Application of Knowledge-Based System in Personalized Health Management Portal

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Abstract- **Weight gain is being one of the prominent and common problems affecting society. Therefore, consumers are increasingly appreciating the expedient access to dietary information. The increasing number of searches on the Internet has massively improved the number of health websites on the Internet. Due to the increasing number of health conscious consumers, we propose the personalized health management portal for users. The modules available in the portal are personal and medical profile management, diet monitoring, workout monitoring, alert and notification, personalized diet planning and menu construction. The distinctive novelty of this portal is the capability to recommend personalized diet plan and menu construction to its users. The solutions are recommended based on a knowledge-based approach that allows fast and dependable decision making process. This personalized weight management solution would be a great way to assist online consumers to manage and maintain their weight based on their preferred health and weight requirements.**

Keywords- Health Management Portal; Diet Plan; Menu Construction; Knowledge-Based System; Personalization

I. INTRODUCTION

Considering the prevalence of weight gain Malaysian the Third National Health & Morbidity Survey (NHMS III) was conducted in 2006 to determine the nutritional status of a nationally representative sample of Malaysian adults aged 18 and above found that some 29% of Malaysian adults were overweight and 14% were obese. In short, 43% of Malaysian adults, or 2 in 5, are now either overweight or obese. Weight gain and obesity is the most common and serious nutritional problem affecting Malaysians. Most Malaysians are aware of dangers of being overweight. The population of people who search for health related information on the Internet has been increasing progressively over the years. Research shows that there are more than 12.5 million Internet searches about health-related issues daily [1]. The related information on the World Wide Web is no longer a new loom for the online to seek out their information and there is a number of health management websites that offer information on obesity and solutions for its user on the Internet. There have been many attempts in the current weight management practice to make weight management more accessible, effective and efficient through the use of information technology such as the electronic patient record applications [2], the health information kiosk [3] and medical diagnosis systems. One such attempt is a web-based system for dietary menu planning and management [4]. While such web-based systems are currently in existence, their focus is mainly to assist healthy individuals to calculate their calorie intake and to help them to monitor their selection of menus based upon pre-specified calories value. This personalized health management portal is a personalized weight management and monitoring web based system. This portal is aimed to shore up conservative face-to-face consultation with a web based portal. This system will also be used to monitor and manage the health status of its users who want to maintain and manage their weight. The objective of this health portal is to focus on the concept of user-driven innovation where the personalized health management portal will deliver the weight management and monitoring system customized according to its users' needs.

The personalized health management portal is able to provide unique services to fulfill the personalized weight management needs of its individual users. In terms of meal plan recommendation, the personalized health management portal will meet the needs of its users individually.

Section II discusses the literature review on the related studies to the proposed system including rule-based and case-based reasoning. The research methodology is for the proposed system is discussed in section III. Section IV of this paper provides the proposed framework for personalized health management portal. Section V of this paper provides the discussion and the adoption result for the proposed system and the final section of this paper discusses the conclusion and future work of this paper.

II. LITERATURE REVIEW

The literature review studies the obesity problem and the strategies to overcome obesity. Also in this section, we will also study the nature of web application and web 2.0 technologies. Discussion on weight management portal and knowledge based system is discussed in detail in this literature review section.

A. Obesity

Obesity has become one of the most common and serious nutritional problems affecting not only individuals but the whole society. Obesity is a chronic disease affecting all age groups and is a common disease in many countries. Obesity increases the likelihood of various diseases, particularly heart disease, type 2 diabetes, breathing difficulties during sleep, certain types of cancer and osteoarthritis [5]. There are various causes of obesity and they pertain to both men and women. The contributing factors to obesity are improper diet, sedentary lifestyles, genetics, medical and psychiatric illness, social determinants, and infectious agents. Obesity is mainly caused by unhealthy diets where users' food over-consumption is not counter-balanced with physical exercise. There are many different ways to overcome this serious nutritional problem. These strategies are important to overcome the obesity problem. One strategy to be named would be emphasizing on diet and exercise as a part of the healthy lifestyle. Emphasizing on diet and exercise is an important factor since diet is the main contributing factor. Most people have difficulties in determining the correct measurement and balance of calorie intake. Even though they exercise, without the correct and balanced measurement of calories they will also gain weight. Users can engage in any form of activity but they must also pay attention to the calorie expenditure of their body.

