Meal Preparation Algorithm for Diabetic Patients Using Machine Learning

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Abstract

With the rapid development of society, people's life became more complicated therefore they have no more time to pay attention to their food patterns and healthy habits. As a result, many people suffer from non-communicable diseases such as diabetes, pressure, and cholesterol. Therefore, this proposed system basically considers the type 2 diabetic patient and as the main aim, the system creates three meal plans with evening snacks for users using the proposed algorithm. In addition, the system provides patients' daily active habit monitoring system, and the final output of this system is developed as an android mobile application to introduce the product to the market, it has been named U-HEALTH. For the meal plan generating algorithms process, have been used the Random Forest and K-Nearest Neighbours (KNN) machine learning algorithms. And the food data set has been created for Sri Lankan food style to generate the algorithm and KNN was used to classify the process of the food data set and the Random Forest was used to create the decision of the meal plan preparation, meal preparation decision tree accuracy is 84.33% when comparing with other meal preparation models[3], this algorithm generates three main meals with evening snacks for the diabetic patient, the decision tree has been created based on the user-health fact, food adoration, food allergy, nutrition content, gender, age, and users BMI, BMR counts are used as K value in KNN algorithm to the food classification process.

Keywords: Decision Tree, Diabatic Patient, Food Scanning, Health Monitoring System, K-Nearest Neighbour algorithm (KNN).

1   Introduction

Diabetes can be called a chronic and non-communicable disease that happened when the pancreas not able to is to make enough insulin count according to the needs of the body. Insulin is a hormone made by the pancreas. To do daily work, humans need the energy that is provided by insulin, in other words, insulin's main duty is the convert blood glucose to energy. All sugar including food makes glucose also, all carbohydrate foods have starch, which is finally broken down into glucose that all glucose transfers to the blood and store as blood glucose. Insulin helps glucose get into the cell by converting it into energy.

But chronic cannot make enough insulin so glucose does not convert energy and the glucose level of the blood gradually increase. that cause to happen diabetes and as a side effect causes the failure of various organs and tissues.

Due to that level of increase in glucose happened diabetes, diabetes also can be divided as mainly three categories type 1, type 2, and Gestational diabetes (GDM). Type 1 happens through a combination of genetic and environmental conditions. Control type 1 needs drugs or insulin and this has no age limit, and type 2 diabetes happened bad health and food habit that can control by converting a healthy lifestyle without drugs and insulin. but

worse case control needs drugs or insulin, type 2 happened a lot of times in 90% of adult people. Gestational diabetes (GDM) happened during pregnancy time and can be occurred both the child and the mother, after pregnancy that disappears from the mother but some risk having their child to happen type 2 diabetes.

The A1C test in other word tell haemoglobin A1C (HbA1c) is the most famous test used to measure the blood sugar level of the patient over the past three-month time duration and according to that A1C count patient can be categorized as having Normal (A1C Below 5.7%), Prediabetes (A1C 5.7% to 6.4%) and Diabetes (A1C 6.5% or above). Here basically, consider type 2 diabetic patients.

According to the facts and figures on Diabetes in the International Diabetic Federation (IDF), approximately 537 million adults under 20-79 years suffer from diabetic disease. The bad situation is that this age range is categorised under the labour contribution of the world.

The proposed system has the basic aim of fulfilling patients' food and health need and giving health maintenance guidance to the patient under their dietitians. Also, the patient can provide their details through this application without any fearing. Because this has a good security system. Also, there are three categories on this application those are health summary, Calorie Monitoring,

and preparing meal plans. Taking the daily summary part, the patients can get an idea about their daily health summary and how many calories are burned per day, and the user can achieve their daily goal. And all these recodes are saved on the system database and every month-end application sent the patient summary reports to their dietitians. The calorie monitoring section is another one and this section show the calories burn count per day according to the goal. The goal is set by the dietitian considering the BMI count and BMR of the patients also, the calorie goal-setting part has not been allowed for the patients. The calorie burn count is calculated by step counting and these parameters are calculated according to standard details. The third one is Preparing the Meal Plan, this is the basic part of this application, and the proposed system research core is considered in this part. Because type 2 diabetic patient health is dependent on their taken food pattern and their health activities. And the system gives a ready-made three different meal plan with evening snacks for patients according to the algorithm output. When creating the algorithm that makes the decision tree and that decision tree has been generated considering this categorise those are patient's food likeness, BMI count of the patient, nutrition facts, patient age, health fitness, gender and according to food allergies facts and data set.

