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NUTRICARE: Optimizing Diet Recommendations Through a Knowledge-Based Approach

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Abstract— *Noncommunicable disease prevalence, particularly obesity, is a major global health concern. A balanced diet can help with nutritional issues such as malnutrition and obesity. Individuals, on the other hand, frequently lack understanding about the proper nutrients and diets for their health, and gaining access to healthcare specialists can be difficult. Diet recommendation solutions based on artificial intelligence (AI) algorithms have evolved to solve these challenges. These systems use big data and tailored criteria to deliver individualized diet recommendations. Existing approaches, however, have shortcomings, such as a lack of expert oversight and consideration of various individual characteristics. We propose a knowledge-based diet recommendation approach for Sri Lankan people in the age of 18-60 which do not have any special conditions. To give precise and safe diet recommendations, this approach considers data such as gender, BMI, pathology report results, food allergies, dietary preferences, and physical activity levels. The incorporation of expert supervision improves the effectiveness of this approach. This study contributes to the creation of a sophisticated and all-encompassing approach to tailored nutrition advice.*

Keywords— **Diet Recommendations, Knowledge-based, Decision tree Algorithm, Personalized recommendations**

I. INTRODUCTION

Unhealthy eating habits have been identified as major factors to noncommunicable diseases (NCDs) such as cancer, diabetes, and heart disease (Benefits and statistics about eating healthfully detailed, no date). According to the World Health Organization (WHO), there has been a worrying increase in overweight people, with 1.9 billion adults and 41 million children under the age of five were afflicted in 2016 (Healthy diet, no date). Obesity prevalence has risen, increasing the risk of chronic diseases such as type 2 diabetes and cardiovascular disease (Abhari et al., 2019) . To stop this trend and its negative health repercussions, immediate action is essential, particularly among children.

In order to promote adequate nutrition, it is critical to incorporate healthy eating habits and an active lifestyle into everyday activities (‘Diet-Right: A Smart Food Recommendation System’, 2017). However, many people are unaware of the foods that are helpful to their health, and receiving advice from healthcare professionals can be difficult owing to time and cost constraints (Mishra et al., 2021). In order to address this issue, artificial intelligence (AI) algorithms provide a viable answer in the form of nutrition advice systems. Big data and modern technologies are used by AI-powered recommender systems to deliver personalized nutrition suggestions based on individual needs, including medical history, lifestyle, and personal attributes (Trang Tran et al., 2018; What is a Recommendation System?, no date).

While diet recommender systems (DRS) have grown in popularity, most existing techniques fail to take into account many factors at the same time. Furthermore, many strategies are still in the research phase, with no practical application. Notably, none of the previous studies suggested a method for ongoing expert monitoring during the recommendation process. Thus, the purpose of this research is to remedy these gaps by creating Nutricare, a knowledge-based enabled nutrition recommender system designed specifically for the Sri Lankan population aged 18 to 60.

This approach will use the Classification and Regression Tree (CART) methodology to provide tailored meal recommendations by incorporating parameters such as gender, BMI, pathology report results (e.g., blood sugar levels), food allergies, dietary preferences, and activity levels. Through expert supervision, the system will deliver tailored nutrition guidance while also ensuring accuracy and user safety. This approach intends to provide a comprehensive diet plan divided into nutritional guidelines, general remarks, and specific food suggestions for optimal nutrition.

The system aims to provide precise and practical information for establishing a healthy and balanced diet by integrating specialized knowledge of Sri Lankan food

and nutrition. Users will have access to individualized diets and will be able to submit input on their diet plans via an easy-to-use mobile or web-based application. The rest of the paper consists of the methodology, discussion, and conclusion of the knowledge-based approach to diet recommendation. Nutricare strives to contribute to the prevention and management of NCDs by providing individualized nutrition advice, thereby encouraging greater health and well-being among the Sri Lankan community.

II. LITERATURE REVIEW

Per In this section, we provide a comprehensive review of the existing literature pertaining to the diet recommender systems. Thirty-five papers were examined and chosen based on particular criteria from scientific sources such as IEEE Xplore, ScienceDirect, and PubMed. Keyword-based search tactics such as Google Scholar and direct searches inside scientific databases were used. The search method was improved by combining keywords with logical operators for more effective results.

