Fuzzy Expert System for Fitness Advisory

Furqan H. 1, Sofianita M. 2 and Shuzlina A-Rahman 3

1Universiti Teknologi MARA (UiTM), Shah Alam, Selangor, Malaysia, aanhod@gmail.com
2, 3Universiti Teknologi MARA (UiTM), Shah Alam, Selangor, Malaysia, {sofi, shuzlina}@tmsk.uitm.edu.my

ABSTRACT
Healthy lifestyle is not only depending on how frequent physical exercise is being done but it is also concerned on the daily food consumption. There are systems available for users in monitoring and practicing healthy lifestyle. However, most of the commercial systems ignore the food calories consumed by the user. This paper addresses the issue of food consumption and suggests the suitable physical fitness by proposing a fuzzy expert system (FES). The unique feature of FES is the employment of Malaysian food databases that designed for Asian people. FES is delivered on mobile web environment with an interactive graphical user interface.

Keywords: Calorie Tracking, Diet, Fitness Advisory, Fuzzy Expert System, Fuzzy Logic.

I INTRODUCTION
Malaysian nowadays tends to supply too much energy into their body system. Almost 60% of Malaysian aged 18 and above falls under overweight category (World Health Organization, 2013) whilst Azmi et al. (2009), stated that Malaysian adults aged 18-59 years have a serious and rising weight problem that will eventually relate to health problems. The Ministry of Health Malaysia (2010) also stated that 6 out of 100 Malaysians are diagnosed with diabetic related diseases. Many of them are unaware of their calories intake and lack of exercise thus lead to unhealthy lifestyle. Healthy lifestyle is not only depending on how frequent physical exercise is being done but it also concern on the daily food consumption. In general, people commonly do not know the exact amount of calories of the food intake in daily life and somehow exceeded the amount of energy that is needed for their own bodies. Calories are the unit measurement of energy for food that mainly contain carbohydrates, protein and fat (Zahri, 2008). Apart from “fueling up” the body (LearningSeed, 2008), food consumption is needed as it gains nutrition and keep the energy to sustain throughout daily activities. Study shows that, consuming high protein daily can increase feeling of fullness, reduce food intake, help maintain muscle mass and even help prevent weight regain (Weisenberger, 2014). Certain people eat according to the calories that they need per day but avoiding the exercises as suggested whilst other people exercise constantly but they are not taking the right meals and forgetting how their bodies need to balance with their physical activities. That is why obesity, diabetes and heart attack are no longer a shock nowadays because most of the people do not know the right way of using the systems to manage their calories, even though they know the consequences. Therefore, people tend to apply exercises without proper recommendations from reliable doctors or systems.

There are few commercial systems in the market such MyFitnessPal (http://goo.gl/2nLF), RunKeeper (http://goo.gl/FvH0) and Runtastic (http://goo.gl/4RLigK) are still lacking as these systems do not serve the right suggestion and not suitable to Asians people. These systems also do not have the features to indicate food intake and its consequences. The system focuses more on food calories usage and does not suggest ways to control the surplus and ignore the consumption of daily food. Considering the differences in diet taken and natural behavior among different populations, systems specifically for Asians or Malaysians are hardly found in the literatures. RunKeeper and Runtastic for example, primarily focused on the physical activities but do not calculate the rigorous amount of the calories needs to undergo the tiring sessions of exercises.

An expert, Mr Mohd Razali Salleh, from the Faculty of Sport Sciences, Universiti Technology MARA, has highlighted that there is a need to have a better system incorporates intelligent features that counts daily food consumptions based on the user profiles. Considering his comment and the limitation of the existing systems, we proposed this system that provides better features that able to advise users as well as making users aware on managing balance diet whilst having healthy lifestyle. This issue is also pointed out by Health Minister Datuk Seri Dr. Subramaniam, alerted that Malaysians consumed 500 and 700 calories extra daily and this could cause various health problems and chronic diseases (MalayMailOnline, 2013). The remainder of this paper is organised as follows. Section 2 reviews the related past studies. Section 3 presents the methodology and the techniques underlying the proposed system. Section 4 and 5 presents the results and discussion respectively.
Finally, the paper provides the conclusion and future work in section 6.

II RELATED STUDIES
Fuzzy logic is a mathematical discipline that can be used to reach the structure in which the behaviors are interpreted. The basis is formed by the ‘true’ and ‘false’ values and Fuzzy Set theory (FST) through which values in between either ‘partially true’, ‘partially false’ is determined. Fuzzy Expert System is based on knowledge or rule which lies into the fuzzy ‘if-then’ rules. Fuzzy expert system (FES) is one of the popular intelligent methods being employed nowadays that integrates the components of fuzzy logic and expert system. A study has been conducted by Allahverdi et al. (2007) on determining the alternatives to existing methods in treating the Coronary Heart Disease (CHD) risk. Researchers started with the alternative that is being presented for scenarios where larger numbers of rule antecedents were applied to the same rule consequent and the result indicated the value of the method. Researchers then used the Framingham risk scoring to assess the 10-years risk for CHD development. The Framingham calculation involved the age, total cholesterol, systolic blood pressure, treatment for hypertension and cigarette smoking. The system presented alternative results to the doctor promptly as the data of a patient were inputted to the system.