To create the meal-preparing algorithm here used the self-made food data set according to the Sri Lankan Food Culture for that firstly food data was gathered from the Kaggle site. And secondly, the data set cleaning and preparation process was done using Azure Machine Learning Tool by considering food nutrition facts, sugar count and carbohydrate level and finally removing the missing data of the data set. After doing that process now has low sugar and low carbohydrate content including food data set as the final output, as the second step by considering nutrition facts and Sri Lankan food style this data set categorize under sixth categories as Breakfast, Morning Beverage, Lunch, Evening Snack, Evening Beverage, and Dinner. For this categorisation purpose generate has been used the KNN algorithm has and as the K value was used the nutrition fact and Sri category Styles. Using the second step categorising data sets and considering patients' health details as input thirdly generate the decision tree using the random forest algorithm, as the result of the decision tree provides three main meals with an evening snack as a diet plan for the patients. Considering the accuracy, KNN provides an 84.33% of accuracy level and the Decision tree provide a 72% accuracy level compare with other meal preparation system [3][6][13][14][15].

The rest of the paper discusses the related work, technologies, methodology and results that were used to develop the system and meal preparation algorithm.
.

2   Related Work

People are not more careful about their eating food items and their content ingredients therefore, this android base wearable implementation considered the food, and it is contained nutrition compounds to monitor and identification of health according to the recommended calorie count for a day. For doing this calorie count process system is used as a food identification method. The process of that happened, as first step, should be to recognize the food and then extract the feature by mining text, the next classification of the food and according to the classification of food nutrition is database loads the nutrition count for the relevant food. This process's main task is categorizing and labelling the foods. Also, the freshness of foods determines the level of the nutrition count [1]. This system's main aspect prevents the treatment process of the obesity level patient and introduces a healthy and good food pattern to the users. That has calories assuming framework. If some user has permitted calorie intake this help users track the food and maintain that permitted level of calories. For food recognition, this system has used the Naive Bayes training mechanism and the classification this system has used the machine learning classification technique under the cloud base environment. Also, this system checks the freshness of the fruits, and that system provides high accuracy and data processing than their previous system. And this system process can calculate the calorie rate of liquid and mixed foods [2]. To make the automated accurate classification method for the fruits, this research introduced the technique and the testing process for increasing the data set accuracy for the two types of data sets. To develop this classification process as a first step, take the two different data sets the first one is the public data set and the other one is the self-made data set. The public data sets have included fruit images and their background, and the self-made food image is used in the comprehensive environment. Under the convolutional neural network of food processing, here has been tested several experiments by changing input parameters until getting the highest average of classification accuracy which is 99.8% for the public data set. The self-made data set classification accuracy is 90.2%. after doing several improvements to the self-made classification it has increased up to 98.9% by adopting the proposed techniques of data enhancement. [13]. This system provides the framework is the sub-task framework that identifies the ingredient of the food that scan. That system has encoded and decoded two branches and provides food information to the user as text and images. And yummy-28 provides as a result set, the final out of this framework better than the previous similar one [4]. An Image super-resolution algorithm proposed by this paper and this algorithm combined with deep learning and wavelet transformation. It was network designing and the information captured by the more effectively. And that details compared with other neural networks, parallelly training the different models by using process cross-connection and residual learning techniques. The result shows the better achievement of this system by comparing other systems [5]. The proposed system was developed for the buying persons, because when they buy a wholesale fruit. They had to check the product externally of the product and when checking all the product set one by one is a huge process. Therefore, this system introduces the quality checking conveyor belt. For the process, developers had to train the data set for that process

