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Diet Recommendation System for Diabetic Patients

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ABSTRACT
Diet plays a key role in maintaining health and prevention of diseases. One of the most common diseases which is faced by people all over the world is Diabetes. This disease cannot be cured completely but it can be controlled by following a healthy diet and lifestyle. Our aim is to make a system that helps users to get a proper diet and exercise plan from time to time and help them to create a balance in overall calorie intake throughout the day. The system would recommend meal plans to the user on a daily basis and with many options to choose from for a particular meal plan for a day. Also, the user will be able to choose any type of exercises they want to do as per their convenience out of the options that will be suggested to them by the system.
KEYWORDS - Diet Recommendation, Diabetes Management, K-means,Decision Tree Classifier.

I. INTRODUCTION

It is evident from the literature, that the incidence of diabetes is increasing and although there are methods to control it, there are still patients who lack the required knowledge and skills to manage and control their condition. Diabetes is a disease that occurs when our blood glucose is too high. Blood glucose is our main source of energy and comes from the food you eat. Insulin, a hormone made by the pancreas, helps glucose from food get into our cells to be used for energy. Sometimes our body doesn't make enough—or any—insulin(Type-1) or doesn't use insulin well(Type-2). Glucose then stays in our blood and doesn't reach our cells.

Over time, having an excessive amount of glucose in our blood can cause health problems. Some major problems faced by patients are heart attack or stroke,

eye problems that can lead to trouble seeing or going blind, pain, tingling, or numbness in your hands and feet, also called nerve damage, kidney problems that may cause our kidneys to stop working, teeth and gum problems

An individual with diabetes needs to have a proper balance in their daily routine so that their health is maintained and diabetes is in control. Our proposed system, uses their health records and recommends them a perfect combination of diet and exercise to maintain good health.. This work is made easily accessible and available to the users in the form of a website, so that they can get their plans wherever and whenever they want to.

The organization of the paper is as follows. Section II presents the literature review of the system followed by Section III that presents the proposed system. Section IV presents the results and discussion of the system. Section V concludes the system. While at the end,references are presented.

II. LITERATURE REVIEW

Steven S Coughlin, Mary S. Whitehead, Joyce Q Sheats Jeff Mastromonico.[1]In their paper - Smartphone Applications for Promoting Healthy Diet and Nutrition by , highlights the point that there have been rapid developments in technology that have encouraged the use of smartphones in health promotion research and practice. Most Common techniques include providing feedback, goal-setting for healthy eating, healthy cooking, grocery decision making, self-monitoring of energy and nutrient intake, weight tracking, and many more. The paper also highlights the point that smartphones have the potential to improve the accuracy and completeness of self-monitored dietary intake in weight-control intervention and they tend to reduce the burden of monitoring dietary intake using traditional paper-based records. Accuracy of diet and nutrition measurements obtained using mobile devices has generally been found to be good. Participants prefer applications that are quick and easy to administer and those that increase awareness of food intake and weight management.

In the paper, Food Consumption and its impact on Cardiovascular Disease: Importance of Solutions focused on the globalized food system by Barry M. Popkin, W. R. Kenan, Jr. Distinguished Professor. [2] we get an overview of :

1. Development of the modern, globalized food system and its implications for the food supply. 2. A consensus on the evidence relating various macronutrients and foods to CVD and its related comorbidities.3. An outline of how changes to the global food system can address current diet-related public health problems, and simultaneously have beneficial impacts on climate change. This paper provided a state-of-the-art review of the link between specific macronutrients and foods and

cardiovascular diseases (CVD) and summarized how the global food system contributes to dietary patterns that greatly increase the risks for the population to experience ill health.

In the paper, Application of machine learning methodology to assess the performance of diabetics program for patients with type 2 diabetes in family medicine clinics in Mexico by Yue You, Svetlana Vladislavovna Doubova, Diana Margarita Pinto Masis, Ricardo Pérez-Cuevas, Víctor Hugo Borja-Aburto, Alan Hubbard. [3] the data is collected from the clinics and the laboratory databases.The machine learning algorithms that were used was specifically a regression tree, where the outcome was the estimated treatment impact and the primary analysis of Diabetes impact on glucose control.

This paper generally tells about the glycemic control of type 2 diabetes patients.How much people were T2D by using databases and performing algorithms on them.

