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A Review and Research Panorama on Food Recommender System Based on Health Care

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Abstract: In recent years, food recommendation systems have garnered increasing attention due to their pivotal role in promoting healthy lifestyles**.** Much of the current research in the food industry is dedicated to devising strategies for recommending suitable food products based on user preferences, health considerations, or a combination of both. These systems offer users the ability to not only receive personalized food recommendations but also to monitor their nutritional intake, encouraging them to make constructive changes to their dietary habits. This paper aims to provide a comprehensive overview of various recommender systems in the domain of recipe recommendation. Furthermore, it conducts a systematic review of the diverse contributions made in the field of food and diet recommender systems, considering user preferences, health factors, or a fusion of both. Additionally, the paper delves into the research challenges faced, the datasets employed, and the methodologies applied in the development of these food recommender systems

Keywords: *Recommender system, diet and recipe, food recommender system, Health and nutrition, Content Based Filtering, Collaborative Filtering, Information Retrieval, Machine Learning*

1 Introduction

The era of the Internet has ushered in an age of unprecedented information overload. As the volume of data continues to swell, the task of extracting meaningful information becomes increasingly challenging. In this information-rich landscape, recommender systems emerge as invaluable tools, facilitating the efficient collection and delivery of pertinent information to users. These systems not only predict user preferences for unrated products but also offer recommendations for novel items. Over time, recommender systems evolved beyond the realm of e-commerce, infiltrating diverse sectors such as media streaming, social networking, and content consumption. The proliferation of data and advancements in machine learning fueled the development of sophisticated algorithms, allowing these systems to decipher complex patterns and predict user preferences with increasing accuracy

In today's fast-paced world, where time constraints and a reluctance to spend hours in the kitchen often hinder our pursuit of healthy eating and balanced dietary intake, the consequences manifest as chronic diseases, obesity, and various other health concerns. Traditionally, individuals seeking to address these issues have turned to nutritionists for guidance. However, this approach has its limitations, primarily the inability to accommodate diverse taste preferences and the challenge of providing personalized, healthy, and nutritionally sound diets to a broad spectrum of individuals simultaneously. Recommender systems present a compelling solution to this conundrum. They have the potential to empower users to transform their eating habits by advising on the right ingredients, in the right quantities, while also flagging dietary components to avoid. A health and nutrition recommender system, thoughtfully designed and meticulously calibrated, can usher users toward a healthier lifestyle without compromising their individual culinary preferences. Such systems hold the promise of not only promoting general well-being but also contributing to the prevention and management of specific health pathologies that users may currently face or could potentially encounter in the future.

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2 Recommender System

In simple terms, recommender systems are algorithms that make appropriate recommendations to users for things like films to watch, books to read, products to buy, Diet to follow or other things depending on the industry. The key elements of recommender system for managing healthy lifestyle:

a. Personalized suggestions: The system has the ability to produce customized suggestions based on the results of the health assessment. These could include recommended exercise regimens, food planning, stress-reduction tactics, and sleep-optimization tactics.

b. Health Evaluation: To start, a thorough health assessment can be carried out via the recommender system. This could entail learning about the user's

past medical history, present state of health, dietary preferences, lifestyle decisions, and degree of fitness.

c. Activity Tracking: The recommender system may monitor a user's daily activities, including steps taken; calories burnt, and sleep habits, by integrating with wearable technology or mobile apps. Over time, this data can be used to improve the recommendations.

d. Nutritional Guidance: One useful feature of the recommender system can be providing meal plans and nutritional advice based on the user's dietary needs and preferences. This could entail offering grocery lists, recipes, and advice on portion control.

e. Behavioural Insights: By offering insights into behavioural patterns, the system can assist users in comprehending their routines and pinpointing areas in which they might make improvements. With this knowledge, people can make decisions that will promote their long-term health.

f. Progress Monitoring: By keeping track of the user's advancement towards their health objectives on a regular basis, the recommender system can adjust and change.

There are different types of recommender systems example- Content based filtering, Collaborative filtering, Hybrid recommender system, Demographic and knowledge based recommender system. Below is a detailed discussion of the various types of recommender systems, in addition to this the design of recommender system.

