038a70-1443-11eb-9321-0242ac1c0002 | New Inspiron 13 5000 Laptop (5301) | $1,099.00 | Intel Core i3-111504 | 8 | 256GB SSD | Intel UHD Graphics | https://i.dell.com/is/image/bellContent//cont
ent/dam/global-site-design/product_images/dell_client_products/notebooks/inspiron_notebooks/inspiron_5300/pdp/notebooks-inspiron-13-5300-laptop-pdp-design-gallery504x350.jpg?format=jpg&wid=570&hei=400
| ee068fde-1443-11eb-9321-0242ac1c0002 | New Inspiron 14 5000 Laptop (5402) | $1,148.99 | Intel Core i5-113507 | 8 | 256GB SSD | Intel Iris Xe Graphics | https://i.dell.com/is/image/bellContent//cont
ent/dam/global-site-design/product_images/dell_client_products/notebooks/inspiron_notebooks/14_5401_5408/pdp/notebooks-inspiron-14-5401-5408-laptop-pdp-design-gallery504x350_silver.jpg?format=jpg&wid=570&
hei=400
| ee785c5c-1443-11eb-9321-0242ac1c0002 | Inspiron 15 3000 (3593) | $1,198.99 | Intel Core i7-106507 | 8 | 1TB_HDD | NVIDIA GeForce MX230 | https://i.dell.com/is/image/bellContent//cont
ent/dam/global-site-design/product_images/dell_client_products/notebooks/inspiron_notebooks/15_3592/pdp/notebook-inspiron-15-3592-in-pdp-gallery-504x350.jpg?format=jpg&wid=570&hei=400
| ee8291a4-1443-11eb-9321-0242ac1c0002 | New Inspiron 14 5000 Laptop (5402) | $1,248.99 | Intel Core i5-113507 | 8 | 512GB SSD | Intel Iris Xe Graphics | https://i.dell.com/is/image/bellContent//cont
ent/dam/global-site-design/product_images/dell_client_products/notebooks/inspiron_notebooks/14_5401_5408/pdp/notebooks-inspiron-14-5401-5408-laptop-pdp-design-gallery504x350_silver.jpg?format=jpg&wid=570&
hei=400
| ee9c7b38-1443-11eb-9321-0242ac1c0002 | New Inspiron 13 5000 Laptop (5301) | $1,249.00 | Intel Core i5-113507 | 8 | 256GB SSD | Intel Iris Xe Graphics | https://i.dell.com/is/image/bellContent//cont
ent/dam/global-site-design/product_images/dell_client_products/notebooks/inspiron_notebooks/inspiron_5300/pdp/notebooks-inspiron-13-5300-laptop-pdp-design-gallery504x350.jpg?format=jpg&wid=570&hei=400
| ee902386-1443-11eb-9321-0242ac1c0002 | New Inspiron 15 5000 Laptop (5502) | $1,298.99 | Intel Core i5-113507 | 8 | 512GB SSD | Intel Iris Xe Graphics | https://i.dell.com/is/image/bellContent//cont
ent/dam/global-site-design/product_images/dell_client_products/notebooks/inspiron_notebooks/15_5501_5508/pdp/notebooks-inspiron-15-5501-5508-laptop-pdp-design-gallery504x350.jpg?format=jpg&wid=570&hei=400
| ee903fa6-1443-11eb-9321-0242ac1c0002 | New Inspiron 15 5000 Laptop (5501) | $1,298.99 | Intel Core i5-103501 | 8 | 512GB SSD | Intel UHD Graphics | https://i.dell.com/is/image/bellContent//cont
ent/dam/global-site-design/product_images/dell_client_products/notebooks/inspiron_notebooks/inspiron_5501_5508/pdp/notebooks-inspiron-15-5501-5508-laptop-pdp-design-gallery504x350.jpg?format=jpg&wid=570&hei=400
| ee9c38c-1443-11eb-9321-0242ac1c0002 | New Inspiron 13 5000 Laptop (5301) | $1,299.00 | Intel Core i5-113507 | 8 | 512GB SSD | Intel Iris Xe Graphics | https://i.dell.com/is/image/bellContent//cont
ent/dam/global-site-design/product_images/dell_client_products/notebooks/inspiron_notebooks/inspiron_5300/pdp/notebooks-inspiron-13-5300-laptop-pdp-design-gallery504x350.jpg?format=jpg&wid=570&hei=400
| ee9a320-1443-11eb-9321-0242ac1c0002 | New Inspiron 15 5000 Laptop (5502) | $1,348.97 | Intel Core i5-113507 | 8 | 512GB SSD | NVIDIA GeForce MX330 | https://i.dell.com/is/image/bellContent//cont
ent/dam/global-site-design/product_images/dell_client_products/notebooks/inspiron_notebooks/15_5501_5508/pdp/notebooks-inspiron-15-5501-5508-laptop-pdp-design-gallery504x350.jpg?format=jpg&wid=570&hei=400

