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A PERSONALIZED HEALTHY DIET RECOMMENDER SYSTEM

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ABSTRACT

Medical Studies have revealed that consumption of healthy foods help the body to fight against diseases. Food provides our body with essential nutrients needed by the body to sustain us for our day-to-day activities. It is also important to note that different people have different tastes, likes and dislikes on the choice of food to eat. It is therefore necessary to develop a method to provide every individual with meals of his choice, while ensuring that the correct proportion of nutrients are present in them. This paper addresses this problem by developing a diet recommender system. The system is made up of two parts: the first part provides content based diet recommendation while the second part uses Pearson Correlation Coefficient to compare food nutrients and recommend alternative food items, thus allowing users to make choices. The goal of the diet recommender system is to recommend a healthy and appropriate food quantity to users. Data of patients were collected from the Obafemi Awolowo University Teaching Hospitals Complex (OAUTHC), Ile-Ife, Osun State, and used to test the functionalities of the system. Standard metrics were also used to evaluate the performance of the system, with the results showing that the system is efficient in diet recommendation. The system could be used by dieticians in the hospitals to assist them in diet recommendation for patients and also in different homes to suggest varieties of meals to users.

Keywords: Nutrition, Pearson Correlation Coefficient, Recommender Systems

1. INTRODUCTION

Medical research has revealed that consumption of healthy foods help to build up the immune system and fight against diseases [1]. Food provides energy, vitamins, and other essential nutrients needed by the body to function properly and for sustenance for day-to-day activities. A healthy diet enhances body growth, promotes good mental function, boosts body beauty and promotes healthy long life.

According to [2], poor dietary lifestyle are key contributors in the development and progression of preventable chronic diseases, such as obesity, type 2 diabetes mellitus, hypertension, cardiovascular disease and several types of cancer. Nutrition therapy could be used to manage chronic diseases by managing the diet based on the belief that food provides vital medicine and helps to maintain a good health [3]. It is important to note that a healthy eating lifestyle helps to reach and maintain a healthy mind and body weight, lowers health risks, such as obesity, heart disease, type 2 diabetes, hypertension and cancer [4].

Based on the importance of diet for sustaining us for our day-to-day activities and disease management, this paper addresses the need for a system that is intensely tailored towards creating a seven day food time-table based on an individual's requirements and food preferences by implementing a content based filtering system that uses Euclidean Distance to recommend substitutes for food allergies or dislike. Also, because different people have different tastes, likes, dislike, challenge of deciding on what to eat from a range of alternatives, it addresses the use of

Pearson Correlation Coefficient for food nutrient comparison and alternative food recommendation.

2. MATERIALS AND METHODS

The developed system is made up of two parts: the first part provides content based diet recommendation and the second part provides alternative food recommendation.

2.1 Content based diet recommendation

The food table is provided by computing the Body Mass Index and Daily Required Energy (DRE). The DRE is computed using Broca index to get the ideal body weight (bw) and the Activity Level (AL) of the user. Broca index is a measure for ideal body weight [5]. DRE (kcal) is distributed into breakfast, lunch and dinner, so as to get the energy required that will be obtained from food for breakfast, lunch and dinner. The ratio 3:4:3, is used to divide the food to Proportion. It is important to eat more in the afternoon because the body is still active and energy in food eaten will not be converted to fat but can easily be expended by the body. The calculated calorie intake of the patient is further divided into macro food nutrient (carbohydrate, protein and fat) ratio because they provide the body with calories or energy

The developed system has a module for adding varieties of diet fixtures for users. It is a typical personalization system in which the foods recommended to users only vary based on the total Daily Required Energy (DRE). Hence, a seven-day food table plan recommended for users is filtered from the added diet fixtures based on users' diet history and allergies. Different sets of food items are selected and passed for diet ranking.

Diets recommended by the model are presented to users in a single interface with ranking done based on the favourite history of the user. This results in having foods that a user likes at the top of the list while those the user is allergic to or dislikes are at the bottom. In essence, diet ranking means sorting food combinations such that a user's favorite food item is among the top of the k recommendations in the seven-day plan and vice versa. Also, if a food allergy or dislike is by chance recommended, it is highlighted in the recommendation result, indicating that users can take substitutes of such food items if they want. Food substitutes are retrieved by determining the Euclidean distance between the allergic food and all other foods in the database found in the same category.

