Food recommendation system for the elderly

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ABSTRACT

When the elderly has any meal, they often have a hard time choosing proper healthy food. Normally, they often select food by themselves or have a caregiver help them find a menu or arrange the dishes they would like to eat. However, food arrangement for the elderly is different from those of other ages since it requires keen consideration about health and the proportion suited to their age. It also means that special care is very important. The objective of the invention of a food recommendation system for the elderly is to introduce nutritious menus and promote good health to elder people. This system utilizes techniques which can assist in menu recommendations to help the elderly to make easier decision on food choices. Therefore, there is a development for a suitable food recommendation system by applying the Clustering Algorithm analysis techniques to separate the elderly into groups according to their behaviors, eating habits, and food preferences, using Slope One Algorithm, which can predict menu-preference scores, as a technique to provide suggestions on food. In addition, the calculation process has also been improved to be more useful in order to raise the quality of the application and increase the accuracy of food recommendations: Root Mean Square Error (RMSE) set at 0.11-0.29, is implemented in forecasting and recommending appropriate menus for each elderly individual, and can be used to improve the application system to meet the users' needs, so that they will be able to select healthy menus for their bodies.

Keywords: The elderly, Eating nutritious foods, Data Mining, Food Recommendations, Slope One Algorithm

INTRODUCTION

Due to the situation of the Thai elderly population in 2017, there were 11.7 million elderly people, aged 60 years or more; accounting for 16.9 percent of the total population. This means that Thailand is expected to become a Complete Aged Society (CAS) in 2021 or in the following year, with an aging population of 1 in 5 in 2019. Therefore, if the future situation continues as expected, it will be the first time that Thailand has a higher elderly population than the younger. What is worrying for the elderly in Thailand is that 30 percent of their country is not ready to provide quality senior care in the upcoming future, especially good health and income security. In

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order to promote good health in today's growing number of older people, they need to know that their wellbeing is largely influenced by a good diet; however, making a decision on which food items to eat for each meal becomes difficult for the elderly to find the satisfying dishes and yet healthy. Let it be stated that the information provided above is the reason why the researcher has conducted the project on food recommendations for the elderly to promote good health due to the fact that the elderly is the vastest population which is continuously increasing in number in Thailand nowadays (Christoph . et al.,2017).

The researcher aims to invent a Web Application to guide the elderly or elderly caregivers to use the Elderly Food Recommendation System more effectively. The system has 2 working processes: use of the Clustering Algorithm as the first step to analyze elderly's behaviors in order to classify or group the elderly into groups according to shared characteristics to bring similar individuals together, and using the Slope One Algorithm involved with Collaborative as the second step to analyze the Food Rating Score. In the Web Application, both processes will work consecutively in order to find people having the same preferences, which can contribute to highly accurate recommendations on elderly dishes.

Thus, this research is created to raise awareness of correct nutrition and good health among the elderly and those who take care of them by advancing the system to be in the form of Web Application integrated with Data Mining to enhance the program to be more intelligent to offer more precise forecast and advantageous results for those who are interested in Data Science to make use of the principles in this research in the future.

RELATED THEORIES AND LITERATURE REVIEW

Data Mining

Data Mining requires a combination of various skills: the excellent ability to understand and apply mathematical and statistical principles, database management system, computer technical skills, application programming, Machine Learning, and any other relevant skills to discover patterns and rules hidden in a large data set having been stored for many years to acquire advantageous knowledge which can be used as criteria to make decisions or plan strategies in various areas.

The algorithm to perform Data Mining is as follows:

The Processes of Data Mining

1. Data Cleansing: The way to detect and correct incomplete information to be as complete as possible. This refers to empty data (Missing Data) that might affect the all over data to lose accuracy. For example, if an age attribute has an empty value and the missing data needs to be fulfilled; so, the most appropriate method needed to be chosen will vary; either by adding the mean of all ages in the blank or deleting all of them.

2. Data Integration: the process of merging data from multiple sources into one dataset to prepare it for further analysis and modeling.

3. Selection: the way to select or retrieve data consistent or related data sets to obtain informative facts. In other words, it is the process to choose an attribute that

can be used for our particular needs and the selection of a suitable data size for the analysis process from the existing saved sources.