Another study of expert system for optimization of food consumption in intelligent home has been done by Seebauer (2011). The researcher focused on the fuzzy logic that involved the mathematical foundation as well as RETE algorithm to prioritize the order of evaluation of activated rules. The expert system worked in two different ways: monitor and diagnostic. In monitoring function, the expert system suggest the dishes in form of weighted list considering the actual content of food products whilst the diagnostic mode took the proposals on required food for selected dishes by using backward chaining chosen by the family favorable dishes.

III METHODOLOGY
A. Knowledge Acquisition
In order to further understand the formulation between fitness and food consumptions, an expert from the Faculty of Sport Sciences, Universiti Technology MARA, Mr Mohd Razali Salleh was interviewed. There are three important calculations: calories calculation, body mass calculation and physical fitness calculation. Calories calculation is the summation of all the food intake of the user (Eq. 1). The food and drinks calories will be stored in the local database according to the type of food or drinks, calories, carbohydrates, protein and fats.

Total calories consumed = Total calories + calories (foods and drinks)

In addition, the amount of calorie or Basal Metabolic Rate (BMR) is based on Ismail et al. (1998). The BMR is used in this system as it is suitable for Malaysian users and verified by the domain expert. The calculation is represented as shown in Figure 1. The prediction equation for BMR is the amount of the energy needed to sustain the daily activity according to the user personal details. Once BMR is calculated, the Total Daily Energy Expenditure (TDEE) is then calculated to gain the amount of energy of the user according to their daily routine lifestyle such as type of work and frequency of user’s physical activity. Next, the calculation of Physical Activity Level (PAL) of the users is resulted by dividing BMR with TDEE. All the three variables (BMR, TDEE, PAL) will produce the amount of excess calories consumed in the system which then be input by the user of the foods and drinks calories. The final calculations involve the suggested physical activities to burn the excess of calories that produce in the system; brisk walking, running and cycling. The excess of calories are gained from the exceeded amount of meal intake from the user according to the total calories needed.

![Figure 1: Prediction Calculation of Basal Metabolic Rate Adopted from Ismail et al. (1998)](http://www.kmice.cms.net.my/)

The total of calories for each activity is different. Consequently, running required more energy than walking even though both activities are performed at the same speed (Cameron et al. 2004). Though running burns more calories than cycling, however cycling develop more on muscle-strength fitness and power (Baker, 2011). This is the reason why the
physical activity is scoped to brisk walking, running and cycling whilst to ensure that the physical activities are suitable for the target user. The equation of physical activities are adopted from (Baker, 2011; Cameron et al. 2004).

Figure 2: Total Daily Expenditure and Physical Activity Level Calculations

B. Knowledge Representation

The knowledge in this FES is signified by using IF-THEN rules. Sample of rules are shown in Figure 3.

<table>
<thead>
<tr>
<th>Rule</th>
<th>Condition</th>
<th>Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rule 1</td>
<td>IF gender is Male AND (Age &gt; 17) OR (Age &lt; 31) THEN BMR = (0.0550 * Weight + 2.480) * 239kcal</td>
<td></td>
</tr>
<tr>
<td>Rule 2</td>
<td>IF gender is Male AND (Age &gt; 30) OR (Age &lt; 61) THEN BMR = (0.0432 * Weight + 3.112) * 239kcal</td>
<td></td>
</tr>
<tr>
<td>Rule 3</td>
<td>IF gender is Female AND (Age &gt; 17) OR (Age &lt; 31) THEN BMR = (0.0535 * Weight + 1.994) * 239kcal</td>
<td></td>
</tr>
<tr>
<td>Rule 4</td>
<td>IF gender is Female AND (Age &gt; 30) OR (Age &lt; 61) THEN BMR = (0.0539 * Weight + 2.147) * 239kcal</td>
<td></td>
</tr>
<tr>
<td>Rule 5</td>
<td>IF daily activity is “extremely active”) THEN TDEE is (weight * 2.2 * 20)</td>
<td></td>
</tr>
</tbody>
</table>

Nth Rule

IF (calcPAL < 1.39)

IF (type is “value”)
RETURN calcPAL
ELSE
RETURN “Inactive”

Figure 3: Sample of Rules

C. Fuzzy Inference System

The Fuzzy inference will calculate the formulation in determining the physical activity level of the individual. The amount of fuzzy value hold to each physical activity level is distinguished from one to another. Thus, this fuzziness value needs to be countered as membership value. The crisp value is given by a logic that commonly uses one or two values; true or false. In this system, the physical activity level is determined by a fuzzy membership set which are sedentary, moderate, active, very active and extremely active. Each membership will have its own physical activity level value corresponding to the degree of membership. The crisp and fuzzy value is visualized in the graph as shown in Figure 4.

