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A Survey on Recommendation System based on Knowledge Graph and Machine Learning

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Abstract - *The work of recommendation system is to guess the thought process of user and to predict the interests of the users. This system can provide suitable information to the user based on the needs of the user while taking care of the interests of the user. For giving better recommendation the data need to be analyzed more effectively. There are various recommendation systems that had been built using different approaches. And till today the research in such system is popular as now days there are many OTT platforms increasing day by day, many shopping, travel etc. websites are increasing who want to improve their recommendations to the users rapidly. So, the main goal of this paper is to provide the overview of various approaches related to the recommendations system as well as to do the comparative study of them based on certain features. After reviewing various papers we observed there are many recommendation systems were built which were majorly based on traditional methods. However, nowadays recommendation system based on knowledge graph have catches the attention of researchers and the industries as they are capable of solving various performance and information sparsity related problems and gives better recommendations as compared to previous approaches.Machine learning is used along with knowledge graph to increase the performance of the system. Also, we will study various proposed algorithms in the papers which have used knowledge graph for better recommendation.We have also given brief idea about our proposed system.Finally, we will suggest different future paths of research in the domain of recommendation system.*

***Key Words*: Knowledge graph, Machine Learning, Recommendation system, Technologies, Approaches.**

1.INTRODUCTION

Recommendation system are used to recommend various services to the user based on the activity and the needs of the user. Recommendation system is widely used in e-commerce[4], entertainment, e-learning, search engines etc do- mains to provide better results to the user. There are certain approaches which are used for building recommendation system like content based filtering, collaborative filtering[22],hybrid filtering, context filtering methods. So, in this paper we are going to discuss about those methods in details. Also, due to fast development of internet, the size of data in each of the application have increased drastically. Hence, it becomes difficult for the user to choose their interests related items or services from huge amount of data.

The recommendation algorithm is the main part of recommendation system. Collaboration filtering recommendation gives recommendations based on the preferences of other similar users for the product features whereas in content based recommendation, this model uses the item's content features. Collaborative filtering is widely used as compared to content based filtering because they are efficient in capturing the preference of user and can be easily applied in multiple scenarios. But in content based filtering lot of effort is required for extracting the features. Also, there is context based recommendation in which as per the contextual information of the user like location, time etc, we recommend services to him/her. In this model, we retrieve patterns from the website or application based on the user's past interaction with the system and then we provide recommendations to the user. Collaborative filtering suffers from problems like data sparsity and cold start problems. To solve these issues, hybrid recommendation is proposed which merges the content level similarity and interaction level similarity. In this model other extra information is also explored like item reviews, item attributes etc. In recent years, introduction of knowledge graph in recommendation system have gained the attention of researchers and industries. A knowledge graph is a kind of heterogeneous graph in which nodes indicate entities and edges indicate the relationship between the entities. For better under- standing the mutual relationship between the items we can map items and their attributes in the knowledge graph. Also, we can map user information into the knowledge graph, this creates the relationship between users and items and can we can capture user preference more accurately. In this survey paper we're also going to do survey of graph based recommendation system using knowledge graph. The paper proposed by C.Liu[16] discussed that how one can include the knowledge graph embedding in the recommendation system. And the paper proposed by Z. Sun[17] explains that how knowledge graph can work as additional information for recommendation system, but the categorization of recommendation approaches are not fine grained in this paper.

1.1 Organization of the paper

In heading 2, we discuss about various concepts used and foundations of knowledge graph required in the recommendation system.

In heading 3, we discuss the basic background required for most of the recommendation system.

In heading 4, we discuss various standard recommendation approaches used in the recommendation system.

In heading 5, we discuss about various knowledge graph based recommendation systems and understand the different approaches used in it.

In heading 6, we discuss about comparative study of literature review.

In heading 7, we discuss about our proposed system.

In heading 8, we discuss about potential research paths in the recommendation system.

In heading 9, we conclude our survey paper and also mention the references used for this paper.

2. VARIOUS CONCEPTS

- Recommendation Systems

The work of recommendation system is to predict and recommend the unobserved items or services to the user.It can be done in the following manner like- first the system learns the representation of target user ui and candidate item vj. Second, for modelling the preference of ui and vj it learns from the scoring function which is defined as f(ui x vj gives y cap i,j).Third, We sort the preference scores for items to generate recommendations for the user. There are many surveys available related to the recommendation system with different emphasis. This system is majorly classified into three categories like content based, collaborative filtering based and hybrid recommendation system. Amongst these categories collaborative filtering recommendation is the most popular one. However, due to development of various deep learning methods the architecture of recommendation system have changed drastically. The paper proposed by S.Zhang,[18] explored how various deep learning techniques are adopted in the current recommendation systems.