4. Transformation: The revision of data to shape it in a suitable form or to transform it into a structured form or any form that can be analyzed in the process. Nevertheless, the information and data selection will be able to improve the efficiency of the data analysis when converting data with these 2 significant steps:

4.1 Data Conversion: The process of converting data to fit in the data analysis, such as the conversion of a text-format data to be in a structured form.

4.2 Data Reduction: the use of various techniques to reduce the data size to be more appropriate when used in the analysis.

5. Data Mining: The process to search for patterns or seek the insight ones or useful information from the overall massive data by many techniques used in this process such as Classification, grouping (Clustering) or matching a relationship (Association). Each technique has a lot of algorithms for modeling. We have to use multiple algorithms to make models for the analysis, and then choose the most appropriate or the most efficient one to actually use.

6. Pattern Evaluation: The evaluation of the patterns obtained from the Data Mining. This process focuses on the testing results of each derived model whether it meets the needs or not, and measure which model is the most sufficient one. Then, we will apply the most excellent model for decision making, or use it to meet other organizational needs.

7. Knowledge Representation: The process of presenting knowledge that has been discovered via presentation techniques which are used to create the easiest comprehension by employing visualization tools, such as a data-summary graph. This information is then presented to the executives in order for them to define more possible strategies. (Bharati M. R.,2000, Jiawei H. et al.,2012).

The Processes of Data Analysis with CRISP-DM

This is a very popular data analysis process in present days which has 6 steps as follows:

1. Business Understanding: The first step is to concentrate on the true understanding of the problem, and then transform that problem into question analysis form (problem in mathematic term) in the Data Mining.

2. Data Understanding: The step after enclosing the analysis problem which attempts to understand the collected information is implemented in order to verify the correctness of such information and consider which data will be used in the analysis for the answer of the problem in Step 1.

3. Data Preparation: This is the most time-consuming process, involving data preparation, data selection, data cleaning and data conversion, which change the data into an analyzable form.

4. Modeling: The process which uses several techniques in Data Mining in order to answer the question of Step 1, in which there will be multiple algorithms to compare to see which one gives the best outcome.

5. Evaluation: The measurement of the selected model's performance. This process plays a significant role in measuring the model's capacity because there are processes utilized which will test the chosen model.

6. Deployment: The process related to business in terms of creating special promotions and supporting managers' in making strategic decisions (Pete C. et al.,2000).

K-Means Clustering

The use of K-Means Clustering is a method to find out the number of clusters. This is an Unsupervised Learning method that does not require any answer class; so, this method is also called Teaching-Free Learning. It is the method of quantifying vectors which aims to divide them into K clusters. With this method, each observation belonging to the cluster with the nearest mean acts as a prototype for the cluster. As a result, the data area is separated into cells. Voronoi is widely famous for cluster analysis in K-Mean Clustering which can lower the variance within the cluster; however, it is not a normal Euclidean distance which would sometimes be Weber's more difficult problem when the mean optimizes the quadratic error, while the geometric median only reduces the Euclidean distance. For instance, a better Euclidean solution can be found by using K-Medians and K-Medoids; the K-Means working technique can inform a specific cluster of each data set, and each cluster has its own center which is the mean of the data in the same group. In short, clustering can be identified as a group of similar information in the same group in which a group is unique and if the unseen data is analyzed, the mean of the data will be calculated to the group the center of the data is closest to, and the mean will finally be placed in such group. Yet, technically, we have to identify and adjust how many segments we desire to classify, and we will continue the action until the most completed result occurs (Jiawei H. et al.,2012).

Recommender System

Recommender System is a subset of Information Filtering System that tries to predict the "rating" and "preference" the user give to an Item. Mostly, the Recommender System is used in Commercial Applications and in many areas of our daily lives which commonly come in forms of the introduction of video and music services. For example, most internet users are really familiar with YouTube, Spotify, and Netflix which recommend movies to the users and assist them in making decisions. Moreover, we usually experience websites selling products online such as Amazon, or a content curator for a social media platform with the introduction of product-sales advertising. Additionally, the Recommender System can come in many other forms such as Facebook and Twitter in which they act as a supporter when people are make choices, state preferences and do things in their daily lives. Besides, from a business perspective, those websites can achieve growing sales since they offer people items of personal interest.

