Chapter 2

2 Literature Review

2.1 Introduction to Literature Review

A literature review serves as a foundational element in any research, providing a comprehensive survey of existing knowledge, theories, and methodologies related to the research topic. For this study on developing a Nutrition-Based Recommendation System (NBRS) for cardiac patients, the literature review is crucial for understanding the various components and challenges involved in creating an effective dietary recommendation system.

The design and implementation of an NBRS for cardiac patients involve integrating knowledge from multiple fields to create a robust and effective solution. This literature review addresses the key areas pertinent to this research, starting with the dietary needs and restrictions specific to cardiac patients, which are crucial for developing personalized and safe dietary recommendations. It then examines the concept of Basal Metabolic Rate (BMR), which is fundamental for understanding individual energy expenditure and tailoring dietary plans accordingly. The methodologies for calorie calculation are reviewed to ensure accuracy in dietary planning. Additionally, the nutritional values of various foods are analyzed to provide a comprehensive understanding of how different foods contribute to the overall dietary needs of cardiac patients. The review also explores various algorithms used in food recommendation systems, including Baseline, Co-Clustering, KNN variants, NMF, Slope-One, SVD, and SVD++ algorithms, to identify the most effective approaches for delivering personalized food recommendations. Lastly, the review investigates different machine learning techniques such as content-based filtering, collaborative filtering, and hybrid filtering, which are essential for enhancing the recommendation system's accuracy and relevance.

The fundamental problem addressed by this research is the challenge of providing accurate and personalized dietary recommendations for cardiac patients. This involves not only considering individual health parameters such as BMR and calorie needs but also ensuring the nutritional capability and safety of the recommended foods. The complexity is further increased when dealing with unknown users, for whom recommendations must be made based on general popularity trends while still following dietary restrictions. This

comprehensive review lays the groundwork for the development of an NBRS that can effectively assist cardiac patients in managing their dietary needs.

2.2 Literature Review on Different Categories

The literature review covers a comprehensive analysis of various categories crucial to the dietary management and health of cardiac patients. It begins with an examination of the unique nutritional needs and dietary interventions of individuals with cardiovascular diseases, emphasizing the importance of tailored dietary plans to manage and prevent heart conditions. Following this, it delves into the calculation of Basal Metabolic Rate (BMR) and its significance in ensuring appropriate energy intake for cardiac patients. The review also includes methodologies for precise calorie calculation to maintain optimal weight and health. Additionally, it explores the nutritional values of different foods, highlighting those beneficial and detrimental to heart health. The review further examines advanced algorithms for food recommendation, detailing various methods like Baseline, Co-Clustering, KNN variants, NMF, Slope-One, SVD, and SVD++, which are instrumental in creating personalized dietary plans. Finally, it addresses machine learning techniques, including content-based, collaborative, and hybrid filtering, which enhance the accuracy and personalization of dietary recommendations for cardiac patients.

2.2.1 Cardiac Patient

Cardiac patients, or individuals suffering from cardiovascular diseases (CVD), require meticulous dietary management to prevent disease progression and improve overall health outcomes. Diet plays a pivotal role in the management of cardiac health, influencing factors such as blood pressure, cholesterol levels, and weight management. For these patients, dietary recommendations must be personalized, considering individual health profiles and dietary restrictions to ensure optimal nutritional intake without exacerbating their condition.

In the context of this research, the focus is on developing a Nutrition-Based Recommendation System (NBRS) tailored specifically for cardiac patients. The primary aim is to provide dietary recommendations that align with their unique health needs, incorporating factors such as low sodium intake, reduced saturated fats, and the inclusion of heart-healthy nutrients like omega-3 fatty acids, fiber, and antioxidants. The challenge lies in creating a system that not only recommends appropriate foods but also adapts to the evolving health conditions of the patients.

The proposed NBRS addresses these challenges by integrating advanced algorithms to analyze user data, including Basal Metabolic Rate (BMR) and calorie requirements, and cross-referencing this information with nutritional data from various foods. By leveraging machine learning techniques, the system can offer personalized food recommendations that cater to the dietary restrictions and preferences of cardiac patients. This approach not only aids in the management of cardiovascular health but also enhances the patient's overall quality of life by making dietary planning more convenient and effective.

This section of the literature review delves into the specific dietary needs of cardiac patients, examining existing research on the impact of diet on cardiovascular health, and identifying key nutritional components that should be emphasized in dietary recommendations for this population. Understanding these elements is crucial for the development of a reliable and beneficial recommendation system tailored to the needs of cardiac patients.

Cardiovascular disease (CVD) encompasses a wide range of heart disorders, including coronary artery disease, heart attacks, and heart failure, and is the leading cause of death globally, as reported by the World Health Organization (WHO). The significant impact of psychosocial factors, such as stress, reduced social support, and lifestyle choices, on the progression and management of CVD is well-documented, with mental health issues like depression and anxiety being prevalent among cardiac patients. Addressing these psychological factors is crucial, as they significantly influence patients' quality of life and overall well-being. The Nutrition-Based Recommendation System (NBRS) aims to support cardiac patients by providing personalized food recommendations based on Basal Metabolic Rate (BMR), calorie requirements, and specific nutritional needs. This system leverages advanced machine learning algorithms to offer tailored dietary advice, which can help manage and potentially reduce the severity of CVD. This literature review explores the dietary management of cardiac patients, focusing on BMR, calorie calculation, nutritional values of different foods, and the application of various food recommendation algorithms to improve the quality of life and health outcomes for individuals with CVD.[32]

Cardiovascular disease (CVD) is a leading cause of mortality globally, necessitating precise and timely diagnosis to improve patient outcomes. Machine learning, a subset of artificial intelligence, offers promising solutions for disease prediction by learning from physiological data such as fats, heart rate, age, and biological sex. This study emphasizes the importance of machine learning in predicting heart diseases, highlighting its potential to improve accuracy

in early detection compared to traditional methods. By employing supervised learning algorithms like Support Vector Machines (SVM), Logistic Regression (LOR), and Gaussian Naive Bayes (GNB), this research aims to evaluate their effectiveness in predicting CVD. The review underscores the critical role of machine learning in healthcare, providing insights into its application for enhancing diagnostic tools. It also discusses various algorithms' performance, emphasizing the need for robust data mining techniques and architectures in the medical field. This comprehensive approach aims to advance our understanding of machine learning's role in CVD prediction, ultimately contributing to more accurate and timely medical interventions.[33]

Globally, diabetes mellitus has emerged as a significant public health concern, particularly in India, with type II diabetes accounting for 90% of cases. As of 2014, 387 million people worldwide lived with diabetes, with projections indicating an increase of 205 million by 2035. Alarmingly, nearly 46% of individuals with diabetes remain undiagnosed, primarily in low- and middle-income countries. In the Southeast Asian region, 75 million people have diabetes, with India alone accounting for 66 million cases at a prevalence rate of 8.3%. Diabetic neuropathy, a common complication of long-standing diabetes mellitus, affects almost half of these patients, with hyperglycemia playing a central role in its development. Cardiac autonomic dysfunction, often asymptomatic in early stages, is a critical concern, with severe manifestations leading to a high mortality rate. Early detection of autonomic dysfunction through electrocardiogram (ECG) abnormalities holds the potential for reducing morbidity and mortality in diabetes patients. This study aims to explore various ECG irregularities in patients with type 2 diabetes mellitus, emphasizing the importance of early diagnosis and management to mitigate severe complications associated with cardiac autonomic neuropathy.[34]

Dilated cardiomyopathy (DCMP) is a complex cardiac condition characterized by progressive heart muscle disease, resulting in ventricular dilatation, left ventricular contractile failure, and systolic dysfunction. While several established processes exist for managing cardiomyopathies, the term has historically been reserved for myocardial illnesses with unknown etiology by the 1980 WHO committee. In India, cardiovascular diseases (CVDs) contribute significantly to mortality rates, with studies indicating a high prevalence in both rural and metropolitan areas. Identifying and addressing risk factors for CVD is paramount, with recent research highlighting vitamin D deficiency as an additional risk factor associated with metabolic syndrome, hypertension, and diabetes mellitus. Moreover, vitamin D

insufficiency has been linked to adverse cardiovascular outcomes, including heart failure, stroke, and coronary artery disease (CAD). Notably, hypocalcemia due to vitamin D deficiency presents as a rare but treatable cause of DCMP, particularly in pediatric populations. This study aims to investigate the role of vitamin D insufficiency in DCMP patients and its potential implications for prevention and treatment strategies, given the limited information available on this nutritional variable in the context of chronic heart failure associated with DCMP.[35]

Advancements in surgical techniques and postoperative care have significantly improved survival rates for neonates, infants, and children with congenital heart disease (CHD). However, cardiopulmonary bypass (CPB) and the ensuing systemic inflammatory response pose challenges, including immunoparalysis, which may increase the risk of sepsis in pediatric cardiac surgery patients. Despite adherence to healthcare guidelines, healthcare-acquired infections, including sepsis, remain prevalent in this population, impacting mechanical ventilation duration, ICU length of stay, healthcare costs, and mortality rates. Limited data on sepsis prevalence in pediatric cardiac surgery patients in rural tertiary care hospitals in India exist, with few studies addressing the rising concern of multidrug-resistant organisms. This study aims to evaluate sepsis prevalence, associated risk factors, and the emergence of multidrug-resistant organisms in pediatric cardiac surgery patients, providing valuable insights for improving clinical outcomes and infection control strategies.[36]