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figure 26. LAPTOPS Table Content

3.4.2.4 Rule-Based System

In terms of the rule-base system, the flowchart below represents the system inference process.

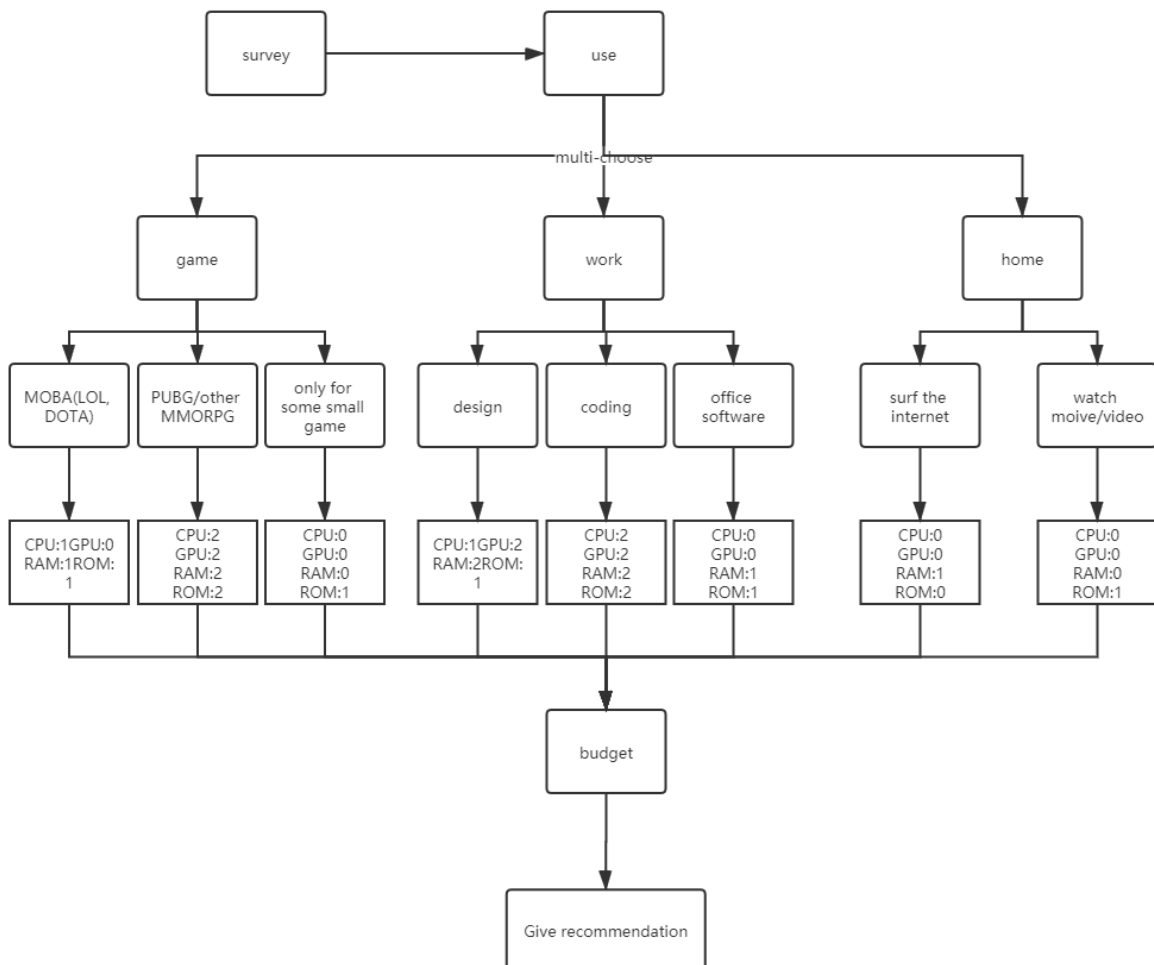


figure 27. Flowchart of Rule-based System

In the process, the key idea is to link the users' preference with laptop configuration. For this purpose, we combine the system requirements of related activity in chapter of 3.3.2 with the score table in chapter of 3.3.3 and we obtained the table below.

Query Question	Required quality	Score vector
game->moba	processor: mid memory: low hard drive: mid graphics: mid	[1, 0, 1, 1]
game->PUBG other big game	processor: high memory: high hard drive: high graphics: high	[2, 2, 2, 2]
game->small game(web game)	processor: low memory: low hard drive: mid graphics: low	[0, 0, 1, 0]
office->design(PS, CAD)	processor: mid memory: high hard drive: high graphics: mid	[1, 2, 2, 1]
office->coding	processor: high memory: high hard drive: high graphics: high	[2, 2, 2, 2]
office->office	processor: low memory: low hard drive: mid graphics: low	[0, 0, 1, 0]
home>watch movie/video	processor: low memory: low hard drive: low graphics: mid	[0, 0, 0, 1]
home>surf the internet	processor: low memory: low hard drive: low graphics: low	[0, 0, 0, 0]

table 6. Knowledge Representation Table

For the budget obtained from the users, the rule is the system will return products of which the price is in the range.

After the users finish the questionnaires, the system will get a score vector for 4 laptop configurations based on their answers and find the closest cluster centers obtained in