In fact, there are 2 guiding methods as follows: 1. Collaborative Filtering: A filtering of information relying on the users, which refers to the analysis observed from other users or taken from the input of others to help predict the preference of a new user, such as online shopping. In this example, User A has similar usage behavior to User B and User A likes product A; so, there is a high possibility that the User B is likely to prefer product A as well. All in all, the prediction is based primarily on the principle of Nearest Neighbor; a user-based or similar item-based base. 2. Content-

Based Filtering: A process that the system will ask for customers' information when they subscribe or sign in a website. This process is also known as the survey of a user's historical profile. It is used in order: to see what products each customer has purchased like when Netflix asks its customers what kind of movies they like or what movies they have seen before. Then it analyzes all of the information collected from the customers to suggest programs or movies to fulfill the users' desire. Thereafter, new alternatives of recommendation are utilized; namely that Hybrid Methods (Hybrid), Context-Aware Approaches, Group-Based Methods and Health-Aware Methods, all of which are used to improve the food recommendation system by rating the nutrients, flavors, and/or even specific food genres: vegetarian diet, reduced starch, sugar and salt. It should be noted that the revision of the methods from the past to the present is challenging for the computer scientists. Scientist in this field search for solutions to develop higher quality and more standardized food recommendation systems, some of which, can be used in the Offline and Online guiding systems.

The study of various food recommendation systems includes various options such as recipes, sets of recipes, meals, plans, groceries and menus. The responses collected for the recommendation are available in several formats like ratline tags, a query of the information, ingredient information, the list of restaurants and recipe shops, and the information about a purchase of cooking ingredients. All kinds of information is passed through various algorithms that the food system is used for: Content-Based Methods (CB), Collaborative Filtering-Based Methods (CF), Hybrid Methods (Hybrid), Context-Aware Approaches, Group-Based Methods, Health-Aware Methods, which in most food recommendation system research still use, user feedback; from the satisfaction scores, behaviors of bookmarking and the way the users share and access to their favorite food. In conducting food recommendation research system which has been modified from the previous one, other introductions, such as products, have also been developed. The current research of food recommendation systems is still at the research stage, indicating the difficulty in recommending food items compared to the other domains since it is hard for the users to guess food flavors. As a result, it is not easy to develop the system to be more efficient and satisfactory. Also, the system has focused mainly on preference, so, there are a lot of remarks that we have to deal with in order to improve the recommendation techniques. Since, people's lives have changed to live in an online society, the food recommendation system started to be of great interest; there is now widespread sharing of cooking experiences, video uploading of diets, and consumption information on social media. All of which influences personal food choice. Hence, this has motivated the researchers to invent new technologies to support food recommendation systems, such as the use of image and video databases to learn about Food Data Analysis which become applications in food computing. Besides all of the reasons, the society, economy, the facts that the researcher focuses on, people who might have obstacles in eating and need to consider more about healthy food, and improve the ways of introducing, suggesting, and understanding and paying attention to the food that the elderly should be careful or not to eat (Christoph T. et al.,2017, Weiqing M. et al.,2019).

In addition, the hospitalization of most of the patients identified by the World Health Organization as a result of unhealthy diets such as heart disease, diabetes and

cancer, has created a new field of research for providing dietary advice to fit into the individual's body personally and offer a model of food recommendations for them together with the nutritional knowledge and the information of the users, in which the main goal is to design a daily meal-plan based on nutritional knowledge and the user's preferences (Raciel Y. T. et al.,2019). Therefore, the Online Eating Behavior Study is a study of an online eating behaviors that uses data from social media to find out how recipes relate to the users, by observing social characteristics and the population of each country for the creation of a predictive model and food recommendation system (Christoph T. et al.,2019).