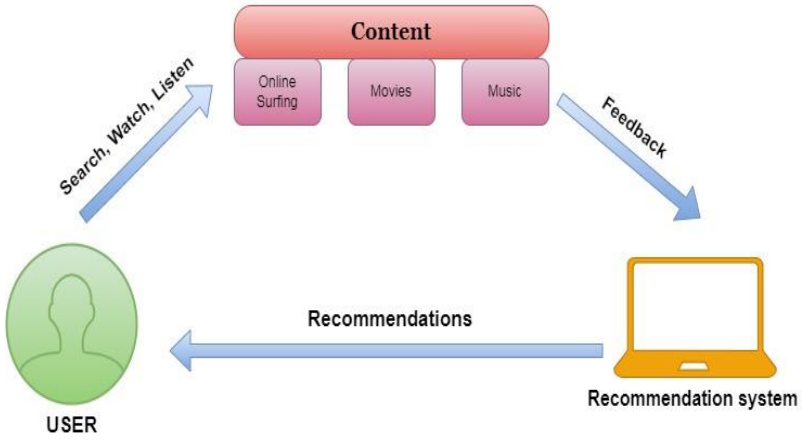

Fig.1. Recommender System Design

2.1 Content-Based Filtering (CB):

Content-Based Filtering harnesses the power of user profiles, which encapsulate users' preferences, and the attributes of available items, such as the genre and director of movies. These systems excel in delivering highly personalized recommendations. At its core, a Content-Based Filtering (CB) system scrutinizes the interplay between a user's preferences and the specific features associated with items they've interacted with. Subsequently, it leverages this analysis to furnish recommendations aligned with the user's interests [14]

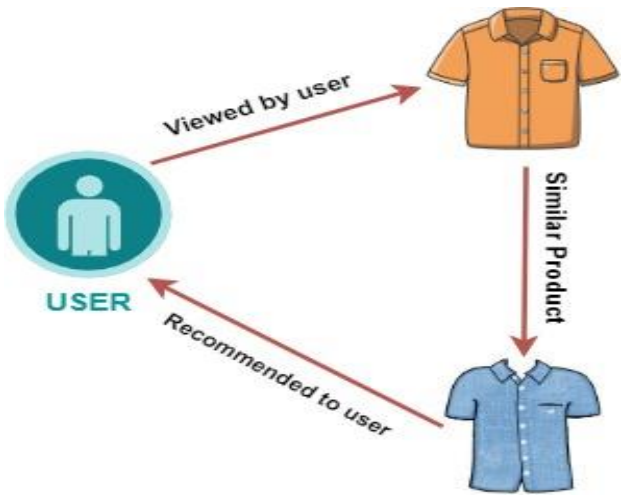

Fig.2. Content Based Recommender System

Advantages

- Content-based filtering doesn't rely on aggregating information from other users. Instead, it focuses solely on the unique preferences and interactions of the individual user. This results in highly tailored recommendations that reflect the user's distinct tastes and interests.
- Content-Based Filtering offers scalability advantages, particularly when dealing with a large user base. Since it doesn't depend on extensive user-user interactions or profiles, the model's computational requirements are often more manageable.
- Content-based filtering is capable to unearth and suggest items that align closely with a user's individual interests, even if those items are not popular among a large portion of users.

Disadvantages

- Content-Based Filtering suffers the risk of over-specialization. When a user's preferences are too narrowly defined, the system may become overly focused on specific categories or attributes of items, potentially neglecting other relevant recommendations.
- Synonym Problem occurs when same item is represented by two or more names in the system. Example, women clothing and women wear are two examples. Many recommender systems fall short in recognizing these distinctions, which lowers the accuracy of their recommendations.

2.2 Collaborative Filtering (CF):

Collaborative Filtering (CF) harnesses the collective wisdom of the masses to guide decision-making. CF operates on the premise that users implicitly or explicitly provide ratings for various items. The recommender system then embarks on the task of identifying like-minded individuals—those whose preferences align closely with a particular user. By analyzing these "neighbours," the system can propose items that have been well-received by users who share similar tastes.

2.2.1 User-Based Collaborative Filtering:

User-Based Collaborative Filtering, a cornerstone of Collaborative Filtering, leverages the ratings and preferences of proximate users to assess and recommend items. In essence, it relies on the fundamental concept of user similarity.

2.2.2 Item-Based Collaborative Filtering:

Item-Based Collaborative Filtering, another facet of Collaborative Filtering, takes a different approach by relying on the user's own ratings of nearby items to predict the rating for a particular item. It pivots on the fundamental concept of item similarity.