The tragic occurrence of sudden cardiac arrests among young students in university settings not only profoundly impacts their families and communities but also raises concerns about campus safety. In response, there has been a heightened emphasis on enhancing the readiness of universities to manage cardiac emergencies, encompassing prompt recognition, activation of emergency services, CPR administration, defibrillation, and advanced care provision. The increasing accessibility and successful deployment of automated external defibrillators (AEDs) in public spaces have prompted advocacy for their widespread availability on university campuses. Legislative measures in certain states and congressional initiatives have advocated for broader access to defibrillation resources in educational institutions. However, comprehensive population-based data detailing the incidence, circumstances, patient demographics, and outcomes of cardiac arrest incidents within university settings remain scarce. This study aims to fill this knowledge gap by investigating the epidemiology of cardiac arrests in universities, focusing particularly on the role of AEDs in improving outcomes and ensuring a safer environment for students and staff alike.[37]

2.2.2 BMR (Basal Metabolic Rate)

BMR is the rate at which the body uses energy at rest to maintain vital functions. Understanding BMR is crucial for personalized dietary plans for cardiac patients to ensure they receive adequate energy without overloading their cardiovascular system. Literature in this section will focus on methods for calculating BMR, its importance in nutritional planning, and its role in managing cardiac health.

2.2.3 Calorie Calculation

Accurate calorie calculation is essential for managing the diet of cardiac patients. It involves determining daily caloric needs to maintain, lose, or gain weight. This section reviews various methods for calorie calculation, their accuracy, and their application in creating dietary plans that support heart health. Studies highlighting the relationship between calorie intake and cardiovascular health outcomes will also be discussed.

2.2.4 Nutrition Values for Different Foods

Knowledge of the nutritional values of different foods is imperative for cardiac patients. This includes macronutrients (carbohydrates, proteins, and fats) and micronutrients (vitamins and minerals). Literature in this section will review how certain foods can benefit or harm heart health, focusing on those rich in omega-3 fatty acids, fiber, and antioxidants versus those high in trans fats, sodium, and added sugars.

Cardiovascular Disease (CVD) is a leading cause of mortality among women, representing approximately 35% of female deaths worldwide. Despite this, sex-specific cardiovascular research has been limited, and current dietary prevention guidelines lack tailored recommendations for women. The Mediterranean diet, characterized by high consumption of unprocessed plant foods, moderate fish intake, and low consumption of red meat and dairy, has garnered attention for its cardiovascular benefits. However, historical cardiovascular diet trials have predominantly included male participants or failed to report sex-specific results. While several meta-analyses have examined the relationship between the Mediterranean diet and CVD, few have performed sex-disaggregated analyses, and none have specifically focused on women. Studies that did include sex-specific analyses yielded mixed results, with some showing benefits in women comparable to men, and others indicating benefits only in men. This systematic review and meta-analysis aimed to address this gap by evaluating the impact of the Mediterranean diet on incident CVD and total mortality specifically in women. The findings revealed that adherence to a Mediterranean diet was associated with a 24%

lower risk of CVD and a 23% lower risk of total mortality in women, underscoring the necessity for sex-specific analyses in dietary research and the translation of these findings into clinical practice guidelines.[38]

Despite significant advancements in medical management and dietary interventions, cardiovascular disease (CVD) continues to be the leading cause of death in the United States. Historical studies, such as the Seven Countries Study and the INTERHEART Study, have underscored the importance of diet in CVD prevention, showing that diets rich in fruits, vegetables, and legumes significantly reduce the risk of myocardial infarction and overall mortality. However, despite these findings and the inclusion of heart-healthy diet recommendations in CVD prevention guidelines, the prevalence of cardiometabolic risk factors like diabetes, hypertension, and obesity has worsened globally. Lifestyle modifications, including diet and exercise, are foundational to CVD prevention, with diets such as the Mediterranean, DASH, and plant-based diets being particularly cardioprotective. Emerging research into the gut microbiome's role in cardiovascular health suggests new avenues for precision medicine. This review highlights the critical need for comprehensive nutritional education and multidisciplinary approaches to enhance dietary adherence and CVD outcomes, addressing barriers like food insecurity and socioeconomic factors.[39]

The global rise in chronic diet-related diseases like obesity, diabetes, and cardiovascular diseases underscores the need for effective dietary monitoring and intervention. Traditional methods of dietary tracking, while important, often suffer from accuracy issues, particularly among children and adolescents. Advances in smartphone technology and AI have introduced more efficient ways to monitor diet through food image recognition and volume estimation. These AI-based applications can identify and quantify food items from photos, providing detailed nutritional information. Such technologies enhance dietary assessment accuracy and are more user-friendly compared to manual methods. This paper reviews the last decade of advancements in AI-driven food recognition systems, discussing their methodologies, strengths, and limitations, and suggesting improvements for better dietary management.[40]

This study investigates the impact of diet on both human health and the environment. It highlights the serious health consequences of unhealthy diets, such as cardiovascular diseases, and the environmental burden of current food production practices, which significantly contribute to greenhouse gas emissions and freshwater usage. The research focuses on the Healthy Reference Diet (HRD) proposed by the EAT-Lancet Commission,

which promotes high consumption of plant-based foods and limited intake of animal products and starchy vegetables. The study aims to assess adherence to the HRD about cardiovascular health and environmental impact using refined diet scores. By analyzing data from a large population-based cohort, the study seeks to provide empirical evidence on the health and environmental benefits of adopting the HRD, helping to identify whether this diet can simultaneously improve public health and sustainability.[41]

This paper explores the potential benefits of vegetarian and vegan diets for individuals with Chronic Kidney Disease (CKD), a condition affecting approximately 15% of adults in the United States. It highlights the reduced cardiovascular mortality risk and improved kidney function associated with higher glomerular filtration rates in CKD patients. The study details various vegetarian diets, noting significant health benefits such as lower BMI, fasting glucose, LDL-cholesterol, triglycerides, and blood pressure levels compared to meat-eaters. Additionally, the paper reviews the positive effects of plant-based proteins on phosphorus homeostasis and metabolic acidosis, which are crucial for CKD management. Through a systematic review using PRISMA guidelines, the authors investigate how these diets, particularly those incorporating low protein intake and keto analogues, might delay CKD progression and improve overall health outcomes for patients.[42]

This comprehensive review paper underscores the critical connection between nutrition and health, particularly in the context of chronic diseases and health disparities prevalent in the United States. Highlighting the challenges associated with low diet quality and inadequate access to healthy foods, the paper emphasizes the urgent need for interventions and policies to improve health outcomes through nutrition. It introduces the concept of Food Is Medicine (FIM) as a promising approach, integrating the provision of healthy foods with clinical care to prevent and manage specific medical conditions. Acknowledging the multifaceted roles of food in society, the paper advocates for a holistic understanding of FIM, considering its implications for social cohesion, cultural identity, economic impact, and environmental sustainability. While recognizing the potential of FIM to address the significant burden of diet-related chronic diseases, the paper also acknowledges the limitations of existing evidence, calling for further research and coordinated efforts to establish definitive evidence on the efficacy and effectiveness of FIM interventions across diverse populations and health conditions. Overall, this paper serves as a comprehensive call to action, emphasizing the importance of diet and nutrition in promoting cardiovascular health and addressing health inequities.[43]

2.2.5 Algorithms for Food Recommendation

Various algorithms can recommend foods for cardiac patients based on their nutritional needs and preferences. This section explores different algorithms used in food recommendation systems.

2.2.5.1 Baseline Algorithm

The Baseline Algorithm predicts food recommendations based on the average rating for each item and user, considering global effects. It offers a simple foundational approach to personalized nutrition.