Preferential Personal Food Model

By adopting the technologies of virtual image and digital display, food recommendations have evolved producing a variety of alternatives, such as paying attention to taste, food patterns, and the quantities needed to meet specific personal satisfaction. Also, data collection of user inquiries and the rating of various combinations of their preferences yield other ways to develop intrinsically healthy, flawless recommendations. (Ali R. et al.,2020, Shuqiang J. et al.,2020) Nonetheless, personal food recommendation modeling has its own learning architecture divided into 3 major themes: 1. Context and Knowledge Incorporation; a combination between Context and Domain Knowledge regarding food and necessary nutrients, 2. Personal Model Construction; a combination of User Profile/Diet Records and the users' historical data of various food interests, which mainly focuses on the users, 3. Heterogeneous Food Analysis; the model concentrating on food items, food structures, cooking ingredients in cooking process and the food that the users pay particular attention to (Weiqing M. et al.,2020).

Slope One Algorithm

Slope One Algorithm is a simple but highly accurate co-filtering algorithm that, when analyzing data, it examines many users or the vast majority of users to help predict what future users may like. It studies one user's behavior with other similar users. For example, User C's purchasing behavior is as same as User A, so it could be possible that the User C purchases the same item as the User A due to the similar purchase made by the User A and User B. (Daniel L et al.,2005)

Table 1 A comparison of users' rating: A = [9.32, 7.01,9.0, 8.45, 8.0] and C = [9.0, 7.0, 8.75, ? 8.5]

User	Production 1	Production 2	Production 3	Production 4	Production 5
User A	9.32	7.01	9.00	8.45	8.00
User B	8.00	7.00	7.50		9.00
User C	9.00	7.00	8.75	?	8.50
User D		8.00		9.00	10.00
User E		7.50	6.52	8.77	

Visual Basic.NET

Visual Basic.NET is a language used for developing programs. It is another language that the Microsoft group has developed. The program has a graphic environment for operating in Windows with the BASIC language as a root and working on a dot network framework. It is designed to have the ability to develop true object-oriented programming, and to provide support for UML design which is the ideal language for developing programs or applications beneath the operating system of Windows and Windows NT.

Microsoft SQL Server 2012

Microsoft SQL Server is a Relation Database Management System (RDBMS) launched by Microsoft as a Client/Server database system running on Windows and Windows NT, using T-SQL to recall the data. As the vast majority of data around the world is stored locally on a Microsoft Windows-based machine operation system, Microsoft SQL is integrated into the process of recollecting and processing the Windows-based data. Furthermore, the other main factor why Microsoft SQL is the most preferred database system is that it is cheap and easy to be acquire.

Weka 3.8

Weka is a program used to analyze all data with data mining in order to analyze the data from large amounts to find relationships and formats, and classify the data. In addition, Weka compiles many data analysis techniques together and also analyzes these data sets via Weka's GUI (Graphic User Interface) screen.

RESEARCH METHODOLOGY

System Development Process

1. The elderly were asked to provide the information on their behavioral characteristics to the system.

2. The behavioral data was then grouped by the Simple K-Means algorithm with three analyzed models (3 clusters). Each group distinguished by the model had different traits. Thus, those who shared the same characteristics were collected in the same group with its own distinctive qualities as follows:

Table 2 The table shows the characteristics of the elderly-group classification.

Cluster	distinguishing characteristics
0	Free time to take a walk is a group of elderly who do not work and is a favorite group
1	Free time to sleep, work 4-8 hours a day and is a group
2	Free time to clean the house, working 1-4 hours a day and is a group that likes to eat sour food.

3. After categorizing the elderly into several similar-characteristics groups, the system displayed the food menus to the elderly; filtering each menu to avoid their pre-existing diseases, and encourage them to consume more healthy food for themselves. In this method, the elders had to give a 5-level preference rating on various food: 5: very high 4: high 3: moderate 2: low 1: minimum.

4. All of the rating scores were analyzed by the Slope One method, which had been written as a script in SQL language. The elders' rating in each group (Cluster) was calculated together, and the results then revealed the food each elderly-group should not consume due to their underlying disease.