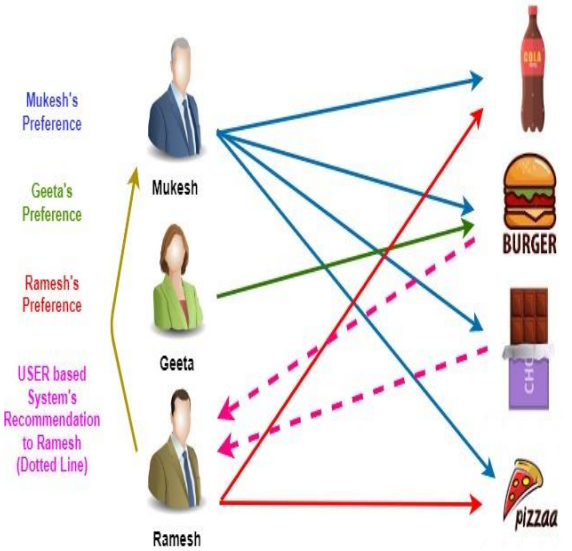

Fig.3. User Based Recommender System

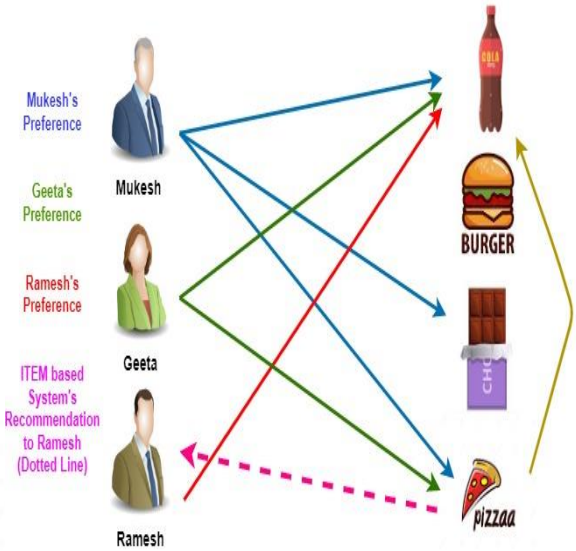

Fig.4. Item-based Recommender System

Advantages

- CF remains effective even when confronted with limited user data. CF can provide meaningful recommendations with relatively small amounts of user feedback.
- CF has capacity to introduce users to novel interests and items. Even if a user hasn't previously exhibited a particular interest, the CF model can still suggest it based on the preferences of other users who share similar tastes.

- CF doesn't demand in-depth domain expertise or intricate knowledge about the items being recommended as it relies on user interactions and ratings, making it versatile and applicable across various domains without the need for specialized knowledge.

Disadvantages

- CF suffers with "cold start issue", when the model lacks sufficient training data for newly added users in the database. Without historical user interactions or ratings for these newcomers, the system struggles to provide accurate recommendations.
- Grey sheep issue occurs when the user feedback does not match the neighbouring user. This problem can be cured by content based approach where item description and user's profile is the key point.
- CF places relatively little emphasis on item descriptions. For instance, in the context of movie recommendations, details such as an actor's name or the film's release year may not carry significant weight in the model's decision-making process leading to less precise or diverse suggestions.

2.3 Hybrid Recommender System:

A hybrid recommender system represents a distinctive subtype of recommendation systems that ingeniously blends collaborative and content filtering techniques. In certain situations, amalgamating these two methodologies can enhance performance and mitigate the limitations of using them in isolation. Implementing hybrid recommender systems offers flexibility, enabling diverse approaches to suit various contexts.