3.4.2.2. According to obtained target products, returning a list of products in the price range to the front-end.

4 CONCLUSION

In this project, we propose and implement a mobile application of personal laptop recommendation system with user-friendly interface. It helps people select their own suitable laptops. After we determined this project theme, we did a lot of investigation and brainstorming on how to recommend a laptop for others. We collected the recommendation rules from the professional laptop websites and experts and finally formed our own. We used much useful knowledge like knowledge modelling, data mining, knowledge representation in this system, which enhanced our knowledge significantly. In the process of implementing the project, we learn quite a lot of new skills and techniques, for example, data crawler, data cleaning, android development and so on.

If we had a longer time to work on this project, we would have worked upon the following points of improvement:

1. Integrate more laptop brands to the dataset and perform clustering for them.
2. Add the score for AMD vendor configuration.

5 REFERENCE

- Rank of Processor. Retrieved from <https://www.365pcbuy.com/article.php?id=409>
- Table of Recommendation for Rom and Ram. Retrieved from <https://zhuanlan.zhihu.com/p/41215988>
- Rank of GPU. Retrieved from <http://www.tiantidi.com/computer/notebook-gpu-benchmark-list/>
- Android Description. Retrieved from [https://en.wikipedia.org/wiki/Android_\(operating_system\)](https://en.wikipedia.org/wiki/Android_(operating_system))
- Scikit-learn Description. Retrieved from <https://en.wikipedia.org/wiki/Scikit-learn>

Appendix 1: Project Proposal

GRADUATE CERTIFICATE: Intelligent Reasoning Systems (IRS)