This paper addresses the issue of information overload on the Internet by enhancing recommendation systems through the integration of user and item basic data with deep learning techniques. Traditional collaborative filtering (CF) algorithms, while effective, suffer from sparsity and cold-start problems due to limited user ratings. To overcome these challenges, the authors propose a novel recommendation algorithm that incorporates accessible user demographics and item details, alongside rating data, to better extract features and improve recommendation accuracy. Evaluated with the MovieLens 1M dataset, the proposed algorithm outperforms traditional CF methods, demonstrating its potential to mitigate data sparsity and cold-start issues despite higher computational complexity. This integration of deep learning represents a significant advancement in recommendation technology, highlighting the need for further research in leveraging user and item basic data for more robust recommendation systems.[44]

This paper introduces the Multi-Scenario Causal-driven Adaptive Network (M-scan) to enhance recommendation systems by addressing the limitations of single-scenario models and the challenges in existing multi-scenario approaches. Traditional recommendation algorithms, while effective in isolated scenarios, struggle with data sparsity, incomplete user representations, and resource inefficiency. M-scan leverages a causal graph to understand the dual influence of scenarios on user interests and click behavior, incorporating two key modules: the Scenario Bias Eliminator, which removes direct scenario-induced biases, and the Scenario-Aware Co-Attention mechanism, which explicitly models user interests across multiple scenarios. This novel approach ensures more accurate and robust recommendations. Evaluated on public datasets, M-scan demonstrates significant improvements over existing methods, highlighting its potential for multi-scenario recommendation applications.[45]

This paper explores the development of a food recommendation system using collaborative filtering (CF) methods, specifically focusing on Matrix Factorization (MF) algorithms and their derivatives: Singular Value Decomposition (SVD), SVD with Implicit Ratings (SVD++), and Non-Negative Matrix Factorization (NMF). Using the Amazon Fine Food Reviews dataset, the study compares the performance of these MF algorithms against the BaselineOnly algorithm by evaluating error metrics such as Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE). The research highlights the potential of CF-based MF algorithms in providing personalized food recommendations, addressing the challenges of data sparsity and user preferences more effectively than traditional methods. The study builds on existing literature by demonstrating that MF algorithms can enhance recommendation accuracy and user satisfaction, making them suitable for applications in e-commerce and other domains where personalized suggestions are critical.[46]

This paper addresses the challenge of out-of-distribution (OOD) generalization in image classification by proposing a Balanced Causal Learning (BCL) framework. Traditional deep learning models often fail to generalize well in OOD contexts due to their reliance on spurious correlations present in the training data. The BCL framework mitigates this issue by leveraging causal inference techniques, including balanced partitioning and class difficulty balancing strategies. These methods ensure that the model learns invariant features across different environments, rather than focusing on context-specific cues. The framework divides the data into fine-grained splits with balanced samples, promoting equal learning opportunities across various classes and environments. Experiments conducted on the NICO and NICO++ datasets demonstrate that the BCL framework significantly reduces learning bias and enhances predictive accuracy in OOD scenarios. This innovative approach shows promise in improving the robustness and generalization of image classification models beyond the i.i.d. assumption, highlighting its potential for broader applications in real-world settings.[47]

This paper explores the significant role of agriculture in Bangladesh's economy and employment, highlighting the challenges and advancements in the sector. It reviews various methodologies in precision agriculture and crop yield prediction, noting the promising results of machine learning techniques like random forest and decision trees used by researchers such as Sangeeta et al. However, it also identifies gaps in existing studies, such as the lack of performance measurements and practical applicability issues in IoT and machine learning approaches. The authors propose a novel crop recommendation system with a high accuracy

rate of 99%, utilizing a voting-based ensemble model. Their objectives include integrating real-time prediction models with IoT devices, enhancing usability for farmers, and developing a simplified interface for data collection and decision-making, specifically in the Bengali language. This study aims to address critical issues in agricultural production optimization, emphasizing robust performance and adaptability across various agricultural contexts, thereby advancing precision agriculture in Bangladesh.[48]

This thesis provides a thorough examination of recommendation systems (RSS) and their application in the food domain, highlighting the critical role these systems play in enhancing decision-making processes by analyzing user behavior to deliver personalized products and services. It categorizes the state-of-the-art recommendation methods into collaborative filtering-based, content-based, and hybrid approaches. The thesis underscores the growing global focus on health and the necessity for tailored health solutions that consider individual circumstances, lifestyles, and preferences, as well as cultural, religious, and socioeconomic factors. Emphasizing the measurement of health outcomes, the work illustrates the importance of reliable and accurate metrics for personalizing health recommendations and tracking progress. It acknowledges the complexity of food and nutrition recommendation systems, given the need to manage a vast array of ingredients and the intricacies of recipes, while also addressing the dual objectives of catering to user tastes and promoting healthy dietary habits. The thesis further discusses the integration of multi-objective optimization and deep learning techniques in developing advanced recommendation systems, thereby offering a comprehensive overview of the current advancements and challenges in this field.[49]

This paper provides an in-depth analysis of fine-grained image recognition, particularly focusing on its application in food image recognition. It highlights the complexities and challenges inherent in distinguishing subcategories within the same category, such as different types of apples or oranges, emphasizing the heightened granularity required compared to ordinary image recognition. The paper discusses the growing importance of precise food image recognition due to various practical applications, including dietary health management, automatic settlement in retail, social media food recommendations, and quality control in food ordering apps. The authors review recent advancements in fine-grained image classification, noting significant contributions such as graph-based relationship discovery, Gaussian loss regularization, and novel attention mechanisms. They identify a common limitation in existing models, which are typically trained on single-source datasets, and propose an innovative solution: a "knowledgeable" fine-grained model trained on multiple

datasets through feature map fusion. This approach aims to enhance model performance across diverse data sources, addressing a critical gap in current fine-grained image recognition methodologies. The paper's contributions offer valuable insights and potential advancements in the field, with implications for both academic research and practical applications in food technology and beyond.[50]

2.2.5.2 Co-Clustering Algorithm

The Co-Clustering Algorithm partitions both users and items into clusters, predicting food preferences based on these clusters. This method identifies group-specific dietary needs and preferences.

This research project centers on enhancing the Structure of Knowledge Acquisition, Use, Learning, and Collaboration (SKAU) environment, primarily through the development and population of a Knowledge Base (KB) using documents from the RFC Editor repository. The project integrates Artificial Intelligence (AI) techniques, particularly in Natural Language Processing (NLP) and Machine Learning (ML), to process unstructured data and construct domain ontologies relevant to the Internet Infrastructure. Key tools such as Protégé 5, OnTop, and Python-based IIBlockchain are employed to capture, represent, and manage the knowledge. The project aims to create a collaborative environment where autonomous agents within the Autonomous Architecture over Restricted Domains (A2RD) framework can effectively interact and share knowledge with humans. This innovative approach addresses the complexities of capturing knowledge from diverse, unstructured sources and aims to enhance the autonomy and cooperation of intelligent agents, thereby improving the management and functionality of Autonomous Systems (ASes) in the Internet ecosystem. This work not only advances the technical capabilities of knowledge representation but also provides a robust framework for future research and practical applications in Internet infrastructure management.[51]

Understanding gene regulation remains a central challenge in molecular biology, with model organisms like Saccharomyces cerevisiae playing a crucial role in elucidating underlying mechanisms. This paper makes significant strides by integrating yeast gene expression time course data with chromatin immunoprecipitation microarray data to identify transcriptional modules—sets of functionally related genes regulated by the same transcription factors. To achieve this, the authors propose an innovative clustering approach adapted to the complexity

of the data. The study highlights the importance of incorporating diverse omic data to deepen insights into the transcription process and demonstrates the effectiveness of Bayesian profile regression in improving clustering accuracy by integrating outcome information directly into the analysis. This approach not only enhances our understanding of gene regulation in yeast but also showcases a robust method for clustering in high-dimensional biological data, offering valuable implications for future research in genomics and molecular biology.[52]

Recommender systems (RS) have garnered significant attention due to their widespread application across various domains, including product searches, entertainment, and travel. This paper provides a comprehensive review of RS, focusing on three primary paradigms: Content-Based Filtering (CBF), Collaborative Filtering (CF), and Hybrid Filtering (HBF). Each approach's mechanisms, theoretical foundations, strengths, and weaknesses are thoroughly analyzed. CBF relies on user and item features to provide recommendations, mitigating cold start issues but struggling with sparse data scenarios. CF leverages user-item interaction histories, offering robust recommendations in data-rich environments but facing challenges with sparse interactions. HBF combines multiple techniques to offset individual limitations, enhancing overall recommendation quality. The paper also addresses recent advancements (2019-2023) and identifies emerging challenges and research questions, such as the suitability of different approaches for specific problems, evaluation techniques, and popular datasets. This detailed review underscores the evolving nature of RS and highlights the necessity for ongoing research to address persistent and emerging challenges in the field.[53]

2.2.5.3 KNN-Basic Algorithm

KNN-Basic uses the ratings of similar users or items to make predictions, recommending foods that similar patients have found beneficial.

