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Federated Learning Based Diet Recommendation System I

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Abstract: In contemporary society, numerous individuals face a wide array of health issues and concerns. Advising an appropriate diet is frequently difficult owing to the diverse needs, including weight loss, weight gain, and overall health maintenance, coupled with the constraints of time. To address this challenge, we embarked on developing a program aimed at promoting healthier eating habits. Our approach focuses on recommending only three categories of goods: those conducive to weight loss, weight gain, and maintaining general well-being. Our System of Dietary Recommendations relies on a comprehensive nutrient database, encompassing precise information about various nutrients. To tailor dietary suggestions, the system considers user inputs such as medical data and dietary preferences, including the choice between vegetarian and non-vegetarian meals within the aforementioned categories. In this discussion, we delve into the realms of food classification, essential parameters, and the application of machine learning techniques. The recommendation engine is built using Nearest Neighbours algorithm which is an unsupervised learner for implementing neighbour searches. It acts as a uniform interface to three different nearest neighbours algorithms: Ball Tree, KD Tree, and a brute-force algorithm based. For our case, utilizing the brute- force algorithm Cosine similarity is used due to its fast computation for small datasets.

Keywords: Diet Recommendation, Machine Learning, Clustering, Health Factors, Vegetarian and Non-vegetarian, Calories, BMI.

I. INTRODUCTION

A food recommendation engine using a content-based approach is a valuable tool in promoting healthy eating habits. In contrast to conventional recommendation algorithms, which rely solely on user behaviour or preferences, a content-based approach focuses on the nutritional content and ingredients of foods to provide personalized recommendations to users. A content-based recommendation engine is a sophisticated type of a system of recommendations that depends on the intrinsic characteristics or content of items to make personalized recommendations to users. Unlike collaborative filtering methods that depend on user behaviour data, content-based recommendation engines focus on the properties of the items themselves.

A content-based food recommendation engine not only assists users in making personalized, health-conscious choices but also empowers them to explore diverse, nutritious options. By promoting a balanced and varied diet tailored to individual needs, this approach contributes significantly to improving users' overall health and well-being, making it a valuable tool for promoting healthier lifestyles.

Content-based recommendation engines leverage the inherent characteristics of items to make personalized recommendations. By analyzing item content, extracting relevant features, recognizing patterns, and comparing items, these engines give users recommendations that align with their preferences, making them a valuable tool in various applications, including movie recommendations, product suggestions, and content discovery platforms.

II. PROBLEM STATEMENT

In today's fast-paced world, the alarming rise in the intake of quick food has led to an appreciable rise in the intake of unhealthy, processed meals. This shift in dietary habits has paved the way for a myriad of health issues, including obesity, hypertension, diabetes, and other related illnesses. These health concerns highlight the urgent need for individuals to adopt a well-balanced, nutritional diet that promotes overall well-being. However, the reality is that not everyone in contemporary society has the luxury of time or resources to engage a personal dietician or a nutritionist.

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These professionals can tailor a diet plan founded on an individual's unique circumstances, ensuring it is both healthy and balanced. This discrepancy between the necessity of proper nutrition and the practical challenges faced by many has created a pressing issue. In response to this challenge, our report delves into the detrimental eating patterns prevalent in society. We recognize the negative impacts of unhealthy diets on people's health and well-being. Our primary objective is to close the distance between the desire for a wholesome way of life and the practical constraints individuals face. In this report, we explore innovative solutions aimed at empowering individuals to make healthier dietary choices, despite the lack of personal dieticians or nutritionists.

We advocate for accessible and convenient tools and resources that provide guidance on balanced nutrition. By leveraging technology, education, and user-friendly interfaces, we aim to equip people with the knowledge and support they need to adopt and sustain healthier eating habits. Through our research and analysis, we propose practical and effective strategies that can be implemented in daily life. These solutions are designed to be inclusive, accommodating various lifestyles, schedules, and budgets. By encouraging individuals to make knowledgeable decisions regarding their diet, we envision a future where everyone can lead a healthier lifestyle, mitigating the negative impacts of poor nutrition and fostering a society where well-being is prioritized.