Twelve papers were chosen from a pool of thirty-five for their high quality and diverse approaches to diet advice systems. The papers were classified according to the artificial intelligence (AI) methodologies used in their approaches. We specifically categorised them as systems that use machine learning, fuzzy logic, and other AI-related techniques.

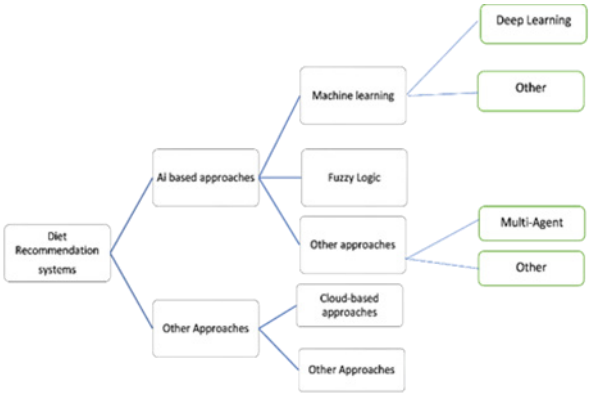

Figure 1. The way the selected papers classified

A. Approaches/ Systems which Used Techniques of Artificial Intelligence

1) Approaches/systems which use machine Learning: Include studies which propose the approaches which use deep Learning

A study(Rostami, Oussalah and Farrahi, 2022) has presented a hybrid food recommender system that will consider some factors that were ignored by the previously implemented and suggested approaches . Some of those factors are the ingredients of food, the time factor and the users and food that do not have any records in the system (Cold Start users and Cold start food items). The suggested method has two phases: a content-based recommendation and a user-based recommendation. The two phases use graph clustering, a deep learning-based approach to cluster both users and food items. To improve the quality of the recommendation by the system a holistic-like approach has been used to consider the time and the issues related to user-community. Recommendation accuracy has improved by the criteria which were not addressed by the previous studies and have been used to recommend food in the proposed approach. This paper also includes a comparison of the suggested approach with five different recommender systems (their newest development stage) using several criteria of performance. This paper has suggested considering the gender, age, weight, height, location, and culture of the users.

Another recommendation by the authors on improvements is to recommend food to the user by considering their health status and increasing the nutritional value of food to improve the system's performance

2) Approaches/systems that use machine Learning: Here are studies which propose approaches which use other Machine Learning related technologies

Implementing an intelligent diet control system in order to improve accuracy was proposed by a research paper by a group of authors (Geetha et al., 2021). This aims to provide a solution to lack of accuracy in the traditional monitoring systems for mismanagement of dietary habits. Additionally, this system enables the users to get dietary reports without meeting dieticians. The suggested model makes use of machine learning to predict a person's future health over the period of a single year by analysing medical history and the body of an individual. Additionally, the proposed approach performs diet recommendation by considering data in the past and present consumption of food. And that recommendation was more trustworthy. In this system the range of calories are calculated using the BMI (Body Mass Index) that has been calculated using the extracted features. Then these parameters will be used by the machine learning algorithm in order to predict the diet plan. This study has analysed several existing recommendation systems and the proposed model over several statistical parameters. The results of this study have proven that the intelligent recommendation system has more accuracy compared to other models. As future work of this study the proposed system can be applied to patients with various diseases.

Kovasznai (Kovasznai, 2011) has presented an expert system for recommending diets for those who need healthy and professional menus. This system, which would be employed in a record management system for health, was constructed using a cased-based approach. The proposed approach has been constructed by utilising ripple down rules (RDR). The overall goal of this is to implement a system in IT, eFilter system that considers the stored data of the clients' health records such as food allergies, diet, and food intolerance to filter available food products collection. Menu planning is an important module of the proposed system that was able to be implemented by C# for .NET framework. A Windows Forms API (Application Programming Interface) employed GUI (Graphic User Interface) was also implemented which has three regions as RDR (Ripple Down Rules) Tree view, Case Attributes and dietetic constraints.