5. The system would provide food recommendations, which could be saved for later viewing to the elder people.

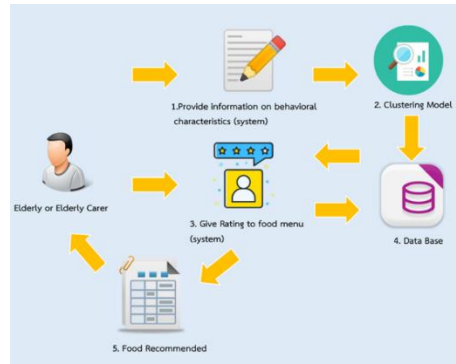

Figure 1 System Operation Diagram

According to the objective of designing and developing a system for the elderly (as a member), the caregivers could investigate the elderly's personal information such as personal history records, the results and history of food recommendations, such as disease background and particular nutritious food for each one, with the following Function Specifications: 1. view and edit personal records 2. Re-check food recommendation history 3. Analyze and suggest appropriate food 4. Calculate calories 5. Observe menus 6. Revise the food menus.

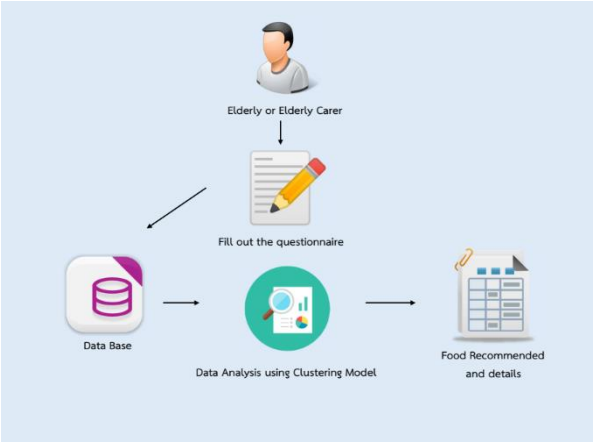

Figure 2 shows the operation of the users

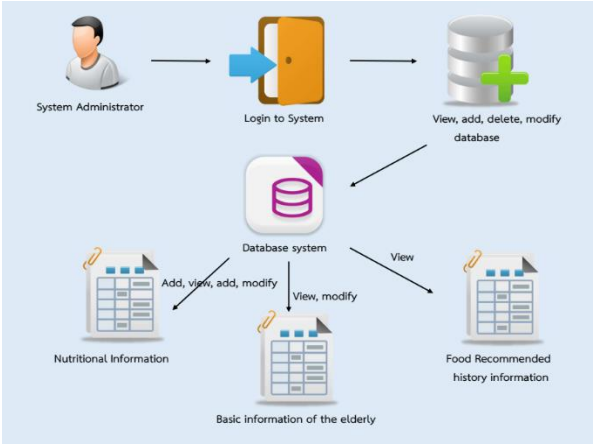

Figure 3 shows the work of the administrators

The development of the food recommendation system for the elders was developed by Windows 10 operating system. In terms of Host or Server, Internet Information Services was used by running the program on Google Chrome using Visual Basic.NET language. Also, with the aim of developing the program, this system used HTML and CSS to create and decorated a webpage. This was done to enable the user's to use the program more easily following the international principles;

using a Microsoft SQL Server 2019 as a database, Visual Studio 2019 as a system development tool, and Weka as a data analysis tool based on the data mining rules.

RESULT

The data analysis for modeling to examine and categorize the groups of the users, and recommend proper, healthy menus.

1 Data Collection

The data collection was done using Google Form to survey and collect 437 elderly's behavior data by keeping eating satisfaction of 308 menus including savory food, fruit and many kinds of beverages. In total, there were 437 instances, collected from 11 attributes: gender, age, leisure, sleep time, family lifestyle, weight, height, exercise habit, work, occupation and food taste.

2. Data Preparation

Since the data from the elderly and caregiver groups using Google Form and the data taken from documents were assembled in Thai language, the information should be converted into English for a more appropriate pattern that Weka could then analyze. Lastly, the data set was saved as .CSV file and imported into modeling process.