here has used Convolutional neural network algorithms are used to analyse the colour, size, and texture of the fruits. CNN edges are used to identify the shapes of the fruits. This paper result sorting the apple according to their quality [6]. Low cost and rapid approach and this used to automatically identify calories and dietary of the food, a lot of applications are developed the identify one food by using the image classification technique, but this system identifies the hyperspectral food such as food plat. Also, this can be used to identify the plat of cooked food that are in various types. In the identification process of hyperspectral food, the system uses a large frequency spectrum of the food, and the food data are collected under a controlled illumination environment and classified using the support vector machine and logistic regression algorithms [7]. Deep convolution neural network-based diet tracking system. Most diet tracking system tracks solid-type foods only by using single-tasking, but the proposed system can track drink-type thing. The drink has all the stuff as bend type, and it is a difficult process to identify the type of food. For that process use the two structured layers that are the hierarchical multitask learning framework and the similar task layer. Using that framework has two main tasks, one is classifier the drink as sugar level and the other one is classified as an alcoholic drink, furthermore, has six auxiliary tasks such as task, shape logo, brand, container, and material. This is used to classify precision with single and baseline multitasking learning [8]. Develop an IOS-based application for food recognition application using one of the deep learning approaches of convolution neural network (CNN). The trained data set system is used to model pre-trained Google InceptionV3 and can be achieved an accuracy level is 82.03% T [9]. A lot of applications can recognize food by image processing, but this implemented mobile application is used to develop that use convolutional neural network (CNN) for the classification process. And application the degree of maturity levels is defined as fruits: red apple, green apple, banana, orange, and strawberry. Here use two images set for the process and the data argument technique is used to train the data [10]. To maintain healthy eating habits this system developed a food diary. to develop healthy eating habits, in the food image recognizing process, before recognizing that we had to identify and classify the food image. For this process, the developers had to keep images in to identify the food. A solution to this system design is an application for image reorganization using convolution neural network algorithms for the data set [11]. The proposed system is used to find quality products that are in pollution-free areas. Because depending on the soil, and the fertility of the land. Therefore, this application detects the pest and context of fruit crops that are classified using image processing. This system proposed the data argument for increasing the data set to prevent over-filtering and improve the deep neural networking rate [12].

3 Summary of the Technology

This part is covered by introducing the technologies that are used to create the system. The proposed android application has used android studio and the proposed meal-preparing algorithms were created by using the user insert data the and data set offered data. And as the technologies, there have been used the KNN algorithm and the Random Forest algorithms as below mentioned.

3.1 Dataset

The basic data is gotten from Kaggle sites, using that data sets to create self-made data sets for meal preparation that fit with the Sri Lankan food styles. For that purpose, need to do and data cleansing and clarification process of the dataset. The data cleansing part is done by using the azure machine learning Tool.

3.2 K-Nearest Neighbour algorithm (KNN)

The KNN is the supervised learning algorithm used for classification and Regression problem solving but the mostly used for the data classification problem in this system KKN was used to classifier food data as Morning, Lunch, Evening and Dinner of the self-made data set. The algorithm prediction is used based on the value their K values. The Calories, Sugar level, Fiber content of food, Veg-Nonveg-vegan behaviour, and Allergies (egg, nuts, beef, glutton, lactose) of the food are used to K values for the self-made data classification process. The main reason for using this algorithm is when the prediction count is increased the algorithm curve becomes so smooth another reason is when using KNN no need to train the model and no need to provide assumptions when comparing with other classification algorithms and also this one quickly adapt to the changes of the data set, the main limitation is that is not dealing with a missing value for that reason before making classification process, the data set was cleaned by using Azure machine learning tool.

3.3 Random Forest Algorithm

The Basic reason for using this algorithm to make a decision tree which has not want a well-prepared data set, is because here used data set is a self-made dataset and sometimes that has some preparation issues, another thing is that the proposed algorithm can deal with numeric and categorized data, these type of the data has on this data set and this algorithm can be used in the actual environment also, in addition to that random forest algorithm has capable to work with metadata, eventually final decision tree accuracy level is 84.33%. And the here proposed system has a small decision tree but when using the huge one it may have an overfitting problem.

The hardware resources were a computer or Laptop (More than 4GB RAM), Internet Router, and Mobile phone (Android Version 5 or Up Version)

Android Studio, Firebase Database (for keeping Patient Data), Python (PyCharm and Jupyter Notebook), Google Colab and Azure Machine Learning tool were the software resources that were used to develop the proposed system.