In the paper, Developing a decision support system to determine carbohydrate intake of diabetic patients by Levente Kovacs, Lorand Vajda, Patricia Pinter [4] use of telemedicine is done.The system was designed to support home monitoring, an example for telemedicine. New patient profiles can be created by typing in medical and personal data using a form with text fields and drop-down menus. Changes in vital signs can be monitored using graphs created automatically. Medicines can be prescribed, which is supported by alerts. There are tools to help warn the patient to take the medicine or to other activities, such as measuring the blood pressure, or doing some training (there are daily programs for each patient determined by the specialist that cause daily alerts). Contact data of specialists can be defined in case they might need to be consulted. Mobile phones were also used in the system along with personal computers. It provides bigger functionality for patients as they can receive alerts about taking medicine or doing some activity regardless of their actual place. They can delay or cancel each alert using mobile phones or check their daily tasks. Mobile phones can be used by the medical staff as well.

In the paper, Design and development of diabetes management systems using machine learning by Robert A. Sowah, Adelaide A.Bampoe-Addo, Stephen Armoo, Firibu Kwesi Saalia [5] KNN algorithm was used. K-Nearest Neighbour (KNN) is a supervised machine learning algorithm that stores available cases and predicts numerical targets based on a similarity measure. The KNN algorithm was used to implement KNN regression using a weighted average of the K nearest neighbours, weighted by the inverse of their distance. The application had two units : A food recognition model and a QnA chatbot. Question-and-Answer chatbot calls the Microsoft QnA maker and language understanding intelligent service API, which uses natural language processing techniques to answer questions in the knowledge base, as shown i. The knowledge base was trained with frequently asked questions from diabetes communities online and data collected from a diabetes specialist . The intelligent question and answer bot answer questions that patients have by simulating how a human would behave as a conversational partner. The key factor of this unit is to empower the patient with greater disease control and incorporate efficient self-management in his or her daily life using a chatbot. It also had medication reminders and activity trackers. It used image processing for meal recommendation. If users click an image of food that he/she is consuming,the system will let them know if it is healthy or not. The accuracy varies depending upon the image quality captured.

In the paper, Food Recommendation System Using Clustering Analysis (K-means) for Diabetic Patients by Maiyaporn Phanich, Phathrajarin Pholkul, Suphakant Phimoltares [6] we get an overview of :

1.K-means algorithm is the unsupervised Machine learning algorithm that plays a major role in solving clustering problems. It is as simple and also the easiest way to categorize the given data through the defined number of clusters (K clusters).

2.The core idea is to define the k-centers, for each cluster identified. It is used to find groups which have not been explicitly labeled (i.e.) unsupervised learning algorithm. It is widely used for customer profiling, market segmentation, computer vision, geo-statistics, and astronomy.3.Initially, the data from the dataset has been collected and preprocessed. Then the neighborhood of the most similar users in the form of clusters has been calculated by applying K-means clustering Algorithm. The active user is classified based on the similarity between the particular user and a cluster center. To start with the k-means algorithm, first cluster centroids (K) have been initialized. K-means is an iterative algorithm and it includes two steps such as (1) Cluster Assignment (2) Move centroid step.The concept of clustering aims to combine the similar entities to a single group. This unsupervised learning methodology analyzes the data and discovers the similarity between each data point and groups the similar data into a single entity. The clustering will minimize the dimensionality of data when the user deals with a large number of attributes. The clustering technique called Improved K-means which falls under the category of point assignment algorithms which is of unsupervised

learning. This methodology aims to find the number of clusters dynamically.

The initial partitions (centroids) have been calculated in a more significant way rather than random selection. This results in reducing the number of iterations. Thus, reducing the number of iterations increases the cluster quality but decreases in the number of empty clusters. The pre-processed data which includes an individual patient's profile that shows the blood glucose levels. Those processed data are going to be provided as input to the clustering technique called Improved K-means.

Thus, after doing the literature survey, we understood that one of the best ways of recommending meal plans to the users of similar categories is by using an unsupervised clustering algorithm. We will be there by using K-means clustering algorithm for food recommendation to the users.

III. PROPOSED SYSTEM

Our solution mainly consists of two parts :