III. LITERATURE REVIEW

This literature review examines papers and studies that investigated utilizing machine learning techniques to food recommendation systems for diets.

Celestine Iwendi et al. (2020) [1] look into their system's capacity for data collection. The objectives of this research framework are machine and deep learning algorithms and how they apply to IoMT data, including Multilayer Perceptron, Logistic Regression, and Naive Bayes (MLP), Gated Recurrent Units (GRU), Recurrent Neural Networks (RNN), and Long Short-Term Memory (LSTM). Thirty individuals' records, including thirteen highlights of various illnesses, and a thousand items were gathered from hospitals and the internet for inclusion in the clinical dataset. In the product area, there are eight features. The characteristics of this IoMT data were investigated and further encoded prior to the application of deep learning and machine learning-based approaches.

Thi Ngoc Trang Tran et al. (2021) [2] demonstrate that their approach is used to showcase a comprehensive review of healthcare recommender system research: Besides, our exploration recognizes from past important outlines concentrates that it gives knowledge for suggested circumstances and approaches. Dietary recommendations, drug ideas, health status forecasts, service recommendations, and recommendations from healthcare professionals are all a part of this kind of proposal. They also give students examples from real-world situations to help them fully comprehend recommendation systems.

Gao et al. (2017) [3] introduced a computational framework for a personalized diet recommendation system. The system used Bayesian personalized ranking along with matrix factorization to learn user preferences from an assortment of data sources. The findings indicated that the approach led to better-personalized recommendation performance than conventional collaborative filtering techniques.

Butti Gouthami and Malige Gangappa (2020) [4] The USDA nutrition dataset will be employed to ascertain the user's suggested diet. A group of grocery shop information that takes the user's preferred food intake keeping in mind. The USDA nutritional data is available in a database for each food item. A USDA ID is used as the baseline value for the input values for every 100 grams. Since they will ultimately be used to estimate the suggested diet, the data required to compute BMI (body mass index) must be provided.

The second input utilized to determine the user's suggested diet is their daily food intake. The diet recommendation is initially created using the food that was eaten that day, and the input nutrient dataset is sorted by a nutritional deficit.
A food recommendation system that considers user preferences and nutritional information was presented by Yera et al. [5]. The suggested meal plan took the user's preferences into account. This tool preserves nutritional data in addition to user preferences.

Iigo Orue Saiz et al. [6] searched for previous research and recommendation systems used in this context in the major databases during the previous five years. The results lead to the following conclusion: Previous works focus more attention on the recommendation system—typically collaborative filtering—than they do on the data or sample description; It is unknown which indices are used to calculate calories or nutrients. In this way, to be viable, it is basic to work with open information or all-around depicted information, which permits the experience to be rehashed by different gatherings, or at any rate to be comparable.

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Hyungbin Kim, Byungchan Kim, Yongho Kim, Cheolwoo You, and Hyunhee Park [7], March 2023, present a novel approach called K-FL, a Kalman filter-based clustering federated learning method, to address non-independent and non-identically distributed (non-IID) data challenges in federated learning. This method aims to reduce weight divergence and enhance model performance by providing a specific model with low variance to each device. Importantly, K-FL is the first clustering federated learning method capable of training a model with fewer communication rounds in a non-IID environment, without prior knowledge or an initial value set by the user. Through simulations, the authors demonstrate that K-FL achieves faster model training and requires fewer communication rounds compared to traditional methods like FedAvg and LG-FedAvg when applied to neural networks using datasets such as MNIST, FMNIST, and CIFAR-10. Together with these gains, the computational time costs are decreased, demonstrating the effectiveness of K-FL in improving federated learning outside of IID contexts.