4   Methodology

In the data gathering process, the target population is diabetic patients in the Colombo area of Sri Lanka and the sample frame is the diabetic patient who is using an android mobile phone in android version 5 (lollipop) or up version. Also, the sample size is people who registered in the database which means users who can log in to our proposed system. This proposed research is done under the non-probability sampling technique. Those are convenience sampling techniques for dietitians and judgmental sampling techniques for patients. According to those techniques, data gathering by giving surveys and interview questions for the target population.

The data gathered data is stored for health analysing of diabetic patients on the real-time database (Firebase).

(Fig. 1) shows the system overview diagram and the proposed diagram all things happened according to that overview.
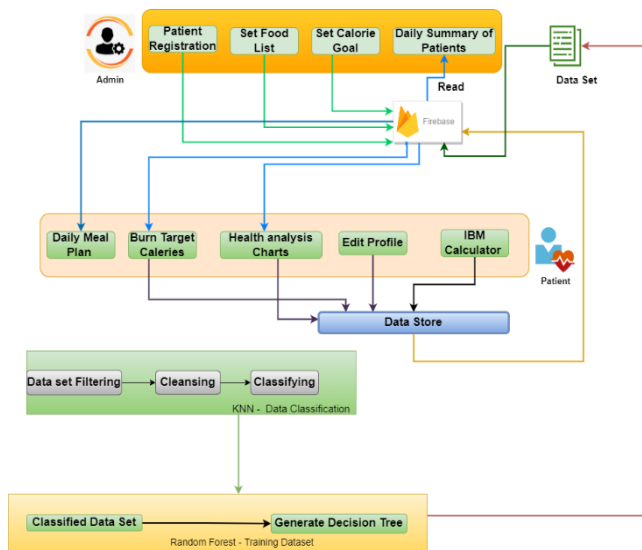

Fig. 1. System Overview Diagram.

The proposed Android application prepare a meal plan and count step and check the heartbeat for that purpose accelerometer hardware sensor is used to get the count he steps counting and the camera sensor is used to get the heartbeat rate to get the heartbeat-measuring to users, they have to cover the back camera by their finger then heat beat counter shows the current heartbeat of the user. And,

according to the step-counting data, the application generate the calories burn count.

Using the formula, the person who has 70kg weight and height 6 feet with an average 4.8 km/h speed every 1000 step burn 400kcal calories count.

The proposed algorithm to prepare a meal plan considers the gender, weight, height, type of activeness, BMI, BRM count of the people and food favourites, and food allergies of the food for patients. And the foods that are used to prepare a meal plan as breakfast or lunch that cannot be repeatable for dinner in one day. Here also consider the variation of the food picking pattern of each three main meals.

5   Results

(Fig. 2) has been shown proposed mobile system graphical user interface designing and that can be used to get an idea about how to work the proposed system that system provides an idea to the user how many calories are burned per day and another thing is the record calories count cannot change by the patient and that are defined by their dietitian by considering health and fitness level of the patient.

Also, this system provides a meal plan displayer, which is the main aim of the system, and the meal plan was generated by the proposed algorithm.
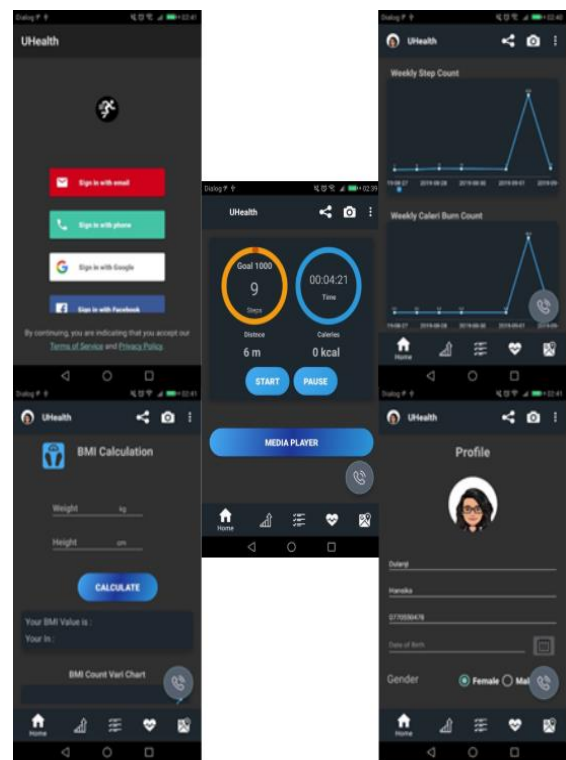

