A Novel Approach Using Hybrid model in Recommendation system By Machine Learning: A Survey

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Abstract: A recommendation system's purpose is to forecast user interests and infer their thinking processes. This system can provide the information required by the user based on their requests and interests. Better recommendations will require a more complete review of the data. Several recommendation systems have been built using various techniques. As OTT platforms, commerce, travel, and other websites multiply and aim to fast enhance their user suggestions, research into such systems has grown in popularity to this point. Recommender System (RS) is a system that assists in decision making by delivering ideas of any form of content that may be of benefit to a user that is closely connected. In this method, RS attempts to forecast the most appropriate things based on the user's choices and limits. These systems categorise based on the methodologies employed to give a recommendation: Hybrid model approaches, content-based recommendations, demographic recommendations, and collaborative filtering (CF). This study examines several machine learning approaches and algorithms used to improve the performance and accuracy of a recommendation system. This paper provides a quick overview of several strategies for item suggestion using distinct recommendation models.

Keywords:-Machine Learning, Hybrid Model Approaches, Collaborative-Filtering (CF), Content-Based Filtering (CB), Demographic recommendations, K-NN Algorithm, K-means Clustering.

1.0 Introduction

A Recommender System is a type of information filtering system that attempts to forecast a user's "rating" or "preference" for an item. Recommender systems are used in a number of contexts, with well-known examples being playlist generators for video and audio services, product recommenders for online businesses, and so on. These systems can function with a

single input, such as music, or with several inputs inside and across platforms, such as news, books, and search queries. These systems are used to provide better product recommendations to clients or customised recommendations to friends.

RS is a technique or algorithm method that analyzes user data and preferences to recommend tailored things, products, material, or information that the user may find interesting or relevant. A recommendation system's primary purpose is to improve user experience by assisting users in discovering products they would not have discovered on their own, hence improving engagement and pleasure. This technology is commonly employed in numerous online platforms to deliver personalised suggestions and help people make better decisions.

Recommender System (RS) employs machine learning algorithms to use advanced data analysis and modelling approaches to present users with tailored and relevant suggestions. These algorithms anticipate and propose products that a user is likely to be interested in by studying trends, interests, and interactions across big databases. This method involves training models on previous user behaviour and item data to create accurate predictions about user preferences and generate tailored suggestions. Machine learning in recommendation systems improves their capacity to adapt and improve over time, giving users with more accurate and meaningful choices.

Machine learning is used by recommender systems to estimate the ratings or preferences of goods for a specific user. They are frequently used in e-commerce systems to recommend things that a consumer might be interested in. These systems are particularly useful for data scientists since they can provide recommendations about what a person might wish to buy or watch. Machine learning-based recommendation systems are powerful engines that utilize machine learning algorithms to segment customers and target them with customised product and content recommendations based on their user data and behavioural patterns (for example, purchase and browsing history, likes, or reviews). A recommender system is a piece of software or an algorithm that makes customised suggestions or recommendations to users. Typically, these suggestions are for goods like as products, services, content, or information that the user may be interested in. These algorithms are frequently utilized in a variety of online platforms and sectors to assist consumers find relevant things among a large number of possibilities.

1.1 Working of Recommendation system

Machine learning recommendation systems anticipate and provide tailored suggestions for consumers by evaluating patterns and correlations in huge datasets. To provide accurate and

relevant suggestions, these systems often employ certain tactics and methodologies. Here's a rundown of how they function and some of the most frequent strategies: These components are critical to comprehending how recommendation systems function and the approaches they utilize to present consumers with individualized and relevant suggestions based on their preferences, behaviour, and item content.

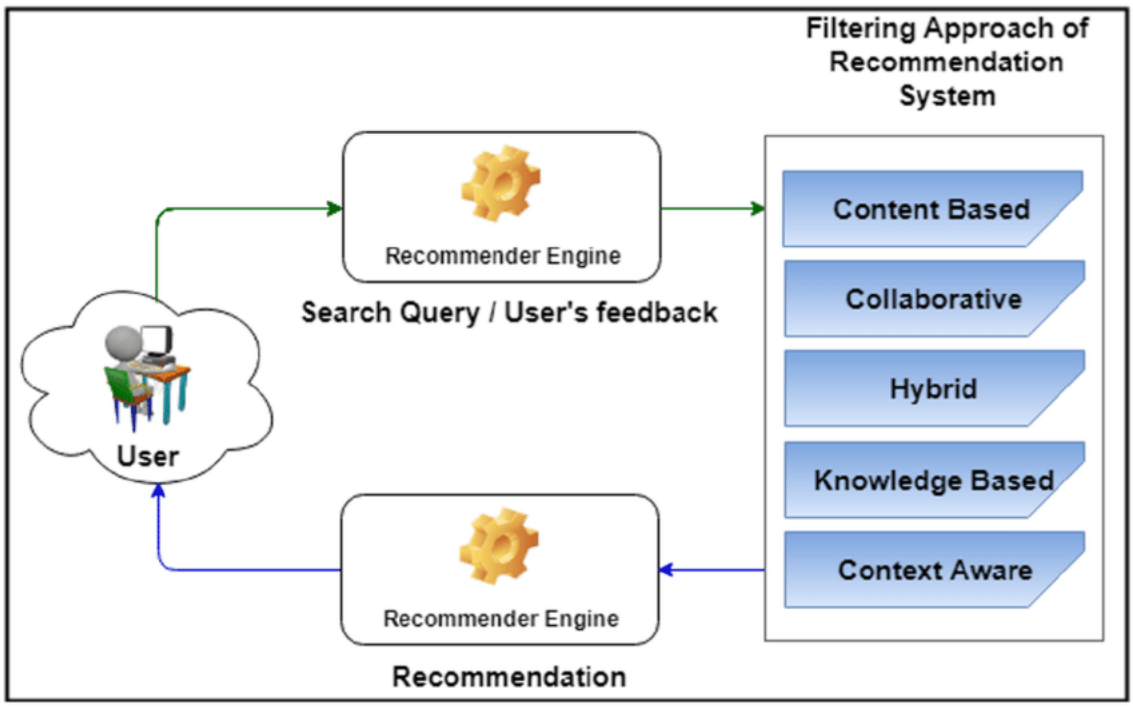

Figure 1.1 a general framework for the recommender system.