	Instance_r	Sex	Age	FreeTime	SleepTime	LiveWith	Weight	Height	Exercise	Work	Occupatio	FoodTyp
2	0	Male	70-79	DharmaLis	4pm	Family	78	174	15-30Min	1-4Hour	Agriculture	Sour
3	1	Male	60-69	WacthTV	2pm	Alone	49	165	15-30Min	4-8Hour	Agriculture	Salty
4	2	Female	70-79	ReadingBc	2pm	HusbandO	53	160	15-30Min	4-8Hour	Agriculture	Salty
5	3	Male	70-79	CleanHous	3pm	HusbandO	37	165	15-30Min	1-4Hour	Agriculture	Salty
6	4	Female	70-79	Sleep	3pm	Family	68	158	15-30Min	4-8Hour	Agriculture	Spicy
7	5	Male	70-79	TreeCare	2pm	Family	73	167	15-30Min	4-8Hour	Agriculture	Sour
8	6	Female	80	PlayPhone	Midnight	Family	56	167	15-30Min	NoWork	Other	Salty
9	7	Male	60-69	Stroll	3pm	Family	72	178	30-40Min	4-8Hour	Trade	Salty
10	8	Male	60-69	TreeCare	3pm	Family	58	162	30-40Min	4-8Hour	Agriculture	Sweet
11	9	Female	60-69	CleanHous	2pm	Family	63	165	15-30Min	NoWork	NoOccupa	Sweet
12	10	Male	60-69	DharmaLis	3pm	Family	56	165	15-30Min	1-4Hour	Agriculture	Sweet
13	11	Female	70-79	Stroll	3pm	Family	55	155	15-30Min	NoWork	NoOccupa	Spicy
14	12	Female	60-69	ListenMus	2pm	Family	62	160	15-30Min	8-12Hour	Agriculture	Sweet
15	13	Male	60-69	Sleep	2pm	HusbandO	45	167	15-30Min	4-8Hour	Agriculture	Salty
16	14	Male	60-69	RaiseAnim	3pm	Family	48	160	15-30Min	4-8Hour	Other	Salty
17	15	Female	60-69	DharmaLis	2pm	Family	64	158	15-30Min	1-4Hour	Agriculture	Salty
18	16	Female	60-69	WacthTV	3pm	Family	54	151	15-30Min	1-4Hour	Agriculture	Sour
19	17	Female	60-69	CleanHous	3pm	Family	62	155	30-40Min	1-4Hour	Agriculture	Salty
20	18	Female	60-69	RaiseAnim	3pm	Family	57	154	15-30Min	1-4Hour	Agriculture	Sour

Figure 4 Shows the prepared data

3. Modeling of the Elderly-Group Analysis

In order to approach people who shared similar behavior patterns and organize them into the same group for the straightest food recommendation analysis, the data was clustered by the Simple K-Means algorithm, with 11 attributes considered: sex, age, leisure activity, lifestyle, weight, height, length of exercise, sleeping during free time, working hours, occupation, and favorite food type. Then

calculations were made to locate a specific center point for each elderly group. After separating groups, there were 3 groups with different information: free-time, work (working hour), food type (the most favorite food type.) This information could be used further to compare the new users to which senior group they should be in to select the most suitable food menus for them. From the analysis of the behavioral data of the elderly, the elder can be divided into 3 groups from the explicitly distinguished behaviors as follows:

Cluster 0: The amount of information is 24%, characterized by the way the elderly spends free time walking, which is a group of the elderly who do not have any work, and like to consume spicy food.

Cluster 1: The amount of data is 55%, characterized by the way the elderly spends free time sleeping and working for 4-8 hours per day, which is a group of those who prefer salty the most.

Cluster 2: The amount of information is 41%, characterized by the way the elderly spends free time cleaning a house and working for 1-4 hours a day, which is a group of those who like sour food.

After analyzing the data groups, each piece of the segmented information is used to suggest new users based on either behavioral group out of the three, and then the food recommendations will be given to the new users in the next step.

4. Food Introduction for the Elderly Using the Slope One Method

Elderly people or caregivers had to provide the rating on the food menus with 5 scoring-levels: 5: very high 4: high 3: moderate 2: low 1: minimum. After that, the ratings were taken, where the difference of each menu pair was calculated and divided by the number of people who gave the rating, following these methods.

Item A was pork soup with radish and Item B was steamed fish and Item C was chicken rice

Table 3 shows the rating on food menus of each user.

