MYHEALTHYKIDS: INTELLIGENT OBESITY INTERVENTION SYSTEM FOR PRIMARY SCHOOL CHILDREN

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ABSTRACT

Sedentary lifestyles and unhealthy diet are the main reasons of childhood obesity. This paper presents MyHealthyKids: Intelligent Web-mobile Children Obesity Intervention System for Primary School to manage and reduce the problems. The main objective of the system is to prevent and to reduce childhood obesity cases that are currently increasing in primary schools in Malaysia. MyHealthyKids consists of three main modules: obesity prediction, children persuasive and recipe suggestion module. The Naïve Bayes is used to predict whether the children are prone to be obese; the persuasive technology is used to encourage the children to participate in physical activities and change their eating habits; and the knowledge-based system is used to suggest a suitable menu for canteen operators in order for them to prepare healthy food for school children. Preliminary test has shown that the system has 73.3% accuracy for prediction and gets good feedback from the children.

KEYWORDS

Childhood obesity, obesity prediction, persuasive technology, obesity intervention, web-mobile technology.

1 INTRODUCTION

Childhood obesity is a chronic disease that is growing at an alarming rate. Sedentary lifestyles and unhealthy diets are the main causes that lead to childhood obesity. Seeing the success of computer and mobile phone technology in getting children's attention, web-mobile technology can be used as a tool in the effort of reducing childhood obesity. Therefore, a web-mobile application is developed for children, parents, and the canteen operators of primary school so that each of them can play their roles in reducing obesity among school children.

This system will use the data mining techniques to predict childhood obesity and categorize them into either underweight, normal, overweight, or obese. Furthermore, the system will suggest the suitable meal sets for each category to the canteen operators so that they can provide the suitable meals to the particular group of children. For the purpose of attracting the children to be more active and leading them to healthy eating behavior, the system used persuasive technology through audio, visual and animation.

The objectives of the system are:

- To predict which child is likely to be obese and need serious prevention measures by using prediction algorithm.
- To instill health consciousness on diet and healthy lifestyle to fight off obesity from the root of this problem by using persuasive technology.
- To provide a convenient way for canteen operators to acquire healthy recipes that is suitable for the children.

The next section of this paper will discuss the system functional requirements. Section III will propose the system architecture and the detail requirement of the system. Section IV will cover system testing and system evaluation and followed by discussion and conclusion section.

2 SYSTEM FUNCTIONAL REQUIREMENTS

The functional requirements for MyHealthyKids are shown in Table 1 below.

Table 1. Functional Requirements Specification

Module	Functional Requirements
Obesity Prediction	This module provides a set of questionnaires to the parent to get information of the children for predictions. The prediction will use the data mining techniques.
Children Persuasive	This module uses the persuasive methods such as friendly competition and physical activities based games to encourage children to exercise more and change their eating habits. The physical activities that suggested by the system are suitable for the children according to their personalities.
Recipe Suggestion	This module prepares and generates recipes that can help canteen operator to prepare healthy menu. The generated menu will clearly state the required ingredient, method of cooking and calorie level. The menu can be classified into the main course, dessert and drinks.

3 SYSTEM ARCHITECTURE

Fig. 1 shows the proposed system architecture for MyHelthyKids. Basically, the system consists of 3 modules. They are obesity prediction module, children persuasive module, and recipe suggestion module. The following sections will describe each of the system components in details.