Let’s define these elements in the context of a recommendation system.

1. **User:** In a recommendation system, the "user" is the person or entity for whom suggestions are created. Users engage with the system by giving information, such as search queries or comments, and they receive individualized suggestions based on their interests and behaviours.
2. **Search Query/User Feedback:**
    - **Search Query:** A "search query" is a precise request made to the recommendation system by a user to discover certain products or information. It is a direct statement of the user's information or item requirements.
    - **User Feedback:** "User feedback" refers to a variety of activities and reactions offered by users. It can comprise both explicit and implicit activities like ratings, likes, dislikes,

comments, and reviews. User feedback assists the algorithm in understanding user preferences and improving suggestion quality.

3. **Recommendation Engine:** The "recommendation engine" or "recommendation algorithm" is the central component of a recommendation system that generates individualized suggestions. It considers user data, item data, and maybe other criteria to recommend items that are likely to be of interest to the user. Content-based, collaborative filtering, and hybrid approaches may all be used to build recommendation engines.
4. **Content-Based:** The term "content-based recommendation" refers to a strategy that proposes items to users based on the content or qualities of those objects as well as the user's profile. This method entails assessing item attributes such as descriptions, keywords, genres, and tags, and then proposing goods that are comparable in content to those in which the user has previously expressed interest. For example, proposing books in genres comparable to those read by the user.
5. **Collaborative:** "Collaborative filtering" is a recommendation strategy that is based on user-item interactions and patterns of user behaviour. It examines historical data to identify links between users and things. Collaborative filtering can be user-based (recommending goods based on the preferences of other users) or item-based (recommending products similar to those with which a user has engaged).
6. **Hybrid:** To deliver more accurate and diversified suggestions, a "hybrid recommendation system" integrates different recommendation algorithms, frequently integrating both content-based and collaborative filtering methods. Hybrid systems strive to increase suggestion quality and overcome the limits of individual techniques by using diverse approaches.
7. **Knowledge-Based:** The concept of "knowledge-based recommendation" refers to the incorporation of domain knowledge or expert-defined guidelines into the recommendation process. This method is very effective when there is a scarcity of user interaction data. To produce suggestions, knowledge-based systems incorporate explicit knowledge about objects as well as user preferences.
8. **Context-Aware:** A "context-aware recommendation system" takes the contextual information around a user's request or interaction into account. Context might include the user's present location, time of day, device kind, and even their current activity or attitude. These systems try to deliver recommendations that are relevant to the user's present condition or requirements by taking context into account.

Limitations of Recommender System

Recommender systems are powerful tools for providing personalized recommendations to users, but they also have several limitations and challenges.

I. **Cold Start Problem**: Recommender systems can struggle with new users or items with little to no interaction history. Since they rely on user behaviour data, it can be challenging to make recommendations until sufficient data is collected.

II. **Data Sparsity**: In collaborative filtering-based systems, user-item interaction data is used to make recommendations. However, this data is often sparse, meaning not all users have interacted with all items. This can lead to difficulties in making accurate recommendations, especially for niche or less popular items.

III. **Scalability**: As the number of users and items grows, the computational and memory requirements of recommender systems can become significant. Scaling up to handle millions of users and items can be a technical challenge.

IV. **Stereotyping and Bias**: Collaborative filtering can lead to recommendations that reinforce existing stereotypes or biases present in the data. For example, if a system recommends mostly male-authored books to male users, it may reinforce gender biases.

V. **Contextual Information**: Many recommendation algorithms primarily rely on user-item interactions and may not take into account contextual information, such as the user's current situation or preferences.

VI. **Dynamic Changes:** User preferences and item popularity can change over time. Recommender systems may not adapt quickly to these changes, leading to recommendations that are outdated.

VII. **Ethical Concerns:** Ensuring ethical recommendations that align with user values and societal norms is an ongoing challenge.

VIII. **Quality of User Feedback:** Relying on user feedback for training and evaluation can be problematic if feedback is sparse or biased.

IX. **Cross-Platform Consistency:** Maintaining consistent recommendations across different platforms and devices can be challenging for multi-platform services.

X. **Cross-Domain Recommendations:** Effectively recommending items across different domains (e.g., books and movies) can be complex.

XI. **Diversity vs. Accuracy Trade-off:** Striking the right balance between recommending popular items and diverse or niche items remains a challenge.

XII. **Long-Tail Recommendations:** Promoting long-tail or less popular items to improve user diversity is an ongoing challenge.

XIII. **Exploration vs. Exploitation:** Balancing exploration (introducing new items) and exploitation (recommending known preferences) is a delicate trade-off.