B. Web Application

The emergence of the World-Wide Web has made the hypertext paradigm more popular than ever. Web applications combine navigation through a heterogeneous information space with operations querying or affecting that information. A web application is an application that is accessed over a network such as the Internet or an intranet. A web application is also a collection of servlets, html pages, classes, and other resources that can be bundled and run on multiple containers from multiple vendors. A web application is rooted at a specific path within a web server. For example, a catalogue application could be located at http:// www.mycorp.com/catalog. All requests that start with this prefix will be rooted to the ServletContext which represents the catalogue application [6]. Web applications are popular due to the ubiquity of web browsers and the ease of using web browsers as a client. The ability to update and maintain web application without distributing and installing software on potentially thousands of client computers is the main reason for its popularity. Common web applications include the web mail, online retail sales, online auctions and many other functions.

C. Weight Management Portal

Today the integration of information technology in weight management has introduced numerous web-based weight management portals that will help users to provide knowledge about the strategies to overcome weight gain [7]. There are a growing number of online users looking for weight gain information and solutions on the World Wide Web. Therefore, web-based weight management solutions are an alternative choice for consumers to restore their weight gain condition. Numerous references, programmes and guidelines about weight management are available on the Internet. Weight management portals have raised consumers' attention to the substance and usefulness of weight management solutions on the Internet. Weight management portals have received great response and are growing.

These portals can also nurture a community's health knowledge. Web-based weight management programmes contain richer contents and are more appealing and motivating in providing weight management information due to their multimedia attractive contents compared to print materials [8]. Web-based weight management programme is more effective in promoting weight management compared to printed materials such as books and leaflets. Moreover, many government portals also provide information on weight management on the web. This benefits the community and will raise awareness of dangerous diseases related to weight gain among citizens. There is no enhancement on interaction and knowledge sharing among users. Furthermore, web-based management programmes and informatics on weight gain only provide information to users. Furthermore, all the weight management portals' contents are provided by one party only and this has restricted intelligent collections in the weight management websites.

D. Knowledge Based System

In a dietary context, different individuals have different individual requirements. Therefore personalization plays an important role in diet plan and menu construction. Personalization is about matching and satisfying user's needs in a specific context [4, 10]. It is important to understand the personalized health requirement of individual users in order to provide them with the best solution. In this way, users will be encouraged to be more proactive in managing their own dietary information. In the dietary context, young teenagers would enjoy fast food more than older people. The older people would prefer home cooked food where the taste of food is much similar like the ones cooked at home. Therefore, we have to understand the different preferences of individuals in order to provide them with the best dietary information such as diet plan and menu construction. In the future, it will be possible to adopt general recommendation for nutritional intake to meet the needs of specific group in the population [5]. Thus, there will be a demand for personalized recommendation from the consumers in the future. Therefore, it is significant to look for solutions in meeting user's dietary demands and desires in the market.

Rule-based reasoning (RBR) is a knowledge representation technique with IF-THEN rule statement [6]. The condition portions of the rule are basically facts and these rules are patterns. A search engine in the system will look for patterns rules that match patterns in the data [10, 6]. INTERNIST is a clinical intelligent system that is used to support diagnosis in the year

1970 [7]. The system is designed using rule-based expert system and has the capability to analyze problems in general health. It is also stated that some of the system requires special rules but this problem can be resolved by formulating rules that are applicable generally. However, problem solving will become more complex if there are too many pattern rules required to match the data [6]. Rule based reasoning is lack in its learning capabilities because it is difficult to acquire new expertise in pattering the rules [8]. Rule based reasoning method needs problem solver to take into account all the domain rules involved. In real-life problem solving, the pressure of time limit has restricted problem solver to look into large uncontrollable rules in solving problems. Rule based reasoning needs to convert knowledge into rules and in problem solving situation. Rule based reasoning will repeat the whole process to solve a problem [8]. This will take momentous time and problem solving process may reach the bottleneck due to time constrain.