Let \widehat{Q} denote all food items in the database such that a food item is represented as \widehat{q}_A . If food items are represented by values of major constituents inherent in the food then, $\widehat{q}_A = q_1, q_2, \dots, q_N$ represents these constituents of a food item say allergic food A. Also if all other food items in the database found in the same category with the allergic food are given as $\widehat{q}_B, \widehat{q}_C, \dots, \widehat{q}_M$. Then, the Euclidean distance between food items \widehat{q}_A and \widehat{q}_B can be defined as Equation 1.

$$N_E(\widehat{q}_A, \widehat{q}_B) = \frac{1}{\sqrt{N}} \left(\sqrt{\sum_{j=1}^N |q_A^j - q_B^j|^2} \right) \dots \dots \dots (1)$$

Hence, the foods $\widehat{q}_B, \widehat{q}_C, \dots, \widehat{q}_M$ are sorted accordingly in an increasing order while the k-nearest are taken as substitutes. Finally, the weekly diet table is displayed for user.

2.2 Alternative food recommendation

Pearson Correlation Coefficient (PCC) is used for anonymous user diet recommendation. PCC is a measure of the strength of the linear relationship between two variables. PCC is used to find the group of food combination close to a set of food items. Let one dataset of food be x, where x

= {x₁, x₂, . . ., x_n} containing n nutrient values and another food dataset y = {y₁, y₂, . . ., y_n} containing n nutrient values. Pearson Correlation Coefficient (r) between x and y can be defined as:

$$r = r_{xy} = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^n (x_i - \bar{x})^2} \sqrt{\sum_{i=1}^n (y_i - \bar{y})^2}} \dots\dots\dots (2)$$

where \bar{x} is the mean of nutrient x_i and \bar{y} is the mean of all food items except x, r is the confidence value such that $0.5 \leq r \leq 0.95$. Two sets of food items correlate if they have a high confidence value.

3 RESULTS AND DISCUSSION

The system was evaluated with information of 30 patients obtained from Obafemi Awolowo University Teaching Hospital Complex (OAUTHC), Ile-Ife, (Nigeria). The Daily Required Energy (DRE) in kcal is computed by the system using the user's body weight, Body Mass Index (BMI), and the user's activity level.

Table 1. Breakdown of DRE into breakfast, lunch and dinner

QUANTIFICATION OF FOOD-PER-DAY (DRE) IN KCAL		
Breakfast Proportion	Lunch Proportion	Dinner Proportion
435 KCal	580 KCal	435 KCal

Real life measurements are usually in grams, hence, the macro nutrients values are converted to grams for easy measurement.

Table 2. Gram equivalence of macro food nutrients

GRAM EQUIVALENCE OF FOOD NUTRIENT			
Macro Food Nutrient	Carbohydrate	Protein	Fat
Breakfast	59.8 g	27.2 g	9.7 g
Lunch	79.8 g	36.3 g	12.9
Dinner	59.8 g	27.2 g	9.7 g

The personalized healthy diet recommender system formulates a seven day meal table by considering the user's food preferences. Hence, a seven day meal plan recommended to a user is shown in Table 3.

Table 3. The result of a seven day meal plan for a user.

DAY	PERIOD	FOOD COMBINATION
SUNDAY	BREAKFAST	CORNFLAKES + MILK
	LUNCH	POUNDED YAM + VEGETABLE + CHICKEN + WATER MELON
	DINNER	PAP + AKARA
MONDAY	BREAKFAST	BREAD + FISH STEW + TEA
	LUNCH	WHEAT + MEAT + EWEDU + PINEAPPLE
	DINNER	BOILED POTATO + FRIED EGG
TUESDAY	BREAKFAST	QUAKER OATS + MILK
	LUNCH	FUFU + OKRO + MELON + ORANGE + FISH
	DINNER	PAP + VEGETABLE + FISH
WEDNESDAY	BREAKFAST	BEANS POTTAGE + PLANTAIN
	LUNCH	EBA + VEGETABLE + BEEF + BANANA
	DINNER	YAM POTTAGE + VEGETABLE + BEEF
THURSDAY	BREAKFAST	FRIED RICE + PLANTAIN + CHICKEN
	LUNCH	SEMO + UGWU WITH MELON + FISH + WATER MELON
	DINNER	QUAKER OATS + MILK
FRIDAY	BREAKFAST	PAP + MOIN MOIN
	LUNCH	AMALA + EWEDU + FISH
	DINNER	RICE + FISH + ORANGE + VEGETABLE
SATURDAY	BREAKFAST	BOILED PLANTAIN + VEGETABLE + BEEF
	LUNCH	JOLLOF RICE + FISH + APPLE
	DINNER	BEANS POTTAGE + BOILED YAM

The shaded part of Table 3 shows the food item disliked by the user. The personalized healthy diet recommender system uses Euclidean distance to sort food in an increasing order while the k-nearest are taken as substitute. This is represented in Table 4.