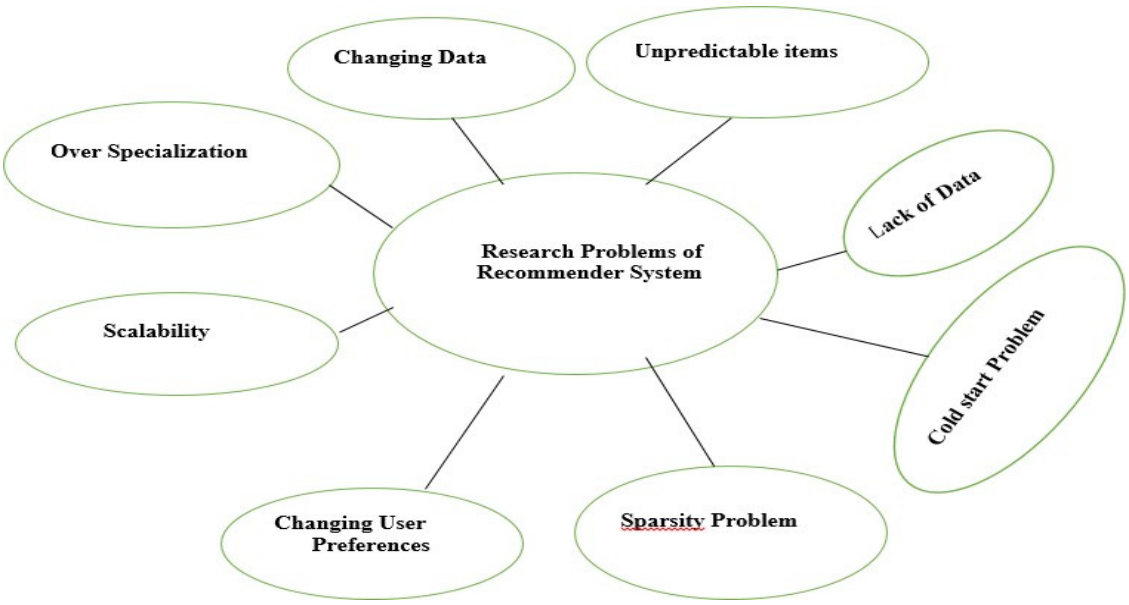

Figure 1.2 Research Problem of RS

1.2 Applications of Recommendation system

Recommendation systems have a wide range of applications across various industries and platforms. They are used to enhance user experiences, improve engagement, and drive sales or interactions by providing personalized and relevant suggestions. Here are some common applications of recommendation systems:

a) **E-Commerce:** Recommendation systems are extensively used in e-commerce platforms to suggest products to customers based on their browsing history, purchase behaviour, and preferences. This can lead to increased sales and customer satisfaction.

b) **Content Streaming:** Streaming services like Netflix, Spotify, and YouTube use recommendation systems to suggest movies, TV shows, music, and videos to users based on their past viewing or listening habits.

c) **Social Media**: Social media platforms employ recommendation systems to suggest friends to connect with, groups to join, and content to engage with, and keeping users more active on the platform.

d) **News and Content Websites:** Online news websites use recommendation systems to suggest articles or content to users based on their reading history and interests, thereby increasing user engagement and time spent on the site.

e) **Travel and Hospitality:** Travel and hotel booking platforms use recommendation systems to suggest travel destinations, accommodations, and activities based on user preferences and travel history.

f) **Online Advertising:** Ad platforms employ recommendation systems to display relevant advertisements to users, increasing the chances of users clicking on ads that match their interests.

g) **Healthcare:** In healthcare, recommendation systems can help suggest treatment plans, medications, and therapies based on patient medical history and symptoms.

h) **Education:** Educational platforms use recommendation systems to suggest courses, learning resources, and study materials tailored to individual learners' needs and learning styles.

i) **Dating Apps:** Dating apps use recommendation systems to suggest potential matches to users based on their preferences, location, and past interactions.

j) **Eating and Dining:** Restaurant or food delivery platforms use recommendation systems to suggest dishes or restaurants based on users' previous orders and reviews.

k) **Financial Services:** Financial institutions use recommendation systems to suggest financial products, investment opportunities, and banking services based on user financial behaviour.

l) **Gaming:** Video game platforms can employ recommendation systems to suggest games, in-game items, and other players to connect with, enhancing the gaming experience.

m) These are just a few examples of how recommendation systems are used across diverse industries to provide users with personalized and valuable suggestions, leading to improved user engagement, satisfaction, and business outcomes.

Table1.2 Name of Recommendation System

System Name	Technique	Application	How It Works	Advantages	Disadvantages
Amazon	Collaborative Filtering, Content-Based.	E-commerce	Analyzes user behaviour and item. Characterist is to suggest products.	• Personalized recommendations. • Scalable for millions of products. • Addresses the "cold start" problem for new users.	• Limited to recommending products in the same domain. • Can lead to filter bubbles.
Netflix	Matrix Factorization	Video Streaming	Decomposes user-item interaction matrix to recommend movies and shows.	• Accurate recommendations. • Handles sparse user-item interactions.	• Requires significant computational resources. • Cold start problem for new content.
Spotify	Hybrid (Collaborative Filtering, Content-Based)	Music Streaming	Recommends music based on user taste and audio features.	• Personalized playlists and Discover Weekly. • Diverse music recommendations.	• Privacy concerns due to user data access. • May struggle with niche music preferences.
YouTube	Neural Collaborative Filtering	Video Sharing	Provides personalized video recommendations based on user engagement.	• Tailored video suggestions. • Considers historical user data.	• Tendency to recommend popular content. • Privacy concerns with user tracking.
LinkedIn	Item-Based Collaborative Filtering	Professional Networking	Suggests connections and job opportunities based on user connections.	• Scalable for a large user base. • Enhances professional networking.	• Limited to recommending connections within the user's network.

					• Cold start problem for new users.
Pandora	Music Genome Project	Internet Radio	Analyzes songs' attributes and user preferences to curate radio stations.	• Precise music recommendations. • Diversity in music selection.	• Limited interactivity compared to on-demand services. • Lesser user control.
Trip Advisor	Content-Based, User Ratings.	Travel Planning	Suggests hotels, restaurants, and activities based on user preferences.	• Provides tailored travel recommendations. • Utilizes user reviews and ratings.	• Depends on user reviews which can be biased. • Limited to travel-related suggestions.
Google News	Collaborative Filtering, Content-Based.	News Aggregation	Customizes news articles based on user interests and browsing history.	• Personalized news feed. • Wide variety of news sources.	• Risk of filter bubbles. • Privacy concerns with user data.
Etsy	Content-Based, Collaborative Filtering.	Handmade Goods	Recommends unique handmade products based on user interactions.	• Curated product recommendations. • Supports independent artisans.	• Limited to recommending handmade items. • Smaller product catalog compared to major e-commerce platforms.
Amazon Prime	Collaborative Filtering, Content-Based.	Video Streaming.	Recommends movies and shows based on user preferences and browsing history.	• Personalized video content. • Integration with e-commerce platform.	• Limited to recommending video content. • Privacy concerns with user data.