Case-based reasoning (CBR) is a reasoning technique in artificial intelligence that uses previous experiences in solving problems [9]. Case based reasoning technique resembles reasoning model of human beings. Case based reasoning uses systems experts' previous experiences to solve new problems which are similar to the previous problems. Instead of relying on static and general rule of the system, case based reasoning has the capability in utilizing its database of previous experiences cases to solve new complex cases. Schmidt & Gierl [10] stated that case based reasoning is mainly used in medical a domain which is mostly applied to diagnostic and healing tasks. Case base reasoning has capabilities which will improve its problem solving skills when new cases are stored in the database [11]. In case based reasoning, when a similar problem is entered, the solution of most similar cases is suggested to the users [12]. In diet context, there are several knowledge-based systems proposed using case based reasoning approach.

Diet menu planning and management system is a case based reasoning applied to solve problems in dietary menu planning [14]. In this system the main feature is the ability of case based reasoning which is used to represent cases which depict the problems and solutions. In adapting to this method, the case based reasoning engine will retrieve the most suitable case according to the category indices. In this system, a case contains a past solution and the features that indicate when the solution is likely to be useful again. The solution for this system is daily menu. The main feature in this system is that it indicates the usefulness, as follows: its nutrient vector, the types of meals and number of foods including snacks. This system follows the operation of case based menu planning by retrieving and adapting daily menus from its case base. DietPal: A web based dietary menu generating and management system [14] is a help for the current healthcare practice to make healthcare services more accessible, effective and efficient through the use of information technology which could include implementation of computer based dietary menu generation.

III. RESEARCH METHODOLOGY

The development process of knowledge-based system has a clear knowledge-engineering methodology. This portal is an integrated knowledge based system for personalized diet plan and menu construction in health portal. The scope of the study is to provide the users with a personalized diet plan and construct a suitable menu based on their preferences and diet plan generated. The process of knowledge engineering is involved in multiple steps from the problem statement to develop a complete system. However, this study is not focused to complete the system development and implementation. Hence, the process of knowledge engineering methodology has been adapted to form this methodology for this study.

A. Phase 1: Study and Compare Existing Diet Application

This research will begin with a study on diet applications in the Internet. The main purpose of this study is to understand about the existing technique and applications offered in the dietary context to users. This study on the existing applications will help to discover new technology and applications which help to improve the proposed idea. Assorted diet websites are compared and the features in each websites are comprehensively studied in order to create a new personalized diet application in the health community portal.

The technology platform is important to develop a capable system in generating a personalized diet plan and recommending personalized diet menu to users. Thus, studies on knowledge based models will expose more clues in proposing an ideal model for personalized diet plan and menu construction in the proposed system. In literature review a study on Artificial Intelligence reasoning techniques namely rule-based reasoning (RBR) and case-based reasoning (CBR) have been done. These are two frequently used reasoning techniques in nutritional recommendation and other health related recommendation. This study will compare knowledge based models and propose an ideal model for personalized diet plan and menu construction.

B. Phase 2: Collect and Analyze Data and Transform Data to Represent Knowledge

As for the data collection and knowledge representation, the qualitative data collection techniques will be used. Based on the research methodology, after conducting the detailed study on obesity and its related application on the Internet a detailed review and comparison on the knowledge based techniques for diet planning and menu construction was done. The data collection is divided into two categories, which is calculation of the diet planning and generating preferred menu of the users' choice. In calculating the suitable diet plan for users, there are a few criteria to be considered. There are basically two methods of calculating how many calories are being burned by users in a day, or how many calories are needed to sustain user's current weight. The quickest and smooth method is based on a general level of activity and can be calculated in one easy step with the

BMR & RMR calculator. For a more accurate estimate of how many calories you burn in a day you can calculate the actual activities that you would perform over a 24-hour period with the activity calculator.

C. Phase 3: Develop a Prototype of Personalized Diet Plan and Menu Construction Module

After the data gathering phase, the development stage begins with the prototype of personalized diet plan and menu construction module. This module will be embedded together with the web technologies, so that the module can be accessed online. To test the prototype, samples of previously solved dietary cases will be stored in case database. New problem will be inserted in the module and the prototype will be able to propose suitable solutions to users.

