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NutriCure: A Disease-Based Food Recommender System

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Abstract:- The human body requires nutrients, vitamins and minerals that are necessary for preventing diseases. Nutritional diseases occur when a body does not get the proper amount of nutrients and this can lead to a variety of health problems. Deficiencies or excesses of nutrients in the diet and eating disorders may lead to chronic diseases such as cardiovascular disease, hypertension, diabetes etc. One common example of nutritional deficiency is the lack of vitamin B-1. It is also known as thiamine. It helps one's body to turn carbohydrates into energy. Thiamine deficiency also can cause nerve and muscle damage and may affect the heart. Therefore, it is necessary to have a proper diet. A balanced diet supplies the nutrients your body requires to work effectively. This paper is the framework to provide a proper nutrition plan to the user. NutriCure is a disease based food recommendation system in which it takes user's health-related data as input and provides a diet plan which is tailored as per their needs as output. Our system could be used as an effective tool to improve nutrition and will also help the user to maintain and improve their health conditions.

Keywords:- *Nutrition, Disease, User preferences, Recommender System.*

I. INTRODUCTION

Nutrition means that a body gets all nutrients, vitamins and minerals to work at its best. It can help to reduce the risk of some diseases which include diabetes, heart diseases, cancer, osteoporosis, etc. Good nutrition helps an individual to improve his/her physical development, mental growth, performance and productivity. Nutritional diseases are caused when an individual's dietary intake does not contain the right amount of nutrients for healthy functioning or when a person cannot absorb nutrients from food. Though most people have been informed about the significance of healthy eating habits, they usually neglect it because of unwillingness to spend cognitive effort on food provision. Nutritional diseases are serious and often not recognized and hence are a consequence of many chronic diseases. Most of the nutrients are readily available in the food. Dietary fibres, vitamins and minerals such as calcium, iron, magnesium, potassium and sodium are the essential supplements that our body needs to avoid these diseases. Apart from these, certain micronutrients which are not produced naturally in our body such as, fluoride, iodine, sulphur, zinc etc are also required to keep the immune balance, haemopoietic system and maintain optimal health. Thus a disease based food recommendation system, which can decide the proper intake of nutrients to cure a particular disease is necessary. NutriCure takes into account the user's health profile and will recommend a combination of nutrients at an appropriate quantity for maintaining health and enhancing immunity by curing the diseases. The main aim of this system is to provide a personalized diet plan consisting of the desired nutrients.

A. Motivation

Nutritional diseases often are not recognized and are becoming a serious problem that can lead to several chronic health conditions. Therefore a disease based food recommendation system is necessary to provide a proper nutrition plan to the user. There are many food recommendation systems that provide the plan without considering any information about nutritional deficiencies or any existing disease. Our system NutriCure takes into account the user's health-related data along with their preferences, creates an end to end nutrition plan and recommends it to the user. The main aim of this system is to provide an individual, a personalized nutrition or food recommendation system based on his/her past or existing chronic diseases.

B. Problem statement

NutriCure is a disease based food recommendation system, where the user enters the past and current health-related data as input and a customized diet plan tailored as per their needs is given as output. It provides dietary assistance to the user which consists of various nutrients, minerals and vitamins, necessary for proper body development, maintaining health and enhancing immunity.

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II. BACKGROUND

Recommender systems are designed to recommend things to the user based on an analysis of their data. It has the capability of producing outputs or recommendations by predicting the set of items based on the user's history. These systems generally work by dealing with huge amounts of information based on the data provided by the user along with their preferences. The design of such systems depends on the domain and the particular characteristics of the data available. Recommender systems differ in the way they analyze the data sources to develop affinity between users and items, which can be used to identify well-matched pairs. It is necessary to identify the properties which will help in creating a successful recommender system in the context of a specific application.

There are some popular algorithms used in developing these systems. Collaborative filtering is used to recommend items to the users that other users with similar tastes have liked in the past. Content-based filtering is based on the preference or ratings a user would give an item. It compares the user's preferences to the features of the items. The one having the most overlapping features is recommended to the user. Hybrid filtering is the combination of both Content-based and Collaborative filtering. It makes the predictions of both the algorithms separately and merges them to give more accurate recommendations.

III. III. RELATED WORK

In this section, we have mentioned research work done in creating a personalized food recommendation system. As this is a very active field and there have been various versions of algorithms used in such systems, we have shown some of the popular ones.