D. Case-based Reasoning

Apart from fuzzy inference, this system has another component for case-based reasoning (CBR). CBR is also a collection of rules that solve the problems by using the previous experience. By having this CBR approach, the integrity of the system will be much higher. The system will handle and solve the problem by using memory-based problem solving. CBR will be re-using the past experiences to solve the current situations. The enhancement of the CBR will make the system acts and performs human-like. One of the problems that CBR will counter is on suggesting the type of physical activity. It is common to say that an individual age below 40 years old still normally manage to perform an exercise such as running whilst individual age 40 years old and however, when the age is getting older, people are normally getting hard to burn their calories by running. Thus, this system will suggest the type of exercise to the user according to their age and capability. Moreover, the system will always keep track the user’s calories throughout the day. While the user input their meals, the system will calculate the balance of the calories needed daily by the user. Hence, if the user is in the range of senior citizen, the system will try to allocate the balance calories and suggest the suitable meal intake for the user. Several cases are selected and identified to be learnt by the system as norms of these cases are recommended by the expert. Thus, this human expertise guidance will inherit into the system and improve the capability of the system.
E. Graphical User Interface and System Requirements

The Graphical User Interface (GUI) of this system is mainly built in Web page and also available in mobile Web. This is to ensure that the system is user-friendly with the user that the user can interact with the system by using personal computer (or notebook) and smart devices platform (smartphones and tablets). Figure 5 and Figure 6 shows the interface of this FES.

The encoding process was done by using Hypertext Markup Language code (HTML), Hypertext Preprocessor code (PHP), Cascading Style Sheets code (CSS) and JavaScript code. Adobe Dreamweaver is the tool that is being used for encoding all the language code purposes. Personal notebook or desktop with an Intel(R) Core(TM) 2 Duo microprocessor or equivalent with a clock speed of at least 1.4 Giga Hertz with a Random Access Memory (RAM) capacity of at least 2 Giga Bytes. 10 Giga Bytes of free memory allocation disk drive. Minimum of Microsoft Windows 7 Home Premium Service Pack 1 32-bit Operating System, Adobe Dreamweaver CS6, DBManager Standard Edition 3.2.4, WampServer 2.1. FES has been tested on a set of users based on their age, gender, daily and physical activity. It is yet to be formally tested on the focus groups. This is the next phase that will be performed in the near future in ensuring the validity of the system.

IV RESULTS

This section presents the results of the FES by showing several snapshots of the FES screens. Input meal page as shown in Figure 7 allows the user to enter the food and drinks, amount per serving, amount of food finished, meal type and date. Amount per serving indicates that the total plate or food that the user consumed at one time whilst amount of food finished indicates that the amount of food that eaten by the user. This button allows the user to input the correct amount of calories whereby there are several users that normally did not finish all of their meal. The meal type indicates the time of the user consumed their meal whether it is in morning (breakfast), afternoon (lunch) or evening (dinner). Date is needed during this process because this information will be used to manage the history of user’s diary and to keep track of the consumption of...
the calories. Users are also allowed to enter meal which is not listed in the database as shown in Figure 8. The food input will be directly displayed in the table as guidance to the user as shown in Figure 9. Lastly, the user will need to submit their input and FES will calculate the amount of calories consumed. As an example, the total calorie consumed by the user is 2323.70 kcal whilst user’s daily calories need only 1975.43 kcal. This will result the excess of calories of the user throughout the day (as shown in Figure 10).

Following this result, FES will produce the total time or distance to perform physical activities as can be seen in Figure 11. There are three of types of physical activities which are brisk walking, running and cycling. These three activities will give the correspond amount of time or distance need to be taken for the selected exercise. Users can choose the one that fit their interest.

V DISCUSSION
This FES is developed to provide a better guideline for Asians users. The study considered four categories of users: on-diet person, diabetic, sportsmen and health aware group of users. FES only need some of the user’s particular information to be saved and users can start using the system to know the right amount of energy and calories their bodies’ need in order to maintain healthy and living ‘non-disease carriers’.
This FES system will automatically calculate the amount of calories needed by users as well and suggesting three main physical activities that are brisk-walking, running and cycling. This system does not advise users to get rid of all the calories they have taken in daily life but it ensures that the calories and energy needs are suffice enough for the users bodies’ to maintain in healthy lives. Since it can be used in mobile platform such as mobile smart phones and tablets, it can be used as guidance anywhere and anytime users favor. The system was tested on variety of users groups according to their age, gender, daily activities and physical activity level. This is to certify that the system is applicable to every single individual.

The formula for calories consumptions are based on Asian people with a wide variety of Malaysian food. Future enhancement would include more responsive menu and to include more physical activities other than brisk walking, running and cycling.

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REFERENCES


VI CONCLUSION

FES was developed to help users in tracking the calories that they have taken per day and applying the suggested physical activities to burn back the calories.