Chapter 1

1 Introduction to Cardiac Patient Food Recommendation System

1.1 Introduction

Cardiovascular diseases are a significant concern globally, and rapidly increasing in the Gujarat region. The researcher's research focuses on providing nutritional recommendations for individuals suffering from heart-related Problems. The Nutrition-Based Recommendation System (NBRS) has been developed, which utilizes machine learning algorithms to suggest appropriate and nutritious foods customized to each individual's needs.

In this research, the Researcher analyzed both primary and secondary sources of information. To understand the food preferences of individuals with heart-related Problems, Researcher distributed a questionnaire for them to fill out. This allowed me to collect data on more than 90 different foods. Each food item was described by four main characteristics: fat, fiber, carbohydrates, and protein content. The researcher also recorded the typical serving size of each food and its calorie content. This dataset was organized into 15 categories to make it easier to manage and analyze. Additionally, users were asked to rate each food item on a scale from 1 to 10 based on their personal preferences. This rating system provided valuable insights into the foods that individuals with heart problems genuinely like. In this dataset, the Researcher carefully chose foods that are highly recommended for individuals with heart conditions. These foods were then sorted into 15 different categories, such as meals, fruits, vegetables, and others like roti, bhakhri, thepla, dal, rice, and plain foods. For fruits, options included apples, mangoes, and more. This organized dataset helps in managing and analyzing the various food options that are beneficial for cardiac patients. In this model, we provide recommendations for food across three categories: breakfast, lunch, and dinner. We also consider the seasonal availability of specific foods or fruits to ensure that recommendations align with what's fresh and accessible during different times of the year. This approach allows for personalized dietary guidance that considers both nutritional needs and seasonal factors.

In this research, the researcher's model recommends food based on two different aspects. Firstly, it considers the daily calorie requirements for men and women, calculated using their Basal Metabolic Rate (BMR), which determines their routine calorie needs. Secondly, the

model takes user preferences, considering the types of food that the user preference. This dual approach ensures that the recommendations address both the nutritional needs of individuals and their tastes and preferences.

To develop this model, the researcher first understands various machine learning techniques, including supervised learning, unsupervised learning, and reinforcement learning. Additionally, the researcher explored different types of recommendation systems and algorithms commonly used in this domain. The algorithms utilized for recommendation systems in this research include collaborative filtering, content-based filtering, and hybrid filtering.

This hybrid model combines three distinct recommendation strategies: user-based, calorie-based, and popularity-based recommendations. By integrating collaborative filtering with matrix factorization algorithms such as Singular Value Decomposition (SVD) and Non-negative Matrix Factorization (NMF), this approach effectively captures both user preferences and dietary requirements. Specifically, the model focuses on providing personalized food recommendations for cardiac patients in Gujarat, taking into account local Gujarati foods and fruits, ensuring that nutritional goals align with the dietary needs of this population. User-based methods personalize recommendations based on individual preferences, calorie-based systems ensure that the food meets heart-healthy nutritional standards, and popularity-based algorithms leverage crowd preferences to suggest widely accepted choices. This fusion of multiple techniques provides a comprehensive recommendation system that enhances the accuracy and relevance of food suggestions in the NBRS model.

1.2 Overview of Cardiovascular Patient

In the research on cardiovascular health, the focus is on supporting individuals with cardiovascular conditions like heart-related problems. These patients often face challenges in managing their diet to promote heart health and reduce the risk of complications. The researcher's work goal is to address these challenges by developing a Food Recommendation System specifically personalized to the needs of cardiac patients. This system provides personalized recommendations for breakfast, lunch, and dinner, ensuring that patients receive the necessary nutrients while adhering to their dietary restrictions.

With a focus on important nutritional factors such as fat, fiber, protein, and carbohydrates, the researcher's model provides a varied selection of heart-healthy and appealing meal choices. By considering over 90+ carefully selected food items, the system ensures that patients have access to a variety of nutritious choices that support their cardiovascular well-being. Additionally, the model takes into account the seasonal availability of foods, further enhancing its practicality and relevance for patients in Gujarat and beyond.

In essence, the researcher's Food Recommendation System serves as a valuable tool in the journey toward better heart health for cardiac patients. By providing personalized dietary guidance that aligns with nutritional needs and seasonal factors, the system empowers patients to make informed choices and take positive steps toward improving their diet and overall cardiovascular well-being.

1.2.1 Challenges and Difficulties of Cardiac Patients

Cardiac patients often face various challenges in managing their diet and overall health. One of the main difficulties is navigating the complexities of dietary recommendations, as they may receive conflicting advice or find it challenging to understand what foods are best for their heart health. Additionally, dietary restrictions, such as limiting salt, saturated fats, and cholesterol, can make it difficult for patients to enjoy their meals and maintain a balanced diet. Furthermore, the availability of nutritious food options that meet the specific needs of cardiac patients may be limited, especially in certain regions or during certain seasons.

Another challenge for cardiac patients is the need to monitor their calorie intake and ensure they are meeting their daily nutritional requirements while still following their dietary restrictions. This can be particularly challenging when planning meals for different times of the day, such as breakfast, lunch, and dinner, and trying to ensure a variety of nutrient-rich foods are included in each meal. Additionally, factors such as taste preferences, cultural effects, and food accessibility may further complicate the process of following a heart-healthy diet. Overall, addressing these difficulties requires a comprehensive approach that considers the individual needs and preferences of cardiac patients while providing practical and personalized dietary guidance.

1.2.2 A Study of Cardiac Patient Nutrition based food

In this research of Cardiac Patients nutrition-based food[1], the researcher explores the complicated details of creating a dietary recommendation model personalized specifically to the needs of cardiac patients[2]. The research accurately considers essential nutritional

parameters such as fat, fiber, protein, and carbohydrates to ensure that recommended foods align with heart health goals. By ordering these parameters, the researcher's goal is to offer dietary suggestions that not only support cardiovascular well-being but also contribute to overall health and life.

Moreover, the researcher's model goes beyond simple nutritional considerations by factoring in the seasonal availability of recommended foods. Recognizing the importance of fresh and locally available options, the model adjusts its recommendations based on seasonal variations in food availability. This ensures that cardiac patients have access to a diverse range of nutritious foods year-round, further enhancing the practicality and relevance of the dietary recommendations provided by the model.

Additionally, the researcher's study involves a comprehensive dataset comprising over 90 food products across 15 different categories. Each food product is carefully selected based on its suitability for cardiac patients, considering factors such as age, gender, height, weight, and activity level. By integrating these health parameters into the recommendation model, the researcher ensures that dietary suggestions are personalized and personalized to the specific needs of individual patients. Overall, the Research on Cardiac Patient nutrition-based food underscores the researcher's commitment to improving dietary management and promoting better heart health outcomes for cardiac patients.

1.2.3 An impact of nutrition base food on Cardiac Patient

The impact of nutrition on cardiac patients is vital for managing heart health. This research highlights how consuming nutrient-rich foods, such as fiber, lean proteins, and healthy fats, can positively affect key health factors like cholesterol, blood pressure, and heart function. Personalized dietary recommendations tailored to individual factors, including age, weight, and activity level, aim to help cardiac patients make informed choices that support their heart health. By integrating nutrition-based interventions, the study seeks to reduce cardiovascular risks, improve overall heart function, and enhance patients' quality of life.