Multi-criteria decision analysis (MCDA) focuses on helping an individual to make decisions among multiple alternatives [1]. AHPSort is a variant of AHP(Analytic Hierarchy Process). It is used to solve MCDA problems by assigning alternatives into predefined ordered classes from most to least preferred [1]. AHPSort requires fewer comparisons than that of AHP which gives a smoother way for decision making on a large scale. This approach of solving MCDA problems can be used for filtering out inappropriate food and incorporating the nutritional context by considering both nutritional and preference aware information [1].

Fuzzy AHP (F-AHP) is another variant of the AHP algorithm. It combines the AHP algorithm and the Fuzzy set theory which is often applied to recommender systems. Fuzzy AHP should be applied when the pairwise comparisons are imprecise because decision-makers are unable to make exact preferences due to some unclear and indefinite information in their decision-making process [2]. The fuzzy AHP method is applicable as a control for the quality and is useful for multicriteria decision-making problems [3]. By using the F-AHP method we can help a decision-maker to make more efficient, flexible and realistic decisions with the help of alternatives and criteria available [3].

The next algorithm we studied is Predictive Data Mining where the data sets are analyzed and the data mining algorithms are applied as the information filtering tools to generate and discover any useful and interesting recommended outputs [4]. A proposal of a healthy eating system based on web data mining, which would track the eating habits and recommend the foods that improve an individual's health and avoid the types of food that raise the risk for illness is presented in [5]. By using the data mining algorithms, the information filtering processes could be performed prior to the actual recommending process which will result in making the framework scalable and improving the system's response time [4].

Another popular algorithm that we studied is the Content-Based Filtering Algorithm. It recommends items to the user similar to the items previously rated by the user. The basic process performed by this algorithm consists of matching up the attributes of a user profile in which preferences and interests are stored with attributes of the items in order to recommend to the user new interesting items [6]. If the profile matches with the user's preferences, it is of tremendous advantage for the effectiveness of an information access process [6].

In [7] the authors have shown a smart recommender system based on hybrid learning methods. The user's data is saved in the user's profile history, filters healthy food items and makes a set of recommendations. Users make use of visual interfaces to communicate their food preferences through comparisons of food items[7]. The learned preferences are utilized for additional re-positioning of the proposals given to them. The hybrid learning method consists of the contents and inference functions for learning and assessment of the production model to match the user's needs [7].

Artificial Bee Colony (ABC) is a very simple, robust, and population-based stochastic optimization algorithm [8]. It is based on the intelligent behaviour of honey bees. A novel collaborative filtering recommendation approach based on the K-means clustering algorithm is proposed in [8]. A detailed explanation of this algorithm is in [10]. Initially, the ABC algorithm is used to overcome the K-means algorithm's problems. And then modified cosine similarity considering the popularity of the products and users preference, to compute the similarity between users in the same clusters, is adopted [8].

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IV. SYSTEM WORKFLOW

In this section, we present an overview of our proposed system as well as its workflow which includes a number of steps. The basic use case diagram is shown in Fig. 1

Fig. 1: Use Case Diagram

A. Proposed System:

NutriCure is a disease based food recommendation system that provides dietary assistance to the users and helps them to cure their diseases. The proposed system takes into account the users information about nutritional deficiencies and their past or existing chronic diseases. This information is the basis for selecting the necessary nutrients which best fit the user's needs. Based on this data, a customized diet plan will be recommended which will be helpful to maintain a healthier lifestyle and cure the diseases if any.

B. WorkFlow:

Step 1: Data Collection

The collection of data sets was one of the important tasks for our proposed system. Most of the data sets contained very few samples that did not fulfil our requirements. Therefore, we decided to scrape the data of food recipes from various websites. We created our own data set aiming at the domain of healthy and nutrient-rich foods. This was done by using Web Scraping.

Web Scraping refers to the extraction of data from a website and storing it in the local storage or database. The data is in an unstructured format which is converted into a structured format. A web data scraper can be proposed by using different libraries for general-purpose programming languages. We wrote the code for scraping several websites to gather food-related data before storing it into a CSV (Comma Separated Values) file and taking it to the next step which was Data Processing.

Step 2: Data Processing:

The data collected in Step 1 was inconsistent and noisy data. This could have led to poor quality of collected data and building a low-quality model. Gathering accurate and high-quality data is important for producing good results. Hence it was necessary for us to process it in order to overcome this issue. Data processing organizes the data in a proper form. We performed data cleaning to fill in the missing values and correct the inconsistencies in our data. The merging of data from multiple sources into a coherent database was done in the data integration task. The next technique performed was data transformation where we performed smoothing and aggregation of data for storing and presenting it in a summary format. Data reduction was helpful in analyzing the representation of our data set without compromising its original integrity.