Fitbit	Content-Based, Hybrid	Health and Fitness	Recommends fitness activities and goals based on user data and goals.	• Personalized fitness recommendations. • Tracks user progress and health metrics.	• Limited to health and fitness recommendations. • Privacy concerns with user health data.
IMDb	Content-Based, User Ratings	Movie and TV Shows	Recommends movies and TV shows based on user ratings and viewing history.	• Personalized movie and TV show suggestions. • Rich metadata and user reviews.	• Limited to recommending movies and TV shows. • Subject to biased user ratings.
Duolingo	Content-Based, User Progress	Language Learning	Recommends language lessons and exercises based on user proficiency.	• Personalized language learning path. • Gamification and progress tracking.	• Limited to language learning recommendations. • May not suit all learning styles.
Yelp	Content-Based, Collaborative Filtering.	Local Business	Provides recommendations for restaurants, businesses, and services	• Personalized local recommendations. • User-generated reviews and photos.	• Relies on user-generated content which can be biased. • Limited to local businesses.
Good reads	User-Based Collaborative Filtering	Book Recommendations	Recommends books based on user ratings and preferences.	• Personalized book recommendations. • Book discovery and reading community.	• Dependent on user-generated ratings and reviews. • Limited to book recommendations.

Zillow	Content-Based, Collaborative Filtering	Real Estate	Suggests houses based on user preferences and historical data.	• Personalized real estate recommendations. • Detailed property information. • Estimates property values.	• Limited to real estate listings. • Market fluctuations may affect recommendations.

2.0 Literature Review and Related work

This section comprised of the content or tools techniques, approach and past research work done.

The proposed approach mainly focuses on analysing the data of social networking sites that generate a huge amount of data daily [1]. The concepts used here are user based collaborative filtering, item based collaborative filtering. User based collaborative filtering takes the data of different users who are similar based on the ratings given to the products and predicts the rating for an unpurchased item and recommends it to the user. To find similarity between the users, k nearest neighbour's algorithm is used. In item-based filtering, rather than comparing users, it compares the similarity of many items and then suggests that item by predicting the rating to that item. This paper also explains about different challenges faced while building a recommender system. Here drawbacks are cold start problem and sparsity problem and this method might be costlier sometimes.

This section comprised of the content or tools techniques, approach and past research work done in the field. The proposed approach, a system that dynamically makes recommendation as per altering behaviour of users with the use of Web Usage Mining [2]. In Web Usage Mining, user's click stream data plays a huge role, this Clickstream data consists of user's path over a website. This data is stored in web log files which is highly unstructured data. This data is pre-processed, and recommendation techniques are applied. In general, there are two types of errors in recommender systems, false negatives and false positives. False negatives mean user is interested in that product, but recommender system fails to recommend. False positives mean user is not interested in that product, but recommender system recommends that product to the user. The proposed system in this paper reduces the false positives that occur regularly in conventional recommender systems.

This section comprised of the content or tools techniques, approach and past research work done in the field. The proposed approach mainly focuses on describes about the current generation of recommender systems techniques [3]. This are classified into three main categories: content based, collaborative based and finally hybrid based recommender systems approaches .This paper describes about various limitations and describe various extensions that can make recommender systems more applicable in various fields in a better way with more accurate result. This extension includes various information regarding the customers and their items. In this paper, they have researched about New User Problem-where the customer is new to the online marketing, the system must provide correct recommendation by using previous ratings, clicks, likes, dislikes and feedback. New Item Problem-In this problem the item is new to the market, so we must be careful while recommending to the customer until and unless it is liked or clicked by the customer.

This section comprised of the content or tools techniques, approach and past research work done in the field. The proposed approach mainly focuses made an emotion-based music recommendation system in which they use signals from wearable physiological sensors (WPS) for analysis emotion of the user [4]. A wearable computing device uses for categorized the emotion of a user which is integrated with a galvanic skin response (GSR) and photo plethysmo graphy (PPG) physiological sensors. This information of a user's emotions is added into any collaborative or content-based recommendation engine as further information. Then emotion recognition issue is considered as arousal and valence prediction from multi-channel physiological signals. Decision tree, random forest, support vector machine, and k-nearest neighbour algorithms machine learning algorithm are used for feature fusion. The results of the recommendation system are checked emotion recognition accuracy [4].

This section comprised of the content or tools techniques, approach and past research work done in the field. The proposed approach make a movie recommendation system uses movie lens data set in which use graph-based structure for overcome a limitation of collaborative recommendation system and ranking problem. Graph-based models make associations between users and items. In which node as user and edge as a relation between a user in which page rank algorithm used for top n item for user preference. The result of this system compares with the collaborative system existing algorithm evolution using recall, precision, f-measure and MAP metrics [5].

This section comprised of the content or tools techniques, approach and past research work done in the field. The proposed approach propose on HI2Rec, which unifies large data to learn the user's and items vector representations for top-N recommendation to address the cold start, sparsity problem. They take the movie-related data out by Linked Open Data. Then knowledge graph model embers use real-word data of user like age, pin code, gender with a vector. Preliminary recommendation list generate are used by that vector. An accuracy recommendation list is generated by collaborative filtering. They compare the result of HI2Rec and state-of-the-art recommendation models in which HI2Rec improvements result [6].

This section comprised of the content or tools techniques, approach and past research work done in the field. The proposed approach, a movie recommendation system based on a hybrid model-based collaborative filtering which makes use of the make better K-means clustering coupled with genetic algorithms (GAs) to partition transformed user space is proposed. Item ploys principal component analysis (PCA) data reduction technique to dense the movie population space, which could reduce the computation complexity in intelligent movie recommendations. The tested results on the Movie lens dataset compare accuracy with the existing system [7].

This section comprised of the content or tools techniques, approach and past research work done in the field. The proposed approach, this paper used of algorithm (2023)Collaborative Filtering & Sequential Data, it has been Research gap cold-start and sparsity problem.it has shown the result provides more accurate recommendations with less bias [13].

This section comprised of the content or tools techniques, approach and past research work done in the field. The proposed approach focuses ,This paper used of algorithm Wide and Deep model.it has been Research gap Recommendation based on data of books with only categories attribute.it has shown the result Improved the Wide & Deep model by converting the double-label into multiple labels. The experimental results show that the accuracy of our book recommendation model is significantly better than traditional recommendation algorithms and hybrid recommendation algorithms [14].