A diet recommendation system was proposed in 2021 (Bundasak et al., 2021) for the elderly people with the intention of encouraging them to have good health by introducing menusthath are rich in nutrients . The system has combined the K-Means algorithm, data mining, and the Slope One Algorithm to provide accurate recommendations for meals of the elderly. This system categorised the elders by considering their behaviours, habits of eating, and food preferences by using the Clustering Algorithm Analysis. And then use Slope One Algorithm to predict menu-preference scores, which is used to make food suggestions. The system has enhanced the calculating procedure by several methods. Those improve the application's quality and the accuracy of food recommendations by the system. Application coupled with Data Mining to improve the program's intelligence and provide more precise forecasting and favourable results. The authors aimed to guide elderly people or their caregivers regarding the effective usage of the system by using a web application. Reliability usage of the system was increased by the focus of the proposed approach on nutrients that an elder should eat by considering the calorie intake of one elder.

3) Approaches/systems which use fuzzy logic: Here are studies which propose approaches which use fuzzy logic

A study (Shrimal et al., 2021) was conducted to propose an approach to assist the users in maintaining their health by changing their daily diet patterns. This study has presented a recommending framework and an Android application based on that framework that provides suggestions for food considering the food preferences and background of the user while assisting the user to monitor targets of calories which suits to their BMI (Body Mass Index). In the proposed system, the user is enabled to enter their own values of BMI, dietary patterns, and food allergies they have with the food. Then the system suggests calorie targets. This system uses fuzzy logic for creating the framework for recommending food and collaborative filtering in order to recommend food considering personal food preferences. As a specific feature of the function, consumers of this system will be able to monitor their steps or workout using a step counter or pedometer in the android-based application. As future work for the system, the paper suggests adding a module that shows nearby restaurants according to the current location of the user, providing full Diet Plans, and providing workout schedules depending on the fitness goals of the user. In addition to those the study also recommends developing the approach using deep learning to improve the quality of the recommendation

A group of authors have conducted a study (Department of Mathematics and Computer Science, Faculty of Sciences, The University of Ngaoundéré, Cameroon et al., 2021) with the main objective of suggesting a method for performing recommendations without any trained data sets that will give the users good recommendations . This study has proposed a recommendation approach that will combine the K-Nearest Neighbor (KNN) Algorithm and fuzzy logic. Here, fuzzy logic has been used for inferring values considering a collection of rules and some inputs, while KNN performs some retrieval actions which are based on current distance measurements by using fuzzy logic systems' outputs. With the intention of evaluating the proposed approach, this study has used an expert system that will recommend food for people in Cameroon who have the two fatal diseases HIV/ AIDS and malaria. For evaluating the system, this study has used two separate test cases, one for malaria and one for HIV. By taking the results in that way, the study has been able to identify that the proposed approach will be able to recommend food recommendations made by the nutritionists and how much it works effectively. The results have shown that the need for trained models or large data sets is not necessary to make a good recommendation. As future enhancements the study suggests for conducting research using this approach for gathering users' data for making huge datasets for exploring machine learning algorithms and to extend the proposed approach to various kinds of other diseases and in different domains.

4) Approaches or systems that use other AI techniques: Here are studies that proposed systems with multi-Agent system technology

A study (Kim et al., 2009) with the aim of providing a solution for lacking healthcare services in individualised and consistent manner and the difficulty assisting the user by providing them with personalised services was conducted in 2009. Personalization diet recommended service (PDRS) assumes that the proposed system will provide recommendations for various diets in accordance with the disease and family history, preferences of food, personal information, and level of activity. The study also believes that this system will facilitate simple home-based coronary heart disease prevention. The proposed approach can be considered a non-pharmacological treatment type, recommending services for customised diets which will manage and prevent coronary heart disease. This system will provide customised diets for those who are worried about coronary heart disease, according to their personal information, health history, disease family medical history, seasonal food preferences, and food consumption. By tracking users' daily nutritional status and managing their overall vital signs with a vital sign indicator, this service can advise users on a particular diet, in other words, it will assist the users by helping them to be free from diseases by providing customised diets. Establishing middleware with context recognition for health management that collects user activity and data on their dietary patterns, such as number of meals, mealtime, etc., is the study's main recommendation for future improvements.

5) Approaches or systems that use other AI techniques: Here are studies which proposed systems which use other techniques of AI

Aberg (Aberg, 2006) has proposed an intelligent food assistant system that will enable the elderly to use the system even at home . This has the intention of improving the quality of life by reducing the dependency of the elderly and disabled. The proposed system will provide recommendations regarding dietary habits in a personalized way. This could help elderly people to change their dietary habits with proper medical assistance. This solution can be identified as a cutting-edge Artificial intelligence- based approach. But this is not a finalised product, and this is an approach that can be used for future research related to elderly malnutrition and AI related solutions. Though this system is specially designed for the elderly by only focusing on individual recommendations, it can also aid younger individuals and could focus on group recommendations.