- Knowledge Graph

Nowadays knowledge graph is emerging as a abstraction tool for organizing world's structured knowledge present in the internet. It is also used for integrating information gathered from multiple data sources. It also plays a major role in machine learning as a method for incorporating world knowledge and also as a target knowledge representation for the extracted knowledge. It also explains what it has learned. It's definition is like :-Given entities(E),relations(R) and knowledge graph is a directed multi relational graph(G) that comprises of triples (S(Subject),P(property),O(Object)).Each edge in the knowledge graph is of the form(head entity, relation, tail entity).It is like an instance of a Heterogeneous Information network. Knowledge graph is created and applied in many domains like question answering system, recommendation system, search engines etc. There are two types of knowledge graph like :- First, Item Knowledge graph-In this, item and its related entities (like item attributes) act a nodes. And edges can represent item's attribute relations(like category, brand etc.) or user related relations(like co-buy, co-view etc.).Second, User-item knowledge graph- In this, items users and their related entities acts as nodes. Inspite of items related rela-tions present in the item knowledge graph, relationships between user and item are also included in user-item knowledge graph(like mention, buy, click etc.).

- MetaPath

It is defined as path P=A0(R1)A1(R2). (Rk)Ak defined on the graph of network G=(A,R),it defines a new composite relation as R1R2. . . ..Rk between entities A0 and Ak, where Ai A and Ri R for i=0,. . . ,k.It is used to extract connectivity features between two nodes in the graph.

- Metagraph

It is somewhat similar to metapath, it's like another metas-tructure which connects two entities in a graph. The major difference between metapath and metagraph is that meta-path defines only one relation sequence whereas meta-graph is a combination of various metapaths. Metagraph can express more structural information between the entities as compared to metapath.

- Knowledge Graph Embedding

Knowledge graph is embedded into low dimensional vector space[19] using knowledge graph embedding. After applying embedding on the knowledge graph each com-ponent of graph(like entity and relation) is represented by a dimensional vector. This dimensional vector still preserves the properties of graph and we can quantify these properties semantically or by higher order proximity in the graph. For understanding various knowledge graph embedding algorithms we can refer to [20][21].

3. BACKGROUND

For the purpose of recommending appropriate items to the users as per needs of the user, this system collects as well as process the useful information about the users and the items.

3.1 Item Profiles

The details about the items need to be considered for better recommendation. So, these details about the items can be obtained from the dataset from standard websites like kaggle etc. or we can extract the information about the items from the web using web crawler etc. and then do preprocessing of the data. The data extracted about the items from web can be in structured, semi-structured or unstructured form. So, preprocessing will be required for the semi structured or unstructured data. Once the data about the items is ready then we can then use it for building recommendation system. If we are using knowledge graph based approach then we use this data to create item based entities in the knowledge graph.

3.2 User Profiles

The recommendation system fully the utilizes the interactions of the user with the system or the service like user's past purchase history ,user's activity etc. in order to give better recommendations to him or her. There are various ways by which we collect information about the users like:-

(i) Explicit way Feedback- In this method , user is involved to get information about him/her. The user can asked to fill certain forms or asked about their preferences related to the different services. The information about the user can be asked in various forms like numerical scale(like rate item or service in scale of 1 to 5),binary scale(like product good or bad),ordinal scale(like user chooses from the list of feeling which explains its inclination towards a particular service),descriptive way(like reviews in the form of text about particular service).If the reviews in the descriptive way are utilized properly then it can help us to understand the preferences of the user related to various items. There are certain aspects of reviews like considering the contextual information, multi-view of a particular review,comparison based reviews etc. The methods of extracting useful information from the user review is usedin various papers.

(ii) Implicit way Feedback- In this kind of method user is not involved in the process of gathering data about him/her. Such methods does the proper analysis of the user purchasing history like how many times user bought a particular product, his rating for the product, how much time the user spent on the website while seeing the product etc. We can also use already available datasets for such methods.