D. Phase 4: Evaluate the Result Against Performance Criteria

After development of prototype stage, the personalized diet plan and menu construction module will be presented to dietitians for module testing and evaluation. The evaluation will be compared against performance criteria. The performance criteria for this evaluation are the suitability and the correctness of the personalized diet plan and menu construction module. In this evaluation, the generated recommended menu and user's personal information would be referred to dietitians to evaluate the validity of and the correctness of the menu constructed. The dietitian's evaluation will show that the menu generated by the system using the case and rule based reasoning is able to generate suitable diet plans and menu based on the user's personal profile and diet requirement.

IV. PROPOSED FRAMEWORK

The personalized health management portal is a proposed weight management and monitoring web-mobile based system [14]. This weight management and monitoring web-mobile based system is a venture in commercializing technology for the weight management and monitoring industry. The healthcare management and monitoring web-mobile based system has different features and modules to help its users to manage their weight via a healthier lifestyle. The backbone technology embedded in the personalized health management portal is the capability to construct a personalized diet plan and menu recommendation to users. Users can use this application to indentify the best technique for their personalized diet plan and menu construction. The personalized health management portal will recommend a suitable personalized balanced diet plan with proper nutrition guidelines for its users. Users can use this application to help them in generating their personalized diet plan based on their personal preferences. Fig. 1 shows the different modules available in the personalized health management portal.
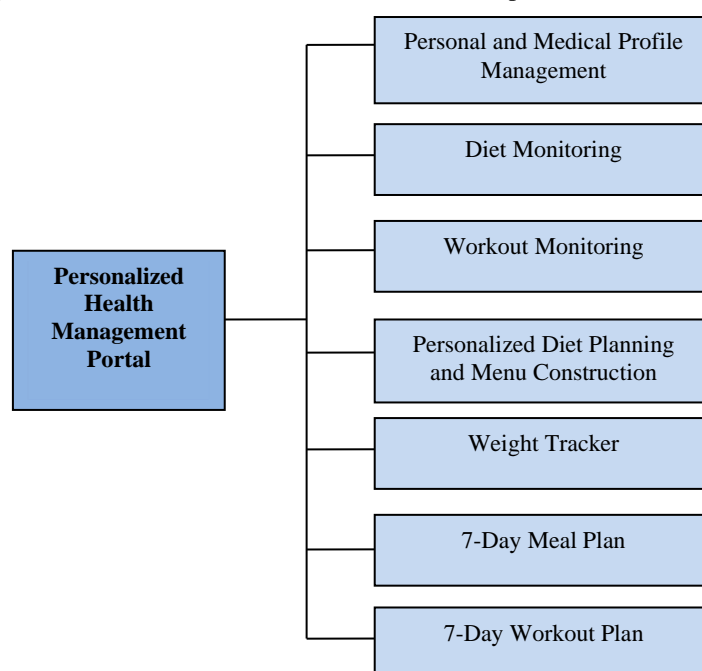
Fig. 1 Modules available in personalized health management recommender portal

A. Module 1: Personal and Medical Profile Management

This module is embedded in the personalized health management portal to record the user's personal and health information based on the user's preferences. Users have to enter their personal information such as their full name, date of birth, age, gender, mobile number, address, email, their preferred user name, weight, height, religion, food allergy, favorite food and restricted food. Fig. 2 shows the print screen of the personal and medical profile management module in the personalized health management portal.

Fig. 2 Personal and Medical Profile Management Module

B. Module 2: Diet Monitoring

The diet monitoring module will help users to monitor the amount of calorie intake in their daily or weekly food consumption. Users are required to record and update their food consumption either on a daily or weekly basis based on their preferences. Based on the individual user record, the diet plan module will deliver calorie analysis to users either via short-text message or email whichever is preferred. Fig. 3 shows the print screen of the diet monitoring module.

Fig. 3 Diet Monitoring Module

C. Module 3: Workout Monitoring

The workout monitoring module will allow users to enter their physical activity on a daily or weekly basis based on their preferences. The system will calculate the total calories burned and suggest a suitable physical activity for them. Based on the activity selected by the users, the system will then generate the amount of calories needed to be burned, the amount of calories burned and the amount of calories remaining. Fig. 4 shows the print screen of the diet monitoring module.