This section comprised of the content or tools techniques, approach and past research work done in the field. The proposed approach, this paper used to Algorithm Collaborative filtering (CF) and Content-Based Filtering is a method.it limitation of this paper Cluster of books did

not consider in recommendation; the authors did not consider borrowing the time and length of books.it brings more possibilities to improve performance of recommendation system [15].

This section comprised of the content or tools techniques, approach and past research work done in the field. The proposed approach focus on collaborative filtering algorithm where books are based on categories and Apriori Algorithm.it has been Research gap the system needs an active internet connection all the time while accessing. It has shown the result an automated and dynamic library recommendation system will help the user to choose the best version of the book of his/ her interest within a few seconds depending on the ratings given to that book [16].

This section comprised of the content or tools techniques, approach and past research work done in the field. The proposed approach, this paper used of algorithm DAO (Data Access Object) E-R mapping.it has been Research gap Recommends based on basic user information.it has shown the result Searched books will be presented on main interface of application from the database [17].

This section comprised of the content or tools techniques, approach and past research work done in the field. The proposed approach This paper used of algorithm Embedding model and, principal component analysis.it has been Research gap Total accuracy of embedding model is 59%.it has shown the result recommendation is produced by training embedding model to learn the pattern of high-rated books from every user and calculate the preferred books as close as possible [18].

This section comprised of the content or tools techniques, approach and past research work done in the field. The proposed approach a paper “Personalized Recommendation System using Machine Learning Algorithm”. Machine learning algorithms, clustering algorithms. The authors failed to explain the impact of clustering in the recommendation system Web-based recommendation system needs to be secure [19].

This section comprised of the content or tools techniques, approach and past research work done in the field. The proposed approach a paper “Online Recommendation System using Association Rule Mining and Collaborative Filtering”. The author detected recurrently occurring patterns, correlations and uses various databases such as relational databases, transactional databases to form associations. They used two approaches i.e., User-based and

Item-based Collaborative Filtering, and used the Pearson correlation coefficient to find similarity between the items [20].

This section comprised of the content or tools techniques, approach and past research work done in the field. The proposed approach a paper “Online Book Recommendation System”. The dataset used in this paper was taken from the website “good books-10k dataset” which contains ten thousand unique books. Features are book_id, user_id, and rating. In this paper, the author adopted a Keras deep learning framework model to create neural network embedding [21].

This section comprised of the content or tools techniques, approach and past research work done in the field. The proposed approach a paper “Hybrid Recommendation System”. In this paper, the author used techniques such as Collaborative Filtering etc. and used the Pearson correlation coefficient. It was published in International Research Journal of Engineering and Technology (IRJET) [23].

This section comprised of the content or tools techniques, approach and past research work done in the field. The proposed approach a paper “An Improved Online Recommender System using Collaborative Filtering Algorithm”. The authors designed and developed a recommendation model by using a quick sort algorithm, 13 collaborative filtering, and object-oriented analysis and design methodology (OOADM). This system produces an accuracy of 90-95% [26].

This section comprised of the content or tools techniques, approach and past research work done in the field. The proposed approach this paper used of algorithm Collaborative Filtering Deep Recommender architecture (CFDR) Collaborative Filtering based Multistage Deep Neural Network architecture (CFMDNN).it has been Research gap Cold start problem and Matrix sparsity problem.it has shown the result Improved performance than traditional collaborative filtering model [27].

This section comprised of the content or tools techniques, approach and past research work done in the field. The proposed approach this paper used of algorithm aggregation based scoring, fuzzy quantifiers, Ordered Weighted Averaging.it has been Research gap Limited to university books recommendation system.it has shown the result Positional aggregation based scoring efficiently finds top-ranked books for a university student [28].

This section comprised of the content or tools techniques, approach and past research work done in the field. In order to assist readers in recommending the right book, this article suggests a straightforward, understandable approach for book recommendations. In recent years, the administration's recommendation system has been at the core of the data analysis difficulty. Network resources are seamlessly integrated and rapidly growing for consumers. In order to provide the user with useful information to aid in decision-making, the intended technique focuses on coaching, feedback, management, reporting, configuration, and exploitation. In order to evaluate how well similarity metrics function when recommending books to a user, researchers employed a User-based mainly cooperative filtering (UBCF) technique. Aid in making decisions and offering knowledge item suggestions [8].

This section comprised of the content or tools techniques, approach and past research work done in the field. In order to determine the relationships between the books that users are interested in and the system's availability of those books in line with book classifications, this analysis used the association rule approach. With better-looking results, this might make it easier for consumers to find books. In addition to improving library efficiency, the book suggestion system also reduced the cost of maintenance. It also helped customers speed up the process of searching through a wide variety of books on shelves and encouraged them to read more [9].

This section comprised of the content or tools techniques, approach and past research work done in the field. This analysis presents the method of recommendation by victimization the collaborative filtering (CF) for university students. The CF technique composes of similarity calculation, prediction and recommendation. In our experiments, matrix resolving technique is additionally adopted to resolve exiguity of rating matrix. Different techniques of similarity calculation are compared. Book recommendation of every student has been generated by using existing borrowing records with time stamp [10].

This section comprised of the content or tools techniques, approach and past research work done in the field. The recommendation system in this analysis uses the Item based mostly cooperative Filtering methodology, wherever this methodology is that the results of combining cooperative Filtering and Item based mostly. Collaborative Filtering uses the rating matrix to calculate ratings, and Item based mostly uses book attributes to calculate similarity attributes between books. The cooperative filtering methodology has been used with success in many applications. The Collaborative Filtering methodology predicts user preferences for things in

an exceedingly word-of-month manner, i.e. user preferences area unit determined by considering opinions within the type of preference ratings. Based on the results of tests conducted, the minimum MAE generated by the system is zero.018 with a maximum accuracy of ninety 99.63% contained within the 1st test, that means that the additional variable information rating information, the higher the MAE price generated [11].