(iii) Hybrid way Feedback- In this method, both the above methods can be used to gather proper information about the user. In this approach both the above methods can fulfill the drawbacks of one another. For better understanding of the user's behavior with the system we can try to use implicit data as validation for the explicit data provided by the user.

4.VARIOUS STANDARD RECOMMENDATION APPROACHES

4.1 Content Based Recommendation

This kind of recommendation system uses the data provided by the user in implicit way(like clicking on a product etc.) or explicit way(like ratings or reviews etc.).Based on these details user profile is generated and used to give certain recommendations to the user. This system also recommend items similar to the items which were positively reviewed or rated/liked by the user in the past. The user and item profiles consist of various features of items and users respectively. For example - The user profile can have attributes like userid, user review, user rating, user purchase etc. The item profile can have attributes like movieid, movie actors, moved I rectors etc. If the user likes the comedy movies, so those comedy movies which are not liked previously by the user will also be recommended to user. There are main steps of content based filtering like:-(i)first, the item attributes are extracted to create item profile for all the items.(ii) Then user profiles for each active users are generated.(iii) Then user profile is compared with the item profile.(iv) Then items are recommended to the user which are new to the user and which matches the user profile more.

There are certain approaches in this method like:-

(a) *Preference based on product ranking:* This approach is used when items are described using different attributes. In this method, user's preference is denoted by (v1,. . . . . , vn, w1,. . . , wn), where vi is the value function which a user specifies for a particular attribute a_i and w_i is the relative importance(i.e.weight)of the attribute a_i .Then the utility of each product is calculated by multiplying each vi with each w_i and then doing the sum of all. So, the product with high utility value are classified and then recommended to the user.

(b) *Exploiting terms on reviews for recommendation purpose:* It's like a index based approach in which each user is classified by the textual content of the reviews. The term based user profiles are created by fetching keywords from the user reviews and then weights are assigned to the each extracted keywords by using TF-IDF technique. The weight indicates how important is each keyword for the user.

(c) *Exploiting context from reviews for recommendation purpose:* In this approach context is extracted from the textual information of user's current scenario and the features which are important to him. The utility score for an item i of a user u is calculated as below:-

Utility(u,i)=a*predicted Rating (u,i)+(1-a)*context score (u,i) Here a is a constant value which indicates the weight of predicted rating. In above formula predicting rating is calculated using standard item based collaborative approach and context score indicates the importance of item i to the target user's context.

4.2 Collaborative filtering Based Recommendation

In this kind of recommendation system, we try to find the similar users which matches the current users interest and recommend those items to current user which similar kind of users had liked. In this approach, we never use the attributes of items for the recommendation purpose. Instead of that we try to classify the users into various clusters of similar types and then recommend to each of the user as per the preference of the cluster. There are various type of collaborative filtering approaches :-

(i) *User Based:* In this approach, those items are recommended to the target user which he/she may like, according to the ratings or reviews given by the other users who have similar kind of interest as that of a target user. The major steps of the user based collaborative filtering can be mentioned as below:- (a)First of all we need to have user- item rating data (b)Then we need to create user-user similarity matrix using pearson correlation as it is most famous and widely used method for finding similarity in collaborative filtering. Similarity between two users is found out by pearson's correlation with values of -1,0,1.-1 means two users are having interests completely opposite, 0 means there is no relation between the interests of the users and 1 means two users are having exactly same kind of interests. (c)Then find the similar users to target user with the help of similarity matrix. (d)Then we need to generate candidate items for recommend- ing purpose. (e)Then we should rank the candidate items as per their prediction. (f)Finally we need to filter possible candidates items and show it to the target user. Drawbacks:- It might be possible that there can be more number of users than items which can lead to much larger user similarity matrices which can result in various performance and memory issues on the larger dataset. So, to deal with such issues we need to use parallelisation techniques.

(ii) *Item Based:* In this approach, we try to find out the relationship between the items(like user who bought P, also bought Q).Also, in this approach we predict the new rating with the help of other items ratings given by the user. Let us understand this approach with simple example, lets say there are three users(A,B and C) and four fruits(like grapes, strawberry, water melon, orange).User A likes grapes, water melon and orange. User B likes grapes and watermelon and User C likes watermelon. So, here grapes are watermelon are similar to each other as they had been liked by the user A and B. So, if I want to recommend more fruits to the user C and as I know already know that he likes watermelon then it is mostly likely that C might like grapes also as grape is similar to watermelon. User based collaborative filtering have certain drawbacks so to deal with it item based collaborative techniques analyze the user-item matrix and finds out the relationships between various items.So based on the identified linear relationships between items it gives the recommendation.