Fig. 4 Workout Monitoring Module

D. Module 4: Personalized Diet Planning and Menu Construction

As for the personalized diet planning and menu construction module, the system will retrieve the user's health information from the personal and medical profile database and match for similarity using the rule and case base system from the case and rule base database. The suggested diet plan and menu constructed will be delivered to users by using the system or Short

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Message Service (SMS) alert. Fig. 5 shows the print screen of personalized diet planning and menu construction module in personalized health management portal.

Fig. 5 Personalized Diet Planning and Menu Construction Module

E. Module 5: Weight Tracker

The personalized health management portal is not just a diet solution provider; it also helps users to monitor their weight based on their food intake. This module will allow users to monitor and track their daily food consumption. This weight tracker module will help users to understand the current status of their health, whether they are on the right track of health or otherwise. Fig. 6 shows the print screen of weight tracker module in the personalized health management portal
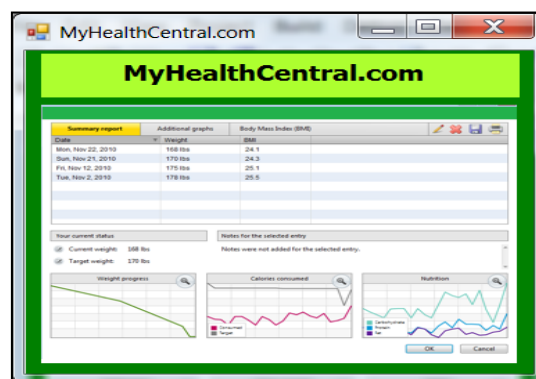
Fig. 6 Weight Tracker Module

F. Module 6: 7-Day Workout Plan

A 7-day workout plan module is embedded in the personalized health management portal to provide users more options in getting their recommended solutions. Some users may be busy with work or too tied to use the system regularly, as for such users they can use the 7-day workout plan module top generate their recommended workout plan for 7 days which will be generated based on the users' weight loss goal, their preferred choice of exercise and their activity level. Fig. 7 shows the print screen of the 7-day workout plan in the personalized health management portal.
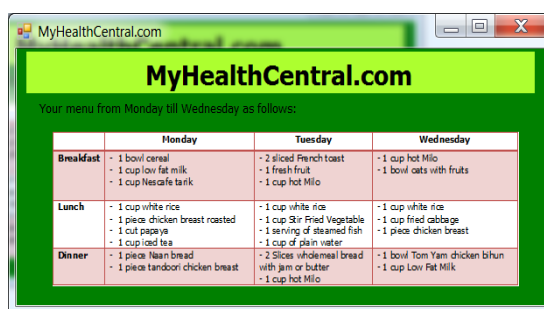

Fig. 7 7-Day Workout Plan Module

G. Module 7: 7-Day Meal Plan (B2B)

The 7-day meal plan module will be embedded in the personalized health management portal. This 7-day workout plan will provide meal plans for 7 continuous days. This 7-day meal plan will be generated to users based on their personal profile

stored in the database. The users can manage their weight by following the meal plan generated by the system for seven days. Fig. 8 shows the print screen of the 7-day meal plan module in the personalized health management portal.

Fig. 8 7-Day Meal Plan Module

V. EVALUATION

Towards the end of this study, evaluation has been carried out to access the diet plan and menu construction proposed by the system with diet experts using sample cases. There were a total of ten samples that have been generated to evaluate the correctness of the system. The sample test case contains different characteristics of people such as normal people, diabetes patient, high blood pressure patient, overweight people and obese people which cover the range to support the knowledge based system. Based on the observation and analysis of the dietitian, the feedback received on diet plan and diet menu generated by the system is acceptable. The result on evaluation analysis concludes that the diet planning and menu construction module shows that the rules derived in the knowledge base are sufficient to create diet plan and menu for various types of users to meet their requirements.

VI. CONCLUSION AND FUTURE WORK

The personalized health management portal offers a holistic solution in weight management and monitoring for users. The backbone technology of the personalized health management portal is the diet planning and menu construction module for its users. There are various modules embedded in this health portal to provide a complete solution for weight management and monitoring. As for its future work, we intend to create a persuasive health management portal for overcome obesity among children which is also an emerging health issue through a funny and interactive way. Furthermore, this way will also be able to educate the young children on the danger of being overweight through games and manage their weight at the same time.