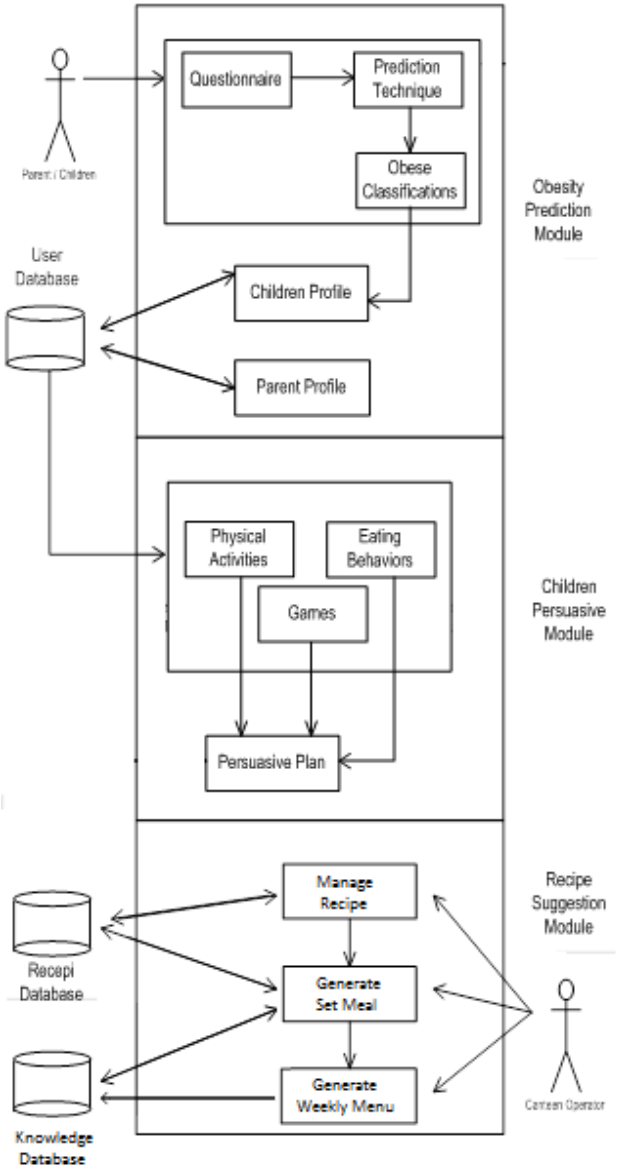

Fig. 1. System Architecture of MyHealthyKids.

3.1 Obesity Prediction Module

There are various types of data mining techniques that have been applied to childhood obesity prediction. The techniques that are widely used are Artificial Neural Network (ANN), Naïve Bayes, and decision tree [1]. ANN is widely used in the prediction and classification due to its advantages of high tolerance to noise and the ability to classify the uncertain input [2]. Applications that are using ANN technique are predicting outcome, diagnosis, and decision making systems [3, 4, 5].

A Naïve Bayesian is probabilities classifications based on Bayes' theorem with a directed graph where the nodes represent the attributes and arcs represent attribute dependency [1, 6]. The Naïve Bayes has been used in medical applications such as skin disease detection and biometric recognition [7, 2]. The strengths of the Naïve Bayes are; it is accurate when samples attributes are independent, simple and computationally efficient, and very suitable for high dimensional inputs. Based on the study of the data mining techniques, the Naïve Bayes was chosen to be applied in the childhood obesity prediction.

The objective of the obesity prediction module is to predict which weight category the child belongs to. The categories include underweight, normal, overweight, and obese. The main components of this module are shown in Fig. 2.

Fig. 2. Obesity Prediction Module

The obesity prediction module consists of questionnaires which include the parents and children's profiles, obesity classification, and prediction technique. The questionnaire is filled by the parents. The main purpose of the questionnaire is to get the information of the children that related to the obesity risk factors so that the system can predict the obesity category of the children. The risk factors that determine the obesity level are categorized as within family, child early birth condition, children activity, and children's nutrition intake. Family risk factors include parental obesity and sibling obesity while the child early condition included birth weight, duration of breastfeeding, and premature birth. The children activity risk factors included sedentary lifestyle and physical activity. On the other hand, the nutrition risk factors included quantities of the nutrition, junk foods, carbonated drinks and fast foods taken by the children.

The children and parents profiles consist of basic information; such name, age, weight, height, and gender. The children profile also stores the result of the obesity category and personality of that particular child.

The obesity classification consists of underweight, normal, overweight and obese categories that are categorized using the calculation of the Naïve Bayes. The Naïve Bayes predicts by calculating the probability of a sample to belong each class. The formula that applied in this system is as follows [8]:

$$P(X|C) = (\text{Number of C samples/ Number of total samples}) * L \quad (1)$$

where P(X|C) is the posterior probability that sample X belongs to class C and L is the risk or probability that each samples belong to class C.

The data are collected from the parent by filling the questionnaires and the probability of each risk factor is calculated by using equation 3. The probabilities of each of the risk factors are calculated. The category of the obesity of the child is determined by multiplying all of the probabilities of the answer (risk factors) that filled in the questionnaires and the highest result will be the obesity category of the child.

3.2 Children Persuasive Module

There are many types of techniques in the persuasive technology that were used to increase physical activities and change the eating habits of the children. There are Encourage Friendly Competition (EFC) and Physical Activities Based Games (PABG) to increase the physical activities among the children [9, 10]. Persuasive games are used to improve children dietary behaviors [11].

EFC is used to motivate children to exercise more or increase the physical activities by comparing the personal fitness information with others [9]. Competitor can act as a catalyst to motivate the person to take part in the physical activities as most people have the desire to win. The weakness of this technique is that if the competitors do not have impetus to participate in this competition, then the technique will not produce any distinct result.