(iii) *Matrix Factorization:* In the matrix factorization, we multiply two different entities to get the latent features. With the help of user rating on the shop items(i.e. input), we want to know how will the user rate the items so that user can get the recommendation on the basis of prediction. For example, we've customer rank table of 6 users and 6 movies, rating are the values from 1 to 5.As every user will not rate every movie so there can be missing values in the matrix and this results in a sparse matrix. So, in place of missing entries we put zero and filled values are given for the multiplication. Using this method, lets say we have scenario like user 3 didn't give rating to the movie 3.So,we'd like to know whether user 3 liked the movie 3 or not.So, using this method we can discover other similar kin d of users with similar kind of preferences of user 3 by taking the ratings from the users of similar preferences to the movie 3 and predict that whether user 3 will like movie or not. In this we get the prediction rating of item by doing the dot product of matrix p and q where p indicate the relationship between user and features and q indicate the relationship between an item and the features. R=PxQT. There are various matrix factorization techniques like SVD(Singular value decomposition),NMF(Non Negative Matrix factorization),PCA(Principal Component Analysis) which are used for finding latent factors from explicit users feedback. Matrix factorization models are becoming more efficient these days as in this we can consider the text, time and social links which helps us to understand the user behaviour in a better way. There are certain problems which occurs in the collaborative filtering approach like :- a)Earlier rate problem -this happens when new user is using the system and has not rated that much items that we can recommend items to them. b)Sparsity problem - it happens when there is much little information available to make appropriate prediction. c)Cold start problem-it is situation when doing prediction becomes difficult due users or items added in the system are new.

4.3 Context Based Recommendation

The recommendation using context based recommendation have mainly three approaches like pre filtering, post filtering and contextual modelling. In the pre filtering approach, we try to reduce the information of user

item matrix using context before applying any recommendation algorithm. In the post filtering approach, we try to reduce the information which is obtain after applying recommendation algorithm using the context. And in the contextual modelling approach, context is included in the recommendation system. In the pre and post filtering method, we generally use the existing recommendation algorithms. But in case of context modelling we can modify the existing recommendation methods.

4.4 Demographic Recommendation Approach

In this approach work on the idea that users having similar demographic attributes(like gender, age, city, job etc.) can have similar kinds of trends in the future. For example you might have noticed that when we go to different state youtube based on your current location starts recommending whatever popular videos are trending in the state thinking that you might also like. This approach focuses more on the demographic location of the user rather than its evaluation history. As this approach does not takes into consideration the user's preference so it may not always be the case that it will recommend items or services to the user in the accurate manner.

4.5 Hybrid Filtering Approach

In this approach, we combine collaborative and content based methods to overcome the drawbacks of both the approaches. There are various ways in which we can implement hybrid filtering like:- (i)After implementing both content and collaborative filtering approach separately then we can combine the prediction logic of both methods. (ii)Using collaborative properties in content based approach or vice-versa (iii)By modelling two or more approaches together like content and collaborative approach together.

4.6 Knowledge based Filtering Approach

This method suggest the items to the user as per how the item satisfy the user preferences using domain knowledge. The recommendation system using knowledge graph should use majorly three kinds of knowledge like knowledge about items, knowledge about users and knowledge based on relationship between the item and the user needs. knowledge graph provides extra information which can be used to solve problems where were present in content and collaborative filtering based approaches. It uses domain knowledge for giving recommendations to the user. However, there are also drawbacks of knowledge based recommendation is that for creating such systems we need to have skills related to knowledge engineering. Semantic relationships present in the knowledge graph can be utilized to improve the accuracy of recommendation system and can increase the recommended items diversity.

The paper proposed by Zhang[22] suggest a method in which collaborative filtering with implicit comments are used and the interaction between the users and items are learned by using knowledge graph embedding method. knowledge graph based approaches have advantage over traditional approaches. In this survey, we'll analyze and focus on various applications developed using knowledge graph and various knowledge based technologies used for recommendation system.