B. Approaches/ Systems which Do Not Use Techniques of Artificial Intelligence

1) Approaches/systems which are cloud-based approaches:

A cloud based smart food recommendation known as Diet-Right was proposed (‘Diet-Right: A Smart Food Recommendation System’, 2017) in 2017. The aim of this study is to provide a solution for selecting a proper diet for patients who have various health flaws that will fulfill their dietary requirements. This will recommend food for the patients, considering their pathological reports. The Diet-Right system will use the ant colony algorithm for the recommendation purpose, and by using that, the system will recommend food lists that are optimal and suitable to the criteria in the user’s pathological reports. The Study has conducted an experiment to inspect the accuracy, cost, performance gain, and convergence time. This study suggests enhancing the system by breaking down the system recommendations for different meal times, such as breakfast, lunch, and dinner, and grouping the food recommendations for diverse groups, such as family, friends, etc.

2) Approaches/systems which are not cloud based : With the aim of providing an approach for Diabetes Mellitus Patients that will provide a weekly schedule for the diet and assist them in prevent/cure or curing the disease by managing their diet, Authors have proposed a genetic algorithm for diet planning (Syahputra et al., 2017) that will use the Harris-Benedict equation to calculate the calorie requirement . The approach will display the menus for breakfast, lunch, and dinner as a weekly schedule (for 7 days). The authors have used a variety of generations and individual to conduct the test for the approach twelve times. The study has identified initialising an individual at random, which will result in the genetic algorithm being probabilistic, as one limitation of the proposed approach. The authors recommend adding food data which has been generated,which results the system being more accurate and having variations as future enhancements for the proposed approach. In addition to that the authors also suggest scheduling diet for DM patients with other complications and adding another factor such as metabolic stress level, when determining calorie requirements as future enhancements.

Elsweiler and Harvey (Elsweiler and Harvey, 2015) propose an approach which combines preferences of the users and the balanced diet when recommending food for them. The researchers of this study have implemented a website (a food portal) for the purpose of collecting data of food preferences of the users. The main steps recommending food in the proposed approach are identifying the nutritional needs for an individual, determining recipe rates in the profile, merging recipes,

recommending the food if they met both above mentioned criteria for recommending food. The Harris-Benedict equation has been used for calculating nutritional needs. The analysis of one hundred personas in this study has shown that a simple algorithm with a medium size collection of recipe rates is enough for recommending food by combining recipe rates and nutritional needs. The study has identified not having adequate breakfasts as a limitation of the proposed approach. As future enhancements, they planned to collaborate with experts in the nutrition field and they intend to conduct a second user survey in which whole daily plans as opposed to just recipes are rated.

A group of authors (Ueta, Iwakami and Ito, 2011) proposed a recommendation system in their study with the aim of identifying a suitable recipe which suits a particular health condition of the users . With the aid of this system the users will be able to make their lives healthier by maintaining a healthy diet though they have no knowledge of nutrients. The system will relieve dieticians from making full recipes manually. We built the approach to accept inputs like "I want to eliminate acne," " I need to control diabetes," and "I want to heal tiredness." The system then generates recipes to address the user's health concerns. To evaluate the system's effectiveness the study compared the resulting one thousand recipes from the proposed system with the manually created recipes. F-Measure, recall, and precision has been used by the system for measuring effectiveness. As for the future work they suggest checking the system's validity with the support of a professional dietitian and considering the past search history when recommending food. In addition to those, another suggested enhancement is to consider the food allergies of the users when recommending the food.

Overall, the literature review emphasisesthe potential of AI in establishing successful diet recommendation systems and recommends routes for further research, such as including health status, cultural variables, and food allergies into the recommendation process.

III. METHODOLOGY

The proposed approach aims to improve individualized diet advice using a Knowledge-Based Approach and the Classification and Regression Tree (CART) algorithm. The main objective is to address the dearth of information and accessibility to professional guidance regarding nutrition and dietary requirements, while also meeting the nutritional needs of Sri Lanka's general population between the ages of 18 and 60, excluding expectant and nursing mothers.