PRACTICE MODULE: Project Proposal

Date of proposal:

20 October 2020

Project Title:

ISS Project – Laptop4you, an intelligent laptops recommendation system on mobile

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:

The proposed intelligent laptop recommendation system will help people select their ideal and suitable laptop in minutes. The system will make use of various advanced machine reasoning techniques and knowledge discovery skills. For this project, our aim is

1. User-friendly interactive interface.
2. In order to facilitate daily use, it should be a mobile application.
3. Recommend laptops only through inquiries about the usage scenarios.
4. Customized suggestion.

Requirements Overview:

- Research ability
- Programming ability
- System integration ability

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

Hardware proposed for consideration:

- GPU, Android Devices,

Software proposed for consideration:

- Android Studio
- Python
- Colab
- Pycharm
- IntelliJ IDEA

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

A team of 2 members.

Methods and Standards:

Procedures	Objective	Key Activities
Requirement Gathering and Analysis	The team should meet with ISS to scope the details of project and ensure the achievement of business objectives.	<ol style="list-style-type: none"> 1. Gather & Analyze Requirements 2. Define internal and External Design 3. Prioritize & Consolidate Requirements 4. Establish Functional Baseline
Technical Construction	<ul style="list-style-type: none"> · 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 	<ol style="list-style-type: none"> 1. Setup Development Environment 2. Understand the System Context, Design 3. Perform Coding 4. Conduct Unit Testing
Integration Testing and acceptance testing	To ensure interface compatibility and confirm that the integrated system hardware and system software meets requirements and is ready for acceptance testing.	<ol style="list-style-type: none"> 1. Prepare System Test Specifications 2. Prepare for Test Execution 3. Conduct System Integration Testing 4. Evaluate Testing

		5. Establish Product Baseline
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 must be packed by following ISS's standard 2. Deployment guideline must be provided in ISS production (ISS standalone server) format 3. Production (ISS standalone server) support and troubleshooting process must be defined.

Team Formation & Registration

Team Name:

Group 10

Project Title (repeated):

Laptop4you - Laptop Recommendation System

System Name (if decided):

Laptop4you

Team Member 1 Name:

LI JIEYU

Team Member 1 Matriculation Number:

A0215428H

Team Member 1 Contact (Mobile/Email):

+65 82438752

lijieyu@u.nus.edu

Team Member 2 Name:

WANG JIAXIN

Team Member 2 Matriculation Number:

A0215427J

Team Member 2 Contact (Mobile/Email):

+65 82438751

wangjiaxin@u.nus.edu

For ISS Use Only		
Programme Name:	Project No:	Learner Batch:
Accepted/Rejected/KIV:		
Learners Assigned:		
Advisor Assigned: Contact: Mr. GU ZHAN / Lecturer & Consultant Telephone No.: 65-6516 8021 Email: zhan.gu@nus.edu.sg		

Appendix 2: System Functionalities and Course Work Knowledge

System Modulal	Function	Coursework
Data preprocessing	Knowledge acquisition and discovery	Machine Reasoning D3
Cluster Model and Performance	Knowledge discovery	Reasoning System D4
Rule-Based System	Machine inference	Machine Reasoning D2

Appendix 3: Installation and User Guide

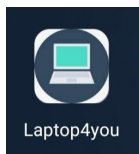
This app is temporarily hosted on a free distribution platform, so you can click the link below if you want to download:

<http://app.dongshijinrong.com/app.php/xyfhsp1hf4rdw>

If the link fails, you can download the apk file directly from github:

<https://github.com/jerry-ljy/Laptop4you/tree/main/apk>

After the installation is complete, then click it!



If you see this page, you have already installed it successfully, congratulations!



Laptop For You



After a short survey, you will
have your suitable laptop
recommendation. Have a try?

LET'S START!