Fig. 2. GUI of the proposed android app

When making the algorithm has been used the two machine learning algorithms for the data set the classification process and the decision tree-creating process KNN and Random Forest algorithm. To classification process provide an accuracy level of 84.33% and the final decision tree-making process provides an accuracy level of 72% when compared with other systems [13].

The final output of the meal preparation algorithm is shown in (Fig.4) below and in the android application every day generates a meal plan for the whole day based on the user input basic data as (Fig.5)

```
Rusk,100g,410 cal

:::::::::: END , OF ,MORNING MEAL :::::::::

Lobster,100g,89 cal

Spinach,1 cup,26

Parsley,2 T.,2

Zander,100g,84 cal

French-fried,10 pieces,155

Beet greens,1 cup,27

:::::::::: END  END , OF ,LUNCH MEAL :::::::::

Apple half,91 g,45 cal

Boysenberry Juice,100ml,54 cal

:::::::::: END  END , OF ,EVENING MEAL :::::::::

Cream of Potato Soup,100g,30 cal

Vegetable Soup,100g,28 cal

Chicken Broth,100g,16 cal
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Fig. 4. Meal Plan Algorithm output

Fig. 5. Meal Plan Generation of the Android App

Finally, all the details are saved on the firebase database, according to that detail, the dietitian can change the meal plan and the daily calorie goal target of their patient. That change depended on the patient's performance. That can be used to count the patient's BMR and BMI count based on the patient's activity level and performance level.

BMI =   Body Mass (kg)/height2 (m)

BMR for male = 88.362 + (13.397 x weight in kg) + (4.799 x height in cm) – (5.677 x age in years)

BMR for female=447.593 + (9.247 x weight in kg) + (3.098 x height in cm) – (4.330 x age in years)

The proposed algorithm gives the three separate meal plans by considering the input values. That is generated by the Random Forest algorithm.
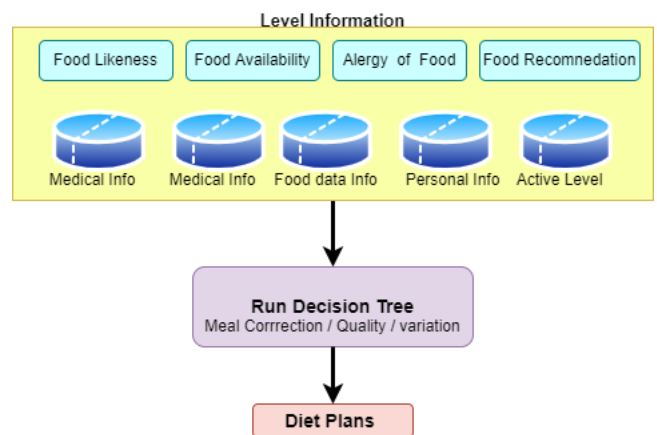

Fig. 6. Framework of the meal menu planning system

Algorithm Implementation

The proposed meal plan generated algorithm is shown as the output decision below for the meal plans.

i.   Recommended Food – Got from the created dataset
ii.   Food Availability (Country Wise) – all foods are available data set is made for Sri Lankan foods
iii.   Gender – Male/ Female
iv.   Nutrition Content - Low /High / Moderate
v.   Calorie Content – Low /High / Moderate
vi.   Outcome – True /False (depending on the final meal plan) calorie goal target of their patient. That change depended on the patient's performance.
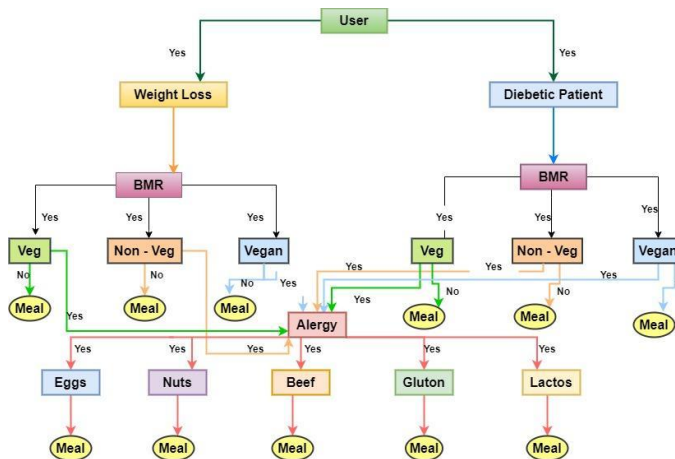
Fig. 7. Decision tree of meal preparation an application

Considering the above (Fig.7) decision, daily meal plans are generated by the proposed algorithm for the system.

As above mentioned, the decision tree is made by using the random forest algorithm and the data classification process is done by the K- Nearest Neighbours algorithm to get the data for meal preparation.

After doing all processes of the above decision tree, the proposed system generates data for Breakfast, Lunch, Evening snake, Beverage and Dinner that categorized using the Random Forest algorithm (Fig.6). The calories count is depended on the IBM count and the BMR count of the patients.