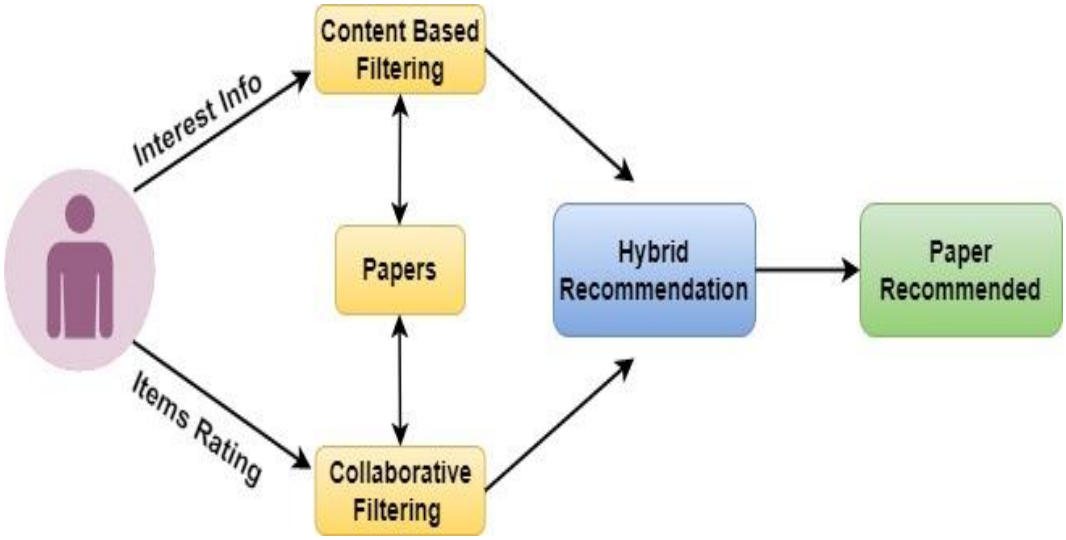

Fig 5- Hybrid Recommender System

2.4 Knowledge Based Recommender System:

Knowledge-Based Recommender Systems are a specialized class of recommendation systems tailored for products that are rarely purchased. These products are often challenging to recommend based solely on historical purchasing behaviour or user profiles. An exemplary scenario where knowledge-based recommenders excel is in the domain of real estate transactions. In situations where users make infrequent or one-time purchases, historical data and user profiles may not be applicable for generating recommendations. Instead of relying on historical data, these systems engage users in a personalized discovery process.

2.5 Demographic Recommender System:

Demographic Filtering is a unique approach to recommendation systems that centers around tracking the collective purchasing behaviour and preferences of individuals based on their demographic characteristics. This method involves categorizing users into groups that share similar demographic features, such as age, gender, location, or income. The core principle of Demographic Filtering is to establish a connection between a new user and a category that corresponds to their demographic profile. Once the user's category is identified, the system leverages the cumulative purchasing preferences of previous users within the same category to make recommendations. The demographic approach can operate effectively without user detailed data points.

3 Literature Review

Pessemier[1] et.al proposed a recommender system to help out the caregivers to select the menu item that favours the patient's preference. The system recommends on 3 bases: Explicit ratingsfor menu items, implicit feedback

which is on the basis of amount of food eaten and the eating behaviour done by the caregiver or patient through mobile app. Ingredients of the menu items: if the ingredients ratings are available, we calculate the preference score and if not available explicitly, we can grasp the ingredients rating from the other menu item ingredients rating. Furthermore, the ingredient can be totally new with no ratings; the collaborative filtering solves the purpose, where the neighbouring patient with similar preferences can be used to identify the ingredients rating. The ingredient prediction is used to calculate the average preference ingredients with the total (n) number of ingredients. The technique solves the problem that if one ingredient is disliked in the menu item the whole menu item should not be discarded as having more liked ingredients. The ingredient prediction is input for the Content based recommender system, which calculates the preference score of the menu item. The portion of the food eaten by the patient is calculated using the outlier detection mechanism of the ELKI framework. The monitoring engine analyze the amount of food eaten by the patient which is self-learning and works parallel to recommendation engine and predicts the amount of food patient can have in future. Furthermore, recording the amount of food intake of each patient gives the clear picture of the quantity of the food that has to be served to each patient and allows identifying the irregularities in the eating behaviour of the patients, which can be indicator of the illness. In their future findings we investigate Recipe diversity; with less diversity in recipe, patients are more likely to have their favourite meal frequently. Therefore, caregivers should specify how often the patient should be served with their favourite. Additional to recipe diversity the restriction in health disease is important and previous meals need to be recorded and considered during recommendation process example: diabetic patients need to eats restricted amount of sugar each day, so choice of breakfast influences the lunch. In calculating the ingredient prediction, the average function can be replaced by the more informed aggregation method such as weighted average in which weights reflects the importance of the ingredient in the menu.[9]

Ge[2] et.al developed a mobile application for food recommender system that can be directly used in kitchen to recommend recipes as per user taste and considering user health. The system describes the novelty of the health-aware food recommender system that the calories balance function is included to measure the calories of the recipe and the calories still needed to user. The critique function is added additionally using tags which makes recommendation simple. The long-term preferences of the user are recorded while registration and the session- based preferences includes which ingredient is available for the cooking. Our future work for the recommender system is recipe diversity and calculating the cooking efforts for the recipe. [6]

Ge[3] et.al proposes a recipe suggesting recommender system that gives high end suggestion towards healthy eating, considering the user's preference taste and tags. The Recommender system uses collaborative based system and extension of matrix factorization, which outperforms the state-of-art algorithms. The system is a tablet-based platform with high human- interactivity. The tags are used in addition to the collecting of information from user inform of ratings. The study shows the tags used improves the rating prediction or information collection for the recommender system. Our future work for the recommender system is to correctly balance the nutrient in the recommendation diet with taste and health factors. The recommendation algorithm may include the negative tags as a novel approachand repetition of the recipes must be avoided.