Appendix 4: Individual Project Report

Individual report of Wang Jiaxin

Intelligent Reasoning Systems is my first course in NUS. It has given me a lot of inspiration as the basis for my exploration in the AI area. During this class, I have been exposed to some heuristic learning methods, knowledge representation, knowledge reasoning and etc. These are all mind stimulating and important for a good foundation in AI.

On the topic of this project, my team member, Li Jieyu, and I reached a consensus almost immediately. As computer-related majors, we are often regarded by relatives and friends as advisers for computer purchases. You know, not everyone knows computer hardware very well, so we can only ask them about the purpose and budget of buying a computer, and then make recommendations based on our own experience. So under this premise, we thought about whether this recommendation process can be realized by knowledge reasoning. After determining the plan, the first step is knowledge representation. We must record the notebook computer products and purchase suggestions in a form that can be recognized by the computer, and then infer the connection between the buyer's requirements and the products.

In this process, I am responsible for collecting information, data cleaning, clustering, and building the database used for Android application reasoning. I wrote a python crawler to get product information from web pages, but this is only the first step. In order for the data to be clustered well, a lot of cleaning work made me realize that a good data set almost determines the training efficiency and accuracy of the model, and the appropriate knowledge representation determines the rationality of reasoning. This is also the process I have learned the most in this project. In future work, I will pay more attention to the selection of data sets and the expression of knowledge.

During the practice module, we used the knowledge learned in class to implement a complete project and solve a problem that we will encounter in our lives. I enjoy it, and the final result also makes me feel very fulfilled. I think maybe this is the true meaning of technology, making life easier and better.

Individual report of Li Jieyu

During the process of establishing this project, I, with my teammate Wang Jiaxin, experienced brainstorming about the project theme, discussion for the implementation methods and teamwork for coding. This experience is very valuable for me. Because as a student whose undergraduate degree was automation, I haven't completely finished a software project from back-end to front-end. In this project, I was assigned the task about developing an android application that can be used to collect users data and present recommendation results. I had to learn everything from scratch, from creating my first android app to using java to design the rule-based system. All the things are brand new to me. The task was really tough. But finally I finished them on time. At present, I find that I have learned so many useful and fancy techniques and skills during this period of time. I believe the knowledge will help me a lot when I need to find a job.

The course really broadened my horizons and led me into the world of AI. Before this course, I thought AI is only for machine learning and deep learning. But now, my mind has changed. AI can be a tool or an option for us human beings to let the machine help with our work. And to get our work done, there are many ways, not only AI. For example, if the task is route planning, some search algorithms like hill climbing or A* are enough to solve the problem. Besides, to settle down some problems, data is very significant. We can do a lot of work with data, like data mining, data cleaning and even knowledge that can be extracted from data.

I had a wonderful time working with my teammate. I learned a lot from my teammate. And I come to understand what Sam told us in the class: the classmates can even teach us more than the lecturers. Even though we get the basic knowledge from the class so that we are able to build the system architecture, I find that it's very common to come across many small problems when implementing the whole system. And at this time, teammates can give each other a lot of help and support and we both can grow through this process.

The final result of this project module satisfies me, although it can be further improved for the aspect of data and rule. I enjoy the feeling when I can successfully open our app on my own mobile phone and get the right feedback from the app. As the lessons proceed, I wish I can learn more in this field and gain more useful knowledge and skills that contribute to my future work.

Appendix 5: Project Non-Disclosure Agreement (NDA)

MUTUAL NON-DISCLOSURE AGREEMENT

This **Non-Disclosure Agreement** (“**Agreement**”) is made on 17th day of September 2018 by and between:

- (1) **NATIONAL UNIVERSITY OF SINGAPORE (NUS)**, (Company registration number: 200604346E), a public company limited by guarantee incorporated in Singapore with its registered address at 21 Lower Kent Ridge Road, Singapore 119077, acting through its **Institute of Systems Science (ISS) at 25 Heng Mui Keng Terrace, Singapore**; and
- (2) **Final Year Project Team and individual student members (FYP TEAM)**

NUS and FYP TEAM shall hereinafter be referred to individually as a “**Party**” and collectively as the “**Parties**”.