User	Item A	Item B	Item C
Arm	4	5	1
Frame	3	4	Didn't rate it
Haft	Didn't rate it	4	5

Calculating Method: Predict chicken rice of User: Frame is calculated by finding the difference of the 3 items from User: Arm and Frame as follows.

$$\frac{\text{Item A – Item B}}{\text{frequency}} = \frac{((4-5)+(3-4))}{2} = (-1), \quad \frac{\text{Item A – Item C}}{\text{frequency}} = \frac{(4-1)}{1} = 3$$

Predict Frame: Item B = 4 + (-1) = 3, Item C = 4 + 3 = 7, and then calculate the value. $\frac{(3x2)+(7x1)}{2+1}$ = 4.33 As a result, we can predict that Frame likes chicken rice (4.33 points)

The improvement of Slop One prediction may be made more accurately, by utilizing the prediction test as follows:

1.Food-preference rating data from 37 elder people rating 308 menus

2.Food-preference rating data from 400 elder people rating 9 menus

3.Food-preference rating data from 437 elder people rating 308 menus; the combination of the representative sample 1 and 2 which are tested by having 400 users rate 9 menus and 308 menus from the additional rating from the prediction using Slop One of 299 menus to obtain all 437*308 recorded rates.

Table 4 shows Slop One's rating prediction's error information through the use of various different methods.

Slop One's Testing Method	Root mean square error (RMSE)
1.Dataset of 37 seniors rating 308 menus	1.68
2.Dataset of 400 seniors rating 9 menus	1.78
3.Dataset of 437 seniors rating 308 menus (combining data 1 and 2 together)	0.45

The testing was diversely conducted to measure the validity into 2 ways from the same data set; one providing food recommendations without the elderly-group classification and the other providing the recommendations with the elderly grouping as its indicator.

Table 5 shows the error in predicting the rating of 37 users giving scores to 308 food menus.

Classification	**Root mean square error in food recommendation using the dataset with the elderly group classification (RMS**	**Root mean square error in food recommendation using the dataset with non-classifying of the elderly groups (RMSE)**	**Root mean square error in food recommendation using the dataset with non-classifying of the elderly groups (individual)**	**Different value between the two tests**
Cluster0	0.96	1.04	1.68	0.08
Cluster1	2.54	2.65		0.11
Cluster2	0.79	1.35		0.56

Table 6 shows the error in predicting the rating of 437 users giving scores to 308 food menus.

Classification	Root mean square error in food recommendation using the dataset from the elderly group classification (RMSE)	Root mean square error in food recommendation using the dataset with non-classifying of the elderly groups (RMSE)	Root mean square error in food recommendation using the dataset with non-classifying of the elderly groups (individual)	Different value between the two tests
Cluster0	0.29	0.41	1.77	0.12
Cluster1	0.24	0.42		0.18
Cluster2	0.11	0.39		0.28

From the testing, it was found that the dataset with the classification of the elderly-group had less errors than the other without the elderly-group classification. The comparison of the error value in Cluster 0 indicated that the elderly segmented dataset had an error mean of 0.29; less than that of the classified model with an error mean of 0.14 by 0.12. For Cluster 1, the outcome of the comparison between the error value of the unclassified dataset (0.42) and the classified dataset (0.24) is 0.18. For the last cluster, Cluster 2, the error value from the comparison between the 2 sets of data; one with the elderly classification (0.11) and the other one without any of the classification (0.39), is 0.28. Therefore, the recommendation of food menus with the classification of the elderly groups provided more relevant suggestions to the elderly's needs (more accurate prediction).

5. Recommended-food filtering to avoid each user's underlying disease

The recommended diets were screened to avoid the food menus that adversely affected the underlying disease of each elderly person: diabetes, high blood-pressure and heart disease. For example, if one had diabetes, the system would have excellent food filtration to help him to reach nourishing food intake, cut harmful menus out of the list, and show only the output of healthy diets for on the system's screen.

The results of the development of a food recommendation system for the elderly was illustrated on the screen when entering the programs, the following steps:

1. When a user successfully subscribed, the system would ask him to provide more information, able to be edited later, about his behaviors. The system then analyzed the user whether he should be in Cluster 0, Cluster 1 or Cluster 2, in which each group had same-behavior elderly members as follows.