In the context of federated learning, Felix Sattler, Simon Wiedemann, Klaus-Robert Müller, and Wojciech Samek [8], March 6, 2019, present the idea of sparse ternary compression (STC). Federated learning reduces the amount of communication overhead during training by allowing multiple parties to work together to train a deep learning model without revealing their local data to a centralized server. Since current compression techniques don't handle upstream and downstream communication well or function well in non-idealized scenarios, their applicability for federated learning is limited. By merging ternarization, Golomb encoding of weight updates, and top-k gradient sparsification, STC is intended to fulfill the demands of federated learning. In typical federated learning scenarios, STC outperforms in comparison to federated averaging.

Sergio Romero-Tapiador, Ruben Tolosana, Ruben Vera, Julian Fierrez, and Aythami Morales Rodriguez, Isabel Espinosa-Salinas, Gala Freixer, Enrique Carrillo de Santa Pau, Ana Ramirez de Molina, and Javier Ortega-Garcia, [9] 19 September 2023 the focus is on promoting healthy eating behaviours to lower the danger of Non-Communicable Diseases (NCDs). The paper explores the use pertaining to artificial intelligence (AI) and image processing to analyze individuals' health based on the food they consume, particularly by leveraging the vast number of food images shared on social media and web platforms. The authors introduce the AI4Food-NutritionFW framework, which enables the development of food image datasets customized to diverse eating habits while accounting for a range of variables like location and way of life. They showcase a new food image dataset consisting of 4,800 diverse weekly diets from 15 distinct profiles, from healthy to unhealthy eating habits. The study evaluates healthy eating behaviors using the Normalized Mahalanobis Distance (NMD) and achieves promising results, with high accuracy and sensitivity. The authors also make their AI4Food-NutritionFW framework and the food image dataset available to the research community. This research opens up opportunities for personalized nutrition and health monitoring based on food images.

Gergely Kovásznai [10] June 2011, discusses the importance of menu construction, both for institutions planning menus under constraints and for individuals who require professionally constructed menus based on dietary guidelines. The paper outlines various approaches to menu construction and dietary analysis, including linear programming, genetic algorithms, and rule-based expert systems, as well as commercial IT systems. The paper introduces a case-based approach for diet recommendation additionally, the creation of an expert system for use in a health profile management system. This approach is rooted in ripple-down rules (RDR) and involves the creation of a special representation for patient attributes and rule actions, with the aim of providing solutions that cater to different menu planning needs and dietary requirements.

Mehrdad Rostami, Usman Muhammad, Saman Forouzandeh, Kamal Berahmand, Vahid Farrahi, and Mourad Oussalah [11]2022, the authors present an Explainable Food Recommendation system in the food diet communication domain. This system utilizes deep learning-based image clustering to provide food recommendations based on visual content and justifications. The paper introduces a new similarity score that considers user preferences for specific food categories, enhancing the recommendation process.

Furthermore, a rule-based explainability component is added to make the recommendation outcomes more transparent and interpretable. Based on a gathered dataset, The outcomes of the experiments show that this method greatly increases the precision of recommendations, recall, F1 score, and Normalized Discounted Cumulative Gain (NDCG) compared to existing food recommendation methodologies. An ablation study is also conducted to validate the technical soundness of the different components of their recommendation system.

Tanmai Muke, Krishnaveni Chilka, Sakshi Channe, Mamata Gandhe, and Ms. Pradnya Mehta [12] from JITER in June 2021, the focus is on a diet-based food recommendation system. The system is designed to assist users in making food decisions that are in line with their medical requirements, especially considering the increased significance of immunity during the Covid-19 pandemic.

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Machine learning algorithms, including K-means clustering, Random Forest Classification, and rank-based collaborative filtering, are utilized to provide food recommendations. This system's main objective is to suggest foods that improve and maintain the user's health, with a specific emphasis on making dining-out experiences healthier. The research paper explores the use of these algorithms and techniques to achieve accurate food recommendations, ultimately contributing to better health and well-being.