1.2.3.1 Types of Food for Cardiac Patients

In this research, the researcher concentrates on identifying the most suitable types of food for cardiac patients, particularly within the Gujarat region, while considering seasonal availability. The focus lies on a diverse range of food items, including cooked dishes, fruits, various grains, and pulses, specifically recommended for cardiovascular health. Each food item is meticulously analyzed for its nutritional content, including essential parameters like

fat, fiber, protein, and carbohydrates. Moreover, the researcher provides the total calorie count for each food product, ensuring patients have comprehensive information to make informed dietary choices. With a dataset comprising over 90 food items categorized into 15 different groups such as vegetables, fruits, grains, cooked dishes, snacks, and others, the researcher ensures a wide array of options personalized to the specific dietary needs of cardiac patients. By considering seasonal availability and focusing on locally accessible foods, the research aims to offer practical and relevant dietary recommendations to support optimal heart health in the Gujarat region.

In this research, the researcher divides their study into two main categories: Gujarati raw and cooked food, and fruits, each catering to the specific dietary needs of cardiac patients.

1.2.3.1.1 Gujarati Raw Food and Cooked Food

In the first category, the researcher dives into the world of Gujarati cuisine, exploring both raw and cooked dishes that are staples in the region. These dishes are crafted from locally sourced ingredients, showcasing vegetables, grains, and pulses[2], all renowned for their heart-healthy benefits. With meticulous attention to detail, the researcher carefully examines the nutritional makeup of each dish, analyzing factors like fat, fiber, protein, and carbohydrates. This thorough analysis forms the foundation for crafting detailed dietary recommendations personalized specifically for cardiac patients. By researching the rich Gujarati cuisine, the researcher's goal is to offer practical and personalized dietary guidance to support the heart health of individuals in the region.

1.2.3.1.2 Fruits

In this research, the researcher carefully selected a variety of fruits like mangoes, watermelons, apples, and many more focusing on their nutritional value for people with heart conditions[2]. These fruits contain important nutrients like proteins, carbohydrates, fats, fibers, and calories, which are crucial for managing heart health. Researchers also made sure to consider the seasonal availability of these fruits to ensure they're fresh and full of nutrients all year round. By studying the nutritional benefits of fruits and their impact on heart health, the Researcher's goal is to provide practical dietary recommendations personalized to the needs of people in Gujarat. Overall, my research aims to offer personalized guidance on incorporating nutritious and delicious fruits into the diets of individuals with cardiac concerns.

1.3 Overview of Machine Learning

Machine learning is like teaching computers to learn from data and make decisions without being explicitly programmed. It's all about training computers to recognize patterns and make predictions based on examples. Think of it as teaching a pet to fetch a ball: you show it a few times, and it learns what to do next. In machine learning, computers are trained using algorithms, which are like sets of instructions that help them learn from data. There are different types of machine learning[3], like supervised learning, where computers learn from labeled data, and unsupervised learning, where they find patterns in data without explicit labels. Overall, machine learning helps computers get smarter over time by learning from experience,

This research work is all about teaching computers to recommend healthy foods for people with heart problems. Researchers use something called machine learning, which is like training a computer to learn from examples. By looking at data about different foods and people's preferences, the computer learns to suggest the best foods for each person. It's kind of like having a smart helper who knows what foods are good for your heart and what you like to eat. This helps people with heart-related Problems make better choices and stay healthy.

1.3.1 Current Use of Machine Learning

Machine learning is like teaching computers to learn from examples and make decisions on their own. It's a bit like teaching a pet trick. you show it what to do a few times, and it learns to do it by itself. With machine learning, we give computers lots of examples and let them figure out patterns and rules on their own. They use these patterns to make predictions or decisions about new data they haven't seen before. Machine learning is used in all sorts of things, like recommending movies, detecting spam emails, and even driving cars. It's like giving computers the power to learn and get smarter over time.

Right now, machine learning is helping people with heart problems by suggesting healthy foods. It works like this: computers learn from lots of data about different foods and what people like to eat. They also calculate the calories needed for men and women, considering their activity levels. Based on this information, the model recommends nutritious Gujarati foods for cardiac patients in three categories: breakfast, lunch, and dinner. It even takes into account the seasonal availability of ingredients. It's like having a smart friend who knows

what's good for your heart, what you enjoy eating, and what's in season. This helps people make healthier choices and take better care of their hearts.

1.3.2 Role of Machine Learning

In developing the Nutrition-Based Recommendation System (NBRS) for cardiac patients in Gujarat, machine learning plays a crucial role. It helps by factoring in seasonal changes in food availability, making the dietary advice more accurate. By analyzing past data on when foods are available, machine learning enhances the NBRS model. It identifies patterns in seasonal availability and adjusts recommendations accordingly. With machine learning, researchers can ensure that the recommended foods are not only beneficial for the patients but also easily accessible during the right seasons. Thus, the NBRS leverages machine learning to provide personalized advice that considers both the patient's needs and the seasonal availability of foods, contributing to better health outcomes for cardiac patients in Gujarat.

1.3.3 Classification of Machine Learning Algorithm

There are primarily three different types of Machine Learning Algorithms[4]. The list of these algorithms is shown in the following image.

