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Overview of Recommendation System: Approaches and their Prosperity

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Abstract: ***The information on the internet is tremendous to retrieve the required data from a vast amount of information available on the internet is strenuous. To make it easier we have a recommendation system or engine. These are chiefly used in commercial applications. This system filters the information dynamically based on user's interests and preferences. It has an essential feature to predict whether an individual user would prefer items or not based on the user's predilection. The recommender system plays a vital role in a variety of areas like product and service-based companies. Web recommender systems are categorized into various approaches such as collaborative filtering, content based, knowledge based and hybrid recommender systems. Many recommender systems are used by some of the popular websites like Amazon.com, Netflix.com etc. This paper focuses on foremost challenges faced by recommender systems and their solutions. Our findings indicate that the use of a hybrid approach is better than other individual approaches. We conclude that the recommender system increases the value and economy to the company by simply satisfying the customer needs and interests.***

Keywords: Recommender System, content-based system, collaborative filtering, knowledge based system, hybrid approach, predilection, strenuous.

I. INTRODUCTION

From the last few years with the rise of many popular websites like Amazon, Netflix and YouTube the need of recommender systems has been increased. From e-commerce websites that suggest buyers to buy articles that interest them to online advertisement that suggest user the right content, these systems are very much involved in our daily online journeys. So, **what are Recommender Systems?** Basically recommender systems are a machine learning technique which aims to predict the user's interests and recommended products in favor to users. Data required by the systems are picked from explicit user ratings after watching a movie or listening to a song, from implicit search engine queries and purchase histories or from other knowledge from the users themselves. Recommender systems generate personalized recommendations. Personalized recommendations however require that the system must know something about any user such as previous search histories. Every system must develop a user model to store user's preferences or interests. Items in recommender systems are ranked according to their relevance. The concept of relevancy is something that the system must determine based on their previous data. Companies using recommender systems focus on key aspects such as increase of sales due to the result of personalized offers and good customer experience. The main advantage of these systems is that they speed up searches and the users find it easy to view or access the content they are interested in. the Companies gain or retain old customers by the means of sending out personalized emails with links to the offers they like or are interested in. The user starts to feel known and is attracted to a company and is likely to buy more and more products. By this the company gains advantage as well as the threat of losing a customer to competitor company decreases.

A. Recommender System Functions Based On Two Kinds Of Information

1) Characteristic Information: Information about items and users.

2) User-item Information: Information such as ratings.

B. We Can Differentiate Recommender Systems Into The Following Approaches

1) Collaborative filtering

2) Content based system

3) Knowledge based system

4) Hybrid system (combination of three types)

In e-commerce setting, recommender systems enhance revenues, for the fact that they are effective means of selling more products [1]. For example, Amazon practically invented the concept of giving personalized product recommendations after online purchases, using an algorithm they call item-based collaborative filtering [2]. In a business, a recommender system gives various advantages to the company. They are:

a) *Improving With Use:* Users tend to attract more where they can view their expected preferences. The fundamental advantage of recommender systems they continuously adjust the preferences of user which makes them stick their company. The more you use the more it improves.

b) *Improves Traffic:* A recommender system helps bringing customer traffic by sending email, messages etc.

c) *Improved Engagement And Delight:* Customers feel more engaged when individual recommendations are made. With this they view more and more products without searching.

Therefore the use of efficient and reliable use of recommender systems in companies provides the user an enhanced experience and also the company earns profits through customers.

II. COLLABORATIVE FILTERING

Collaborative filtering methods are solely based on the user and item interactions. Based on these interactions the system filters new recommendations. Typically these interactions are stored in a matrix (i, j) where user i is represented in rows and item j is represented in column. This matrix is called "user-item interaction matrix." The actual idea behind this method is the past user item interaction which are sufficient to detect similar items and recommend the close proximity to the users. No additional data is required by the system from the users. In short collaborative filtering means if user A likes item A and user B likes item A as well as item B, then the system predicts that the user A would also like the item B and generate the recommendations.