Step 3: Recommendation Generation

In our proposed system we have used the KNN algorithm for generating recommendations. Using this algorithm we can find the nearest neighbour for selecting the

necessary nutrients which best fits the users need. KNN algorithm is a distance-based classification algorithm that assigns a class label of an unknown case to its nearest neighbour [9]. The recommendations generated in our system will be personalized according to the users' needs which will help them to cure their diseases.

V. SYSTEM IMPLEMENTATION

In this section, we present a brief explanation of the implementation of our proposed system.

We scraped the data of food recipes from various websites and created our own data set which aimed at the domain of healthy and nutrient-rich foods. For this, we performed Web scraping which was done manually using python library Beautiful Soup.

Beautiful Soup is a python library that is used for the extraction of data from a website. The data extracted is in a structured form. It is used to parse data from HTML and XML files. When compared to other general scraping or parsing techniques, Beautiful Soup is considered to be faster. It has standard support for the detection of encoding that is very useful for real-world HTML pages which do not give out their encoding correctly. It supports the HTML parser which is included in Python's standard library. Using Beautiful Soup library we sent requests to various websites to obtain recipes using HTML parser, which is a structured markup processing tool and gradually acquired the data.

The data collected was noisy and inconsistent. Therefore, we had to organize the data in a proper form. We performed data cleaning to correct the inconsistencies and fill in the missing values in our data. We brought it into a proper column format and removed the duplicate and null values. Since our system is a disease based food recommendation system, the data only for recipes was not sufficient. We also needed to focus on the user's diseases and nutrients intake. So we scraped data from various websites in order to create columns for diet, nutrients and diseases. We gathered data for diet columns consisting of the values regarding vegan diet, high protein diets, Type A and Type O diet, Paleo-diet and Omni diet. We focused on several nutrients such as Phosphorus, fibres, vitamins C, A, D, E, K, calcium, chloride, magnesium, potassium, sodium, chromium, copper, fluoride, iodine, iron, manganese, selenium, zinc, proteins and carbohydrates for the nutrient column. The disease column consists of various diseases such as anaemia, cancer, diabetes, eye diseases, goitre, heart diseases, hypertension, kidney disorders, obesity, scurvy, rickets and complications during pregnancies. The data then was transformed and reduced by aggregating it and was not compromised with its original integrity. Fig. 2 shows the graph of the number of data items corresponding to each nutrient and Fig. 3 shows the number of data items corresponding to each disease.