"International Research Journal of Modernization in Engineering Technology and Science" in May Recommendations based on user preferences and health considerations. Furthermore to making appropriate food recommendations, these apps let users monitor their nutritional intake and promote better eating practices. A summary of methods for making recommendations to promote the consumption of healthful foods is provided in this paper. It also explores the difficulties involved in creating future nutrition recommendation technologies and talks about the up to date with in food recommender systems today. The K-Nearest Neighbour Algorithm, Pandas, Machine Learning, and Data Cleaning are among the research-related keywords.

Bartolome Ortiz-Viso, Andrea Morales-Garzón, Maria J. Martin-Bautista, and Maria-Amparo [14] 7 June 2023 Vila from the Computer Science Department and University of Artificial Intelligence of Granada, Spain, the authors present a recommendation system that excels in diverse environments. The research acknowledges the increasing role of recommender systems in addressing complex challenges, spanning nutrition, housing, and travel. This recommendation system utilizes various input sources, encompassing both data and knowledge-based inputs, to generate intricate and structured recommendations. The authors create a set of intricate and adjustable objects by using an evolutionary method to piece together several separate components into a flexible structure. An approach that is content-based and considers the preferences of the user is used for further refinement. The application of this strategy to address the topic of healthy diet recommendations in the research paper's conclusion highlights its effectiveness in this specific area. This work's index terms include information retrieval, human-computer interaction, recommendation systems, complex recommendation systems, and applied computing.

IV. METHODOLOGY

a. [1], 2021 Website on Diet Recommendation Using Machine Learning. In this method the body mass index is calculated and accordingly the diet advisory system in along with calories count is provided.
b. [5], 2023 A Food Recommender Technology That Considers User Preference and Nutritional Data Into Account. This federated learning trains a model using non- independent and identically distributed data stored at local devices, the weight divergence causes a performance loss.
c. [7], 2019 Acknowledging an Effective IoMT-Assisted Patient Diet Recommendation 2 System through Machine Learning Model. Introduces a comprehensive framework for personalized daily meal plan recommendations including pre-filtering stage to meet nutritional needs and user preferences.
d. [9], 2022 Recommendation System using Machine Learning. The System aims to address health issues through personalized diet plans, covering aspects like nutrition, exercise, and mental well-being.
e. [10], 2023 Advancing Federated Learning through Novel Mechanism for Privacy Preservation in Healthcare Applications. This methodology aims to address privacy concerns in healthcare data. It proposes the use of Federated Learning (FL) as a decentralized approach to enhance privacy. The objectives include designing FL models, evaluating their performance against centralized models.
f. [11], 2023 A Survey on Securing Federated Learning: Analysis of Applications, Attacks, Challenges, and Trends. It introduces Federated Averaging algorithm as a key approach in Federated Learning where participants locally update their credentials and the server aggregates these updates to create a model allowing collaborative machine Food image datasets. It includes 4,800 diverse profiles, enabling research on personalized nutrition with automatic healthy index, aiding tailored dietary recommendations.
g. [21], 2021 Food Recommendation System. Develop a personalized food recommendation system that considers users' health issues, analyse food nutrition, and integrate user medical history for tailored recommendations.
h. [23], 2011 developing an expert system for diet recommendation. Utilize a case-based approach, incorporating individual health data. Represent rules using the ripple down rules (RDR) approach, defining patient attributes and rule actions.
i. [25], 2023 Diet Recommendation System based on Different Machine Learners. Puts forth a DRS with the deep learning classifier to develop an automatic food suggestion RS based on physical aspects and end goal.
j. [30], 2023 DIET RECOMMENDATION SYSTEM USING MACHINE. Introduce
Machine learning for diet recommendations and highlight health issues related to poor diets. Review related literature, describe data processing, and use machine learning techniques. Present findings and analysis, concluding with potential future directions.

