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A Review on Personalized Recommendation System for Diabetes Clinical Decision Support by using Machine Learning

Venkatesh Kondaveti[1] | Dr. Prasadu Peddi[1] | Dr. G. Venkata Subba Raju[2]

[1]Dept of Computer Science and Engineering, Shri JJT University, Rajasthan
[2]Professor, Stanley College of Engineering and Tech for Women, Hyderabad

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ABSTRACT

Diabetes is a chronic disease that affects millions of people worldwide. The management and treatment of diabetes require careful monitoring and personalized interventions to ensure optimal patient outcomes. With the advancements in machine learning and data analytics, personalized recommendation systems have emerged as a promising approach to support clinical decision-making in diabetes care. This study presents a comprehensive review of personalized recommendation systems for diabetes clinical decision support, with a focus on the utilization of machine learning techniques. The study aims to analyze the existing literature, identify key trends, and highlight the challenges and opportunities in this domain.

Keywords: Diet Recommendation, Diabetes Management, personalized recommendation.

1. INTRODUCTION

Diabetes is a chronic disease characterized by high blood sugar levels, requiring long-term management and care. Effective clinical decision support is crucial in diabetes care to ensure optimal treatment outcomes and patient well-being. With the advent of machine learning and data analytics, personalized recommendation systems have emerged as a promising approach to support clinical decision-making in diabetes management. Personalized recommendation systems utilize machine learning algorithms to analyze large volumes of patient data and provide tailored recommendations for treatment plans, medication dosages, lifestyle modifications, and preventive measures. These systems leverage patient-specific information, such as medical history, demographics, genetic data, and real-time health monitoring, to deliver personalized interventions and improve overall care quality.

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 study 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.

2. REVIEW OF LITERATURE

Ashwini Tuppad & Shantala Devi Patil (2022) Type 2 diabetes has recently acquired the status of an epidemic silent killer, though it is non-communicable. There are two main reasons behind this perception of the disease. First, a gradual but exponential growth in the disease prevalence has been witnessed irrespective of age groups, geography or gender. Second, the disease dynamics are very complex in terms of multifactorial risks involved, initial asymptomatic period, different short-term and long-term complications posing serious health threat and related co-morbidities. Majority of its risk factors are lifestyle habits like physical inactivity, lack of exercise, high body mass index (BMI), poor diet, smoking except some inevitable ones like family history of diabetes, ethnic predisposition, ageing etc.

Baha Ihnaini et al (2021) The prediction of human diseases precisely is still an uphill battle task for better and timely treatment. A multidisciplinary diabetic disease is a life-threatening disease all over the world. It attacks different vital parts of the human body, like Neuropathy, Retinopathy, Nephropathy, and ultimately Heart. A smart healthcare recommendation system predicts and recommends the diabetic disease accurately using optimal machine learning models with the data fusion technique on healthcare datasets. Various machine learning models and methods have been proposed in the recent past to predict diabetes disease. Still, these systems cannot handle the massive number of multifeatured datasets on diabetes disease properly. A smart healthcare recommendation system is proposed for diabetes disease based on deep machine learning and data fusion perspectives.

Objectives

- To provide a comprehensive review of personalized recommendation systems in the context of diabetes clinical decision support.
- To identify key trends and advancements in machine learning techniques used for personalized recommendation systems in diabetes management.
- To evaluate the performance of different machine learning algorithms in diabetes clinical decision support.

3. MACHINE LEARNING APPROACH

Machine learning (ML) has emerged to be a promising field of computer science with wide variety of applications in domains like banking, aerospace, robotics, industry, education, enterprise, astronomy, agriculture, healthcare and so on. A sub-domain of Artificial Intelligence, it relies on learning from data by discovering inherent patterns and application of the newly acquired knowledge to solve problems over previously unseen data. The real-world utility of ML algorithms is very vast and diverse, capable of achieving highly complex tasks that may require human intelligence and expertise by intelligent data analysis. The genetic programming-based ML approach to automatically detect structural defects found in aerospace systems and further build reliable mathematical models for each defect. The models incorporated domain specific knowledge representing the interrelationships in aerospace structures for defect tracking that minimize the need for skilled human inspectors while providing reliable results. Another notable application of ML in challenging real-world premises is proposed by Rampone and Valente (2012), where the authors have used artificial neural networks to assess and forecast landslide hazard using hillslope features. The timely and accurate landslide prediction requires sound expertise to evaluate the degree of hill-slope instability. The proposed model produced promising results with less than 4.3% prediction error. Recently, ML models have been used for detection and understanding of SARS CoV-2 virus genomic pattern,

responsible for the ongoing pandemic. A dynamic programming methodology to identify the nucleotide subsequences from genome data to recognize Spike glycoprotein pattern is presented. The extraction of nucleotide subsequences involved analysis of 5000 SARS-CoV-2 genomes to understand the spike protein, essential for drug/vaccine development and the results showed 99.35% recognition accuracy. Healthcare industry today has witnessed data revolution, not only in the amount and variety of medical data generated, stored, analyzed and accessed at high speeds but also in terms of the number of applications built on top of such huge data, the utility and insights derived from it and the impact of such data driven applications to the society. From the past decade, ML is being increasingly applied to offer diabetes clinical decision support as well as enhance its self-management. Amongst them, the majority of research works focused on developing ML based predictive models aimed at its diagnosis, risk assessment, early prediction and prognosis.