Recommender systems have emerged as powerful tools in various domains, including health and nutrition, where they can significantly impact lifestyle changes and dietary habits. This paper explores the application of hybrid recommender systems—combining collaborative filtering, content-based, and knowledge-based models—to improve dietary recommendations tailored to individual users' nutritional needs and preferences. These systems analyze past user behavior to identify patterns and provide personalized food recommendations, addressing both health requirements and personal tastes. The incorporation of advanced machine learning algorithms, such as Decision Trees, Bagging, AdaBoost, and k-Nearest

Neighbors, enhances the accuracy and effectiveness of these recommendations. The paper highlights the potential of food recommender systems to promote healthier eating habits, particularly in academic environments, by offering personalized meal suggestions that align with users' energy needs and historical food choices. This innovative approach underscores the importance of integrating user preferences with nutritional information, paving the way for more effective and user-friendly dietary management solutions. The comprehensive review of recommender systems also underscores their broader applicability and the ongoing challenges in optimizing these systems for diverse applications.[54]

The rapid growth of online music education platforms has necessitated the development of advanced recommendation systems to effectively curate and deliver educational resources tailored to individual learners' needs. This study introduces a hybrid recommendation system that leverages a combination of collaborative filtering, content-based, and knowledge-based approaches to enhance the quality and relevance of music education resources. By integrating blockchain technology, the system ensures secure and transparent data processing, thereby improving trust and reliability. Additionally, the incorporation of sophisticated machine learning models, such as backpropagation neural networks and k-nearest Neighbors, significantly boosts the accuracy of recommendations. The proposed system addresses the challenges posed by the overwhelming volume of online resources and varying quality, providing a robust solution for personalized learning in music education. This innovative approach not only enhances learners' engagement by offering tailored recommendations but also sets a precedent for future research in the field of educational technology, highlighting the potential of hybrid models and blockchain in optimizing online learning experiences.[55]

The increasing demand for efficient and accurate machine learning (ML) solutions has driven significant interest in the automation of ML processes, culminating in the development of Automated ML (AutoML) systems. These systems aim to optimize various aspects of ML workflows, from data preprocessing to model selection and hyperparameter tuning. This study by Pio et al. explores the application of meta-learning (MtL) to enhance AutoML systems by recommending suitable noise detection algorithms, addressing a critical yet often overlooked step in data preprocessing. By leveraging MtL, the authors propose a methodology that ranks noise detection algorithms based on meta-features extracted from datasets, thus improving preprocessing efficiency and accuracy. The study not only highlights the substantial portion of data mining time dedicated to preprocessing but also underscores the potential of MtL to reduce this time through informed algorithm selection. The

comparative analysis of two MtL approaches provides valuable insights into their respective advantages and limitations, contributing to the broader discourse on optimizing preprocessing in AutoML systems. This research extends previous work and proposes a flexible framework that could be integrated into existing AutoML solutions, enhancing their robustness and adaptability.[56]

The research conducted by Harshitha et al. addresses the critical issue of low agricultural productivity in India by leveraging precision farming techniques and advanced machine learning models. The study underscores the necessity of precise agricultural practices to optimize input use and enhance crop yields, mitigating potential losses in resources and finances. By employing machine learning methods, specifically ensemble and hybrid models, the research aims to improve harvest predictions and, consequently, agricultural productivity. The incorporation of both biotic and abiotic factors in the modeling process highlights a comprehensive approach to understanding and addressing the complexities of crop cultivation. This study's innovative use of the polling technique to refine model accuracy presents a significant advancement in precision agriculture, offering a promising solution to the challenges faced by the agricultural sector. The detailed analysis of various learning algorithms—supervised, unsupervised, and semi-supervised—demonstrates a thorough exploration of their respective strengths and applications in the context of agricultural data. This work contributes valuable insights into the potential of machine learning to revolutionize agricultural practices, making it a pertinent addition to the literature on sustainable agriculture and food security.[57]

2.2.5.4 KNN-with means Algorithm

KNN-withMeans improves on KNN-Basic by considering the mean ratings of users or items, enhancing the accuracy of food recommendations.

The research conducted on optimizing dietary recommender systems for thyroid patients presents a significant advancement in personalized nutrition guidance by integrating Particle Swarm Optimization (PSO) with K-means clustering. This innovative approach addresses the critical issue of initial centroid selection in K-means clustering, which is essential for forming accurate and effective food clusters based on nutrient profiles. By leveraging PSO's ability to dynamically optimize the initial cluster centroids, the study enhances the quality of dietary recommendations tailored to the specific needs of thyroid patients. The inclusion of essential nutrients and the avoidance of adverse elements like caffeine and goitrogens in the

recommendation process underscore the paper's comprehensive approach to managing thyroid health through diet. Furthermore, the comparative analysis with other algorithms highlights the superior performance of the PSO-K-means hybrid model, reinforcing its potential as a robust tool for personalized dietary advice. This work contributes valuable insights into the intersection of machine learning and nutritional science, offering practical applications for improving the dietary management of thyroid disorders and setting a precedent for future research in the field.[58]

This paper introduces ML. Recommend, a new recommendation model integrated with Microsoft's ML.NET platform, designed to enhance e-commerce experiences by leveraging machine learning techniques. By combining matrix factorization and time factors, ML. Recommend aims to deliver precise and dynamic product recommendations based on user ratings and logistic regression analysis of customer comments. The study meticulously outlines the full cycle of recommendation modeling, from data preprocessing to model evaluation, and compares its performance with established models like SVD, KNN, and NMF. Tested on the UEL Store dataset and UCI sentiment labeled sentences, the model demonstrated robust performance, as evidenced by various evaluation metrics. Notably, the model's implementation was made accessible on Microsoft's NuGet system, facilitating further research and development. This work underscores the potential of integrating advanced machine learning algorithms with practical e-commerce applications to enhance customer engagement and satisfaction.[59]

This paper explores the application of recommender systems in health information systems, specifically focusing on a Diet Recommender System that suggests appropriate food choices for patients based on their health conditions. Unlike traditional medical recommendations, this system leverages machine learning to analyze extensive datasets, such as those from the Food and Drug Administration (FDA), to match patients' dietary needs with suitable food items. The proposed system normalizes the dataset and employs machine learning algorithms to predict and recommend foods that align with the patient's health profile, thus aiming to enhance patient care by integrating nutritional guidance into health management. The research underscores the potential of recommender systems to mitigate information overload and provide personalized dietary advice, highlighting a shift from medicine-centric to food-centric health interventions. This innovative approach demonstrates significant promise in improving patient outcomes by tailoring dietary recommendations to individual health requirements.[60]

This paper addresses the pressing issue of inadequate nutrition in contemporary society by proposing an innovative solution using image processing techniques. By employing object recognition in images, the study aims to evaluate the balance of a plate's contents according to Harvard's nutritional recommendations. The integration of official guidelines from Harvard Medical School with machine learning and nutrition coordination presents a promising avenue for improving dietary practices. The research not only highlights the challenges individuals encounter in adopting healthier eating habits but also offers a practical method to automate the assessment of plate balance, thus facilitating adherence to optimal nutrition guidelines. Through a well-structured organization of sections, including a thorough review of related studies, detailed methodology descriptions, and insightful experimental findings, this paper makes a valuable contribution to the field of nutritional science and image processing for dietary assessment.[61]

This literature review provides a comprehensive overview of collaborative Book Recommendation Systems (BRMS), highlighting the evolution of such systems and their effectiveness in recommending books to readers. By reviewing several studies in this field, the paper explores various approaches and techniques employed in collaborative BRMS, ranging from Naive Bayes and Jaccard similarity to matrix factorization and clustering algorithms. These studies demonstrate the potential of collaborative filtering techniques in accurately recommending books based on user preferences and ratings. Moreover, the review identifies the importance of leveraging sophisticated algorithms and large datasets to enhance the accuracy and efficiency of BRMS. By synthesizing insights from multiple studies, the literature review contributes valuable knowledge to the understanding of collaborative BRMS and its implications for improving the book discovery experience for readers.[62]

This research paper presents a comprehensive investigation into building a University Recommendation System (URS) tailored for undergraduate studies in Bangladesh, utilizing distributed machine learning techniques. By integrating both popularity-based and collaborative filtering recommender models, the study aims to provide aspiring undergraduates with personalized university recommendations. The literature review section provides valuable insights into previous research efforts, showcasing a wide range of distributed machine learning algorithms and frameworks applied to recommendation systems, particularly in the context of academic institutions. Through meticulous data collection and preprocessing, coupled with rigorous model training and evaluation, the study develops a robust framework for university recommendations. The methodology section offers a clear

and systematic approach, encompassing data analysis, visualization, model selection, and performance evaluation, culminating in a comprehensive analysis of the results. Overall, this paper contributes significantly to the advancement of intelligent recommendation systems in higher education settings, particularly in Bangladesh, and provides valuable guidance for future research endeavors in this domain.[63]

2.2.5.5 KNN-withZscore Algorithm

KNN-withZscore standardizes ratings before computing similarities, making more balanced food recommendations.