When picking the food for the self-made food dataset, that has been chosen low sugar count food. When generating the Food Plans for each patient that consider the patient's wants and needs for meals. According to the BMR, the BMI and activity level of each person daily can calculate the daily calories need of them. After getting that calorie count that is divided into four different ways to make the meal, those measures are from the whole daily calories count, provided 30% for morning meals 40% for lunch and 10% provide for evening meals rest of 20% present provided to the dinner plan, this count is different from each patient. That depends on their person's BMI, BMR and activity level.

Another is that here the food is limited according to the client's allergies behaviour when applying the decision tree to the system. (Fig.8) is shown the accuracy behaviour of the classified dataset.
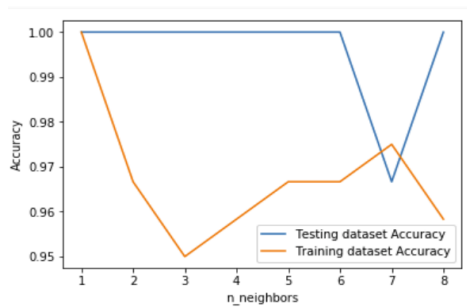

Fig. 8. Accuracy measurement diagram of the classified dataset

Also, this algorithm considers the level of all food's nutrition by considering carbs, fibre, fat, sugar level, calcium, and iron to give a balanced healthy meal plan to diabetic patients. That levels are considered separately for each patient according to their health level.

Conclusion

The aim of this paper is the prepare healthy meal plans for diabetic patients, when compared with other health monitoring applications, this proposed system has so many benefits for the users [3][14][15]. consider the other diabetic patient-based specified applications that monitor only glucose levels, blood pleasure, and reminders like that thing only. But the proposed system's main aim task is the preparing meal plans for diabetic patients by considering their likeness, health fact and allergies behaviour that has for the food. For meal preparation, the food set has been generated Sri Lankan food Style. To prepare this meal plan firstly gather the data from the data sources of Kaggle and then use KNN and algorithm the classification of the food set final product accurate level is 84.33% and the classification is done for breakfast, lunch, evening, and dinner by considering its included fiber, Carbohydrate, and sugar limit, allergies type and veg- non-behaviours of the foods those are used as K value of the K- Nearest Neighbour. Then the Random Forest algorithm is used to generate a decision tree of the meal preparation and the final product of the meal of the proposed algorithm accuracy was provided as 72%. When making the decision tree that considers user health, the likeness of food, food allergy, availability of food country-wise, nutrition content, BMI, BMR counts, gender and other personal diseases. Finally provide the meal plan according to the calorie percentage of each diet. The proposed meal preparation algorithm provides only for diabetic patients and can enhance this one as a diet plan for normal persons, not only meal plan the overall U-Health application provides a health monitoring application also, in enhancing this application by connecting with dietitians this application can be proposed as the virtual clinic of diabetic patients.

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