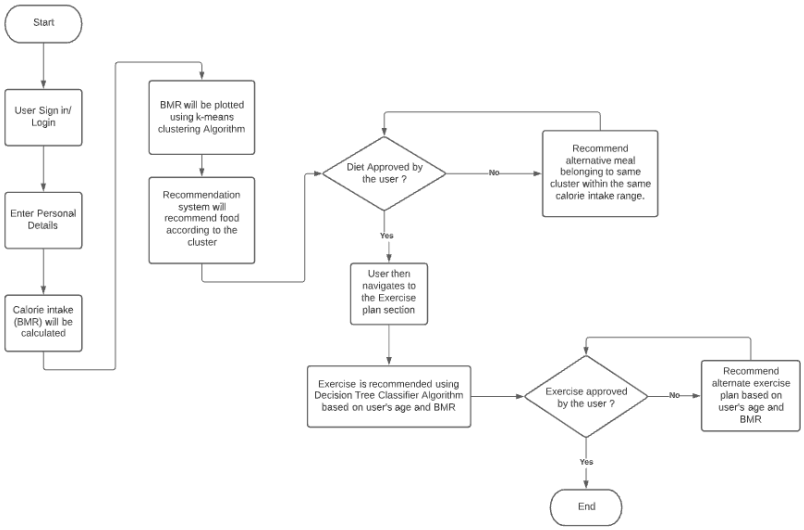

Fig 3.1 : Flow diagram of system

- The users have to first register on the website by entering their email id and password. Then details like age,weight,height,type of diabetes,glucose levels,insulin, contact and location will be asked from the user.
- After registering,the system will then automatically update their calculated BMI and BMR values on their profile.
- The neighborhood of the most similar users in the form of clusters has been calculated by applying K-means clustering Algorithm.
- The active user is classified based on the similarity between the particular user and a cluster center.
- As soon as the user clicks on ‘get the diet plan’ , the user will then be given a diet plan by recommendation algorithm according to their cluster range.
- If a user wants to change the meal, they have an option to get a new one which is present in their cluster range.
- The user can also get an exercise plan by clicking on ‘get the exercise plan’ on a daily basis. Decision Tree Classifier is used for exercise recommendation.
- The Decision Tree Classifier will classify the user’s class label according to their age and BMR and will recommend them the exercises accordingly.
- If a user wants to change their exercise plan, they have an option to get a new plan which

- Diet recommendation system :

Our main aim is to help users to get a proper diet plan in order to maintain his/her health routine in diabetes. The user will be entering his/her personal details such as Age, Weight, Height, Type of Diabetes, Glucose levels,Insulin usage, Contact and Location, thereby creating his/her profile. Our System will calculate his BMI and BMR using their details and accordingly the diet plan will be suggested to the user.

- Exercise recommendation system :

With a good diet, Proper exercise is also required to maintain a balance physically and mentally. We will be recommending users different types of exercises on a daily basis according to their age as well as BMI.

The recommendation system gives users a freedom of choice in both the plans to select any type of meal and exercise for a particular day as per their convenience.

will be recommended by the classifier within the user's BMR and age range.

IV. RESULTS AND DISCUSSIONS

The system takes the user's details such as age, height, weight, type of the diabetes and glucose levels. The BMI and the corresponding BMR is then calculated by the system using the standard formulas. The active user's BMR as well as their current glucose level are considered and accordingly clusters are obtained in the graph by using K-means algorithm

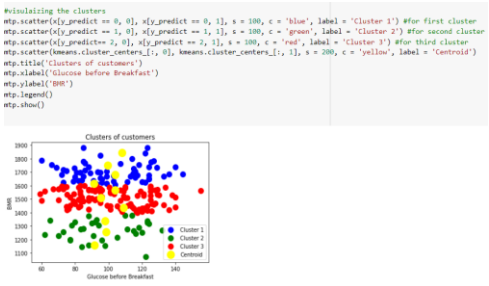

Fig-4.1 : Subplot of BMR and Glucose values using K-means

```
[ ]  query.min()
```

predicted_clusters	BMR
0	1609
1	1399
2	1073

Fig-4.2 : Minimum BMR values of the predicted clusters

```
[ ]  query.max()
```

predicted_clusters	BMR
0	1880
1	1601
2	1380

Fig-4.3 : Maximum BMR values of the predicted clusters

The above subplot is the visual representation of the clusters that are formed by K-means considering BMR and Glucose values. Glucose is the parameter that is considered on X-axis whereas BMR is the parameter considered on Y-axis.Every user's Euclidean Distance will vary depending upon their values each day. If a particular user has changes in their glucose as well as BMR values, then their Euclidean Distance will change. This might lead to change in their cluster type.

For example, if a user that belonged to cluster 0 has changes in their glucose levels as well as BMR and after updating his status, the model predicted that he should belong to cluster 1, so his cluster type will change and he will then be recommended food as similar to the other users of cluster 1.