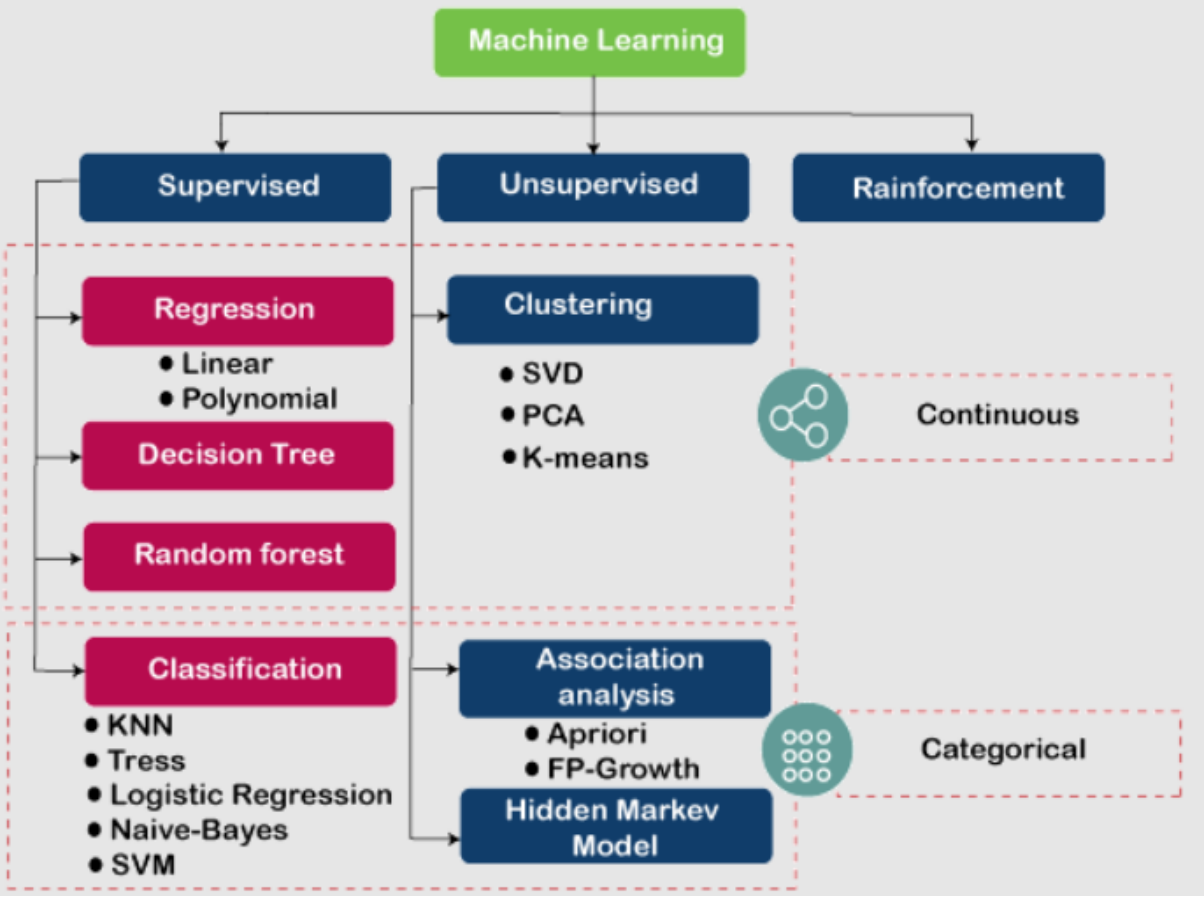

Figure 1 Classification of Machine Learning[5]

As per the above diagram, it can be observed that there are three types of machine learning algorithms, which are listed and described as follows.

1.3.3.1 Supervised Machine Learning*:*

Supervised machine learning[7] is a type of learning where the algorithm is trained on a labeled dataset, meaning that each input data point is associated with a corresponding output label. The goal is to learn a mapping function from the input variables to the output variable, enabling the algorithm to make predictions or decisions when new unseen data is presented[8]. In supervised learning, the algorithm learns from the provided examples to generalize patterns and relationships, allowing it to accurately predict outcomes for unseen data. Common supervised learning tasks include classification and regression.

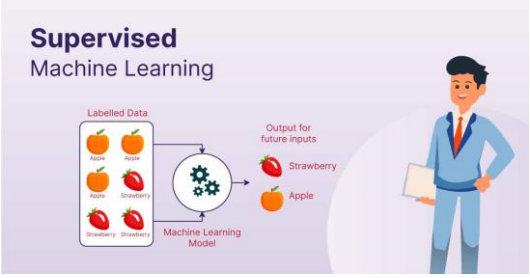

Figure 2 Supervised Learning Example[9]

1.3.3.1.1 Regression

Regression in supervised learning is a statistical method used to model the relationship between a dependent variable and one or more independent variables. It aims to predict continuous outcomes by finding the best-fit line or curve that minimizes the difference between the predicted and actual values. Common regression techniques include linear regression, polynomial regression, and logistic regression, each suited for different types of data and relationships.

1.3.3.1.2 Decision Tree

A decision tree is a supervised learning algorithm used for both classification and regression tasks. It models decisions and their possible consequences by creating a tree-like structure, where each internal node represents a feature or attribute, each branch represents a decision rule, and each leaf node represents an outcome or final decision. Decision trees are intuitive and easy to interpret, allowing users to visualize the decision-making process. They can handle both numerical and categorical data and are often used in scenarios where interpretability and transparency are crucial. However, they can be prone to overfitting if not properly pruned or regularized.

1.3.3.1.3 Random Forest

Random Forest is an ensemble learning technique that combines multiple decision trees to improve predictive accuracy and control overfitting. In this method, a large number of decision trees are generated during training, where each tree is built using a random subset of the data and a random selection of features at each split. This randomness helps to create diverse trees, which when aggregated (typically through averaging for regression tasks or voting for classification tasks) results in a more robust and accurate model. Random Forest is effective for handling large datasets with high dimensionality and can also provide insights into feature importance, making it a popular choice for various machine learning applications. Its resilience to noise and overfitting makes it particularly useful in real-world scenarios.

1.3.3.1.4 Classification

Classification is a supervised learning technique used to categorize data into predefined classes or labels. In this process, the algorithm learns from a labeled training dataset, where each instance is associated with a specific class. The goal is to create a model that can accurately predict the class labels for new, unseen data based on the patterns learned from the training data.

Common classification algorithms include Logistic Regression, Decision Trees, Random Forests, and Support Vector Machines (SVM). Classification tasks are widely used in various applications, such as spam detection, sentiment analysis, and medical diagnosis, where the objective is to assign a category to an input based on its features. Performance metrics such as accuracy, precision, recall, and F1-score are often used to evaluate the effectiveness of classification models.

1.3.3.2 Unsupervised Machine Learning:

Unsupervised machine learning is a type of learning where the algorithm is trained on an unlabeled dataset, meaning that the input data lacks explicit output labels. The goal is to uncover hidden patterns, structures, or relationships within the data without guidance or supervision. Unsupervised learning algorithms[10]attempt to group similar data points together, discover underlying distributions, or reduce the dimensionality of the data. Common unsupervised learning tasks include clustering, dimensionality reduction, and anomaly detection.

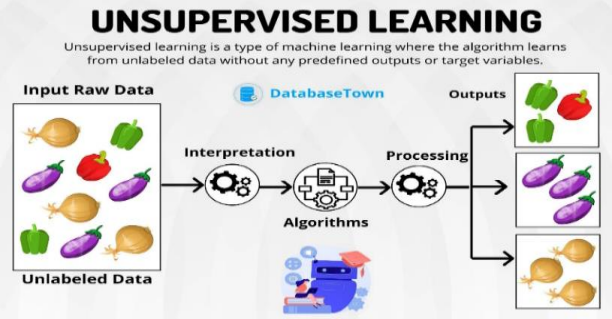

Figure 3 Unsupervised Learning Example[11]

1.3.3.2.1 Clustering

Clustering is a technique in unsupervised learning where the goal is to group similar data points together without predefined labels. It helps to discover patterns or structures in data by dividing it into clusters based on shared characteristics. Since it's unsupervised, the algorithm learns from the data itself without any prior knowledge of the correct output, making it useful for tasks like customer segmentation or image grouping.

1.3.3.2.2 Association analysis

Association analysis is a technique in unsupervised learning used to discover interesting relationships or patterns between variables in large datasets. It identifies associations by finding rules that describe how different items or events occur together. For example, in market basket analysis, association analysis helps discover which products are frequently bought together. The most common method for this is the Apriori algorithm, which generates association rules like "If a customer buys bread, they are likely to also buy butter.

1.3.3.2.3 Hidden Markev Model

A Hidden Markov Model (HMM) is a statistical tool used to model systems that transition between states over time, where the actual states are not directly observable. Instead, we only see the observable data that is influenced by these hidden states. HMM works by estimating the probability of transitioning between hidden states and the likelihood of generating specific observations from those states. It is commonly used in sequence analysis, such as in speech recognition, natural language processing, and bioinformatics, where the goal is to understand patterns in data that evolves over time.

Collaborative filtering is typically covered under the domain of recommendation systems, which can fall into both supervised and unsupervised learning depending on the specific approach. In the context of unsupervised learning, collaborative filtering often utilizes techniques such as clustering or matrix factorization to group users or items with similar

characteristics or preferences. This approach does not rely on explicit labels but instead learns from user behavior and interactions to make recommendations. Hidden Markov Models (HMM) can also be used in collaborative filtering, particularly when the system needs to predict sequences of user interactions over time, such as in dynamic recommendation systems.