WHEREAS:

- (A) The Parties wish to [work on an ISS/NUS project as student members’ final year project] (the “**Purpose**”).
- (B) The Parties now wish to enter into this Agreement to regulate how Confidential Information is to be treated while they are in possession or in control of Confidential Information of the other Party on the terms and conditions as set out herein.

In consideration of the premises and mutual covenants contained in this Agreement, the Parties agree as follows:

1. DEFINITIONS

Unless specifically defined in this Agreement or unless the context requires otherwise, the following terms shall have the following meanings:

- (a) “**Affiliate**” means any entity which, directly or indirectly, Controls, is Controlled by, or is under common Control with, a Party. For the purpose of this definition, “**Control**” means possession, direct or indirect, of the power to direct the management and policies of the controlled entity, whether through the ownership of voting securities, by contract or otherwise. “**Controlled by**” and “**under common Control**” are construed accordingly.
- (b) “**Confidential Information**” means all personal data (as defined in the Personal Data Protection Act 2012, hereinafter the “**PDPA**”), information, whether written, oral, pictorial or in other tangible form including prototypes and samples that is disclosed by the Disclosing Party to the Receiving Party in connection with the Purpose which currently is or which in the future may be identified by the Disclosing Party as proprietary or confidential and includes, without limitation, all information which by its nature the Receiving

Party knew or should have reasonably known was or would be proprietary or confidential. Information disclosed orally, visually or in intangible form, and identified as confidential at the time of such disclosure shall be considered Confidential Information.

- (c) “**Disclosing Party**” means the Party who discloses that piece of Confidential Information, whether inadvertently or not.
- (d) “**Receiving Party**” means the Party who is in receipt of that piece of Confidential Information.
- (e) “**Representatives**” means directors, officers, employees, agents, subcontractors, students and professional advisors of such Party and such Party’s Affiliates.

2. **Rights and Obligations**

- (a) The Disclosing Party shall have sole discretion to decide which Confidential Information it discloses to Receiving Party for use in connection with the Purpose.
- (b) The Receiving Party shall use the same degree of precaution (but in no event less than a reasonable degree of care) as it would use to protect its own confidential or proprietary information of like importance to maintain the confidentiality, and prevent unauthorised use or disclosure of Confidential Information of the Disclosing Party.
- (c) The Receiving Party shall not use, adapt or reproduce the Confidential Information, in whole or in part, for any purpose except for the Purpose only.
- (d) The Receiving Party shall hold and keep in confidence any and all Confidential Information and not disclose such Confidential Information or any part thereof to any third party without the Disclosing Party’s prior written approval except:
 - (i) to its Representatives strictly on a “need to know” basis, and who are bound by obligations of confidentiality; or
 - (ii) in the event that the Receiving Party is obligated or requested to disclose any Confidential Information as a result of a court order or by any governmental or regulatory authority, provided that the Receiving Party, if it is not legally or by such order prohibited from so doing, promptly notifies the Disclosing Party of any such requirement and cooperates with the Disclosing Party to limit such disclosure.
- (e) The Receiving Party shall procure that each Representative strictly complies with all of the Receiving Party’s obligations under this Agreement as if those obligations were imposed on that person. The Receiving Party shall be responsible for any unauthorised use or disclosure of any Confidential Information of Disclosing Party by any of its Representatives.
- (f) The Receiving Party shall comply with the PDPA and all subsidiary legislation related thereto (collectively the “**Data Protection Legislation**”)

with regard to any and all personal data that it receives from the Disclosing Party.