Bianchin[4] et.al proposed a recipe recommender system with personalized menu generation considering the both short-term, long-term preferences and medical issues. Content based filtering approach is feature based matching between profiles and recipes used for recipe selection against each user. Finally, recipes are ranked and suggested to the user accordingly. The information of the user is collected with the FFQ (Food Frequency Questionnaire) and Phenotype (constraints related to religion or pathologies) is used to prepare the prescriptions, that states what to be avoided and eaten and finally, recipe is recommended.

Gaur[5] et.al recommends a healthy food and calorie recommender system on the basis of the BMI, DNA, eating habits and genetic disease. The paper uses information retrieval technique with rules from the recommender engine. The paper states the types of recommender system with the literature review. The BMI is calculated on the various factors and according to those factors the calorie a person needs to consume in a day is calculated and further the factor affecting health in youth like eating habits, DNA, BMI, Genetic disease are considered to apply rules to the model and final output is given by the recommender system to opt healthy food options. The future scope includes adding more values or features by data mining

Agapito[6] et.al proposed a DIETOS (diet organizer system) recommends the nutritional diet healthy and the chronic disease patients (diabetic, chronic kidney disease (CKD), hypertension. The real time questionnaire helps to get the health profile of user with their answers. The food recommendation is done through the DIETOS catalogue, contains typical food from Calabria. Our future work will focus on using hybrid approach by combining both the explicit food preferences and the

preferences learning during DIETOS use.

Vivek[7] et.al presented two approaches to recommend recipes, user-based approach and item- based approach. The user-based approach states the similarity of the users according to preferences of the user while rating the recipes. The similarity of users is calculated by the Pearsons Correlation Coefficient Similarity and Euclidean Distance Similarity. The item- based approach states the similarity between two recipes and uses tanimoto coefficient similarity and log likelihood similarity. User-based approach shows the better recommendation results.

Franco[8] presents a personalized nutritional recommender system which accesses the dietary intake, developing Food Frequency Questionnaire (FFQ) and recommends the personal nutrition advice to adults. The paper evaluates the personal advice by Randomised Control Trait (RCT). The presented paper increases the effectiveness and the access rate with various features: dietary intake, user preferences, other user responses, population data and nutritional expert knowledge.

Ribeiro[9] et.al presents a mobile application for meal recommender system for the older adult group named as SouChef. The meal plan is created taking into account the taste, health conditions and the activity level. The application usage results were conducted and 70% of the users found satisfied with the recommendations provided. The recommender system uses content-based algorithm with the information retrieval technique. The future scope includes the deciding the number of meals and setting of the repeated meals.

Leipold[10] et.al presents a mobile nutritional recommender system that uses the user's personal nutritional intake through the recipe nutritional values and helps user to self- monitor and makes necessary changes into the user eating habits. The traffic light scheme is used to measure the current nutrient intake value, red shows warning, and yellow shows attention and green for optimal intake. The other objective of the paper is to examine the usage of the application with pre and post survey questionnaire. The future work is presented as availability of seasonal fruits and veggies, personal preference, group constellation, higher dependency on user accurate input, repeating recommendations, performance and ease of intake tracking.

Tran[11] et.al studies various types of recommender system in food domain, considering individual preferences, considering individual health problems, balancing between both preferences of the individual and health problems, group recommendations in food domain are the types of RS that grabs attention. Moreover, the paper presents the overview of recommendation techniques and research challenges for individual and group in nutritional food domain. The collaborative filtering, content-based filtering, hybrid recommender system and knowledge base recommender system techniques used for individual and the group recommendation approaches are aggregated model that aggregates the individual's interest and form a group profile, the aggregated prediction aggregates the individual interest and integrates the interests and comes up with a single interest for a group. Hence for future challenges we can focus on user information, recommendation algorithms, changing eating behaviours, explanation provision, bundle recommendations and achieving fast consensus in group.

Todor[12] et.al in their study presented a mobile application for recipe recommender system taking into account the taste of user and the disease user suffers, on the basis of multi agents, rule engine and ontology approach. The multi agent system used for the recommendation which gathers the knowledge about the user disease or allergies from the hospital/ health care institution servers to obtain the health history of the patient and based on the scoring system the meal/recipe preferred by the user is recommended but taking into the account disease the user suffers from and what needs to be avoided in that particular disease or allergy. The owl ontology stores the food information related to the chronic diseases. A rule engine is used to evaluate the recipes or the meal, according to the user preference and the ingredients to be avoided related to the diseases. The mobile application is developed for the user to visualize their profile and recommends recipe according to their taste and health issues.