1.3.3.3 Reinforcement Machine Learning:

Reinforcement learning is a type of machine learning where an agent learns to make decisions by interacting with an environment[12]. The agent learns from trial and error, receiving feedback in the form of rewards or penalties based on its actions. The objective is to maximize cumulative reward over time by discovering the optimal policy, which specifies the best action to take in each state of the environment. Reinforcement learning is well-suited for sequential decision-making tasks, such as game playing, robotics, and autonomous driving.

For this research, the researcher focused on supervised learning, a type of machine learning where computers learn from examples provided to them. Within supervised learning, various filtering techniques are employed to enhance the learning process. These include content-based, collaborative, and hybrid filtering techniques. Each technique uses different algorithms to filter and process data[13], helping computers make accurate recommendations. The researcher further explored these filtering techniques and their relevant algorithms to expand the scope of their work.

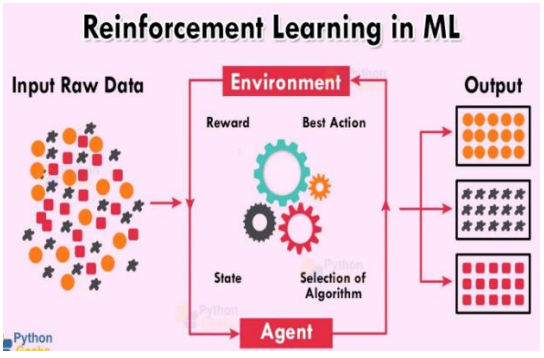

Figure 4 Reinforcement Learning Example[11]

1.4 Overview of Recommendation System

A recommendation system is like a helpful friend who suggests things you might like based on your past preferences. It looks at what you've bought, searched for, or watched before, and uses that information to recommend new items, movies, music, or anything else you might

enjoy. It's all about making your life easier by helping you discover new things that match your interests without having to search for them yourself.

As per the researcher's work, a recommendation system[14] serves as a valuable model for suggesting nutritious foods to individuals with heart conditions. Think of it as a knowledgeable assistant who understands the dietary needs and preferences of cardiac patients. By analyzing data on food preferences, nutritional values, and seasonal availability, the recommendation system can offer personalized suggestions tailored to each individual's health requirements. This system essentially acts as a guide, helping researchers provide targeted dietary advice that aligns with the specific needs of cardiac patients, ultimately promoting better health outcomes.

1.4.1 Introduction to Recommendation System

Recommendation systems are indispensable tools across various domains, assisting users in discovering relevant items or content based on their preferences and behaviour. These systems utilize powerful algorithms to analysed user data, item attributes, and interaction patterns to generate personalized recommendations. In e-commerce, recommendation systems suggest products based on browsing history, purchase behaviour, and similar users' preferences. Similarly, in streaming services, they offer movie or music recommendations tailored to individual tastes. Moreover, in the domain of healthcare, recommendation systems play a crucial role in providing personalized dietary advice for individuals with specific health conditions, such as cardiac patients in the researcher's work. These systems employ various techniques, including collaborative filtering, content-based filtering, and hybrid approaches[15], to enhance recommendation accuracy and coverage. They significantly contribute to enhancing user experience, increasing user engagement, and driving business revenue by facilitating better decision-making and reducing information overload. As technology continues to advance, recommendation systems evolve to meet the increasingly diverse and dynamic needs of users across different platforms and industries, including healthcare.

1.4.1.1 Types of Recommendation System

Recommendation systems come in different types, each with its own way of helping you find what you like. Content-Based Filtering looks at things you've liked before and suggests similar items. Collaborative Filtering suggests things based on what people similar to you have liked. Knowledge-Based Filtering uses what it knows about you to suggest items.

Demographic-Based Filtering suggests things based on your age, gender, or where you live. Utility-Based Filtering suggests things based on how useful they are to you. The researcher used Hybrid Filtering, which combines a few methods to make better suggestions. These different types of recommendation systems make it easier for you to find what you want online and make your experience better.

Basically, there are two types of recommendation systems: personalized and non-personalized. These are shown in the following figure, along with their different types.

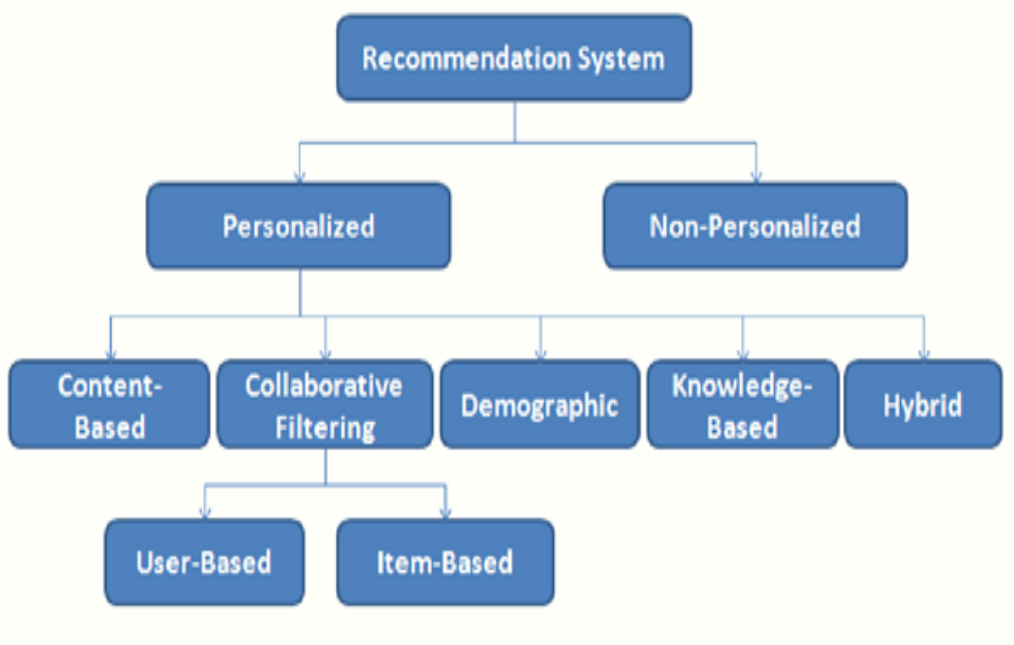

Figure 5 Types of Recommendation System[16]

Personalized Recommendation System:

A personalized recommendation system is like having a helpful friend who suggests things just for you based on your interests and past behavior. It looks at what you've liked before, what you've searched for, or what you've bought, and uses that information to recommend things you might enjoy. It's all about making your experience more tailored to your preferences and helping you discover new things that match your interests.