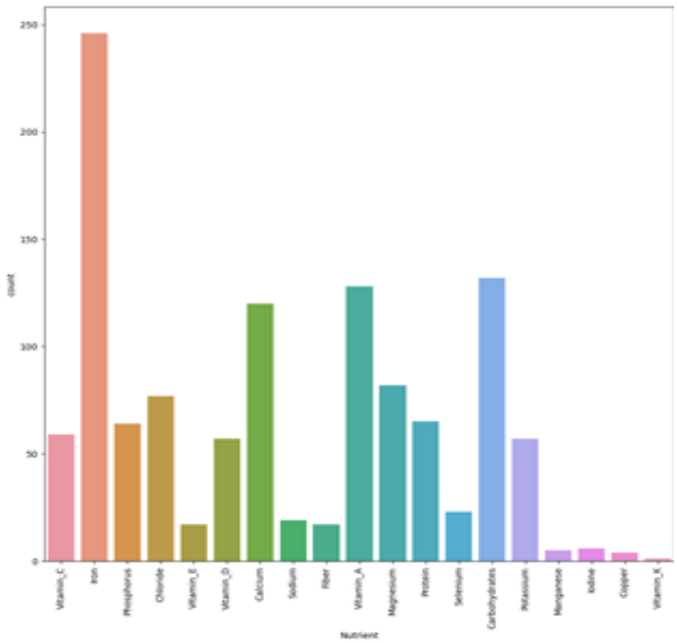

Fig. 2: Nutrient Graph

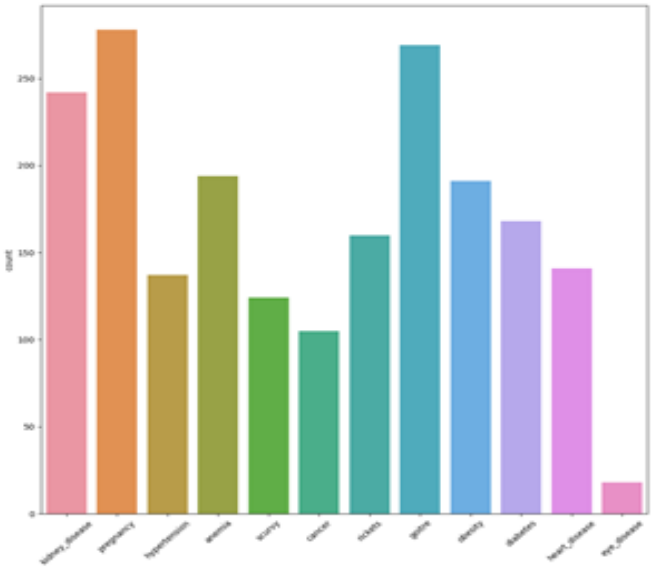

Fig. 3: Disease Graph

For recommendation generation, we focused on two variants. The first one is disease-based and dietary restrictions, where the user enters his or her disease information. The system will also take in the users vegetarian or non-vegetarian preferences. To customize recipes for people with dietary restrictions we filtered the recipes by setting specific parameters. The second variant is an end to end testing with demo users. We created 100 demo users for testing our proposed system. When a new user logs in there are no ratings present in the system. The system needs the user's history in order to provide recommendations. In our proposed system, whenever a new user will log in, he or she will get the recommendations from the recent food consumption history of users with similar tastes, as well as the ones with the highest ratings. Hybrid filtering is comparable to our system. This testing was useful for validating the efficiency of NutriCure's recommendations.

We have used the KNN algorithm in order to generate recommendations. The working of the KNN Algorithm is explained with the help of the following steps.
Step 1: Load the data and test it as well.
Step 2: Choose the value of k. It can be an integer. We selected the value of k as 40. We found this value, by testing the dataset with the implemented code by calculating Root Mean Square Error and Mean Absolute Error. The value which generated the smallest error was selected.
Step 3: Calculate similarity or distance based on distance function. The most commonly used distance functions for continuous variables are Euclidean distance and Manhattan distance. This helped us to find the similarity between new sample and training cases and find the k-closest recipe for the user in terms of nutrients, diet and diseases.
Step 4: Sort the distance in ascending order and rank the minimum distance. The smallest distance value is ranked on top and is considered as the nearest recipe.
Step 5: End.

When KNN makes a prediction about a diet plan, it will calculate the "distance" between the target recipe and every other recipe in its database. Using this algorithm, we were able to find the nearest neighbour for selecting the necessary nutrients which best fits the users need.

In the subsection below, we have shown the functionality of our proposed system in the following steps:

1. *Register:* The interface allows "User" or "Admin" to sign up by providing credentials to register with the application.
2. *Login:* "User" or "Admin" will log in with their accounts.
3. *Health and disease input:* The system takes the users' health and disease-related information as input.
4. *Preferences input:* The system asks to enter their Vegetarian and Non-vegetarian preferences.
5. *Recommendation generation and viewing:* A personalized nutrient-rich diet plan is recommended to the user based on the input collected from Step 3 and 4 and can be viewed by them.

VI. VI. FUTURE SCOPE

In our proposed system we have used the KNN algorithm. As future work, we can extend the functionalities of NutriCure by applying better classification algorithms to generate more accurate results. The users which have similar preferences can also get the recommendation of recipes that they haven't tried yet. This will be helpful to enable sharing and improvement in the system. We can also use larger data sets which will provide a baseline for new combinations of food recipes. We can also improve the validation of data for our system. NutriCure is designed in a way where it takes the users disease-related information and Vegetarian and Non-vegetarian preferences. Along with these, we can add input options for users BMI (Body Mass Index) and BMR (Basal Metabolic Rate) as well, to estimate the physical fitness of an individual. Based on this data the system can then recommend the recipes which will help in improving their health conditions. The system's functionalities can further be extended by providing an interactive interface between the users and health specialists. By establishing specific connections they can communicate with each other through chatbots or emails.

VII. VII. CONCLUSION

This paper presents a detailed overview of our proposed system, NutriCure. It is a disease based food recommendation system that focuses on generating a personalized diet plan according to their nutritional necessities, diseases and preferences. We created our own data set aiming at the domain of healthy and nutrient-rich foods. We have used the KNN algorithm for generating recommendations. For recommendation generation, we focused on two variants. The first one was disease-based and dietary restrictions which will allow users to choose their preferences. The second variant was end to end testing where the system was tested by demo users and also received a positive response. NutriCure could be used as an effective tool to improve nutritional necessities and can also help the user to maintain and improve their health conditions.

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