- (g) The Receiving Party's obligations contained herein shall not apply to information which:
 - (i) is already in the possession of or known to the Receiving Party or its Representatives prior to disclosure to the Receiving Party by the Disclosing Party;
 - (ii) is or becomes part of the public domain through no fault or breach of this Agreement by the Receiving Party or its Representatives;
 - (iii) is received by the Receiving Party from a third party who is not under, or in breach of, any obligation of confidentiality in disclosing the same; or
 - (iv) is independently developed by Receiving Party whether on its own or jointly with a third party(ies) without use of or reference to the Confidential Information.
- (h) Each Party may disclose the existence but not the terms of this Agreement.

3. **No Grant of Rights.** The Receiving Party acknowledges that the Confidential Information is the confidential and proprietary information and property of the Disclosing Party and that other than the right of use granted under **Clause 2**, the Receiving Party acquires no other rights in the Confidential Information disclosed to it by Disclosing Party or otherwise. Nothing herein shall be construed as granting to the Receiving Party, expressly or by implication, any right or license to or vesting any interest in the Receiving Party in relation to the Confidential Information. In particular, the Receiving Party shall not file any patent application containing any claim to any subject matter derived from the Confidential Information of the Disclosing Party.
4. **Term and Termination.** This Agreement is effective from the date first written above (the "**Effective Date**") and shall stay in force for a period of six (6) months thereafter unless terminated by a Party giving the other Party written notice of one (1) month (the "**Term**"). The obligations under **Clause 2** survive for three (3) years from the date of expiry or earlier termination of this Agreement.
5. **Publicity.** Each Party shall not, and shall procure that its Representatives shall not, publish any news releases, publicity, advertisements or marketing materials, or make any references, statements, announcements or denial or confirmation in any medium concerning all or any part of the discussions under this Agreement, including without limitation the existence of this Agreement, without the prior written approval of the other Party.
6. **No Further Obligations.** Neither this Agreement nor disclosure of any Confidential Information shall be construed as creating any obligation on either Party (i) to furnish information to the other Party or (ii) to enter into any other

agreement or transaction with the other Party. Each Party reserves the right to, in its sole discretion, terminate discussions with the other Party at any time.

7. **Representations and Warranties.** The Disclosing Party makes no representation and provides no warranties under this Agreement, whether express or implied, with respect to the Confidential Information. WITHOUT LIMITING THE GENERALITY OF THE FOREGOING, CONFIDENTIAL INFORMATION IS PROVIDED BY THE DISCLOSING PARTY "AS IS" WITHOUT ANY REPRESENTATION OR WARRANTY AS TO ITS ACCURACY, COMPLETENESS, MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE AND/OR NON-INFRINGEMENT OF THIRD PARTY RIGHTS. In addition, the Disclosing Party shall not be liable for any indirect, special, incidental or consequential damage or loss arising from any use of the Confidential Information by the Receiving Party even if the Disclosing Party has been advised of the possibility of such damage or loss.
8. **Remedies.** The Receiving Party acknowledges and agrees that, in the event of any breach of this Agreement, legal remedies would be inadequate for Disclosing Party, who therefore shall be entitled to apply for appropriate equitable remedies, in addition to any other remedies which it may have at law.
9. **Notices.** Unless otherwise agreed, any notice or written communication (collectively referred to as the "**Notices**") from either Party to each other pursuant to the terms of this Agreement or in connection with this Agreement shall be in the English language and shall be sent or delivered to the respective address, facsimile number or electronic mail address specified below (or to such other addresses, facsimile number or electronic mail address as the intended recipient shall notify the other Party in writing):

If to NUS

Attention: Mr. GU ZHAN / Lecturer & Consultant
Address: Institute of Systems Science, 25 Heng Mui Keng Terrace,
Singapore 119615
Email: zhan.gu@nus.edu.sg
Facsimile: 65-9011-2860

If to FYP TEAM

Attention:
Address: Institute of Systems Science, 25 Heng Mui Keng Terrace,
Singapore 119615
Email:
Facsimile:

All Notices shall be deemed received:

- (a) in the case of hand delivery, on the day of delivery;
- (b) in the case of sending by prepaid post:

- (i) where posted in the country of the addressee, on the third (3rd) business day following the day of posting; and
- (ii) where posted in any other country, on the seventh (7th) business day following the day of posting; or
- (c) in the case of registered post, upon written acknowledgment of receipt by the receiving party;
- (d) in the case of email or facsimile, upon completion of successful transmission, on the same business day if sent during normal business hours, or on the following business day if sent after normal business hours.