To provide customized nutrition recommendations, the NUTRICARE system needs particular input from the users. Gender, Body Mass Index (BMI), blood sugar, blood pressure, blood cholesterol, exercise level, and food preferences are among the details that are required. Additionally, NUTRICARE considers any food allergies, dietary restrictions, and particular foods that are highly advised against consumption by the user.

A key component of offering personalized nutritional advice is user classification. In order to classify users, NUTRICARE takes into account a variety of variables, including BMI, blood sugar, blood pressure, blood cholesterol, exercise level, and food preferences. To provide individualized recommendations, the system divides people into many groups, each of which represents a particular range or condition.

Classification and Regression Tree (CART) method is the foundation of NUTRICARE's recommendation process. The user's dietary choices, constraints, and nutritional objectives are used by CART to create a prediction model. Based on a variety of factors or attributes, the algorithm divides the data into subgroups. This procedure continues up until a predetermined stopping condition, such as a minimum observation requirement or a maximum tree depth, is satisfied. Due to its capability to manage classification tasks and forecast the guidelines on the user's dietary choices and nutritional goals, the Classification and Regression Tree (CART) algorithm was chosen. A popular decision tree method is CART, which enables the development of interpretable models that are simple for both users and specialists to comprehend.

The constant supervision by a nutritionist is a crucial component of NUTRICARE.

In order to increase the precision and relevance of the system's recommendations, the expert continuously examines them and modifies the decision tree algorithm as needed. This guarantees that the system's suggestions for a healthy diet are accurate and tailored to the user.The NUTRICARE system collects user inputs, sorts them into categories, and then makes general suggestions based on the user's category that have been validated by experts in nutrition. The system encourages the user to enter details about foods they need to avoid because of allergies or dietary restrictions if they want to look at meal options. This enables the food filtering component of the system to suggest appropriate substitutes that satisfy the user's unique nutritional demands.

The algorithm also offers approximations of the nutritional values per 100 grams of the suggested meal options. The proposed technique offers a user-centric approach to diet planning by combining these factors, with the goal of improving individuals' dietary habits and general well-being. The following figure indicates the overall system structure.

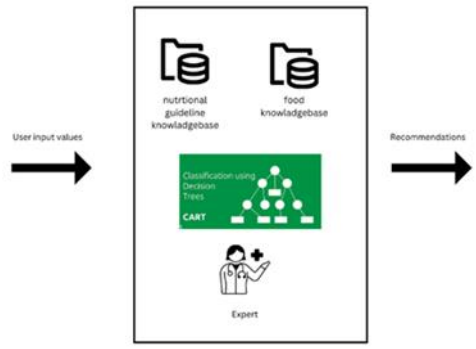

Figure 2. Overall System Structure

IV. RESULTS AND DISCUSSION

We reviewed diet recommender systems in great detail as part of our study, paying particular attention to their development methodologies. Throughout this investigation, we discovered a number of problems with the recent research on diet recommender systems. Numerous current systems are plagued by a lack of attention for critical elements, which results in suggestions that aren't as good as they may be and low user satisfaction. We discovered that systems using machine learning techniques had the highest accuracy out of all the methods used in the previous research. These techniques showed a lot of promise for making nutrition recommendations that are more specific and personalized. Additionally, we searched for the opinions of professionals in the field of health in order to guarantee the efficacy of a diet recommender system. The outcomes of our discussions with these professionals underscored the significance of ongoing oversight and management by a qualified expert. By incorporating human expertise, the system is able to generate recommendations that are more knowledgeable, precise, and tailored to the individual needs and objectives of each user.We found important elements that have a big impact on how effective a diet recommender system is based on the advice of experts and our own research. Age, Body Mass Index (BMI), mealtimes, medication use, dietary allergies, preferences, and amount of physical activity are some of these factors.

The proposed approach includes a personalized diet advice approach based on user categories as well as a comprehensive food knowledge base. The expected outcomes include both health outcomes and the precision of the technique Through a Knowledge-Based Approach and the Classification and Regression Tree (CART) algorithm, suggested approach seeks to improve personalized dietary guidance. The main goal is to address the lack of knowledge and accessibility to expert nutrition counseling while addressing the nutritional needs of Sri Lanka's general population, ages 18 to 60 (excluding pregnant and nursing mothers).