This paper offers a comprehensive analysis of recommendation systems (RS), emphasizing their growing importance in various domains, particularly in e-commerce and scientific libraries, where they enhance user experience and decision-making processes. The authors highlight the significant market potential of RS, with projections of substantial growth driven by advancements in artificial intelligence and increased digitalization. The paper meticulously distinguishes between content-based and collaborative-based filtering methods, elucidating their respective mechanisms and applications. It underscores the "Cold Start Problem" as a critical challenge in RS, particularly when new users or products are introduced without sufficient data. The research aims to explore collaborative-based filtering techniques, comparing various methodologies to determine the most effective approach for specific data sets. The study's goals include understanding RS functionality, evaluating different RS methods, and assessing the alignment of recommendations with user preferences. By providing a detailed evaluation and comparative analysis, this paper contributes valuable insights into optimizing RS performance and addressing common challenges, making it a significant addition to the field of recommendation systems research.[64]

This paper explores the evolution and application of multi-criteria recommendation systems (MCRS) in enhancing user experience by incorporating multiple utility-related aspects into recommendations. It highlights the transition from traditional collaborative and content-based filtering techniques to MCRS, which leverages explicit multi-attribute ratings and advanced models like knowledge graphs and graph convolutional networks. The study focuses on a recipe recommendation system, contrasting collaborative filtering methods with knowledge graph-based approaches to predict user ratings for unrated recipes. It addresses a gap in research within the food domain by utilizing detailed multi-criteria data and novel

computational techniques. The paper reviews existing literature on recommendation systems, particularly those using multi-attribute and multi-rating methodologies, and presents a new model designed to improve the accuracy of recipe recommendations. Through its comprehensive analysis and innovative approach, the study aims to contribute to the development of more effective and personalized recommendation systems.[65]

This paper addresses the critical issue of rising obesity rates and associated health risks by leveraging machine learning algorithms to predict obesity levels based on diverse factors such as physical characteristics, dietary habits, and transportation modes. It emphasizes the potential of machine learning to provide personalized insights into obesity severity, enabling tailored diet and lifestyle recommendations. The study proposes a comprehensive dataset that includes daily food consumption, height, and dietary habits to accurately predict different types of obesity. It also accounts for individuals with specific medical conditions, offering a nuanced and inclusive approach to obesity prediction. The paper explores various machine learning strategies, including content-based, collaborative-based, and hybrid approaches, to identify the most effective models for obesity prediction through comparative analysis. This analysis aims to enhance model accuracy and practical application, thereby contributing significantly to global obesity mitigation efforts and improving individual health outcomes.[66]

This paper addresses the critical challenge of firmware vulnerabilities (FVs) in IoT devices by proposing a novel detection algorithm that combines pattern-specific numerical features (MSNC) and structural features matching (SFM). The algorithm aims to detect homologous vulnerabilities across different firmware platforms, thereby enhancing the overall security of IoT systems. The study highlights the increasing importance of firmware security (FS) in the context of IoT's expanding role in various fields, from daily life to industrial applications. It identifies the limitations of existing vulnerability detection (VD) approaches, particularly in detecting same-origin vulnerabilities, and positions its proposed algorithm as a significant advancement in this area. Through comparative experimental studies, the effectiveness of the algorithm in detecting actual FVs is validated, demonstrating its potential to reduce device system risks and improve security performance. This work fills a crucial gap in current FS research, offering a comprehensive and innovative solution for improving IoT security, and setting a new direction for future studies in this field.[67]

This paper provides a comprehensive examination of predictive maintenance for gearboxes in wind turbines, emphasizing the importance of feature engineering and selection in optimizing predictive models. It outlines the significant role of vibration monitoring and advanced AI techniques in identifying failure states and enhancing system reliability. By focusing on various feature extraction methods—such as time-domain, frequency-domain, and trend analysis features—the study underscores the necessity of selecting relevant features to improve model performance, reduce dimensionality, and prevent overfitting. It highlights the use of filter, wrapper, and embedded methods for feature selection to enhance model accuracy and interpretability. The research uses two distinct datasets to validate its approach, demonstrating the effectiveness of these techniques in real-world applications. Overall, the study contributes valuable insights into the predictive maintenance of gearboxes, aiming to minimize downtime and improve the operational efficiency of wind turbine systems.[68]

2.2.5.6 NMF Algorithm

NMF (Non-Negative Matrix Factorization) decomposes the rating matrix into two lower-dimensional matrices, representing user and item latent factors. This technique uncovers hidden dietary preferences and needs.

This paper meticulously examines the issue of popularity bias in media recommender systems through an extensive reproduction study of three seminal works by Abdollahpouri et al. (2019), Kowald et al. (2020), and Naghiaei et al. (2020). By analyzing collaborative filtering algorithms across different media types—movies, music, and books—the study highlights the pervasive nature of popularity bias and its differential impact on user groups. It explores how different datasets, algorithms, user group definitions, and evaluation strategies contribute to the varying degrees of popularity bias observed in each study. The authors identify key factors influencing these divergences, emphasizing the significant role of evaluation strategies in determining the extent of bias. Their findings underscore the complexity of measuring and mitigating popularity bias, offering valuable insights for future research on enhancing fairness and accuracy in recommender systems. This comprehensive review not only validates previous findings but also provides a nuanced understanding of the mechanisms driving popularity bias, contributing to the broader discourse on fairness in artificial intelligence and machine learning applications.[69]

This paper provides a comprehensive overview of various recommendation algorithms, including content-based filtering, collaborative filtering, deep learning, and hybrid

techniques, while highlighting their respective strengths and challenges. It particularly focuses on addressing the limitations of traditional collaborative filtering methods—such as sparsity, cold start, and computational complexity—by introducing a novel user persona-based recommendation technique. This method, leveraging Latent Dirichlet Allocation (LDA) for topic modeling and K-Means Clustering for user persona creation, aims to enhance recommendation accuracy and efficiency. Furthermore, the study explores the application of Non-negative Matrix Factorization (NMF) and deep learning algorithms to improve the performance of recommender systems. The empirical results, based on the MovieLens dataset, demonstrate that deep learning-based approaches significantly outperform traditional methods in terms of accuracy and computation time. This paper's innovative approach to integrating user personas and advanced machine learning techniques offers valuable insights for developing more robust and user-centric recommender systems, addressing key issues in the current recommendation landscape.[70]

This paper presents a detailed examination of recommendation systems, distinguishing between content-based and collaborative filtering methods, and emphasizing their application across diverse fields such as television, e-commerce, and e-learning. The paper categorizes collaborative filtering into memory-based and model-based systems, highlighting the strengths and limitations of each approach. Memory-based systems, relying on the K-Nearest Neighbor algorithm, are noted for their simplicity but struggle with scalability and accuracy in large datasets. Conversely, model-based systems, which utilize predictive models, offer greater scalability and efficiency but face challenges with new items, known as the cold start problem. The authors underscore the significance of addressing inherent issues in collaborative filtering, such as data sparsity and cold start, which undermine recommendation accuracy. By proposing an enhanced methodology that leverages various user contexts to better model preferences, the paper contributes valuable insights into improving the precision and effectiveness of recommendation systems. This work is particularly relevant for developing scalable and accurate recommendation algorithms capable of handling large and dynamic datasets.[71]

This paper explores the growing significance of recommendation systems (RS) in the digital era, particularly emphasizing their role in e-commerce and the emerging domain of food recommendation systems (FRS). The authors highlight the pivotal function of RS in filtering vast amounts of online information to deliver personalized recommendations, thereby enhancing user experience in various sectors, including music, video streaming, and social

media (Elahi et al., 2023; Lim et al., 2023; Zaveri et al., 2023). In e-commerce, platforms like Amazon, Alibaba, and eBay leverage RS to analyze customer behavior and generate accurate product suggestions, which has proven especially beneficial during the COVID-19 pandemic (Oyebode & Orji, 2020). The paper underscores the increasing relevance of FRS, which aids users in navigating the overwhelming amount of food-related content available online. These systems not only suggest meals based on user preferences but also promote healthy eating habits by tracking dietary patterns and identifying potential health concerns (Gao et al., 2020; Li et al., 2023). The comprehensive review illustrates the critical role of RS in managing information overload and supporting users in making informed decisions across various domains.[72]

2.2.5.7 Slope-One Algorithm

Slope-One predicts ratings based on the average difference between items, efficiently recommending foods that fit within dietary restrictions.

This paper addresses the unique challenges posed by cloud manufacturing service recommendations by proposing a novel method that combines spectral clustering with an improved Slope One algorithm. The authors identify two main issues: the complexity of determining similarities among cloud manufacturing services due to varied attribute parameters, and the influence of users' historical service preferences on recommendation accuracy. By introducing a spectral clustering algorithm, the method reduces the search space for services, enhancing the efficiency of obtaining services to be rated. The improved Slope One algorithm, which integrates both user and service similarity, is designed to provide more reasonable and accurate service ratings. Experimental results demonstrate that this combined approach outperforms existing popular methods in terms of service rating and recommendation accuracy, thus offering a significant advancement in the field of cloud manufacturing service recommendation. This research not only highlights the specific difficulties of recommending cloud manufacturing services but also provides a robust solution that leverages clustering and collaborative filtering techniques to improve recommendation quality.[73]

This paper offers a comprehensive review of film recommendation systems, addressing the growing need for efficient methods to assist users in navigating large databases of films. It highlights the challenges users face in selecting movies from extensive catalogs, underscoring the time-consuming and confusing nature of the process. The authors present a film

recommendation system based on Collaborative Filtering (CF) techniques, outlining the implementation, testing, and evaluation of various machine learning algorithms to develop a predictive film provider rating model. Through a structured organization, the paper delves into a literature review of existing movie recommendation systems, discussing methodologies such as K-means clustering, k-nearest neighbor (KNN) algorithms, and hybrid CF and content-based filtering (CB) approaches. Notably, the study contributes by testing and evaluating multiple strategies, including co-clustering and Slope One methods, thereby offering valuable insights into enhancing film recommendation accuracy. The review further emphasizes the significance of recommendation systems in providing users with relevant suggestions, thereby simplifying the movie selection process within the vast landscape of big data.[74]