PABG is the approach that is used to increase the enthusiasm to increase the physical activities by playing games [11]. The games will encourage the user to exercise more to enable them to play the next stages of the games. The strengths of this technique are it can increase the motivation to continue physical activity routines and can be played anywhere. The weakness of this technique is that it must use certain hardware such as a sensor.

The third technique is the Persuasive Games (PG). PG is used to encourage health dietary behavior by changing unhealthy eating behavior [11]. The games can assist parents or counselor in encouraging healthy dietary behaviors of the children [11]. The strengths of this technique are parents can change the verbal persuasions into persuasive games and make the communication between them and their children more pleasant. The weakness of this technique is the parent may need to accompany their child when playing the games to make sure that their child follows the instructions in the games and give rewards.

After having evaluated the strengths and weaknesses of these techniques, PG and PABG were chosen. The persuasive games might be the most effective technique for children because most children love to play games. Moreover, they can gain a lot of nutrition information while playing the games. The objective of this module is to develop a persuasive plan to persuade the children to increase their physical activities and changing their eating behaviors. The components in this module are shown in Fig. 3. This persuasive plan component consists of three sub-components: games, physical activities and healthy eating behaviors as shown in Fig. 3.

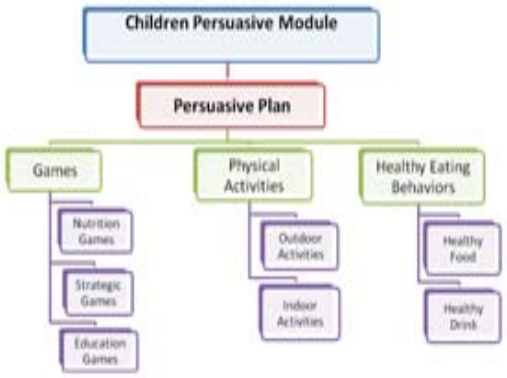

Fig. 3. Persuasive Module

The games sub-component consist three types of games that are nutrition games, strategic games and education games. The nutrition game is the game that provides the basic nutritional information about healthy food. The strategic game requires the children to think how to solve the situation in the game. The education game educates the children about healthy foods while playing.

Physical activities sub-component consists two types of activities which are outdoor and indoor activities. Few examples of outdoor activity are jogging, swimming and cycling and indoor activities are dancing and doing aerobics. Healthy Eating Behaviors sub-component consists two types of eating behaviors that advice the children about healthy food and drinks based on their obesity category.

3.3 Recipe Suggestion Module

The objective of this module is to generate daily and weekly menu for canteen operators. In the recipe suggestion module, there are 3 main components (Fig. 4).

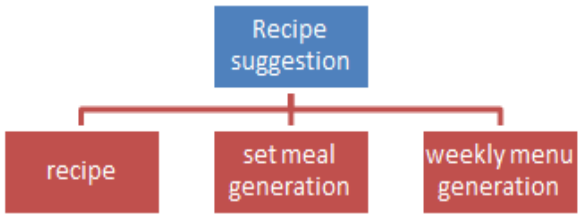

Fig. 4. Recipe Suggestion Module

The recipe can be classified into 3 types: main course, drink, and dessert and it contains essential information such as the ingredient, cooking method, and nutrition value. The module is developed using Case-based reasoning (CBR) and Rule-based Reasoning (RBR) techniques.

At first, the CBR module will select the best case in the database. Then, the RBR module is applied to select suitable dishes according to the child requirement [11]. A set of rules has to be created to ensure random recipes that can build up a set menu that is within the calorie level. Then, the CBR can play a role as a knowledge base to display relevant sets of menu that were previously generated when similar query was requested.

There are 5 classes of the set menu. Each has different range of calorie levels that are suitable for different weight of children. In order to have various sets of menu, the recipe will be randomly selected and combined to become a set. If there is no similar case, the system will use RBR to generate a different set of meals. The primary school children need around 1200 – 2400 calories daily [1]. Thus, we classified five cases and calculate the average daily caloric intake for 3 meals a day as shown in Table 2.

Table 2. Calorie level

Daily Calorie intake	Average calorie
1000 – 1300 calories	333 – 433 calories
1300 – 1600 calories	433 – 533 calories
1600 – 1900 calories	533 – 633 calories
1900 – 2200 calories	633 – 733 calories
2200 – 2400 calories	733 – 800 calories

The system will use the rule base to generate a case if no similar case was found. If the case requires low calories, then high calorie food will be eliminated. Then, a food will be randomly picked from the shortlisted recipe to become the main course of the menu. Once the main course is set, the system will choose a suitable drink using the similar rule followed by a fruit with the calorie level within the remaining calories point. Each set that was generated are stored into the database.