4. MACHINE LEARNING-BASED PERSONALIZED HEALTH RECOMMENDATION SYSTEM

Machine learning is one of the fastest growing technologies being applied to healthcare domain. It provides superior benefits in improved disease diagnoses, analyses and prevention. Many machine learning-based systems have been designed to provide personalized lifestyle recommendation / intervention. For example, the supervised machine learning algorithm to classify users and help caregivers to personalize their intervention feedback. The system was trained through the participants' profiles, activity performance, and feedback from the caregivers. A prototype system, CoachMe, was presented, aiming to promote healthy lifestyle and activities and reduce risk of chronic diseases.

In recent years, the field of healthcare has witnessed significant advancements in machine learning and data analytics, leading to the emergence of personalized health recommendation systems. These systems aim to provide tailored and evidence-based recommendations for individuals, considering their unique characteristics, health conditions, and preferences. By leveraging machine learning algorithms, personalized health recommendation systems have the potential to transform healthcare delivery by improving treatment outcomes, enhancing patient engagement, and enabling proactive disease prevention. Traditional healthcare approaches often follow a one-size-fits-all model, where treatment plans and interventions are generalized for a broad population. However, individuals have diverse health profiles, genetic factors, lifestyles, and environmental influences, making personalized care a critical aspect of effective healthcare delivery. Personalized health recommendation systems address this need by leveraging patient data, such as electronic health records, wearable devices, genetic information, and lifestyle data, to generate personalized recommendations for various healthcare aspects. The primary objective of a machine learning-based personalized health recommendation system is to analyze large volumes of heterogeneous data and extract meaningful insights. These insights can range from predicting disease risk, identifying optimal treatment options, suggesting lifestyle modifications, recommending preventive measures, or even providing real-time monitoring and feedback. By integrating patient-specific data, clinical knowledge, and advanced algorithms, these systems offer tailored and actionable recommendations to healthcare providers, patients, and caregivers. The development and implementation of a machine learning-based personalized health recommendation system involve several key steps. These include data collection and preprocessing, feature extraction and selection, algorithm development and training, model evaluation, and deployment in real-world healthcare settings. Ethical considerations, data privacy, and regulatory compliance are essential factors that need to be addressed throughout the entire process.

5. PROPOSED SYSTEM

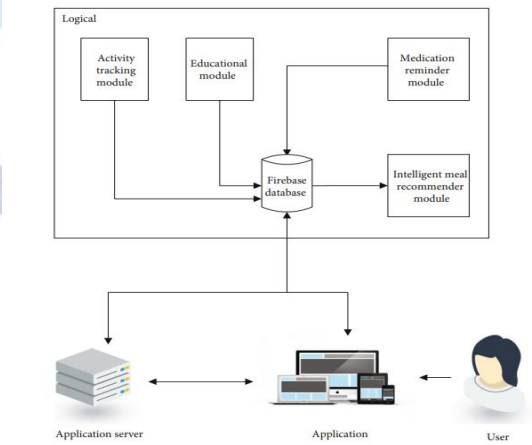

Figure: System architecture for the implemented system with all submodules

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.

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.

6. 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.

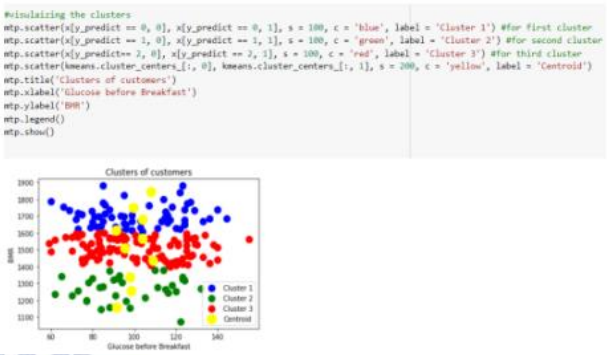

Figure: Subplot of BMR and Glucose values using K-means

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

predicted_clusters	BMR
0	1609
1	1399
2	1073

Figure: Minimum BMR values of the predicted clusters

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

predicted_clusters	BMR
0	1880
1	1601
2	1380

Figure: 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.

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.

7. CONCLUSION

Personalized recommendation systems based on machine learning techniques have the potential to significantly enhance clinical decision support in diabetes care. This review has highlighted the importance and benefits of using such systems in diabetes management, as well as the challenges and opportunities associated with their implementation. The findings of this review indicate that personalized recommendation systems can leverage patient-specific data, such as electronic health records, wearable devices, and mobile applications, to provide tailored recommendations for treatment plans, medication dosages, lifestyle modifications, and preventive measures. By analyzing large volumes of patient data and extracting meaningful patterns, these systems can support healthcare professionals in making informed decisions and improving patient outcomes. 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.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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