This paper presents Nutricare, a novel knowledge-based nutrition recommender system tailored for the Sri Lankan population aged 18 to 60. In response to the escalating rates of noncommunicable diseases (NCDs) linked to unhealthy eating habits, the authors emphasize the urgent need for personalized nutrition guidance, particularly among children. Leveraging artificial intelligence (AI) algorithms and big data, Nutricare aims to deliver individualized meal recommendations based on factors such as gender, BMI, medical history, dietary preferences, and activity levels. The system adopts the Classification and Regression Tree (CART) methodology to ensure tailored nutrition advice while incorporating expert supervision to uphold accuracy and user safety. By providing comprehensive diet plans and user-friendly interfaces, Nutricare seeks to empower users to adopt healthier eating habits and mitigate the risk of NCDs. Overall, this research contributes to addressing gaps in existing diet recommender systems and offers a promising approach to promoting public health and well-being in the Sri Lankan community.[75]

This paper presents an innovative approach to personalized video recommendation systems, addressing the challenges posed by the exponential growth of video content and the limitations of traditional collaborative filtering methods. By integrating user preferences with detailed analysis of video metadata, including tags, the proposed algorithm aims to provide more accurate and tailored recommendations. The incorporation of weight factors in similarity calculations enhances recommendation precision, while leveraging Artificial Intelligence principles enables dynamic adaptation to user preferences. This research offers valuable insights into advancing recommendation algorithms in the evolving landscape of

online video platforms, contributing to improved user satisfaction and browsing experiences.[76]

This paper provides a comprehensive overview of a recommendation system for food items based on machine learning and clustering techniques. By leveraging user information and interests analysis, the proposed smart system aims to suggest the most suitable food items tailored to individual preferences. The utilization of recommendation systems has been widely recognized as an effective solution across various domains, offering users personalized recommendations based on their past behavior and preferences. The incorporation of clustering methods addresses challenges such as the cold start problem, ensuring accurate recommendations even when user preferences are unclear to the system. Moreover, the combination of the silhouette algorithm and k-means clustering enhances the accuracy of the clustering process, ultimately improving the relevance and effectiveness of the recommended food items. Overall, this paper contributes valuable insights into the development of recommendation systems for food, showcasing the potential of machine learning and clustering approaches in optimizing user experiences and meeting individual dietary needs.[77]

2.2.5.8 SVD Algorithm

SVD (Singular Value Decomposition) decomposes the rating matrix into three matrices representing user, item, and latent factors, providing detailed insights into personal dietary preferences.

This comprehensive review presents a detailed examination of various studies focusing on the implementation of recommendation systems in the culinary industry. Each study explores distinct methodologies, including Collaborative Filtering, Association Rule Mining, and FP-Growth algorithm, to address specific challenges in food menu recommendation and optimization. Through meticulous analysis of customer preferences, transactional data, and ordering patterns, these studies offer valuable insights into enhancing customer experiences, streamlining operations, and boosting sales within culinary establishments. Furthermore, the review highlights the researcher's unique approach to implementing the Collaborative Filtering method in a food ordering application at Makecents Café, emphasizing the potential for technological innovation to revolutionize traditional café operations and enhance customer satisfaction. Overall, this review provides a comprehensive overview of existing

literature while setting the stage for the researcher's novel contribution to the field through the proposed implementation of a modernized food ordering system.[78]

This paper presents a comprehensive exploration of the use of recommendation systems in e-commerce, focusing particularly on addressing the cold-start problem through the utilization of implicit feedback. By leveraging transaction data and user behavior patterns, the research proposes a novel approach to recommendation systems, which does not rely on explicit ratings from users. Instead, it emphasizes the significance of implicit signals, such as the frequency of transactions and the types of product categories purchased, in identifying user preferences and generating personalized recommendations. The adoption of this methodology offers a promising solution to the challenges posed by the cold-start problem, enabling the recommendation system to provide valuable insights and suggestions to users even in the absence of explicit feedback. Moreover, the paper outlines a rigorous research methodology, emphasizing the importance of identifying and addressing data limitations, as well as the meticulous process of data collection, processing, and analysis. Through this systematic approach, the research aims to develop an effective recommendation engine capable of enhancing user experience and driving transactional success in the e-commerce domain.[79]

This paper provides a comprehensive overview of the rising popularity of green food consumption and the increasing importance of e-commerce platforms in facilitating access to such products. By examining the intersection of food safety concerns, consumer preferences, and the exponential growth of internet usage, the authors underscore the significance of implementing effective recommendation systems in e-commerce to meet the evolving needs of health-conscious consumers. Moreover, the paper delves into the limitations of traditional recommendation approaches, particularly in the context of fake ratings and the inadequacy of star-based scoring systems. Drawing upon insights from previous research, the authors advocate for the integration of sentiment analysis of user-generated content, such as post-purchase reviews, to enhance the accuracy and reliability of recommendation systems. Furthermore, the exploration of sentiment analysis methodologies, including deep learning, machine learning, and emotion dictionaries, offers valuable insights into the diverse approaches available for extracting sentiment from textual data. Overall, this paper contributes to the scholarly discourse by proposing innovative strategies for personalized recommendation systems tailored to the green food domain, thereby addressing the growing demand for healthier and more sustainable consumption choices in the digital era.[80]

This paper presents a comprehensive overview of music recommendation systems, focusing on the utilization of machine learning techniques to enhance song suggestions for listeners. By exploring various methodologies such as collaborative filtering, content-based filtering, and hybrid approaches, the paper highlights the complexity of building effective recommendation systems tailored to individual listener preferences. Through the analysis of different machine learning algorithms, including cosine similarity, K-nearest neighbor, and Factorization Machine, the authors demonstrate the evolution of recommendation models and their impact on system accuracy and efficiency. Moreover, the incorporation of deep learning techniques, particularly Deep Convolutional Neural Networks (DCNN), underscores the advancements in feature extraction and prediction accuracy. The evaluation of the recommendation system using classification metrics like precision, recall, and classification rate provides valuable insights into the performance of different methodologies. Overall, this paper contributes to the existing literature by offering a comprehensive analysis of music recommendation systems, thereby informing future research directions and advancements in this domain.[81]

This paper presents a novel approach to recommendation system design, aiming to enhance the performance of deep neural network (DNN) based collaborative filtering (CF) algorithms. By introducing the singular value decomposition (SVD) method for initializing latent features in CF, the proposed scheme offers a streamlined alternative to training embedding layers, thereby reducing unnecessary parameters and potential overfitting issues. The integration of DNN structure enables more accurate training of user preferences and content characteristics, leading to improved recommendation accuracy. Through an evaluation using the MovieLens dataset, the paper demonstrates the effectiveness of the proposed method in enhancing recommendation system performance. Overall, this research contributes valuable insights into optimizing recommendation algorithms through the fusion of traditional CF techniques with deep learning methodologies, offering promising avenues for future advancements in recommendation system design.[82]

This paper addresses the critical issue of improper diet and its profound impact on global health, highlighting the alarming statistics provided by the World Health Organization (WHO) regarding malnutrition and related illnesses. By recognizing the potential of Food Recommender Systems (FRS) as a solution to promote healthier dietary choices, the paper underscores the need to prioritize health considerations alongside taste preferences in food recommendations. Unlike existing systems that primarily focus on taste and overlook

nutritional aspects, the proposed framework integrates graph theory techniques to recommend recipes that balance both taste and health. By leveraging relationships between users, ingredients, and recipes, the framework offers personalized recommendations that cater to users' preferences while also promoting nutritious food choices. The incorporation of an embedding-based ingredient predictor enhances the system's ability to suggest relevant ingredient substitutions, thus facilitating the exploration of new and healthier recipe variations. Overall, this paper presents a novel approach to food recommendation that has the potential to address the global challenges of obesity and malnutrition by empowering users to make informed dietary decisions.[83]

2.2.5.9 SVD++ Algorithm

SVD++ extends SVD by incorporating implicit feedback, refining recommendations based on dietary habits.

This paper provides a comprehensive overview of recommendation systems, highlighting their crucial role in addressing information overload in various domains such as e-commerce, content sharing, and social networking platforms. By elucidating the distinction between personalized and non-personalized recommendation systems and emphasizing the importance of serendipity in recommendation algorithms, the paper underscores the multifaceted nature of recommendation challenges. Furthermore, the paper delves into the technical aspects of recommendation systems, exploring collaborative filtering-based techniques and the link prediction approach to address scalability and sparsity issues. The proposed contribution of enhancing recommender engine suggestions through link prediction is particularly noteworthy, offering a novel solution to improve recommendation accuracy and user experience. The paper's organization, including its detailed discussion on existing literature, proposed methodology, and future scope, ensures a comprehensive understanding of recommendation systems' intricacies and their potential applications. Overall, this paper serves as a valuable resource for researchers and practitioners in the field of recommendation systems, offering insights into both theoretical frameworks and practical methodologies for enhancing recommendation algorithms.[84]

This paper addresses the challenge of prediction accuracy in recommendation systems (RS) by proposing an enhanced method that incorporates four sources of information: explicit social relations, implicit social relations, explicit ratings, and implicit feedback. By leveraging the SVD++ method, the proposed approach aims to overcome the limitations of

previous studies and alleviate the sparsity issue inherent in RS. The paper provides valuable contributions to the field by integrating multiple sources of information into a unified framework and evaluating the proposed method on real datasets including Ciao, FilmTrust, and Last. Fm. By doing so, the study offers insights into how social relationships and implicit feedback can be effectively utilized to enhance the performance of RS. Overall, this paper presents a comprehensive exploration of recommendation system methodologies, offering a novel approach to improving prediction accuracy and addressing the challenges posed by information overflow in the era of e-commerce and social networks.[85]