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REFERENCES

[1] The Malaysian Association for the Study of Obesity (MASO) 2009 Conference (August 2009) [Online], [Accessed 25th October 2010], Available from World Wide Web: http://blogmoh.moh.gov.my/?p=414.

[2] Noah, S.A.; Khairudin, N.; Shahar, S.; Norulhuda, S.; Abdullah, S.; Hamid, H.A.; , "Dietary Menu Planning and Management System - An Automated Case-Based Approach," *Information and Communication Technologies, 2006. ICTTA '06. 2nd* , vol.2, no., pp.3611-3612, 0-0 0 doi: 10.1109/ICTTA.2006.1685001.

[3] Seljak, B.K.; , "Dietary Menu Planning Using an Evolutionary Method," *Intelligent Engineering Systems, 2006. INES '06. Proceedings. International Conference on* , vol., no., pp.108-113, 0-0 0 doi: 10.1109/INES.2006.1689351

[4] Ricken, D., 2000. Personalized views on Personalization, Communications of the ACM, vol. 43, no. 8.

[5] Silva, O. C., Knoll, R., & Jager, M., 2007. Personalized nutrition: An Integrative process to success. Genes Nutrition,vol. 2, no. 1, pp. 23-25.

[6] Wang, W. M., Cheung, C. F., Lee, W. B. and Kwok, S.K., 2007, 'Knowledge-based treatment planning for adolescent early intervention of mental healthcare: a hybrid case-based reasoning approach', *Expert Systems*, Vol. 24, No. 4.

[7] Miller, R. A. et al., 1982, 'INTERNIST-1: an experimental computer based diagnostic consultant for general internal medicine', *New England Journal of Medicine*, Vol. 307, pp.468-476.

[8] Lee, M. R., 2002, 'An exception handling of rule-based reasoning using case-based reasoning', *Journal of intelligent and Robotic System*, Vol. 35, pp. 327-338.

[9] Wu, D. D., Weber, R. and Abramson, F. D., 2004, 'A case-based framework for leveraging nutrigenomics knowledge and personalized nutrition counselling', paper to be presented in the workshop in CBR in Health Sciences, *European Conference*.

[10] Schmidt, R., & Gierl, L., 2001, Case-Based Reasoning for Antibiotics Therapy Advice: An Investigation of Retrieval Algorithms and Prototypes', Artificial Intelligence in Medicine, vol. 23, no. 2, pp. 171-186.

[11] Wang, W. M., Cheung, C.F., Lee, W. B., & Kwok, S. K., 2007, Knowledge-Based Treatment Planning for Adolescent Early Intervention of Mental Healthcare: A Hybrid Case-Based Reasoning Approach, Expert systems- The journal of Knowledge Engineering, vol. 24, no. 4, pp. 232-251.

[12] Aktas, M.S., Pierce, M., Fox, G. C., & Leake, D., 2004, 'A Web based Conversational Case-Based Recommender System for Ontology Aided Metadata Discovery', Proceedings of the Fifth IEEE/ACM International Workshop on Grid Computing (GRID 2004), vol. 14, pp. 69-75.

[13] Ravana, S. D., Abdul Rahman, S. S., & Chan, H. Y., 2006, Web-Based Diet Information System with Case-Based Reasoning Capabilities, International Journal of Web Information Systems, vol. 2, pp 154 – 163.

[14] Neesha Jothi, Wahidah Husain, Faten Damanhoori. 2011. Personalized Health Recommender Portal: A Competitive Advantage for Businesses and Health Management for Consumers. *Proceedings of the International Conference on Research and Innovation in Information Systems (ICRIIS'11),* Kuala Lumpur, 23-24 November 2011.

[15] Neesha Jothi, Wahidah Husain, Nasriah Zakaria. 2012. MyHealthCentral.com: Integrating Knowledge Based System in Personalized Diet Plan and Menu Construction. *Proceedings of the 2nd Annual International Conference on Web Technologies & Internet Applications (WebTech 2012).*Bali,Indonesia, 7-8 May 2012.