Significant improvements in general health are among the benefits of the proposed strategy that are anticipated. Users who follow the individualized diet recommendations should benefit from increased energy levels, weight loss or maintenance, and a decrease in risk factors for chronic diseases including diabetes and cardiovascular problems. Individual characteristics including age, gender, weight, height, health conditions, and food preferences are taken into account. The diet guidance provided by NUTRICARE is personalized to each user's unique health conditions It is anticipated that as a result, participants' nutritional intake will increase, allowing them to consume more vital vitamins, minerals, and dietary fibre while still maintaining a healthy balance of macronutrients.

The customized strategy aims to produce balanced and suitable nutrient recommendations for each user category. The algorithm makes an effort to offer precise and tailored recommendations that match user needs and tastes by taking into account a variety of factors. This more personalisation may enhance adherence to advised diets, resulting in better long-term results. Despite the positive results, the suggested strategy has several drawbacks. The degree of detail and accuracy of the user-input have a significant impact on the recommendations' accuracy and utility. Dietary recommendations may be insufficient if the information is inaccurate or lacking. It is important to realize that the system's suggestions may not fully account for individual variances or dietary restrictions because they are based on broad norms. According to the study's findings, NUTRICARE has the ability to improve health and offer sensible dietary advice. Individual nutritional needs and tastes are catered for by the system's tailored approach and extensive food knowledge base, which also encourages better long-term adherence to recommended diets and enhanced general health. The system provides an effective and user-centered approach to diet planning, assisting people in developing better eating practices and overall wellbeing.

V. CONCLUSION

The goal of our research was to solve the difficulties in delivering individualized and precise nutritional advice. As a result, we proposed a novel knowledge-based approach for food recommendation. The major goal was to provide individualized and secure dietary advice to Sri Lankans between the ages of 18 and 60, excluding those with certain medical concerns. The NUTRICARE system works to provide exact and pertinent dietary advice by taking into account key user factors like gender, BMI, pathology reports, food allergies, dietary preferences, and levels of physical activity.

We highlighted the need for a comprehensive and expert-led solution by highlighting the shortcomings of current diet guidance systems that we discovered through our literature review. The Classification and Regression Tree (CART) algorithm was used in our study's applied approach to categorize consumers and offer tailored

recommendations based on a variety of characteristics. These variables include BMI, blood pressure, cholesterol, blood sugar, blood pressure, degree of exercise, and food preferences.

The approach is made even more effective by the inclusion of ongoing nutritionist oversight, which guarantees that the suggestions are reliable, accurate, and catered to specific needs. The system can provide useful insights into a person's specific dietary needs and health goals by utilizing expert knowledge.

The suggested method has certain drawbacks even though it provides accurate and user-centric nutritional guidance with some encouraging results. Recommendations' correctness and value are largely dependent on how full and accurate user inputs are. Due to the system's reliance on general standards, inaccurate or lacking information may result in suggestions that are less than ideal and may not fully take into account individual variances or dietary limitations.

In conclusion, NUTRICARE makes a significant addition to the field of individualized nutrition planning. It provides a complete, expert-led solution that takes into account each person's specific dietary requirements and preferences. The method attempts to optimize overall health outcomes and promotes better adherence to advised diets, leading to improved wellbeing and a potential decrease in risk factors for chronic diseases.

Future improvements to this study could include combining more diverse and broad data sets, such as genetic information, to further refine the suggestions' accuracy. Incorporating real-time monitoring of users' health metrics and physical activity levels could also improve the system's ability to adapt and deliver dynamic recommendations. Incorporating a feedback mechanism to analyze the effectiveness of the recommendations and make required adjustments would also assist to continuous system improvements. Overall, our knowledge-based approach to diet recommendation shows promise in promoting healthier eating habits and enhancing individuals' overall well-being. This method has the potential to favorably improve people' health outcomes and contribute to global efforts to address noncommunicable diseases, such as obesity, through optimal nutrition by leveraging the expertise of nutrition specialists and utilizing a comprehensive knowledge base.

REFERENCES

Aberg, J. (2006) Dealing with Malnutrition: A Meal Planning System for Elderly., p. 7.