The odoridis[13] et.al presented an overview of AI based nutritional recommender system. The recommender system is breakdown into the task specific components and the methodology used with each component is discussed. The components of AI Food analysis, Eating behaviour, additional parameters are compared to the traditional State-of-art approach. The components are further classified, FOOD ANALYSIS: Category recognition, Ingredient and cooking instruction recognition, Quantity Estimation (Calories and nutritional content). EATING BEHAVIOUR ANALYSIS: chewing rate, mastication count, meal duration etc. ADDITIONAL PARAMETERS: user activity level, goals, dietary restrictions etc.

Tang[14] et.al proposes a three-part algorithm to recommend the recipes with health benefits and the taste required to the user. The first part uses the linear regression model and identifies the nutritional content of a recipe. The second part models the user rating score using the GNN (Graph Neural Network) algorithm on ingredient-recipe and recipe user graph from our recipe-

rating dataset. The last part combines the first part and second part to recommend healthy and tasty recipes according to the user preference.

Pawar[15] et.al introduced a hybrid food recommender system that recommends recipes for cancer patient to eradicate cancer while considering user preferences using rating recipes and anti-cancer properties of each recipe. The collaborative and content-based techniques are used for the recommending recipes. The most common technique for Content-based technique used is matrix factorization and In Collaborative Filtering the Alternating Least Square (ALS), Bayesian Personalized Ranking (BPR) and Logistic Matrix Factorization (LMF) is tested and ALS outperforms of all. The paper proposes an extension gSVD++ to themachine learning algorithm SVD++. The SVD++ considers the implicit feedback given by the user such as the eating history but our extension algorithm provides both implicit feedback explicit feedback (user rating). Our future scope for the recommender system is testing different algorithms with more features and the diseases like diabetes, high blood pressure etc.

S.No	Citation	Food RS Type	Methodology	Functionality	Research gap	Dataset
1.	(Pessemier, Dooms, & Martens, October 2013)	Balancing Between user taste and health needs of Users	Already known recommendation algorithm of duine framework, Collaborative filtering algorithm is used for new ingredient in the menu. Content based filtering Approach is used for selecting the menu item on the basis of preference score. Standard regression analysis to predict optimal amount of menu item for the patient	The hybrid recommender system for patient is proposed that prefers the patient taste and health with 3 strategies: explicit rating, implicit rating and the ingredients rating.	In this paper the disease pattern of the user is not disclosed. Future work includes recipe diversity, recording previous meals as patients diet gets affected with the meal and quantity, calculating the ingredient prediction the average function can be replaced by the more informed aggregation method as the weighted average in which weights reflects the importance of the ingredient in the menu.	
2	(Ge, Ricci, & Masimo, Health-aware Food Recomm ender	Balancing between user taste and heath needs	Binary prediction, Likert scale for rating, health-aware recommender Algorithm (extension of Matrix factorization)	The mobile application is developed, which propose an algorithm in which user can balance according to his personal taste and health. Long-term and session-based	There is a necessity to expand this algorithm taking into account the cooking efforts and the	

	System, 2015)			preferences are gathered. T ags can be used as critique for recommendations.	recipe diversity. Beside this using expert nutritionist's domain knowledge, we can construct healthy recommendations.	
3	(Ge, Elahi, Tobías, Ricci, & Massimo, 2015)	Considering user taste and make healthier choices	Collaborative Matrix Factorization	A food recommender system proposes taking into account the user taste and healthy choices. The tags are used in addition to the ratings while collecting the user information. The extension of matrix factorization out performed in comparison to the content- based algorithm.	Future work of interest may include correct balance recommendation diet with taste and health factors. The recommendation algorithm may include the negative tags. Repetition the recipes must be avoided.	
4	(Bianchini, Antonellis, Franceschi, & Melchiori, 2016)	Balancing between user taste and health needs	Content Based Filtering	This paper proposes PREFer: Food recommender system based on the medical prescription considering both the long-term preferences, short-term preferences. Recipes are selected for the user's using content-Based filtering and menu is filtered, sorted considering the medical prescription of the user.	Our future work in case of violation of the ingredients due to health or religious reasons, the substitute to the ingredients will be provided. Further, novelty of the recipes is necessary for the best of the menu generation.	Allrecipes.com
5	(Gaur & Singh, 2016)	Considering nutritional needs of users	Inference engine uses rules and information retrieval technique.	A healthy on the basis of the calories: a user can have according to the various features as BMI, genetic disease, DNA and eating habits	The future work is extension of feature or value of the data as this system works	