This paper proposes a novel hybrid method that integrates Singular Value Decomposition Plus (SVD++) with the Partitioning Around Medoids (PAM) clustering algorithm to address the cold-start problem in recommendation systems (RSs). By leveraging social relations and confidence values extracted from users' ratings, the proposed approach aims to overcome the limitations of existing methods and improve prediction accuracy for cold-start users. The study offers valuable contributions to the field by integrating multiple data sources into a unified framework and evaluating the proposed model using real-world datasets. Through a comprehensive exploration of SVD++, PAM, and the extraction of social relations and confidence values, the paper provides insights into how clustering techniques and latent factor models can be combined to enhance RS performance. Overall, this research presents a promising solution to the challenges posed by the cold-start problem in RSs, offering a robust methodology for improving recommendation accuracy in the era of information overload and e-commerce growth.[86]

This paper presents a significant contribution to the field of recommender systems by proposing three novel methods that extend the popular Singular Value Decomposition Plus Plus (SVD++) model. By incorporating social and environmental information into the latent feature vector, these methods aim to enhance recommendation accuracy by leveraging contextual data. The paper provides a clear and detailed explanation of each proposed method, supported by rigorous mathematical formulations, ensuring transparency and reproducibility. Furthermore, the experimental evaluation conducted on four real datasets demonstrates the effectiveness of the proposed methods in terms of Mean Absolute Error (MAE) and Root Mean Square Error (RMSE) metrics. Overall, this research offers valuable insights into improving recommendation quality by integrating contextual information into collaborative filtering models, thereby advancing the state-of-the-art in recommender systems.[87]

2.3 Literature Based on Machine Learning Techniques

The literature review on machine learning techniques in dietary recommendations for cardiac patients encompasses a detailed exploration of various methodologies and their applications. Machine learning, a subset of artificial intelligence, plays a pivotal role in analyzing vast datasets to uncover patterns and make precise predictions. The review categorizes these techniques into three primary types: content-based filtering, collaborative filtering, and hybrid filtering. Content-based filtering relies on the attributes of food items to recommend similar options, ensuring nutritional balance tailored to individual preferences. Collaborative filtering leverages the preferences and behaviors of a larger user base to suggest dietary choices, enhancing the recommendations' relevance and diversity. Hybrid filtering combines both methods to improve accuracy and personalization, addressing the limitations of each approach when used in isolation. By integrating these machine learning techniques, dietary recommendation systems can provide highly personalized, effective, and adaptable nutritional advice for cardiac patients, ultimately contributing to better health outcomes.

2.3.1 Types of Machine Learning

In the context of dietary recommendations for cardiac patients, machine learning techniques can be broadly classified into three types: content-based filtering, collaborative filtering, and hybrid filtering. Content-based filtering makes recommendations based on the specific attributes of food items, ensuring that the suggestions align with individual dietary needs and preferences. Collaborative filtering, on the other hand, generates recommendations by analyzing the eating patterns and preferences of a broader user base, enhancing the diversity and relevance of the suggestions. Hybrid filtering combines both content-based and collaborative methods to maximize the accuracy and personalization of dietary recommendations, addressing the limitations inherent in each approach when used independently. By leveraging these machine learning types, the recommendation system can offer more tailored and effective dietary guidance, ultimately improving health outcomes for cardiac patients.

2.3.1.1 Content Base Filtering

Content-based filtering recommends items by comparing their features with user preferences. For cardiac patients, this means suggesting foods based on their nutritional content and health benefits.

This study delves into the challenges of online shopping, particularly the issues of information overload and time-consuming decision-making processes, exacerbated by the abundance of available products and reviews. It underscores the pivotal role of customer reviews in influencing purchasing decisions and highlights the need for sophisticated recommendation systems to address these challenges effectively. By proposing a dual approach that combines content similarity and sentiment analysis of written reviews, the study offers a novel solution to enhance the recommendation process. By leveraging advanced technologies such as Artificial Intelligence and Natural Language Processing, the proposed system aims to streamline the decision-making process for online shoppers, ultimately improving the overall user experience in e-commerce platforms.[88]

This paper presents a novel framework, Food Recommendation as Language Processing (F-RLP), which integrates Language Model-based recommendations with food-specific data to enhance personalized food recommendations. By addressing the limitations of existing Language Model-based recommendation systems, particularly in accurately interpreting food-related language nuances and integrating diverse contextual factors, F-RLP offers a comprehensive solution to bridge the gap between user expectations and system performance. The proposed framework encompasses a holistic approach, combining specialized LLM training, context injection techniques, and counterfactual data retraining to refine the recommendation process. By leveraging these advancements, F-RLP promises to transform culinary experiences by offering more tailored, contextually aware, and culturally informed food recommendations, ultimately promoting healthier and more satisfying dietary choices.[89]

This paper delves into the critical intersection of nutrition, health, and technology, aiming to develop a sophisticated system for food selection using artificial intelligence, specifically employing the Genetic Algorithm (GA) to optimize food nutrition compositions. By addressing the pressing need to promote healthier food choices amidst rising health afflictions linked to diet and lifestyle, the study proposes a comprehensive approach that considers individual nutritional needs and preferences. Leveraging meta-heuristic methods like GA, known for their near-optimal solutions and computational efficiency, the research seeks to empower consumers with personalized food recommendations tailored to their caloric and nutritional requirements. The systematic approach to data acquisition, focusing on single-serving menu items from a commercial restaurant, adds empirical grounding to the proposed methodology. Overall, the paper offers a promising avenue for leveraging technology to

enhance dietary practices, potentially mitigating the prevalence of diet-related diseases and promoting individual well-being through informed food choices.[90]

This paper addresses a pressing concern in today's society regarding unhealthy eating habits and the lack of effective diet monitoring solutions. By reviewing existing literature and popular diet monitoring applications, the authors identify several shortcomings, such as the inability to accurately track Asian foods' calories and the lack of personalized meal plans. Through a systematic approach involving brainstorming sessions, surveys, and interviews with potential users, the authors gather valuable insights into user requirements for an improved diet monitoring application. Leveraging advanced technologies like the Mask-RCNN model for image recognition and content-based filtering recommendation algorithms, the proposed Diet Monitoring and Recommender Application MyPlate aims to address these shortcomings by providing accurate calorie counting and personalized food intake recommendations. Overall, this paper contributes to the development of a user-friendly and effective tool to monitor dietary habits and promote healthier eating practices, filling a crucial gap in the current landscape of diet monitoring applications.[91]

This paper adeptly navigates the contemporary landscape of information overload, highlighting the pivotal role of recommender systems as indispensable tools in efficiently managing and delivering relevant content to users across diverse sectors. By tracing the evolution of recommender systems beyond e-commerce into domains like media streaming and social networking, the paper underscores their transformative impact on user experiences. Moreover, the paper effectively articulates the pressing need for personalized dietary guidance in combating the rising tide of chronic diseases and obesity. It astutely positions recommender systems as potent allies in promoting healthier lifestyles by offering tailored nutritional advice that accommodates individual tastes and preferences. Overall, the paper provides a comprehensive overview of the potential of recommender systems to revolutionize not only content consumption but also dietary habits, ultimately contributing to improved well-being and disease prevention.[92]

2.3.1.2 Collaborative Base Filtering

Collaborative filtering uses the preferences of similar users to make recommendations, effectively identifying popular heart-healthy foods among groups of cardiac patients.

This paper offers a critical examination of the current state of recommender system (RecSys) research, shedding light on prevalent issues in both model development and evaluation

protocols. By highlighting the disconnect between the formulation of research tasks and real-world contexts, the paper underscores the need for a more nuanced understanding of RecSys applications. It adeptly navigates through concerns regarding baseline models, evaluation protocols, and reproducibility challenges, providing insightful commentary on the complexities inherent in benchmark evaluations. Moreover, the paper astutely addresses the limitations of existing datasets and the implications of simplified task definitions on model generalization. Overall, it presents a thought-provoking analysis of the challenges facing RecSys research and advocates for a more context-aware approach to model development and evaluation, thereby contributing significantly to the discourse on advancing RecSys methodologies.[93]

This paper presents a comprehensive investigation into the crucial relationship between dietary habits and health outcomes, emphasizing the importance of nutritional intake in mitigating the prevalence of diet-associated illnesses. By synthesizing insights from various sources, including scholarly research and technological advancements, the paper underscores the significance of individual food selection in fostering a healthy and sustainable food system. Moreover, the paper delves into the methodologies employed by researchers to leverage artificial intelligence, particularly genetic algorithms, in optimizing food nutrition compositions to meet diverse consumer needs. With a clear objective to develop a system that empowers users to make informed food choices tailored to their specific circumstances, the paper provides valuable insights into the potential of artificial intelligence in revolutionizing dietary practices. Overall, this paper contributes significantly to the discourse on leveraging technology to promote healthier eating habits and underscores the importance of personalized approaches in addressing dietary-related health challenges.[90]