We will now calculate the minimum and maximum of each cluster.

```
query1.min()
```

predicted_clusters	Glucose
0	60.0
1	62.0
2	59.0

Fig-4.4 : Minimum BMR values of the predicted clusters

```
query1.max()
```

predicted_clusters	Glucose
0	144.2
1	132.0
2	155.0

Fig-4.5 : Maximum BMR values of the predicted clusters

The minimum and maximum of the BMR values are 1073.1399, 1609 and 1380,1601,1880 respectively. The minimum and maximum of the glucose values are 60,62,59 and 144,132,155

respectively. Every new user's BMR and glucose value will be plotted and labelled in one of the clusters as per their value.

```
kmeans.labels_
```

```
array([1, 2, 2, 0, 2, 1, 1, 1, 2, 2, 1, 2, 1, 0, 0, 0, 2, 0, 2, 2, 2, 2,
       2, 2, 1, 2, 2, 2, 2, 2, 0, 1, 2, 1, 1, 1, 2, 2, 0, 2, 0, 0, 2, 2,
       0, 2, 0, 2, 0, 2, 1, 0, 0, 2, 2, 2, 1, 0, 0, 2, 2, 0, 1, 0, 1, 2,
       2, 0, 2, 0, 2, 0, 2, 0, 2, 1, 0, 1, 0, 1, 1, 1, 2, 2, 2, 2, 2, 2,
       0, 2, 2, 0, 2, 2, 1, 2, 2, 0, 0, 0, 2, 2, 1, 0, 2, 2, 1, 2, 0, 1,
       2, 0, 0, 0, 2, 2, 1, 1, 0, 0, 2, 2, 2, 1, 0, 2, 2, 2, 0, 2, 2, 2,
       0, 1, 2, 2, 2, 2, 0, 0, 2, 0, 1, 2, 2, 2, 2, 2, 0, 2, 2, 2, 2, 2,
       2, 0, 0, 2, 0, 2, 2, 0, 0, 0, 2, 2, 1, 0, 2, 0, 2, 2, 0, 0, 0, 2,
       2, 2, 2, 0, 2, 2, 1, 2, 2, 2, 1, 2, 0, 0, 0, 1, 2, 2, 2, 0, 2, 2,
       2, 0], dtype=int32)
```

Fig-4.6: Cluster labels of the BMR values.

The recommendation system that we will be considering is content based. According to the user's cluster value and diabetic type, we will be recommending them diet plans. If it helps the user to improve their health conditions gradually and their glucose levels are getting towards normalcy, then we will be using those diet plans to recommend it to similar users belonging to the same cluster. In this manner, a variety of diet plan options will be provided to users on a daily basis.

A comparative study was done with other clustering algorithms.The data was tried on different types of clustering algorithms like BIRCH and DBSCAN. Balanced Iterative Reducing and Clustering using Hierarchies (BIRCH) is a clustering algorithm that can cluster large datasets by first generating a small and compact summary of the large dataset that retains as much information as possible. This smaller summary is then clustered instead of clustering the larger dataset. Whereas the Density-based spatial clustering of applications with noise (DBSCAN) algorithm is based on this intuitive notion of clusters and noise. The key idea is that for each point of a cluster, the neighborhood of a given radius has to contain at least a minimum number of points.

After performing the accuracy score check, following are the results that were obtained.

Clustering Algorithms	Accuracy
K-means	93%
BIRCH	52%
DBSCAN	60%

The accuracy of the K-means obtained was highest i.e 93% . Other clustering algorithms didn't give us the expected outputs.
Thus, we will be using the K-means algorithm against BMR and Glucose values to obtain the clusters and recommend the meal plan accordingly.

Fig-4.7 : Overview of the accuracy check performed for exercise recommendation.

The exercise that is recommended to the user is done with help of the Decision Tree Classifier Algorithm. For recommending exercise to the user we've selected two parameters into consideration that are user's age(Because specific age people can only do specific exercises) and BMR values and the best possible exercise is recommended to the user. In the above graph, we can see the accuracy of various algorithms and among all of them the Decision Tree Classifier algorithm performed the best, with the accuracy of 87.9 % with runtime 40s.. Because of the best accuracy score and least runtime, we chose the Decision Tree Classifier Algorithm for recommending the exercise to the users.

V. CONCLUSION

An accuracy of 93% for food recommendation and an accuracy of 87.9% for exercise recommendation was achieved for this system. The said accuracies will provide recommendations to the users. Accuracy can be improved by adding more data into the system. The increase in the number of data values will help in the formation of clusters more precisely, thereby improving the accuracy of the system. The scope of our project can be extended by providing the users with the data of all the clinics nearby so that the user can contact the nearby doctors easily. The reminder system can also be added, so that the users get notified on a regular basis for checking their glucose levels and consulting the doctor timely.

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