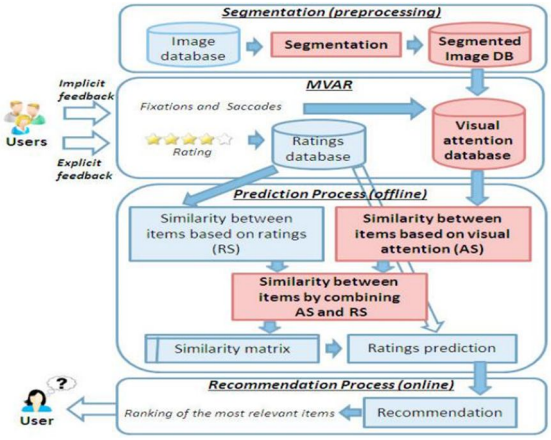


Figure1. Architecture of the proposed Collaborative Filtering recommender system with Attentive Similarity (CFAS) method. The red rectangles represent the main contribution of this work.

Furthermore collaborative filtering is classified into two categories:

A. Memory Based

Memory based approach does not include any model and directly works with past interactions. It uses a technique known as a nearest neighbor search. In a memory based system there are two approaches:

1) *User Based:* To make new recommendations to our user, user-user method tries to identify the "profiles" of similar users (nearest neighbors) to suggest items that are popular among the neighbors. This was first introduced in Group Lens for recommending news article based on other users' interest or rating [3]. This method has been used for movie recommendations. This method is known as user-centered.

2) *Item Based:* Here to make new recommendations, item-item method finds items similar to the ones the user has positively interacted. Two items are considered to be similar if maximum number of users that have interacted with both of them did it in a similar way. This method is known as item-centered.

One of the biggest flaw of memory based collaborative filtering is that it is not scalable: in bug systems with huge number of users using huge number of items, the generation of a new recommendation system is very complex and extremely time consuming.

B. Model Based

This method is based on machine learning and data mining techniques. Model based system trains a model that explains user-model interactions to make predictions. To overcome the space and scalability issues of memory based approaches, model-based algorithms were developed. These methods build a model which learns or observes user-item interactions by the factor of low dimensional representations [4]. For example, matrix factorization algorithm involves in decomposing of huge user-item matrix into two smaller matrices called user-factor matrix and factor-item matrix. The first containing user representations and the second containing item representations.

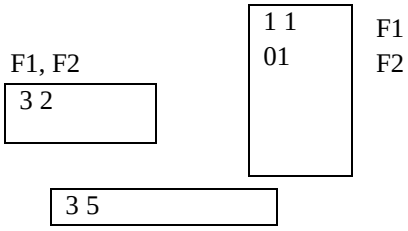
The matrix factorization algorithm represents the user-item interactions as the product of the corresponding smaller matrices.

Item matrix and user matrix have latent factors known as features.

1) *User Matrix:* According to the user if it is his favorite movie then he will give 3 points and if his favorite actor is acting then he will give extra 2 points.
2) *Item Matrix:* These contain binary values and if the features are satisfied it is denoted by 1 else 0.

Let us assume that our matrices have two features each.

By performing dot product of user and item matrices we obtain a 5 which is the missing rating.



C. Issues with Collaborative Filtering System

1) *Cold Start:* There exist two types of problems in cold start (user and item). When a latest user enters about whom the system does not have any knowledge and he has rated only a handful of items which makes it difficult to find similar users. This is called as user cold start problem. But when new item arrives, the number of users who rated that item is only handful. When such low data is available, Collaborative filtering approach does not succeed to anticipate the similarity in items. This is a cold-start for the just arrived items as rating for them cannot be predicted and therefore, system will not be able to recommend new items until a handful people have rated it. This is the second problem which is item cold start problem.
2) *Sparsity:* Data sparsity implies to the difficulty in finding enough reliable users since in general the already existing users only rated few items [6].
3) *Gray Sheep Problem:* This problem arises due to unusual users who rarely match to others interests.
4) *Shared Account Problem:* This problem arises when two users use the same e-commerce account. For example when a mother and son uses the same account, mother views items like clothes and the child views mobile phones then system gets confused and can show clothes to mother and vice versa.