					only on calories rather than the disease and diet to be focused on in that disease.	
6	(Agapito, et.al., 2017)	Considering nutritional needs of users	DIETOS database includes tables about user profile, food, pathologies, and questionnaire. Clinical pathologies table includes about the disease. User profile table includes user's personal and health info including the answer to the questionnaire. Food table include about the food description. Questionnaire table includes question and answers to the question designed by the medical group. Flowcharts are implemented in DIETOS as questionnaires.	DIETOS provides nutritional recommendation to both healthy and the chronic disease with the regional food. User's health data is maintained using the real time medical questionnaires. DIETOS gives accurate health profile as user provide with several measurements like creatinine, blood glucose, blood pressure.	Future work may include recommendations using hybrid approach by combining both the explicit food preferences and the preferences learning during DIETOS use. The food database should consider the national food at least except the regional food.	
7	(Vivek, Manju, & Vijay, 2017)	Considering user taste or preference	Item based collaborative filtering uses tanimoto coefficient similarity and loglikelihood similarity. User based collaborative filtering uses pearson correlation coefficient similarity and euclidian distance similarity.	This paper recommends the recipes according to the taste or preference of the user and finds similarity between the recipe (how common the recipe is between two users) or the similarity between users (how similar the users are according to their preferences) using two approaches user-based approach and item-based approach. recommendation of the user-based approach is more appropriate and running time for item-based approach is better.		Allrecipe data set, Simulated data set
8	(Franco, 2017)	Balancing between	FFQ (Food Frequency	The paper presents design, development and		

		user taste and health needs	Questionnaire) Randomized Control Trial (RCT)	evaluation of a recommender system that grasp the dietary intake using FFQ and suggests meaningful personalized nutritional advice to adults.		
9	(Ribeiro, Machado, Ribeiro, & Vasconcelos, 2017)	Balancing between user taste and health needs	Content based recommender system, Herris-Benedict equations, Information retrieval technique.	An application SousChef is developed for the meal recommendation for the older adults considering the health, their personal preferences and their activity level. The usability of the application is tested and results shows that the 70% of the older adults were satisfied with the usability.	Our future work can be extended to decide number of meals an adult plan and how often the meal can be repeated.	Portuguese Food Composition database elaborated by INSA
10	(Leipold, et.al., 2018)	Considering nutritional needs users	The participants behaviour is measured by the open analytical tracking tool named matomo formely piwik. The traffic lights scheme is used to describe nutrients intake. RED (For warning), Yellow (For attention), Green (for go on). Food frequency questionnaire was developed to measure the dietary intake, background, cooking habits, technology habits and post study survey was designed to have feedback for each application feature through system usability scale (sus) questionnaire.	The paper proposes mobile nutrition recommender system employs personal features, based nutritional intake, to encourage users to adopt healthier eating habits. The study shows 43% of the participants will use the application on daily bases and 85% prefers intake check daily and food frequency questionnaire on weekly bases.	The real-life situations were not modelled. So, our future work will focus on developing these situations availability of certain seasonal fruits and veggies, high dependency on user accurate input, diversification of recommendations; as the system repeats recipes, performance and ease of intake tracking.	
11	(Tran, Atas, Felfering,&	Considering user taste, nutritional	Collaborative filtering, Content recommender	The paper presents overview of various types of recommender	Our future research continues to collect user	recipekey.com ndb.nal.usda.gov www.sge-ssn.ch.

	Stettinger, 2018)	needs, the Balance between the user taste & health need and group recommen-dations	system, Hybrid recommender system.	system with different types of techniques used in it.	information, explaining recommendations, improving recommendation algorithm (health, taste, ingredient availability), changing eating behaviour and cold start problem.	
12	(Todor, Adriana, & Kristijan, June 2018)	Balancing between user taste and health needs of users	The Multi agent architecture is used for the recommendation. Owl ontology stores the food- disease information. A rule engine is used to evaluate the recipes according to the user preference and the ingredients to be avoided related to the diseases.	The mobile application is developed for the user to visualize their profile and recommends recipe according to their taste and health issue. The preference of the ingredients is taken manually by this app.	Further work of interest may include ontology extension for the diseases and the ingredients. The quantity of each ingredient in food recipes can be taken into account. human expertise and computer efficiency can be combined, by involving recommendation and intervene if required. The real-world evaluation of the proposed recommender systemneeds to be focusedon	Websites like webmd.com
13	(Thomas, Vassilios, Kosmas, Lazaros, & Petros, June 2019)	Considering nutritional needs of users	Food Category Recognition: SVM, CNN. The CNN performed the best. The combination of both traditional and CNN outperformed the task. Food ingredients & cooking instruction recognition: CNN, DBN, Bi-directional RNN. Food Quantity estimation: CNN, CGAN, Random Forest method. Eating behaviour analysis: HMM,	The overview of AI Nutrition recommender system is provided. The system is divided into various components with specific task to be performed by each component. The paper states technique used by each component for the specific task.	The future work includes combining the nutritional needs with the taste of the user and to determine the efficiency of each machine learning algorithms to evaluate the proposed system.	Food Category Recognition: Food-101, UEC-FOOD100, UEC-FOOD256. Food ingredients and cooking instructions recognition: Recipe1M, VIRE- Food 172, Yummly 28K, Yummly 66K. Food Quantity Eastimation: Food-pics 896, Menu Match, Yummly 28K, Recipe1M, Eating