Table 2.0 Literature Review and Related work

Author Name	Technique	Work	Research gap
Yingtong Dou [1]	k nearest neighbous algorithm	User based collaborative filtering, item based collaborative filtering.	cold start problem and sparsity problem
Prajyoti Lopes [2]	Content-based and collaborative filtering system	Web usages mining for first time and aims on predicting users preference and behaviours.	accuracy approximately 80 to 85 percent archives
Gediminas Adomavicius1 and Alexander Tuzhilin[3]	content based, collaborative based and finally hybrid based	the system must provide correct recommendation by using previous ratings	More applicable in various fields in a better way with more accurate result.
D DegerAyata, Yusuf Yaslan, and Mustafa E. Kamasak [4]	Decision tree, random forest, support vector machine, and k-nearest neighbour algorithms machine learning algorithm	The recommendation system are checked emotion recognition accuracy.	Low accuracy

Maryam KhanianNajafabadi, Azlinah Mohamed, ChooWouOnn [5]	Collaborative based algorithm	graph-based structure for overcome a limitation of collaborative recommendation system and ranking problem	Overcome measure of recall, precision, f-measure and MAP metrics
Ming He, Bo Wang, And Xiangkun Du[6]	collaborative filtering	Compare the result of HI2Rec and state-of-the-art recommendation models in which HI2Rec improvements result.	the cold start, sparsity problem
Zan Wang, XueYub, NanFeng, ZhenhuaWang[7]	collaborative filtering	reduce the computation complexity in intelligent movie recommendations	the Movie lens dataset compare low accuracy with the existing system
M. Kommineni, P. Alekhya, et.al[8]	Collaborative filtering using Constrained Pearson Correlation as similarity measure	Reduce performance of book recommendation	Recall, F1 Score, Mean Absolute Presidion
P. Jomsri,[9]	UCL Model	Calculate the Precision and performance	Precision

C. Sirikayon, P. Thusaranon [10]	Collaborative filtering (CF) using Pearson correlation as similarity measure	To address the cold-start problem including social network information, or content-based methods for new items.	often struggle to provide accurate recommendations for new users or items with limited interaction data
S. S. Sohail, J. Siddiqui [11]	Combination of item-based approach and collaborative filtering	context-aware recommendation algorithms that consider real-time user context	Do not effectively incorporate contextual information such as time, location, and user context into the recommendation process.
N. Kurmashov, K. Latuta et.al [12]	Collaborative filtering method based on Pearson correlation coefficient	Quality of recommendations, Speed of getting recommendations	Traditional recommendation systems often prioritize popular items
Taushif Anwar, V. Uma, Shahjad[13]	Collaborative Filtering & Sequential Data	Provides more accurate recommendations with less bias	single type of data (e.g., text, images, ratings
Yihan Ma ,Jieteng Jiang et.al[14]	Wide and Deep model	The accuracy of our book recommendation model is significantly better than traditional recommendation algorithms.	More interpretable and providing users with explanations for their recommendations.

AshleshaBachhav , ApekshaUkirade[15]	Collaborative filtering (CF),Content-Based Filtering	More possibilities to improve performance of Recommendation system.	Recommendations are not discriminatory or biased against certain user groups.
Anoop .A,N AyushUbale[16]	Collaborative filtering algorithm where books are based on categories and Apriori Algorithm	Best version of the book of his/ her interest within a few seconds depending on the ratings given to that book	Balancing personalization with user privacy is a challenging problem.
Wenyu Li; DaqiangChena ndroid et.al: [17]	DAO(Data Access Object) E-R mapping	Searched books will be presented on main interface of application from the database.	Traditional user profiles in book recommendation systems may not capture the diverse interests and reading habits of users effectively.
R.Rahutomo,A.S.P erbangsa et.al[18]	Embedding model and, principal component analysis	Total accuracy of embedding model is 59%	Readers often have reading preferences that go beyond single book recommendations.
DhirmanSarma, TanniMittra et.al[19]	machine learning algorithms, clustering algorithms	Developing algorithms that can suggest sequences of books or reading lists tailored to a reader's interests or reading goals.	Failed to explain the impact of clustering in the recommendation system Web-based recommendation system needs to be secure.

AviRana and K.Deeba, et.al. [20]	Collaborative Filtering (With Jaccard Similarity)	Investigating contextual recommendation techniques for book recommendations, considering factors like the reader's current environment and emotional state	CF difficulties are scalability,sparsity, and cold start

3.0 Techniques of recommendation System

The techniques of Recommender System are briefly explained in subsequent paragraph.

3.1 Hybrid Approaches:

In a hybrid method, we combine the two and more advised techniques content-based, collaborative filtering and knowledge-based filtering—to acquire the greatest benefit, achieve the highest level of success, and reduce the issues and difficulties associated with those applications. Multi-method hybrid techniques are used. The frequent item-set creation is made easier and the best rules or patterns are found from each group using association rule mining with the clustered set (hybrid model).The hybrid recommendation system is a unique kind of system that uses data from both collaborative data and content-based data at the same time to offer to consumers an item that is similar to or close to another item. Combining the two aforementioned strategies might occasionally result in a more effective resolution of the larger issues.

Weighted:

We have a tendency to combine numerically each recommend element given a unique score by the system.

Switching:

The system has multiple decisions of different recommendation item to the user, user to user and items to items.

3.2 Content-based recommendations:

In the content-based filtering approach the characteristics of an item are analyzed to recommend items to the user. The foundation of content-based filtering strategies is the item description and user interests. In the item rate list, it also suggests items that are nearly identical to those that a particular user has loved. In fact, the content-based system matches the user's data, such as age, gender, location, and the rated item list on the placement hold on in his account, with the comparable items have a common specification in order to offer new things that fit his/her preferences. The following phases are included in the content-based recommendation method: Content-based recommendations are a type of personalized recommendation system that suggests items to users based on the features and attributes of the items themselves, as well as the user's preferences. This approach focuses on analyzing the content or characteristics of items to make suggestions that are similar to items the user has shown interest in or interacted with before.