III. CONTENT BASED SYSTEM

The principal idea of content based recommender system is to propose the items to a user which are related to previous items rated thoroughly by him. For each of the items we need to build an item profile. An item profile is the representation of an item. From item profiles we are going to infer user profiles. The user profile deduces the likes of the user known by past interactions or precisely asking the users about their interests. A content based system might consider the age, gender and other personal details when making the predictions. That's the reason when you sign up for different websites they ask you to optionally provide date of birth etc. This is just used to improve the efficiency of the system.

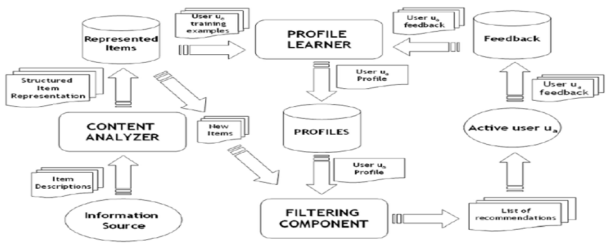


Fig. 2. High level architecture of a Content-based recommender system

However there are disadvantages associated with content based system. They are:

1) *Content Description:* In few domains generating the right description of content is very difficult. Especially in domains that consist of music or video items the generation of content is a humongous task.
2) *Over Specialization:* A content based system cannot select the items for which the user hasn't given any rating or suggestion. Additional techniques must be implemented in order to provide recommendations outside the scope of user.
3) *Subjective Domain Problem:* Content based systems have problems in differentiating between subjective domains.
4) *Filter Bubble:* The users of a system are confined only to some particular information that the system thinks you might like. It is like you are trapped inside a universe (commonly defined as bubble) created by the system. This limits user's options to view and results in user in losing interest in other content.

In contrast to the disadvantages we also have few advantages of content based systems. Few are listed below:

a) *User Independence:* Content based methods have to analyze a single user's profile foe recommendations. This would thus produce more reliable results with few users.
b) *Transparency:* In collaborative filtering recommendations are given on the basis of other users who have the same features whereas content based system uses feature-level basis.
c) *No Cold Start:* New items can be suggested to users even before they were rated by other users.

IV. KNOWLEDGE BASED RECOMMENDER SYSTEM

Knowledge-based recommender systems are a unique type of recommender system which are established on the grounds of explicit knowledge with regards to item sorting, user inclination, and recommendation standard. This system can be applied in scenarios where alternative systems cannot be applied.

Both content-based and collaborative systems require a significant amount of data about past buying and rating experiences [7]. They cannot handle the cold start problems and methods that are generally suitable to domains in which the product is highly customized.

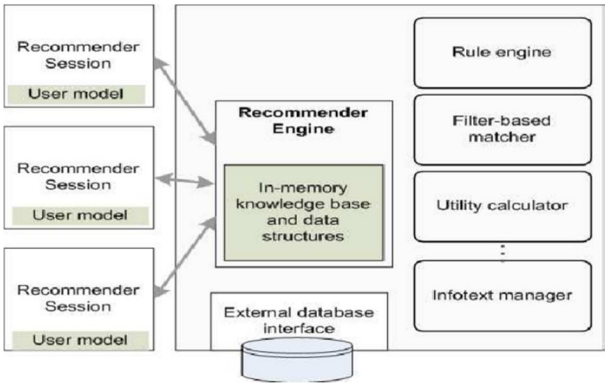


Figure 3. Architecture overview.