Table 4. Food allergy or dislike and recommended substitutes

Food Allergy or Dislike	Food Substitute
Chicken	Beef Fish Stock fish Dried Fish

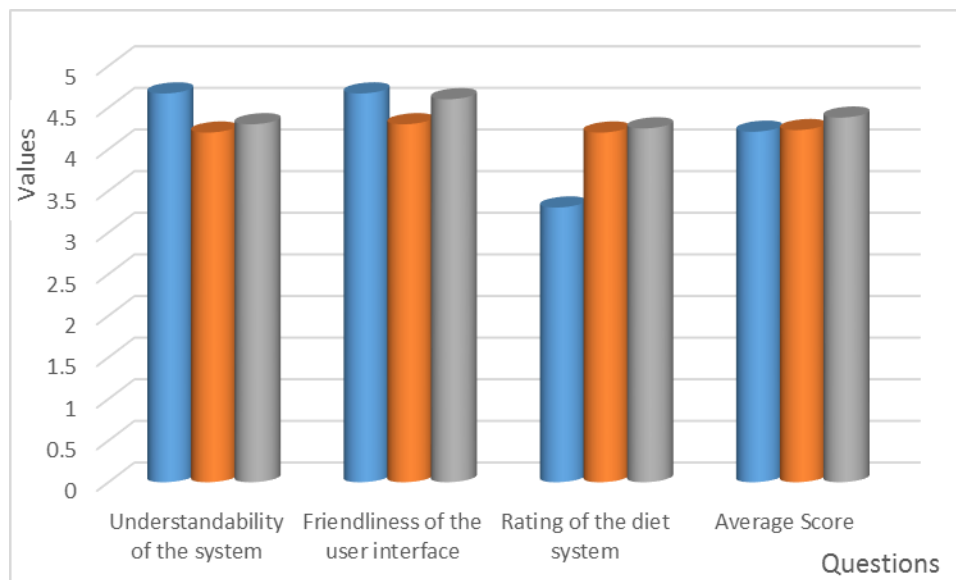
The diet recommender system recommends alternative food combinations by comparing food nutrients to find sets of food items close in nutrient. Pearson Correlation Coefficient was used to find the strength of the relationship among the food. For a selected combination, for instance, Amala + Ewedu + Meat + Orange, the algorithm compares each food with foods found in the same domain.

Table 5. Result of food nutrient comparison

DAY	FOOD COMBINATION	MACRO NUTRIENT			CONFIDENCE VALUE
		CHO	PRT	FAT	
1	Eba	20	3	0	0.881
	Meat	0	7	5	
	Carrot	5.61	1	0.3	
	Boiled pumpkin vegetable	1.4	0.2	0	
2	Pounded yam	20	3	0	0.835
	Smoked Fish	0	7	1	
	Boiled pumpkin vegetable	1.4	0.2	0	

The confidence value shows the relationship that exist among a set of food items. The closer the confidence value is to 1, the more related the sets of food. The confidence value in Table 5 shows the foods are well related as their values are close to one

The personalized healthy diet recommender system was evaluated by nutritionists. The result was compared with the result of evaluation from [6] and [7] in Figure 1.

*Fig. 1. Comparative Analysis of existing works by Nutritionist*

The result shows that the developed system is more accurate and efficient with an average score of 4.38. Hence, the proposed system is very efficient in diet recommendation.

4. CONCLUSION

Good food helps to improve body growth, boosts the immune system by preventing diseases and infections, promotes good mental function, enhances body beauty and promotes healthy long life. A personalized healthy diet recommender system that considers an individual's daily energy requirement in order to maintain a healthy weight and reduce the risk of chronic diseases has been developed by considering the food preferences of the user. Standard metrics were also used to evaluate the performance of the system, with the results showing that the system is efficient in

diet recommendation. The system could be used by dieticians in the hospitals to assist them in diet recommendation for patients and also in different homes to suggest varieties of meals to users.

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