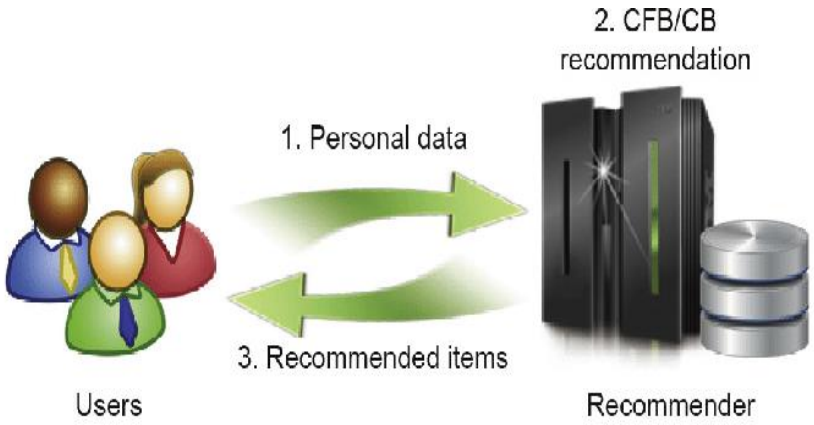

Figure 6 Personalized Recommendation System Example[17]

Non-Personalized Recommender System:

A non-personalized recommender system suggests things without considering your individual preferences. Instead, it offers the same suggestions to everyone based on general trends or popularity. It's like a one-size-fits-all approach, where everyone gets similar recommendations regardless of their interests or behavior. While it may not be as tailored to your specific tastes, it can still be useful for providing popular or trending items that many people might enjoy.

Based on these two types of recommendation systems, there are many different varieties. Their descriptions are provided below.

Figure 7 Non-Personalized Recommendation System Example[18]

1.4.1.1.1 Content Base Filtering

Content-Based Filtering[19] recommends items based on the characteristics of things you've liked before. It analyzes the features of items you've shown interest in and identifies similar

ones for recommendation. For instance, if you have previously enjoyed action movies, the system may suggest more action-packed films for your viewing pleasure. It operates by understanding your preferences and suggesting items that align with your past choices, akin to a knowledgeable advisor offering recommendations based on your established interests.

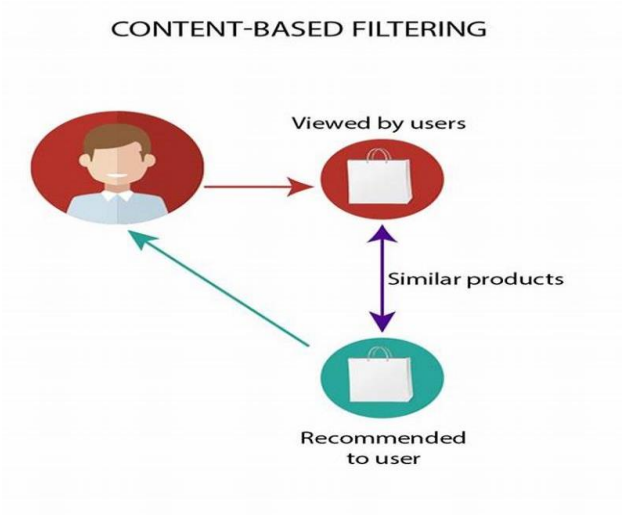

Figure 8 Content Base Filtering Example[20]

1.4.1.1.2 Collaborative Base Filtering

Collaborative Filtering recommends items by analyzing the preferences and behavior of users similar to you. It identifies patterns in the choices made by users with similar tastes and suggests items that those users have enjoyed. For example, if people with similar movie preferences to yours have liked a particular film, the system might recommend it to you as well. Essentially, it leverages collective user data to provide personalized recommendations, similar to a knowledgeable advisor guiding you based on the preferences of people similar to you.

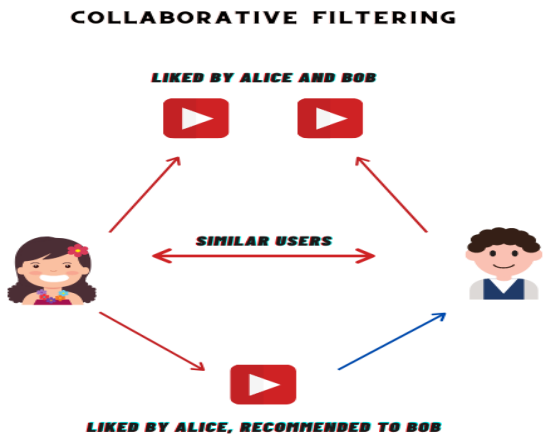

Figure 9 Collaborative Base Filtering Example[20]

Collaborative filtering, a type of recommendation system, can be further divided into two distinct approaches: user-based and item-based filtering.

In user-based collaborative filtering, the system recommends items based on the preferences and behavior of similar users[21]. It identifies people with similar tastes to the user in question and suggests items that they have liked or interacted with. For example, if User A and User B have similar viewing habits on a streaming platform, the system may recommend movies that User B has enjoyed to User A.

Conversely, item-based collaborative filtering[22] recommends items based on their similarity to other items that the user has liked or interacted with. Instead of focusing on similar users, this approach looks at the similarity between items themselves. For instance, if a user has purchased a particular book, the system may recommend other books that are similar in content or genre.

Both user-based and item-based collaborative filtering methods influence patterns in user behaviour or item attributes to make recommendations, providing users with personalized suggestions based on their preferences and interactions.

1.4.1.1.3 Knowledge Base Filtering

Knowledge-based recommendation systems explicit knowledge about users' preferences and item characteristics to generate personalized recommendations. Unlike collaborative or content-based filtering, which rely on historical user interactions or item attributes, knowledge-based systems incorporate domain knowledge to make recommendations. These systems often employ rules, expert systems to gather user preferences and match them with relevant items. By considering user preferences, constraints, and domain-specific knowledge, knowledge-based recommendation systems can offer personalized suggestions even in incomplete data.. Overall, knowledge-based recommendation systems provide a valuable approach to personalized recommendation, particularly in domains where explicit knowledge plays a crucial role in decision-making.

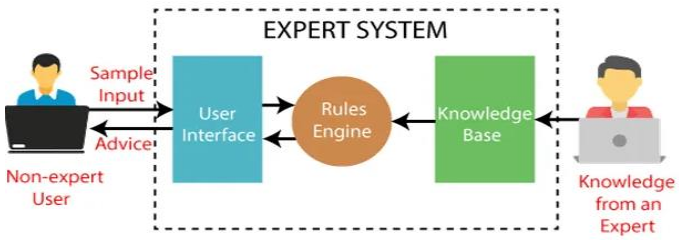

Figure 10 Knowledge Based Filtering Example[23]

1.4.1.1.4 Demographic Base Filtering

Demographic-based filtering is a way of recommending things that takes into account details like your age, gender, where you live, or what you do for a living. By looking at this information, the system can suggest things that are more likely to be a good fit for you. For example, it might recommend certain movies based on your age group or suggest local events based on where you live. This method helps make recommendations more relevant because it considers that people's preferences can differ based on these details. It's like having a personalized guide who understands what you might like based on who you are and where you're from.

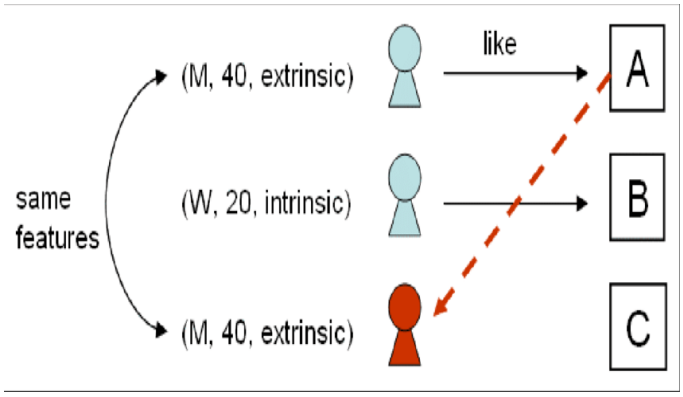

Figure 11 Demographic Base Filtering Example[24]

1.4.1.1.5 Utility Base Filtering

Utility-based recommendation systems make suggestions by evaluating the utility or value that items provide to users based on their preferences and needs. These systems consider various factors such as item attributes, user preferences, and contextual information to determine the utility of items for individual users. By quantifying the perceived value or usefulness of items, utility-based recommendation systems can offer personalized recommendations that maximize user satisfaction. They are particularly effective in domains where users have diverse preferences and where the utility of items varies based on specific user needs or situations. Overall, utility-based recommendation systems aim to optimize recommendation outcomes by prioritizing items that offer the highest utility to users.