How can one handle such customization and paucity of ratings? Knowledge-based recommender systems rely on explicitly soliciting user requirements for such items [8]. The retrieval and exploration process is facilitated by knowledge bases describing the utilities and/or trade-offs of various features in the product domain. The use of knowledge bases is so important to an effective retrieval and exploration process that such systems are referred to as knowledge-based recommender systems [9].

One of the important distinguishing characteristic of knowledge-based systems is a high level of customization to the specific domain. This customization is achieved through the use of a knowledge-base that encodes relevant domain knowledge in the form of either constraints or similarity metrics.

A. *Item Domain*

Few Examples of item domains for recommender systems are financial services, digital cameras etc. Knowledge-based systems are appropriate in situations where customers want to specify their requirements and in areas where it is difficult to get ratings for items that have greater complexity in terms of the types of items and options available. It is useful for time sensitive constraints.

B. Conversational Systems

In this case, the output of the feedback loop determines the user requirements and preferences.

The complexity of the item domain makes the filtering difficult because it cannot provide a systematic order of user preferences all at once. These systems reduce this complexity so as to make the filtering of the user preferences more efficient.

C. Search Based Recommendation

In search-based systems, user preferences are determined by using a preset sequence of questions which curb the set of admissible items. An example question is "Which type of gear system do you prefer in a car?".

From the point of technical view, the search-based recommendations can be enforced on the foundation of constraint-based recommender systems.

D. Navigation Based

In a navigation-based recommender system, the user preference and interest will provide the requests to the changing requirements according to the current feedback [10].Critiques that are being applied to this system. Unit critique is the change of a single attribute. Dynamic critique is used for critiquing history and compound critique is used for multiple changes of requests to a respective item at a single time. An example is "I would like to prefer a car like this but with higher mileage".

V. HYBRID SYSTEM

Hybrid recommender systems combine multiple recommendation technique to achieve greater efficiency with fewer of the drawbacks of any individual one [11].

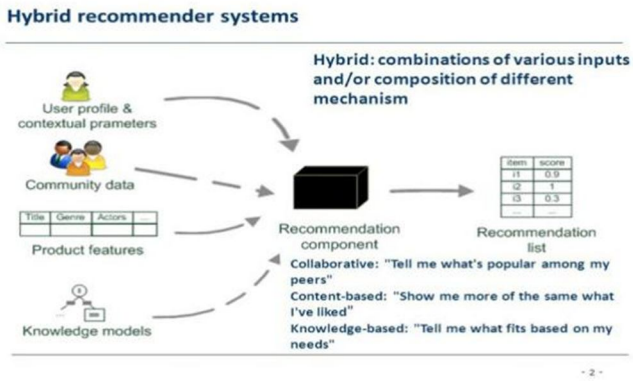


Fig 4 Hybrid recommender systems

Most commonly collaborative filtering is combined with any other technique. Hybrid recommender system is mainly classified into mainly:

1) *Weighted Recommended System:* One of the most elementary of hybrid systems. In this system, the score of a suggested item is considered from the results of all the accessible recommendation techniques that are conferred in the system [12]. For example, the P-tango system uses this hybrid. At an initial state, this system gives collaborative and content-based systems that were given equal weights but were changed as the predictions of users were changing.
2) *Switching:* A switching hybridization system uses in-item level sensitivity and it uses some basis to switch between recommender systems. For example, if we combine content and collaborative recommender system, the system first uses the content system and if it does not make a correct recommendation then it switches to a collaborative system. Switching hybrid systems has many benefits but the major benefit is to maintain the sensitivity level of its recommended components[13].
3) *Mixed:* This presents many recommendations from different techniques of the system simultaneously. The PTV system uses this type of system to recommend a program to the viewers. The content-based system is used to show the text formatted descriptions whereas the collaborative system is used to show preferences of likeminded users. Finally, the two recommendations are combined together in the program.