10. Governing Law and Jurisdiction. This Agreement shall be governed by the laws of Singapore and subject to **Clause 11**, the Parties submit to the jurisdiction of the courts in Singapore.

11. Arbitration. Any dispute arising from or in connection with this Agreement, including any question regarding its existence, validity or termination, shall first be referred to the authorised representatives of the Parties for amicable settlement. Any dispute which cannot be resolved by amicable discussions within thirty (30) days of referral shall be submitted to the Presidents of the respective Parties or their nominees for resolution. If the Parties fail to resolve such dispute through good faith negotiations, such dispute shall be referred to and finally resolved by arbitration administered by the Singapore International Arbitration Centre (the “**SIAC**”) in accordance with the Arbitration Rules of the SIAC (the “**SIAC Rules**”) for the time being in force, which rules are deemed to be incorporated by reference in this Clause. The seat of the arbitration shall be Singapore. The tribunal shall consist of one (1) arbitrator. The language of the arbitration shall be English. Nothing in this Clause shall preclude a Party from resorting to any court of competent jurisdiction for interim or interlocutory injunctive relief.

12. Miscellaneous.

- (a) Entire Agreement. This Agreement sets forth the entire agreement and understanding between the Parties as to the subject matter hereof.
- (b) No Agency or Partnership. This Agreement does not create any agency or partnership relationship between the Parties.
- (c) Use of Name or Marks. Neither Party may use the name, or any proprietary marks, of the other Party without the other Party’s prior written approval.
- (d) Amendments. Any amendment to this Agreement must be made in writing and duly signed by the authorised representative of the Parties.
- (e) Severance. A court or administrative body of competent jurisdiction’s determination that any provision of this Agreement is invalid or unenforceable shall not affect the other provisions of this Agreement, which shall remain in full force and effect. Parties agree to substitute any invalid

or unenforceable provision with a valid and enforceable provision which achieves similar effect as the invalid or unenforceable provision.

- (f) No Waiver. No waiver by a Party of any breach or default by the other Party shall operate as a waiver of any succeeding breach or other default or breach by such other Party. A waiver must be specific, irrevocable and in writing, to be effective. A Party's failure or delay in exercising any right or remedy provided under this Agreement or by law shall not constitute a waiver of that or any other right or remedy, nor shall it preclude or restrict such Party from any further exercise of that or any other right or remedy.
- (g) Rights of Third Parties. A person or entity who is not a party to this Agreement shall have no right under the Contracts (Rights of Third Parties) Act, Chapter 53B to enforce any term of this Agreement.
- (h) Counterparts. This Agreement is executable in counterparts, each of which constitutes an original, and all of which together constitute one and the same agreement PROVIDED THAT this Agreement shall be of no force and effect until all counterparts are exchanged.
- (i) Electronic Execution. This Agreement and any counterparts may be executed electronically whether by facsimile or by emailed portable document format ("**PDF**") document (or other mutually agreeable document format) and such electronic version shall be treated as an original.

IN WITNESS WHEREOF the Parties have executed this Agreement on the date first above written.

For and on behalf of:

NATIONAL UNIVERSITY OF
SINGAPORE

For and on behalf of:

Final Year Project Team

Signature of

Name: Mr. GU ZHAN

Designation: Lecture & Consultant,

For and on behalf of National University
of Singapore acting through its Institute
of Systems Science

Signatures of

Name :LI JIEYU

Matriculation No. :A0215428H

Name :WANG JIAXIN

Matriculation No. :A0215427J