1.4.1.1.6 Hybrid Filtering

Hybrid filtering is like having a super-powered recommendation system that combines different methods to give you even better suggestions. By mixing techniques such as collaborative filtering and content-based filtering, it offers a wider range of personalized recommendations[25]. These systems use smart algorithms to blend the results and adjust

based on what you like or what the items are like. Hybrid filtering isn't just for shopping or entertainment it's also used in areas like healthcare and diet recommendations to give more precise and comprehensive suggestions that suit individual needs.

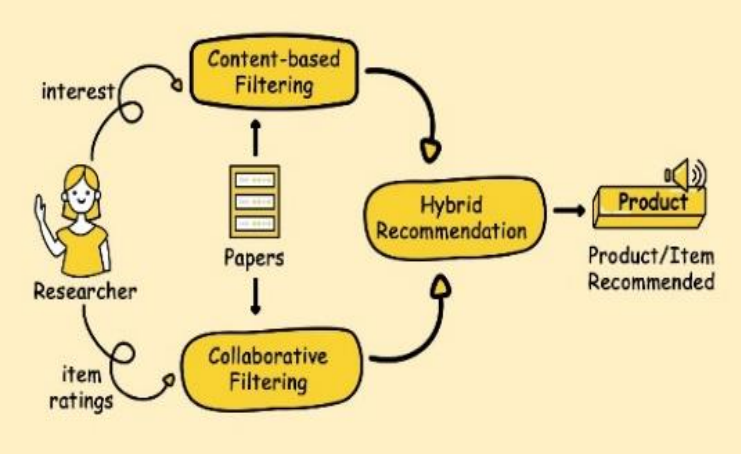

Figure 12 Hybrid Base Filtering Example[26]

In this research work, Researchers use a method called hybrid filtering to create their recommendation model. It's like having a super-smart assistant that combines different ways of making suggestions to give even better advice. By blending techniques like collaborative filtering and content-based filtering, the model can offer a wide range of personalized recommendations. Specifically, the researcher uses the Random Forest algorithm to recommend food for cardiac patients. This algorithm is like a powerful tool that helps the model analyze lots of data about food and patients to suggest the best options for heart health. So, the researcher's model not only considers what foods people like but also what's best for their hearts, making it a valuable tool for improving dietary choices and promoting better health outcomes.

1.4.2 Overview of Category of Recommendation System

A recommendation system suggests items based on user preferences, past behavior, or similarity to other users. Categories include Movie Base, Product Base, Music Base, and Health Base Recommendation Systems. These systems are crucial in e-commerce, entertainment, and health domains. Techniques like collaborative filtering, content-based filtering, and hybrid approaches are used to generate recommendations. Collaborative filtering analyzes user interactions, content-based filtering suggests similar items and hybrid methods combine both approaches for better accuracy. Recommendation systems enhance user experience, engagement, and revenue for online platforms.

1.4.2.1 Movie Base Recommendation System

The Movie Base Recommendation System[27] suggests films to users based on their preferences and viewing history. It analyzes similarities among users with comparable tastes to provide personalized recommendations. Utilizing collaborative filtering techniques, it identifies movies liked by similar users to make predictions. This system enhances user experience on streaming platforms by offering relevant and engaging content suggestions. It considers factors such as genre preferences, ratings, and watch history to tailor recommendations. Movie-based recommendation Systems play a crucial role in increasing user engagement and retention. They contribute to platform success by guiding users to discover new films aligned with their interests.

1.4.2.2 Product Base Recommendation System

The Product Base Recommendation System suggests items to users on e-commerce platforms based on their browsing history, past purchases, and product attributes. It employs collaborative filtering techniques to identify products liked by similar users and make personalized recommendations. By analyzing user interactions and product similarities, this system enhances the shopping experience by providing relevant and tailored suggestions. It considers factors such as product categories, price ranges, and user preferences to generate recommendations. Product-based recommendation Systems play a vital role in increasing user engagement and driving sales on e-commerce platforms. They contribute to customer satisfaction by guiding users to discover products that align with their needs and preferences.

1.4.2.3 Music Base Recommendation System

The Music Base Recommendation System suggests songs or playlists based on user listening history and preferences, using collaborative filtering to personalize recommendations. It enhances music discovery by offering relevant suggestions aligned with user tastes, genres, and artist preferences. This system boosts user engagement and satisfaction on music platforms, guiding listeners to discover new music they enjoy.

1.4.2.4 Health Base Recommendation System

The Health Base Recommendation System is like having a smart guide for your health. It has different parts that help with diet, nutrition, and managing diseases. The Diet Base Recommendation System creates personalized meal plans based on your needs, like how many calories you need and what nutrients you should get. Then, the Nutrition Value Base Recommendation System suggests foods that are rich in important stuff like vitamins and

minerals. Finally, the Disease Base Recommendation System advises on how to manage or prevent specific health issues, using what we know about the disease and how food can help. These systems work together to help you stay healthy by giving you personalized advice and support for your nutrition and health needs.

1.4.2.4.1 Diet Base Recommendation System

The Diet Base Recommendation System[4], [28] provides personalized dietary plans personalized to individual needs and goals, considering factors like calorie intake, macronutrient balance, and dietary restrictions[28]. It leverages user-specific information to offer recommendations aligned with health objectives, promoting balanced nutrition and overall well-being. By analyzing user preferences, nutritional requirements, and lifestyle factors, this system aims to optimize dietary choices and support users in achieving their health and fitness goals effectively.

1.4.2.4.2 Nutrition Value Base Recommendation System

The Nutrition Value Base Recommendation System offers recommendations for foods rich in specific nutrients essential for health and well-being, aligning with user preferences and nutritional requirements. In the context of your research, it focuses on recommending foods with high nutritional value[8], such as those rich in proteins, carbohydrates, fats, and fiber, tailored to meet the dietary needs[13] of cardiac patients in Gujarat. By analyzing nutritional parameters and user profiles, this system aims to support individuals in making informed dietary choices that contribute to their overall health and well-being.

1.4.2.4.3 Disease Base Recommendation System

The Disease Base Recommendation System in this research focuses particularly on cardiovascular patients, specifically cardiac patients, addressing their specific dietary needs and health concerns. Within this context, subcategories such as the Diabetics Disease Patient Food Recommendation System and the Cardiovascular Disease Patient Food Recommendation System[29] provide tailored dietary guidance to support cardiovascular health. Leveraging knowledge of disease pathology and nutritional therapy, these systems offer personalized recommendations aligned with individual health needs, considering parameters such as calorie intake, macronutrient balance (including proteins, carbohydrates, and fats), fiber intake, and nutrient density. The research highlights the importance of nutrition in managing cardiovascular conditions, particularly among cardiac patients, and aims to empower them with the information needed to make healthier food choices. By

analyzing disease-specific parameters and user profiles, the recommendation system strives to improve dietary and overall health outcomes for cardiovascular patients in Gujarat.