In the weekly menu generation, it will use the CBR to find a suitable case from the knowledge base. The system will choose five different levels of meal sets every day in a week. For example, five sets are chosen for Monday with a different level of calorie.

4 SYSTEM TESTING AND EVALUATION

This section discusses the testing strategy and evaluation of each module in the system.

4.1 Obesity Prediction Module

Fifteen parents aged 26 to 48 years old were invited to test the prediction module in the system. The parents were asked to fill in the questionnaires to obtain the information of their child at age 3 to 5 years old. Then, the system will predict the weight category of the child based on the information. The results of the prediction are compared to the child`s current weight category (the children age are between 7 to 10 years old). If the result matches, the prediction in the system is correct or vice versa. Table 3 shows the result of predictions of 15 cases. The results show that the prediction is 73.3% accurate.

Table 3. Prediction Results

No	Past Condition	Predict Condition	Current Condition	Match (Yes/No)
1	obese	obese	obese	Yes
2	obese	obese	obese	Yes
3	normal	overweight	overweight	Yes
4	overweight	normal	normal	Yes
5	underweight	normal	underweight	No
6	normal	normal	normal	Yes
7	normal	normal	normal	Yes
8	overweight	obese	normal	No
9	underweight	normal	normal	Yes
10	normal	overweight	overweight	Yes
11	normal	overweight	underweight	No
12	normal	overweight	overweight	Yes
13	obese	obese	obese	Yes
14	overweight	obese	obese	Yes
15	normal	overweight	normal	No

4.2 Children Persuasive Module

The module design different persuasive plans for children that have obesity and underweight problems. The persuasive plan is a weekly plan that suggests physical activities and healthy eating behaviors (tasks) for the children to follow and complete them within a week. The system will provide games for the children to play as a reward if the children successfully complete the required tasks.

In order to evaluate the effectiveness of the persuasive plan, 30 children from different backgrounds who have the obese or overweight problem were invited to test our system. Based on the feedbacks from the children that we obtain by giving them questionnaires, we identify that 20 out of the 30 children felt that the system interfaces are interesting and attract them to continue to explore the system. Twenty children from twenty five that are obese felt that the games are very attractive as a reward for completing the tasks. Basically, 20 out of the 25 children felt that the persuasive plan has successfully persuaded them to exercise, improved their eating behaviors, and helped them to control their weight.

4.3 Recipe Suggestion Module

There are 3 components in this module: list of recipe, set meal generation, and weekly menu generation. The recipe module extracts the data from the database. A few set of menu are generated to test whether the system produces accurate results. The total calorie level of the menu sets are checked if it is within the required calorie level. The weekly menu generation is supposed to generate 5 different sets of meal from different calorie level daily.

5 Discussion

The Naïve Bayes technique is able to provide high sensitivity and accuracy for the system prediction. However, it requires the assumption of attributes independencies [2]. In this practice, the attributes are independent [2]. The obesity classifications depend further that the physiological factors and involve the genetic, sociological and psychology. To obtain better results from predictions, more attributes or risk factors have to be considered.

The advantage of the children persuasive module is that it can generate persuasive plans for different weight category children. The persuasive plan also changed every week to avoid repetition. This module also encourages the parents to spent time with their children to monitor their progress. The strength of the children persuasive module in the system is that the persuasive plan may eventually succeeded in persuading the children who have the obese problem to control their weight.

The recipe generation module is aimed to generate set of recipe for children using the RBR and CBR techniques. Vast number of nutritious food data is needed for the module to generate various set of recipes.

6 CONCLUSION AND FUTURE WORK

Preliminary test on the MyHealthyKid shows that its accuracy of predicting childhood obesity is around 73.3%. Based on the feedbacks, the persuasive module was able to persuade and instill

healthy lifestyle habits in the mindset of the children, but with one assumption that all information given by the children is true. The recipe suggestion module was also able to generate different menus for the children.

For future work, the first part is to study more algorithms that can be implemented for prediction. The second part is to add a variety of persuasive games in the system with the aim to provide wider choices of games and better interactions such as collecting the gaming results and analyzing the results. The third part is to improve the recipe suggestion module by increasing the size of the food database and using other selection method such as the Genetic Algorithm.

7 ACKNOWLEDGEMENT

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