4) *Cascade:* The idea of a cascade hybrid is to ensure a stringent hierarchical hybridization, where a feeble recommender cannot overcome decisions made by a powerful one, but it can be merely improved [14]. This system involves a staged process. In this, the foist recommender system is used to make a rough ranking of users items and the second system furthermore refines the items according to user's likes. This allows avoiding the low-priority preferences will never be recommended.
5) *Feature Combination:* In feature combination system the features of one recommender system are inserted into another system. Basically the features of two recommender systems are combined into a single system to overcome the problems of individual systems.
6) *Feature Augmentation:* This system is very similar to the feature combination. In this, a specific technique is used to generate the rating and categorization of an item. The information obtained will be used for organizing the next recommendation technique [15]. This also improves the functionality of the core system.
7) *Meta Level:* The Meta level recommender system is the most widely used recommender system. In this system, the output produced from one of the recommender systems will be used as an input of any other recommender system. It is the most sorted system of all the others.

VI. SOLUTIONS

1) *Cold Start:* To overcome the cold start problem we can use the demographic information of the user such as age, gender, hobbies, etc from the user's social networking websites. We can use a hybrid recommender system to suggest items to a new user.
2) *Sparsity:* The problem of Sparsity can be resolved using a hybrid recommendation technique. Instead of using content-based alone we can combine the content-based and collaborative technique together which will result as a solution of sparsity [16].
3) *Gray Sheep Problem:* The users of gray sheep can be identified and separated among other users by conducting offline clustering techniques such as k-means clustering and etc. By doing this way the performance gets better and recommendation error will be minimal [17].
4) *Filter Bubble:* The best way to overcome this problem is to view and like various contents on the internet so that the scope of recommendation is increased. Try to explore different things and start mapping data instead of just filtering.

Why is hybrid recommender system better than individual approaches?
In a real world scenario, the use of hybrid recommender system is much better than using any other pure recommendation systems. In comparison the hybrid recommendation system provides accurate recommendations. For example, collaborative method only tells what is popular among neighbor users, concept based method shows us more of the similar items that we have liked and a knowledge based method tells the user what is the best fit item based on his needs. The integration of these three systems is a hybrid system which provides the user all the facilities the pure systems provides with minimal or no drawbacks at all. One method's flaw is covered by the next method and so on. Hybrid recommender system integrates different recommendation systems or techniques in order to gain better system optimization. This system also prevents limitations caused by other recommender systems. The motive of hybrid systems is that a combination of algorithms will provide effective recommendations than a single algorithm. This limitation or problem of one algorithm can be overcome by another. Using more than one recommendation techniques can overlook the weaknesses of an individual technique in a combined model. The combination of systems can be done in many ways: separate implementation of algorithms and combining the result, utilizing some content-based filtering in collaborative approach, utilizing some collaborative filtering in content-based approach, creating a unified recommendation system that brings together both approaches.

VII. CASE STUDY

1) *Amazon:* Retail giant like Amazon credits recommender systems with 35% of their revenue. When we look into its AI solution, it uses various recommender systems to achieve its goal. They show users the items that are frequently purchased and also show the items similar to the ones they have viewed. Not only Amazon uses recommender systems onsite but also offsite. Like they send emails to their customers about their interests and likes. They revealed that due to recommender system there was an increase of 29% in its sales which raised their turnover by 135.99 billion in 2016 [18].
2) *Best Buy:* Best buy which is another retail company which began using recommender system in 2015. It was the time when Amazon was ruling the market but instead of giving up Best Buy concentrate on their online sales which resulted an increase of 23.7 in its second quarter sales of 2016.

VIII. CONCLUSION

Recommender systems are proving to be more and more useful for websites like Amazon and Netflix for mass customization. Out of various recommender system techniques, the most widely used technique is hybrid recommender system as it combines two or more pure approaches to overcome the individual problems and to add benefits. Recommender systems narrow down the pool of selection options the users to a few meaningful choices that are more likely to be purchased. They satisfy user needs, increases the economy of the company, improves retention, form habits, accelerate work etc. Therefore recommender systems are powerful new technology that benefits users by enabling them to find what they like and conversely help the companies.