2. After completing Step 1, the user could click on the menu recommendation section, and the system would express the list of menus that the user had to rate by giving either 1 to 5 point to each menu. Then, when the user clicked on the data analysis button, the system then recommended a menu that avoided negative impacts

on the user's underlying disease. Moreover, the user could record the recommended menu for the later reviewing.

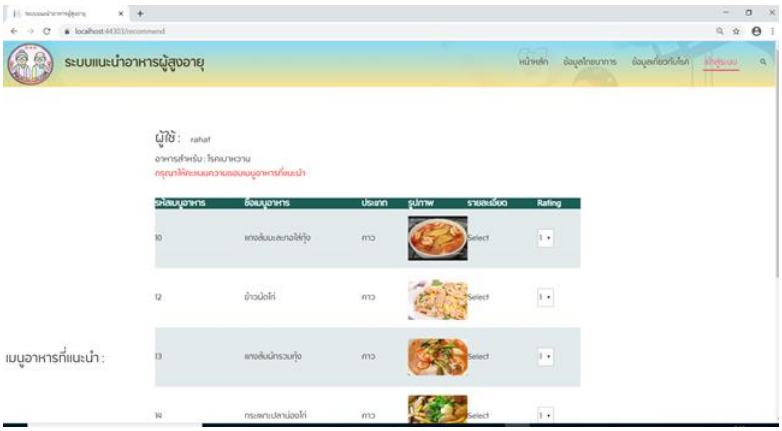

Figure 5 shows the menus that the user has to rate by displayed food that avoids personal disease of the user.

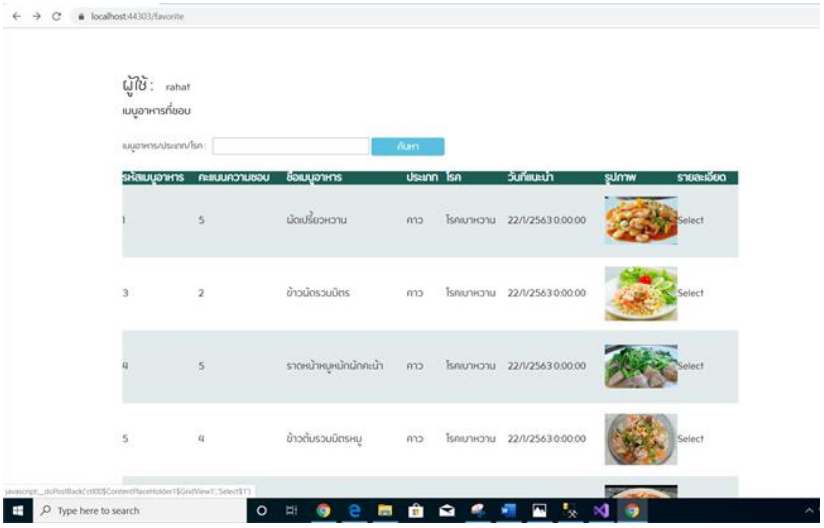

Figure 6 shows the user-recommended food menu avoiding the user's congenital disease.

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CONCLUSIONS

Based on the results of the analysis of the experiments to find the recommended dietary methods for the elderly, the existing data sets as a guide and the rating of 37 users to 308 dishes, could provide enough information without the information from the other 400 users. Moreover, the processing of calculation was also faster. The addition of 3 user clusters could increase the accuracy of the data analysis, leading to more efficient menu recommendations. The method of separating the user groups was used in the development of the system. From the improvement of a food recommendation system, the elderly and caregivers could achieve an analysis of their favorite food, more suitable diets for their underlying disease and their daily routine. In the section, the information of the elderly's behavior is employed to separate those with similar trait who must be analyzed in the same group because each group has distinctly different preference. Therefore, the use of Rating information of the elderly in the same cluster is beneficial for the introduction of food menu, since it helps promote more precise and faster online forecast which can provide suitable food recommendations to each elderly person with a specific underlying disease. However, In the future, further developments of the researchers to improve the food recommendation system for the elderly will increase their focus on nutrient considerations and take into account the individual calories that should be received per day in order to take care of elderly people more closely and increase the convenience while they are using the system.

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