1.4.2.4.3.1 Cardiovascular Disease Patient Food Recommendation System

The Cardiovascular Disease Patient Food Recommendation System[30] is all about helping people with heart problems eat better. It gives personalized suggestions for foods that are good for their hearts. By looking at things like how much salt and unhealthy fats are in foods, the system helps promote healthy eating habits that can lower the risk of heart problems. The research focuses on creating a model specifically for recommending foods to people with heart conditions in Gujarat, considering their nutritional needs and what foods are available at different times of the year. Ultimately, the goal is to give cardiac patients the information they need to make smart choices about what they eat and improve their heart health overall.

Figure 13 Food Recommendation for Cardiac Patients[26], [31]

In this researcher's work, a key focus is on developing a Nutrition-Based Recommendation System (NBRS) tailored to the dietary needs of people in Gujarat, particularly those suffering from cardiovascular diseases. Among the prevalent health concerns in the region, cardiovascular disease stands out prominently. Through observation, the researcher noted the high incidence of cardiovascular ailments among the population. Consequently, the researcher is dedicated to creating an effective NBRS specifically designed to recommend nutritious foods suitable for individuals with cardiovascular conditions. This initiative's objective is to address the health challenges faced by the people of Gujarat by providing

personalized dietary guidance, ultimately promoting better heart health and overall well-being.

In this model, the researcher is working on creating a food recommendation system that covers all three main meals of the day: breakfast, lunch, and dinner. The goal is to ensure that every patient can meet their daily calorie requirements through the suggested foods. Additionally, the system pays close attention to four important nutritional parameters: fat, fiber, protein, and carbohydrates. By considering these factors, the model can offer recommendations that align with the dietary needs of cardiac patients.

To make the recommendations, the researcher has compiled a list of over 90 highly recommended food items for cardiac patients. Each item in this list is carefully chosen to provide essential nutrients while also being suitable for heart health. Furthermore, the system takes into account the seasonal availability of foods to ensure that patients have access to fresh and locally available options throughout the year.

Overall, the researcher's model aims to provide comprehensive and practical dietary guidance for cardiac patients, helping them make informed choices about what to eat to support their heart health. By offering personalized recommendations based on nutritional requirements and seasonal factors, the system empowers patients to improve their diet and overall well-being.

1.5 Problem Statement

The researcher's thesis focuses on addressing the dietary needs of individuals with heart conditions in the Gujarat region, specifically by developing a Nutrition-Based Recommendation System (NBRS) tailored to Gujarati food and fruits. The aim is to provide personalized dietary guidance using machine learning algorithms that consider both nutritional requirements and user preferences.

The primary challenge lies in creating an effective recommendation model that accurately suggests suitable foods while accommodating individual tastes, dietary restrictions, and the seasonal availability of Gujarati food and fruits. Given the diverse and rich culinary traditions of Gujarat, it is essential to ensure that the recommended foods align with the cultural preferences and dietary habits prevalent in the region.

To achieve this goal, the researcher has gathered extensive data on Gujarati food and fruits, including nutritional content, serving sizes, and calorie information. Additionally, user

preferences have been captured through surveys and ratings, allowing for the customization of recommendations based on individual tastes and dietary requirements.

The recommendation system employs machine learning algorithms, including Random Forest and other collaborative filtering techniques, to analyze the collected data and generate personalized dietary recommendations. These algorithms leverage the vast dataset to identify patterns and associations between different food items, enabling the system to suggest appropriate meals and snacks tailored to each user's specific needs.

Furthermore, the system 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. By considering seasonal variations in food availability, the NBRS enhances the relevance and practicality of its recommendations, promoting healthier eating habits among individuals with heart conditions in the Gujarat region.

Overall, the researcher's thesis addresses a crucial need for personalized dietary guidance among individuals with heart conditions in Gujarat. By developing a Nutrition-Based Recommendation System tailored to Gujarati food and fruits, the research aims to improve the overall health and well-being of individuals in the region by providing them with practical and effective dietary recommendations tailored to their unique needs and preferences.

1.6 Need and Importance of Research

Research plays a vital role in uncovering new knowledge and addressing important issues, especially in the field of healthcare. As a researcher, it's essential to understand the need and importance of conducting studies to improve the lives of people, particularly those affected by conditions like cardiovascular disease. By researching issues like nutrition-based recommendations for cardiac patients in the Gujarat region, researchers can identify effective strategies to promote heart health and enhance overall well-being.

Through investigation and analysis, researchers can identify gaps in current knowledge and develop innovative solutions to address them. In the context of cardiac health, understanding the dietary needs of individuals with heart conditions is crucial for developing personalized that can significantly impact patient outcomes. By exploring the nutritional value of foods and their effects on heart health, researchers can provide valuable understandings that inform and improve patient care.

In summary, research is vital in addressing the complex challenges facing healthcare, including the management of cardiovascular disease. By conducting studies like the one focused on nutrition-based recommendations for cardiac patients in Gujarat, researchers can make meaningful contributions to improving patient outcomes and advancing the field of cardiac care.

1.7 Research Objectives

In developing the nutrition-based recommendation system for cardiac patients in Gujarat, the researcher followed seven distinct objectives, each crucial for the research's success. These objectives acted as guiding principles, shaping the research's direction and ensuring its effectiveness in addressing the dietary needs of individuals with cardiovascular conditions. By systematically outlining these objectives, the researcher aimed to achieve a comprehensive understanding of the dietary factors influencing heart health and promoting optimal nutrition among cardiac patients.

Manage Cardiovascular patient dataset: The first objective in my research is to organize data about patients with heart-related Problems. This involves collecting information about their diets, preferences, and health status. By managing this dataset effectively, researchers can better understand the needs of cardiovascular patients and develop tailored dietary recommendations.

Collecting the data set for Gujarat food & raw fruits based on nutrition: The second objective of my research is to gather data on the nutritional value of Gujarati foods and raw fruits. This involves compiling information about the fat, fiber, protein, and carbohydrate content of various food items commonly consumed in Gujarat. By collecting this data, the researcher can assess the nutritional quality of local foods and fruits, helping in the development of personalized dietary recommendations for cardiac patients in the region.

Analyze structural features for recommending nutrition-based recipes to the user: The third objective of the research is to analyze the structural characteristics of recipes for recommending nutritious meals to users. This involves analyzing the ingredients, and nutritional content of different recipes. By understanding these features, researcher can recommend healthy and balanced meal options personalized to the dietary needs of cardiovascular patients.

Design & develop the dataset with the nutrition specification for suggesting the Gujarati recipes to the user as per their requirement of the body: The fourth objective of my research is to create a dataset containing nutritional information for recommending Gujarati recipes based on individual body requirements. This involves designing a database that includes details such as calorie counts, protein levels, and other key nutrients. By developing this dataset, the researcher can offer personalized recipe suggestions that align with the specific dietary needs of cardiac patients in Gujarat.

Design & development model that allows end users to get the recommended recipe based on the user body aspect by providing suitable input: The fifth objective of my research is to design and develop a model that enables users to receive personalized recipe recommendations based on their body requirements. This involves creating an interactive system where users can input their age, gender, weight, and activity level to receive personalized recipe suggestions. By developing this model, the researcher's goal is to provide cardiac patients in Gujarat with easy access to nutritious recipes that meet their specific dietary needs and preferences.