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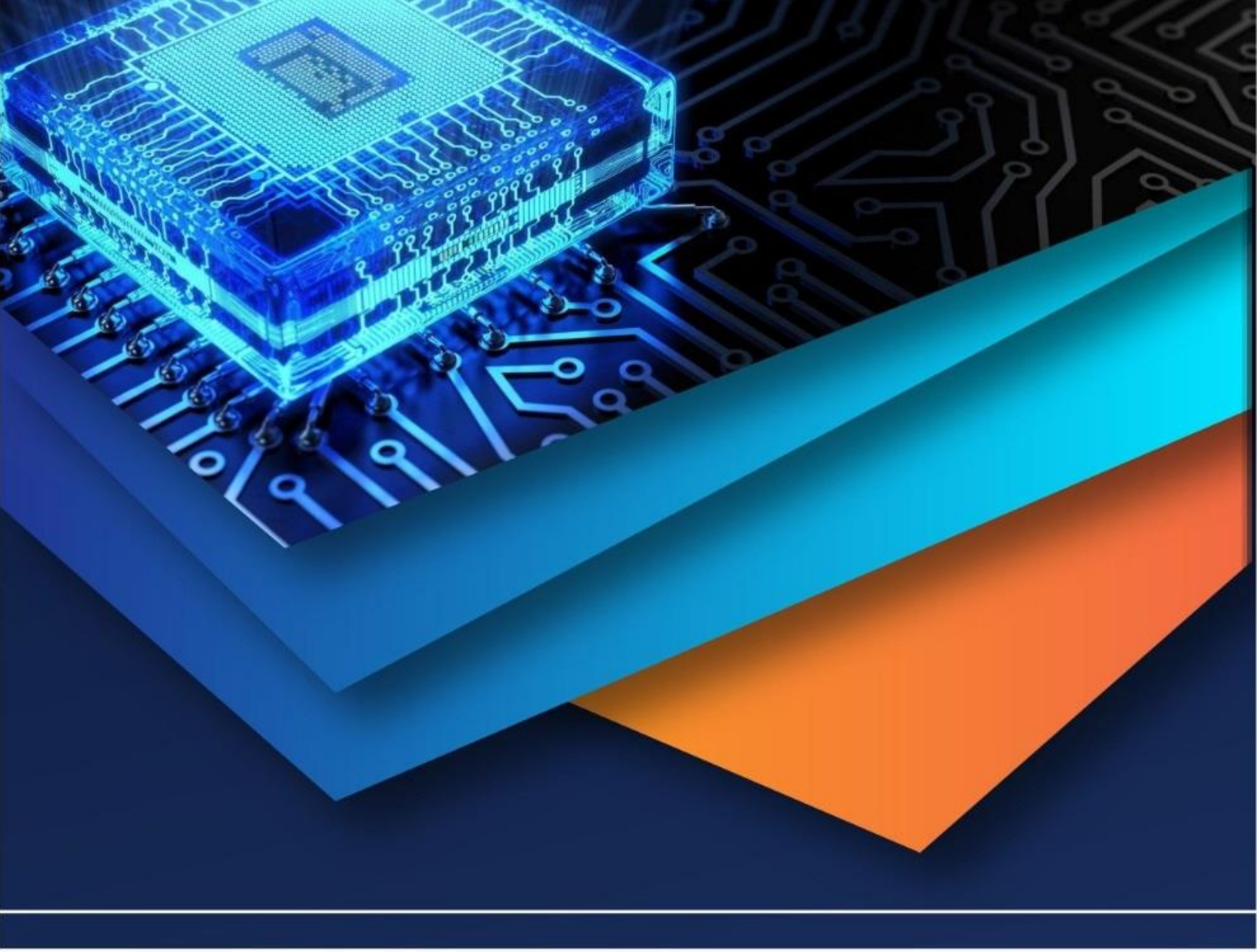

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