Benefits and statistics about eating healthfully detailed (no date). Available at: https://www.k-state.edu/today/announcement/?id=8989 (Accessed: 19 October 2022).

Bundasak, S. et al. (2021) 'Food recommendation system for the elderly', 18, pp. 152–167.

Department of Mathematics and Computer Science, Faculty of Sciences, The University of Ngaoundéré, Cameroon et al. (2021) 'Combining Fuzzy Logic and k-Nearest Neighbor Algorithm for Recommendation Systems', International Journal of Information Technology and Computer Science, 13(4), pp. 1–16. Available at: https://doi.org/10.5815/ijitcs.2021.04.01.

'Diet-Right: A Smart Food Recommendation System' (2017) KSII Transactions on Internet and Information Systems, 11(6). Available at: https://doi.org/10.3837/tiis.2017.06.006.

Elsweiler, D. and Harvey, M. (2015) 'Towards Automatic Meal Plan Recommendations for Balanced Nutrition', in Proceedings of the 9th ACM Conference on Recommender Systems. RecSys '15: Ninth ACM Conference on Recommender Systems, Vienna Austria: ACM, pp. 313–316. Available at: https://doi.org/10.1145/2792838.2799665.

Geetha, M. et al. (2021) 'Human Body Analysis and Diet Recommendation System using Machine Learning Techniques', in Proceedings of the Fist International Conference on Advanced Scientific Innovation in Science, Engineering and Technology, ICASISET 2020, 16-17 May 2020, Chennai, India. Proceedings of the Fist International Conference on Advanced Scientific Innovation in Science, Engineering and Technology, ICASISET 2020, 16-17 May 2020, Chennai, India, Chennai, India: EAI. Available at: https://doi.org/10.4108/eai.16-5-2020.2304203.

Healthy diet (no date). Available at: https://www.who.int/news-room/fact-sheets/detail/healthy-diet (Accessed: 15 October 2022).

Kim, J.-H. et al. (2009) 'Design of Diet Recommendation System for Healthcare Service Based on User Information', in 2009 Fourth International Conference on Computer Sciences and Convergence Information Technology. 2009 Fourth International Conference on Computer Sciences and Convergence Information Technology, Seoul, Korea: IEEE, pp. 516–518. Available at: https://doi.org/10.1109/ICCIT.2009.293.

Kovasznai, G. (2011) 'Developing an expert system for diet recommendation', in 2011 6th IEEE International Symposium on Applied Computational Intelligence and Informatics (SACI). 2011 6th IEEE International Symposium on Applied Computational Intelligence and Informatics (SACI), Timisoara, Romania: IEEE, pp. 505–509. Available at: https://doi.org/10.1109/SACI.2011.5873056.

Mishra, N. et al. (2021) 'Research Problems in Recommender systems', Journal of Physics: Conference Series, 1717(1), p. 012002. Available at: https://doi.org/10.1088/1742-6596/1717/1/012002.

Rostami, M., Oussalah, M. and Farrahi, ue (2022) 'A Novel Time-Aware Food Recommender-System Based on Deep Learning and Graph Clustering', IEEE Access, 10, pp. 52508–52524. Available at: https://doi.org/10.1109/ACCESS.2022.3175317.

Syahputra, M. et al. (2017) 'Scheduling Diet for Diabetes Mellitus Patients using Genetic Algorithm', Journal of Physics: Conference Series, 801, p. 012033. Available at: https://doi.org/10.1088/1742-6596/801/1/012033.

Trang Tran, T.N. et al. (2018) 'An overview of recommender systems in the healthy food domain', Journal of Intelligent Information Systems, 50(3), pp. 501–526. Available at: https://doi.org/10.1007/s10844-017-0469-0.

Ueta, T., Iwakami, M. and Ito, T. (2011) 'Implementation of a Goal-Oriented Recipe Recommendation System Providing Nutrition Information', in 2011 International Conference on Technologies and Applications of Artificial Intelligence. 2011 International Conference on Technologies and Applications of Artificial Intelligence, pp. 183–188. Available at: https://doi.org/10.1109/TAAI.2011.39.

What is a Recommendation System? (no date) NVIDIA Data Science Glossary. Available at: https://www.nvidia.com/en-us/glossary/data-science/recommendation-system/ (Accessed: 16 October 2022).

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