Here's how content-based recommendations work and some key points to consider:

1. **Item Representation**: Each item in the system is represented by a set of attributes or features. These attributes can include textual descriptions, keywords, genres, tags, images, audio, or any other relevant information that describes the item's content.
2. **User Profile**: The system builds a user profile based on the items the user has interacted with in the past. This profile reflects the user's preferences and interests in terms of the features present in the items.
3. **Item Similarity**: The system identifies items that are similar to the ones the user has shown interest in. This similarity is calculated based on the shared attributes and features of the items.
4. **Recommendation Generation**: The system then generates recommendations by selecting items that are similar to those the user has interacted with. Items with the most similar features and attributes to the user's past preferences are prioritized.
5. **Addressing Cold Start**: Content-based recommendations are useful in addressing the "cold start" problem, where new users or items lack sufficient data for other recommendation

techniques. Since content-based methods rely on item attributes, they can still make relevant suggestions based on item features.

6. **Personalization**: Content-based recommendations provide personalized suggestions based on the user's unique preferences. The system tailors recommendations to the user's past interactions and the content features they prefer.
7. **Diversity**: One limitation of pure content-based approaches is that they might lead to recommendations that are too similar to each other. Techniques are often employed to ensure a diverse set of recommendations.
8. **Feature Extraction**: Extracting meaningful features from items can be a challenge, particularly for complex items like images or audio. Machine learning techniques, such as natural language processing or image analysis, are often used to extract relevant features.
9. **Combining Approaches**: Content-based recommendations can be combined with other methods, such as collaborative filtering or demographic recommendations, to create hybrid systems that leverage the strengths of each approach.

   Examples of Content-Based Recommendations:
10. **Movie Recommendations**: A content-based system for movies might recommend films based on their genres, directors, actors, and plot keywords, aligning with a user's past movie preferences.
11. **Music Recommendations**: A music streaming service could suggest songs similar to those a user has liked in the past, considering attributes like genre, artist, tempo, and mood.
12. **News Articles**: A news app might recommend articles based on the topics and keywords present in articles the user has read before.
13. **Recipe Recommendations**: A recipe website could suggest new recipes based on ingredients and cuisines the user has shown interest in Content-based recommendations are particularly effective when users have distinct and well-defined preferences, and when items have rich and varied attributes that can be used for comparison

3.3 Collaborative-Filtering (CF)

This approach builds a model from a user's past behaviour as well as similar decisions made by other users to predict items that user may have an interest in.

In Collaborative Filtering (CF), is recommending item to a user, based on the past ratings of all users collectively. CF classify into two types: User-based and Item based. User-based CF works like, for instance, a user U and a set of other users V whose ratings are similar to the

ratings of the selected user U and uses the ratings from those like-minded users to calculate a prediction for the selected user U. In Item-based CF, build an item-item matrix determining relationships between pairs of items and using this matrix and data on the current user, infer the user's taste Recommender systems are tools that, designed for interacting with large and complex information spaces.

It is a mechanism to recommend System. The suggestion function is only available to registered users here. Both item-item and user-user filtering are employed in the collaborative filtering. Calculating how similar the books are to one another and then recommending them is a crucial part of collaborative filtering. Cosine similarity is used in collaborative filtering to measure similarity. Find out or forecast the rating that the targeted user will give the specific book after that. The cold start issue with collaborative filtering is one of the most significant ones. That is, when a new user joins, there is no information available about that individual. They don't have any prior borrowing or purchases. So they provide a fresh book recommendation and expert answer here. The expert and new book suggestion module will suggest books as though they were best-sellers, just released, classics, etc. In other words, it will suggest items that are highly rated or well-liked novels.

3.4 Knowledge-Based Filtering

Items are recommended to a customer by using the knowledge of the item domain. It collects the customer's preferences on a specific product and uses its knowledge to find the products according to the customers' preferences. Knowledge-based filtering refers to a type of recommendation system that utilizes explicit knowledge about items, users, or their preferences to make personalized recommendations. Unlike other recommendation approaches that rely solely on user behaviour (like collaborative filtering) or item attributes (like content-based filtering), knowledge-based filtering incorporates domain-specific information to enhance the accuracy and relevance of recommendations.

Here are the key components and concepts related to knowledge-based filtering:

1. **Explicit Knowledge**: This involves information that is explicitly provided and not inferred from user behaviour or item attributes. This could include data like user profiles, item specifications, metadata, tags, genres, or any other structured information about users and items.

2. **User Profiles**: Knowledge-based filtering often starts with creating detailed user profiles based on demographic information, historical preferences, stated preferences, or any other relevant data. These profiles help in understanding user preferences and interests.
3. **Item Knowledge**: Similarly, detailed information about items is crucial for knowledge-based filtering. This could include characteristics, features, attributes, and any other relevant information that helps in understanding the nature of items.
4. **Domain-Specific Knowledge**: In some cases, recommendations might be enhanced by incorporating domain-specific knowledge. This could include rules, constraints, or expertise related to the items or users in question.
5. **Hybrid Approaches**: Knowledge-based filtering can be combined with other recommendation approaches like collaborative filtering and content-based filtering to create hybrid recommendation systems. This leverages the strengths of each approach to improve the overall quality of recommendations.
6. **Cold Start Problem**: One challenge with knowledge-based filtering is the "cold start" problem, where there might not be enough data available about new users or items to make accurate recommendations. However, knowledge-based approaches can help mitigate this by relying on the explicit knowledge available.
7. **Personalization**: Knowledge-based filtering can provide highly personalized recommendations since it takes into account explicit user preferences and detailed item information.
8. **Scalability**: Depending on the complexity of the knowledge representation, knowledge-based filtering systems can sometimes struggle with scalability, particularly when dealing with a large number of items and users.
9. **Content Enrichment**: Knowledge-based systems might require a continuous effort to enrich the metadata and information about items to ensure the recommendations remain accurate and relevant.

Examples: A knowledge-based filtering system for movies might use information like genre, director, actors, release year, and user preferences to recommend movies. A knowledge-based system for e-commerce might consider product features, user reviews, and purchase history to provide tailored product recommendations.