This paper addresses a critical gap in existing food recommendation systems by introducing GreenRec, a dataset that integrates environmental and nutritional impacts alongside a health index for food recipes. By pairing each recipe with key sustainability indicators based on established standards, the authors enrich the dataset, enabling the development of green food recommendation systems. The significance of this contribution lies in its potential to nudge consumers towards more sustainable food choices, considering the substantial environmental impact of food production and consumption. Moreover, by making the data and codes publicly available, the authors foster transparency and encourage further research in this domain. Overall, this work lays a solid foundation for the development of green food recommendation systems and represents a commendable effort in addressing the intertwined

challenges of environmental sustainability and public health enhancement through dietary choices.[94]

This paper provides a comprehensive overview of the transformative role of recommender systems in addressing the challenges of healthy eating and balanced dietary intake in today's fast-paced world. By highlighting the limitations of traditional approaches to nutrition guidance and emphasizing the potential of recommender systems to provide personalized dietary recommendations, the authors underscore the importance of leveraging technology to promote healthier lifestyles. The paper effectively articulates how recommender systems can empower users to make informed food choices, tailored to their individual preferences and nutritional needs, ultimately contributing to improved well-being and the prevention of chronic diseases. Overall, this literature review offers valuable insights into the intersection of technology and nutrition, paving the way for further research and development in this vital area of public health.[92]

2.3.1.3 Hybrid Filtering

Hybrid filtering combines content-based and collaborative filtering to leverage the strengths of both methods, providing highly accurate and personalized food recommendations for cardiac patients, considering both nutritional needs and user preferences.

This paper offers a compelling exploration of the transformative potential of recommender systems in addressing the challenges of healthy eating and balanced dietary intake in our contemporary society. By contextualizing the rise of recommender systems within the context of information overload and evolving consumer behaviors, the authors underscore their significance as indispensable tools for guiding individuals towards healthier lifestyle choices. The paper adeptly highlights the limitations of traditional approaches to nutrition guidance and convincingly argues for the adoption of recommender systems as a viable solution. Through its nuanced analysis, the paper effectively articulates how these systems can empower users to make informed food choices tailored to their preferences and nutritional needs, ultimately contributing to improved well-being and the prevention of chronic diseases. Overall, this literature review serves as a valuable resource for understanding the intersection of technology and nutrition, offering insights that are pertinent for both academic research and practical applications in public health initiatives.[92]

This comprehensive exploration delves into the pivotal role of recommendation systems, particularly in the context of promoting healthy eating habits and supporting individual

dietary needs. By elucidating the fundamental workings of recommender systems and their personalization capabilities, the paper underscores their significance in guiding users towards healthier food choices. The inclusion of diverse information sources, ranging from nutritional composition to dietary preferences and user feedback, highlights the multifaceted approach employed by these systems to curate personalized recommendations. Moreover, the emphasis on health factors underscores the importance of considering users' health goals, dietary restrictions, and ingredient quality in recommending the healthiest food options. Overall, this paper serves as a valuable resource for understanding the intricate interplay between recommendation systems and health considerations, offering insights that are pertinent for both academic research and practical applications in promoting healthy lifestyles.[95]

This paper offers a comprehensive exploration of the Next-Basket Recommendation (NBR) task within the context of food recommendation systems, shedding light on its significance and evaluating existing methodologies. By elucidating the fundamental principles of NBR and its applications across various domains, the study underscores the increasing importance of this area of research in predicting user preferences for collections of items over sequential interactions. Moreover, the paper addresses the critical issue of evaluation methodologies in NBR, particularly focusing on the limitations of traditional binary relevance assessments and proposing novel non-binary evaluation metrics. Through a series of empirical experiments, including online user studies and offline evaluations, the paper not only validates the efficacy of these non-binary metrics but also provides insights into the performance of state-of-the-art NBR algorithms. Overall, this work contributes valuable insights into the evaluation and improvement of NBR methods, bridging the gap between theoretical advancements and practical applications in food recommendation systems.[96]

2.4 Research Gap

The research embarks on developing a Nutrition-Based Recommendation System (NBRS) geared towards individuals with heart conditions, employing machine learning algorithms to account for both nutritional requirements and user preferences. However, there are noteworthy research gaps that necessitate further exploration:

Algorithmic Diversity: While the study incorporates various algorithms like Random Forest, it overlooks a broader spectrum of recommendation techniques. Algorithms such as Singular Value Decomposition (SVD), Gradient Boosting, and others are worth investigating to gauge their potential in enhancing recommendation accuracy and robustness.

Novel Recommendation Approaches: The research overlooks emerging recommendation methods like deep learning-based systems or contextual recommendation models. These innovative approaches could offer fresh perspectives and advancements in personalized dietary guidance, enriching the recommendation model's effectiveness.

Seasonal Food Availability Integration: While the model considers seasonal food availability, it lacks depth in addressing this aspect. Further exploration is needed to dynamically adjust recommendations based on real-time seasonal variations and regional dietary preferences, enhancing the model's responsiveness to seasonal changes.

Real-World User Feedback Validation: Despite incorporating user preference surveys, the research lacks extensive validation through real-world user feedback. Conducting user trials with individuals having heart conditions can provide invaluable insights into the system's practical implications and user acceptance, aiding in iterative refinement for enhanced usability.

By addressing these gaps, the research can advance the development of nutrition-based recommendation systems for individuals with heart conditions, ensuring more accurate, versatile, and user-friendly dietary guidance tools. The algorithms considered in this study, including Baseline, Co-Clustering, KNN-Basic, KNN-withMeans, KNN-withZscore, NMF, Slope-One, and SVD, offer a diverse toolkit for algorithmic exploration and enhancement.

2.5 Review Finding

The review findings relevant to the researcher's thesis on developing a Nutrition-Based Recommendation System (NBRS) for individuals with heart conditions in the Gujarat region are as follows:

Data Collection and Organization:

- Extensive data on Gujarati food and fruits, including nutritional content, serving sizes, and calorie information, was collected.
- User preferences were captured through surveys and ratings to customize recommendations based on individual tastes and dietary requirements.
- The dataset was organized into categories to facilitate analysis and recommendation generation.

Algorithm Selection:

- Machine learning algorithms, including Random Forest and collaborative filtering techniques, were chosen to analyze the collected data and generate personalized dietary recommendations.
- Random Forest was selected for its versatility and robust performance in handling high-dimensional data, while collaborative filtering techniques were chosen for their ability to identify patterns and associations between different food items.

Consideration of Seasonal Availability:

- The NBRS takes into account the seasonal availability of food items, ensuring that recommendations align with what is fresh and accessible during different times of the year.
- This consideration enhances the relevance and practicality of recommendations, promoting healthier eating habits among individuals with heart conditions in the Gujarat region.

Personalized Dietary Guidance:

- The NBRS provides personalized dietary guidance by considering both nutritional requirements and user preferences.
- Recommendations are tailored to each user's specific needs, accommodating individual tastes, dietary restrictions, and cultural preferences prevalent in the Gujarat region.

Improving Overall Health and Well-being:

- The research aims to improve the overall health and well-being of individuals in the Gujarat region by providing them with practical and effective dietary recommendations.
- By offering personalized dietary guidance, the NBRS encourages healthier eating habits among individuals with heart conditions, ultimately contributing to better health outcomes.
- Overall, the review findings highlight the researcher's comprehensive approach to developing an NBRS tailored to Gujarati food and fruits. By leveraging machine

learning algorithms and considering both nutritional requirements and user preferences, the research aims to address the dietary needs of individuals with heart conditions in the Gujarat region and promote healthier eating habits and improved overall well-being.

2.6 Conclusion

In conclusion, the literature review chapter provides a comprehensive overview of the existing research relevant to the development of a Nutrition-Based Recommendation System (NBRS) for individuals with heart conditions in the Gujarat region. Through an in-depth analysis of primary and secondary sources, the researcher has gained valuable insights into various aspects of dietary recommendation systems, including data collection, algorithm selection, consideration of seasonal availability, and personalized dietary guidance.

The review findings underscore the importance of leveraging machine learning techniques, such as Random Forest and collaborative filtering, to analyze extensive datasets of Gujarati food and fruits. By incorporating user preferences and nutritional requirements into the recommendation process, the NBRS aims to provide practical and effective dietary guidance tailored to the specific needs of individuals with heart conditions.

Furthermore, the researcher's emphasis on considering the seasonal availability of food items reflects a nuanced understanding of the cultural and environmental factors influencing dietary habits in the Gujarat region. This approach enhances the relevance and practicality of the recommendations, ultimately promoting healthier eating habits and improved overall well-being among the target population.

Overall, the literature review sets the stage for the researcher's thesis work by highlighting the gaps and opportunities in existing research and informing the development of a novel NBRS tailored to Gujarati food and fruits. By building upon the insights gained from the review findings, the researcher aims to contribute to the advancement of dietary recommendation systems and ultimately improve the health outcomes of individuals with heart conditions in the Gujarat region.