Design and develop components of NBRS based on the different parameters like BMI, BMR, and Blood Pressure of the User: The sixth objective of my research is to design and develop components of the Nutrition-Based Recommendation System (NBRS) that consider user parameters such as BMI, BMR, and blood pressure. This involves creating algorithms that analyze these factors to generate personalized dietary recommendations for cardiac patients. By incorporating these parameters into the NBRS, the Researcher provided more accurate and personalized guidance to users based on their health profiles.

Testing and performance evaluation by analyzing results of NBRS Proceedings: The seventh objective of my research involves testing and evaluating the performance of the Nutrition-Based Recommendation System (NBRS) by analyzing its outcomes. This includes assessing how well the system provides dietary recommendations to cardiac patients in Gujarat and determining its effectiveness in improving their nutritional habits and overall health outcomes. Through rigorous testing and evaluation, Researchers ensure that the NBRS meets the needs of users and delivers valuable guidance for managing cardiovascular conditions.

1.8 Advantages of Study

The study offers numerous advantages poised to significantly impact the field of cardiovascular health. It provides a groundbreaking model for dietary recommendations tailored to cardiac patients in Gujarat, addressing the prevalent heart disease concerns in the region. By leveraging machine learning algorithms, it ensures personalized recommendations based on individual health parameters, fostering improved dietary habits. The study's emphasis on Gujarati cuisine and seasonal fruits facilitates culturally relevant and accessible dietary choices for patients. Furthermore, the comprehensive dataset and analytical approach contribute to a deeper understanding of dietary patterns and their implications for cardiovascular health. Ultimately, the study's findings and recommendations aim to enhance patient well-being, promote healthier lifestyles, and reduce the burden of cardiovascular diseases in Gujarat.

1.9 Scope of Study

The scope of this study covers the development and implementation of a Nutrition-Based Recommendation System (NBRS) specifically for cardiac patients in the Gujarat region. This includes gathering data on the nutritional content of Gujarati foods and raw fruits, designing a database to store this information, and creating algorithms that consider user parameters like BMI, BMR, daily activity level, Height, and Weight to generate personalized dietary recommendations. Additionally, the research analyzed the structural features of recipes and developed a user-friendly interface that allows individuals to access recommended recipes based on their body aspects and nutritional requirements. Through testing and evaluation, the effectiveness of the NBRS will be assessed, ensuring that it provides valuable guidance for improving the dietary habits and overall health outcomes of cardiac patients in Gujarat.

Furthermore, this research extends to investigating the seasonal availability of food items and considering preferences for recommended recipes. By focusing on the unique dietary needs and preferences of cardiac patients in Gujarat, this research contributes to the advancement of personalized nutrition for cardiovascular health management. Through the development and implementation of the NBRS, individuals with cardiac conditions will have access to personalized dietary recommendations that promote heart health.

1.10 Limitation of Study

The research's success with the limited Gujarati food selection sets the stage for potential expansion in the future. This could involve incorporating a broader array of foods commonly consumed in Gujarat, thereby refining and enriching the recommendation system. By doing so, we can enhance the system's effectiveness in providing tailored meal suggestions for cardiac patients, ensuring that their dietary needs and preferences are thoroughly addressed.

1.11 Organization of Thesis

1.11.1 Introduction

This chapter presents the development of a Nutrition-Based Recommendation System (NBRS) aimed at addressing the growing incidence of heart problems in Gujarat. By leveraging machine learning techniques and analyzing local Gujarati foods, the NBRS provides personalized dietary recommendations tailored to the specific needs of cardiac patients. The focus is on integrating nutritional expertise with advanced data analysis to empower patients to make informed, culturally relevant dietary choices that support their heart health.

1.11.2 Literature Review

The literature review for developing a Nutrition-Based Recommendation System (NBRS) for cardiac patients in Gujarat covered several key areas. It explored different machine learning methods like supervised, unsupervised, and reinforcement learning to see how they could be applied in recommendation systems. The review also examined various types of recommendation systems, such as movie, product, and healthcare-based systems, to understand their principles. Additionally, the researcher looked into filtering techniques like content-based, collaborative, and hybrid filtering, analyzing their strengths for generating personalized food recommendations. The review also focused on the nutritional needs of cardiac patients, including factors like Basal Metabolic Rate (BMR), Body Mass Index (BMI), and food nutrient composition, to build a strong foundation for creating a personalized NBRS model for the Gujarat region.

1.11.3 Analysis and Design of NBRS Model

In this chapter, we also focus on gathering data related to Gujarati food and fruits, along with their nutritional values. This data forms the foundation for creating personalized dietary recommendations. The collected information includes essential nutrients like proteins, fiber,

carbohydrates, and fats, ensuring that the system offers culturally relevant and nutritionally balanced meal suggestions tailored to individual user needs.

1.11.4 NBRS Model Development

The development of the Nutrition-Based Recommendation System (NBRS) involves creating a model that gathers user health data, dietary preferences, and restrictions to provide personalized meal recommendations. Using advanced algorithms and nutrient analysis, the system delivers personalized suggestions to promote balanced nutrition and healthier eating habits.

1.11.5 Results and Discussion

In the "Results and Discussion" section of this thesis, the researcher presents the findings and interprets the outcomes of the study regarding the development and evaluation of the Nutrition-Based Recommendation System (NBRS) for cardiac patients in Gujarat. The section begins with a comprehensive presentation of the results obtained from the experimental phase, including the performance metrics and outcomes of the NBRS model.

Through detailed analysis and interpretation, the researcher discusses the implications of the results of the research objectives and hypotheses. Key findings, such as the accuracy of dietary recommendations, user satisfaction, and the impact on dietary adherence among cardiac patients, are thoroughly examined and discussed.

Moreover, the discussion delves into the strengths and limitations of the NBRS model, highlighting areas of success and areas for improvement. The researcher critically evaluates the effectiveness of the model in addressing the dietary needs and preferences of cardiac patients, considering factors such as model robustness, and scalability.

Furthermore, the discussion explores the practical implications of the study's findings for clinical practice, public health policy, and future research directions. Insights gained from the results are synthesized to provide actionable recommendations for healthcare professionals, policymakers, and researchers seeking to enhance dietary interventions for cardiac patients.

Overall, the "Results and Discussion" section serves as a comprehensive analysis of the research findings, offering valuable insights into the development, evaluation, and implications of the NBRS model for promoting heart health among cardiac patients in Gujarat.

1.11.6 Conclusion and Future Scope

Conclusion:

The researcher, study on the Nutrition-Based Recommendation System (NBRS) for cardiac patients in Gujarat. They summarize what they've learned from the study and its potential impact. The researcher highlights the importance of personalized dietary advice in promoting heart health and suggests areas for further research, like improving the NBRS model's accuracy and expanding its reach to other populations. Overall, this section reflects on the study's findings and outlines future possibilities for enhancing personalized nutrition interventions for cardiac patients.

Future Scope:

In the future, the Nutrition-Based Recommendation System (NBRS) could benefit from enhancements such as incorporating diverse dietary preferences and integrating real-time health data for more personalized recommendations. Expanding its scope to address other health conditions and collaborating with healthcare professionals could further optimize the NBRS's effectiveness in promoting overall well-being.