In essence, knowledge-based filtering enriches the recommendation process by incorporating explicit information about users and items, allowing for more accurate and fine-tuned suggestions, especially in situations where user behaviour data might be limited.

3.5 Demographic Recommendations

A method of determining a correlation between users based only on their demographic profiles. The demographic approach has a cold start issue for the new item since no users with the same demographic profile have shown a preference for it. Users with a similar demographic profile are advised. This method of advice-giving divides users by age group and area of residence using information from user profiles, such as age, gender, demographics, education, and hobbies, as well as the users' opinions about how they rate certain items. Demographic recommendations are a type of personalized recommendation that relies on demographic information about users to make suggestions. Demographics refer to characteristics such as age, gender, location, education level, income, and other relevant attributes that provide insights into a user's profile and preferences. These characteristics can play a significant role in influencing a user's preferences, interests, and needs.

Here's how demographic recommendations work and some considerations:

1) **Data Collection**: To provide demographic recommendations, the system needs access to users' demographic data. This data can be collected during the registration process, through user profiles, or through explicit user input.
2) **User Segmentation**: Demographic information helps in segmenting users into groups with similar characteristics. For example, users in the same age group or geographic location might share common preferences.
3) **Personalization**: Recommendations are tailored to each user's demographic profile. Users are presented with items that have been popular or well-received among users with similar demographic attributes.
4) **Content Alignment**: The recommended items are aligned with the user's demographic traits. For example, if a user is a young adult, they might receive recommendations for products, services, or content that are relevant to that age group.
5) **Addressing Cold Start**: Demographic recommendations can be particularly useful for new users who have not provided sufficient behaviour data for other recommendation techniques. By relying on demographic data, the system can still make relevant suggestions.

6) **Ethical Considerations**: While demographic recommendations can be effective, there are ethical concerns related to using sensitive demographic data. Privacy issues and potential biases need to be carefully considered and addressed.
7) **Limited Personalization**: While demographic information provides a basis for personalization, it might not capture all aspects of a user's preferences. Two users with the same age and gender might still have vastly different interests.
8) **Combining Approaches**: Demographic recommendations can be combined with other recommendation methods, like collaborative filtering or content-based filtering, to create hybrid systems that provide a more comprehensive and accurate set of recommendations.

Examples of Demographic Recommendations:

9) **Streaming Services**: A video streaming platform might use demographic data such as age and location to recommend movies and TV shows that are popular among users in a particular age group or region.
10) **E-commerce**: An online retailer might use demographic information to suggest products that are commonly purchased by users with similar demographics.
11) **News Platforms**: A news app might recommend news articles based on the user's location and age group, ensuring that the content is relevant to their interests.
12) **Travel Booking**: A travel website could use demographic data to suggest travel destinations and packages that are often chosen by users with similar demographic characteristics.

Overall, demographic recommendations can be a valuable tool in a recommendation system's arsenal, especially when combined with other approaches to provide a well-rounded and accurate set of suggestions to users. However, it's important to handle demographic data responsibly and transparently while addressing potential biases and privacy concerns

The comparative analysis of various techniques of recommender System is shown in Table 3.1.

Table 3.1: Comparative Analysis of different Techniques of Recommender Systems

Techniques of RS	Working	Advantage	Disadvantage	Techniques
Model based CF Recommendation	Predict users' rating of unrated items	• Great starting point	• Expensive Model building Lose useful • Information for Dimensionality reduction Technical.	• Association rule • Clustering • KNN • Decision Tree • CNN • Regression
User based CF Recommendation	Calculating Similarities score between user	• No knowledge about user features needed • Serendipitous recommendation	• New user Cold start • Data sparsity • Scalability • User Data Privacy	• Correlation Based • Pearson correlation • Cosine based
Item based CF Recommendation	Calculating similarities between item	• No knowledge about item features needed • Serendipitous recommendation	• New item Cold start • Data sparsity • Scalability • Time Consuming for huge item	• Correlation based • Cosine Based • Pearson correlation
Content based Recommendation	Work on user past history	• No need for data on other users. • No cold start and sparsity. • Able to recommend users with unique taste, new and unpopular items.	• Limited content • Analysis Over specialization	• TF-IDF Term Frequency and Inverse Document Frequency

Hybrid Recommendation	Combine more than one technique	Overcome Limitation of Content base filtering and collaborative filtering	• Increased complexity • Increased expense of implementation	• Combination of Collaborative and content based filtering Techniques

4.0 Proposed Work

Recommender Systems are useful for the recommendation of interesting and useful items based on the analysis of historical data or behaviour or buying patterns of the actual user. Therefore, a Hybrid Recommender system is purposed that consists of combination of different types of approaches of recommendation using machine learning approaches such as KNN Classification, K-means Clustering and Association Rule Mining. The proposed system will be helpful to resolve the problem of Cold-Start and Sparsity etc.

5.0 Conclusion

This paper explores various techniques for enhancing recommender systems, with a focus on improving performance and accuracy. It identifies areas ripe for further research and innovation in the field. The study covers different recommendation methods commonly used in recommendation systems. Additionally, it conducts a survey of existing recommendation systems, highlighting their advantages and limitations. The paper goes on to compare these diverse recommendation techniques, emphasizing their respective strengths and weaknesses. Notably, many papers in the field tend to revolve around content-based and collaborative filtering approaches. However, there is a clear opportunity for diversification and exploration of other recommendation systems. Hybrid recommendation systems, particularly those that combine K-NN classification and K-means clustering, are identified as a promising approach for enhancing system performance. In the pursuit of improved recommendations, the paper discusses key evaluation parameters such as accuracy, precision, and the confusion matrix. It advocates for the use of hybrid recommendation systems that leverage multiple algorithms and clustering techniques. The process often involves creating clusters for closely related items or users through K-Means clustering, followed by optimizing recommendations for enhanced relevance and diversity. Overall, the hybrid approach aims to harness the strengths of multiple

recommendation techniques, ultimately delivering more valuable and varied recommendations to users.

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