			SVM.			Behaviour Analysis: Food intake cycle, Splendid chewingdetection
14	(Tang, Zheng, &Lai,2019)	Balancing between user taste and health needs of users	Linear Regression, Graph Neural Network	The healthy recipe recommender system uses three-part algorithm. The first part uses linear regression to predict the nutrition of the recipe with the ingredients given. The second part predicts the user rating using the GNN algorithm on the ingredient- recipe and recipe-user graph build using the recipe rating dataset. The third part combines the two parts to recommend healthy and tasty recipe with the preference of the user.	Other machine learning algorithms can be tested for better recommendations.	
15	(Pawar, Gupta, Arora, Mehta, & Patil,2021)	Considering nutritional needs of the user	Collaborative recommender technique: Alternating least square (ALS), bayesians personalized content-based recommender SVD++. Support vector classifier	A hybrid food recommender system is proposed for beating cancer using the recipes recommended while considering user preferences using rating recipes and anti-cancer properties ofeach recipe. The ALS algorithm outperforms from all the CF algorithms tested.	Our future scope includes testing different algorithms with more features and other diseases like diabetes, obesity, High blood pressure etc	1M+ and K&Ndatasets.

4 Research Challenges

After the critical review of literature following challenges have been recognized to be studied:

- The extension of the ontology of the diseases, ingredients with diversification of recipes needs to be introduced. 13
- Dealing with the Collaborative Filtering cold start problem in health and nutrition recommender system should be inculcated.
- The disease-ingredient exemption data is not available.
- The testing and evaluation of the performance of the health and nutrition recommender system in the real world is missing.
- The investigation of the other variable which could lead to the improvement of the recommender system such as recording previous meals and its quantity, number of meals in a day and how often the meal should be repeated should be included. 10
- The feedback-based system is not embedded till date, the feedback or reviews can be used as the explicit preferences of the user.
- Combining the human expertise and computer efficiency is need of an hour, the involvement of the physician to view nutritional recommendation and intervene if required is upper hand to the system.13
- The development of real-world situations like the availability of certain seasonal fruits and veggies according to the seasons needs to be added.7

- The focus on explaining the recommendation by the health and nutrition recommender system and keeping the logs for the accepted and rejected recommendations should be promoted.13
- The researchers till date have not modelled the explicit user preferences through social media, sensing mobile devices only questionnaire is used. The implicit user preferences have used the recipe rating but no paper considered recipes reviews and preferences learned during the recommender system for accurate recommendation.

5 Research Methodology

This section outlines the framework for the systematic development of the smart food and diet recommender system. The data is collected and the following methodology states the steps to be used and develop a smart food recommender system taking disease and allergies into account.

- The recommender system techniques will be studied and analyzed.
- Conceptualizing the data and creating the protocol for recommender system.
- The search of the data related to the recommender system and screen is performed for the appropriate data related to the field of food and health recommender system. At last, the system will be tested and evaluated.
- In depth study is done to get abstract data to get desired result.
- Finally, synthesize and interpret the results.

Fig.6. Steps for Systematic Review

6 Conclusion

In this paper, we discuss different types of food recommender systems in order to give an overview of recommender systems in the healthy food domain. The all three types present some current studies in the area of healthy foods, which mainly concentrate on individualized recommendation by taking preferences and/or dietary requirements into account. Many food recommender systems use well-known recommendation techniques, such as collaborative filtering recommendation, content-based recommendation, and rule-based recommendation. In addition, hybrid approaches are also used to enhance the performance of the recommender. Even though they are viewed in various contexts, food recommendation systems in general all play a crucial role in providing food items that meet the preferences and nutritional requirements of users and also convincing them to comply with healthy eating habits. Some issues for further research here include referring to user information, recommendation algorithms, trying to alter eating habits, providing explanations, diversification of recipes and calculate the quantity of food.

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