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I. DATASETS

The recommended diet for the user will be determined using the USDA nutrition information. Every food item's nutrition information is maintained in the USDA database. [5, 19] In this diet recommendation system, to calculate the recommended diet, the nutrient dataset is first sorted based on the BMI value, and deficit nutrition is determined using the food consumed that day. The recommender provides dietary advice. The samples of datasets used are in below figures (1) and (2).

Food_iten	Breakfast	Lunch	Dinner	VegNovVe	Calories
Asparagus	0	1	1		22
Avocados	1	0	0	0	160
Bananas	1	0	0	0	89
Bagels ma	0	1	1	0	250
Berries	1	0	0	0	349
Brocolli	0	1	1	0	25
Brown Ric	0	1	1	0	362
Cauliflowe	0	1	1	0	32
American	1	0	0	0	331
Coffee	1	0	0	0	2
Corn	1	1	1	0	97
Dark choc	0	0	1	0	556

Figure 1: Sample food dataset

Calories	Fats (gm)	Proteins(g	Iron(mg)	Calcium(m	Sodium(m
160	15	2	0.55	12	7
89	0.3	1.1	0.26	5	1
349	0.4	14	6.8	190	298
331	24	20	0.84	497	966
2	0	0.3	0.02	2	1
97	1.4	3.3	0.55	2	253
93	2.1	5.6	2.63	2	9
97	6.9	3.8	0.12	2	52
553	44	18	6.68	2	12

Figure 2: Sample nutrient dataset

II. DATA PREPROCESSING

Data pre-processing is a step taken to prepare data for modelling with LSTM (Long Short- Term Memory) networks. Pre-processing helps in transforming raw data into a format that is suitable for analysis, reduces noise, and enhances the quality of the data. Cleaning the data and making it suitable for a machine-learning model, which also improves a model's accuracy and effectiveness is a required task. Feature Engineering is the process of enhancing or selecting significant features from the dataset.

The process involves identifying the relevant variables, removing unwanted features, and creating derived features. Train-Test Split is partitioning the available dataset into sets for training and testing is crucial in evaluating the model's performance. LSTM can memorize the training data too well and result in over fitting. Therefore, the model needs to be validated using an independent test set.

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III. COLLABORATIVE FILTERING

Collaborative filtering a commonly utilized method in diet recommendation systems to generate personalized food suggestions for users. This technique operates on the principle of analysing consumer inclinations and behaviours to offer tailored recommendations. In summary, collaborative filtering in diet recommendation systems utilizes the strength of collective user wisdom, enabling the system to suggest foods and meals that align with an individual's unique preferences, making how the process for choosing a healthier diet more personalized and user-friendly.

V. METHODS ABOUT MACHINE EDUCATION

Machine learning methods to assess and recommend foods based on user input, including Multilayer Perceptron (MLP), Logistic Regression, Naive Bayes, Gated Recurrent Units (GRU), Recurrent Neural Networks (RNN), and Long Short-Term Memory (LSTM). Preferences and dietary requirements. These algorithms help in processing and understanding user data for personalized recommendations.

VI. TECHNIQUES FOR COMPRESSION

In the framework of federated learning, which trains machine learning models over several decentralized devices, it's crucial to optimize the communication process to make it more efficient. Compression techniques contribute significantly to reaching this objective by minimizing the quantity of data transferred between these devices.

Compression techniques in allowing for federated learning more efficient communication between devices by reducing the volume of data transmitted. These techniques, including sparsification, quantization, and encoding methods, play a pivotal role in achieving faster model training, minimizing communication overhead, and making federated learning a practical and scalable approach, especially in scenarios involving non-IID data distributions.

VII. CONCLUSION AND FUTURE RESEARCH AREA

Personalized diet recommendation systems have shown great promise in the use of machine learning algorithms. Nutrition education aims to encourage people to eat a healthy diet.

Particular attention is paid to dietary interactions that are essential for formulating dietary guidelines. a health-based medical dataset that automatically determines which foods are healthy based on variables like age, gender, height, and weight.

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