5. RECOMMENDATION SYSTEMS CREATED OVER KNOWLEDGE GRAPHS

When Google introduced knowledge graph its purpose was to improve the search engine' s searching capability and to improve the user experience. Knowledge graph actually provides machine-readable data organized in the form of graph. This graph data interconnects and describes the entities. As we know that the data in a knowledge graph can be accessed via web and can be consumed automatically so because of these characteristics many applications have been created using knowledge graph like question answering system, recommendation systems etc. Knowledge graph based recommendation system fully utilizes the connections between the entities representing the items, users and the interactions between them. These connections can be direct or indirect. The relationships present in the knowledge graph acts as a additional information and this information can help us to deduce inference between the entities to explore new relationships. According to the paper proposed by Liu[23] and Zou[24],the recent knowledge graph based recommendation approaches can be divided majorly into four types like linked open data based, knowledge graph embeddding based ,ontologies based recommendation and the path based recommendation.

a) *Ontology based recommendation:* In this method, ontology is used for modelling the knowledge using the information like users and their context, items information and the information about domain. While defining ontology we create various semantics and structures which help us to create some rules for generating recommendations to the user. So, the items which fulfills the rules as per the user's preference will shown as recommendation to the user. The drawback of this method is that it is time consuming process and it also requires little bit of expertise.

b) *Linked open data based recommendation:* As rich semantic information can be extracted from linked open data so it can help us to find the similar attributes among the items to be recommended. This method helps us to overcome the problem of data sparsity. However ,there are some recommendation systems which depends on outside data so this kind of data can affect the recommendation results.

c) *Path based recommendation:* This method is very normal way of using knowledge graph in the recommendation system. In this method we try to explore different patterns of relationships between entities in a knowledge graph and in this way it helps to give better recommendation to the user. This method actually depends on hardcoded metapaths and they are difficult to optimize. The drawback of this method is that when entities and relationships are not from the same domain then in that case it becomes difficult to design metapaths for it[24].

d) *Embedding based recommendation:* This method is more popular because it provides an easy and efficient way for generating recommendations[16].In this method, we can convert the knowledge graph by using knowledge graph based embeddings then the recommendation model can fully utilize the learned entities and relationships embedding to produce better results[24].The main goal of this method is to make the processing of knowledge graph easier while preserving its structure. Knowledge graph embedding is used to enhance the information of users and items and then it is used for calculating the similarity between users and items[16].Some of the examples of such embedding models are TransE, TransD, TransH, TransR etc. Introduction of knowledge graph embedding in recommendation system includes using of traditional recommendation algorithm. In the pa- per[16], as per the relationship between recommendation algorithm and knowledge graph embedding there are majorly two ways for doing these tasks:-independently learning and jointly learning.

6. LITERATURE REVIEW

Table : Comparative Study of Literature Survey

Author	Pros	Cons	Methodology Used
Haithem Mezni [1]	Able to give multi-relational representati-on of contextual data related to users and services, which the previous approaches like matrix and tensor based failed to give.	1) Their model does not work for the uncertain factors like incomplete context information, missing reviews or feedback. 2) Their system's average accuracy is almost half i.e 50.52 percent	1) For finding similarity between the context of two or more users and services used concept of subgraph-aware proximity. 2) Content and collaborative filtering
Sihang Hu [2]	Their recommend-ation algorithm performs better than SP rank algorithm which is novel hybrid recommend-ation algorithm to compute top N recommend-ation.	Their model mainly focuses on point of interest which are obtained from user review.But other contextual information can also improve recommend-ation.	Content based filtering and directed graph
Tiantian He [3]	Their method combines graph clustering and multiview learning so as to perform the task of clustering in the multiview featured graph	Their model is based on unsupervise-d learning so it does not have support for vertex embedding for attributed graph as it is used in supervised learning model	Attributed graphs and contextual correlation which preserves multiview features based graph clustering
Cairong Yan [4]	1) Their method provides different recommend-ations for active and inactive users respectively. 2) Their paper claims to solve the cold start problem and sparsity problem which was problem in previous recommend-ation systems.	1) More parameters need to be considered for recommend-ation other than userid,itemid, itemtags , season,st-yle,gender and customer score for improving recommend-ation. 2) Approach is based on knowledge graph but does not go in detail between the entities	Collaborative filtering,data augmentation for improving quality of data,factorizatio-n machine model for high accuracy of recommendatio-n,knowledge graph

Xiaoliang Fan [5]	1) Their approach fully utilizes the concept of spatial and temporal correlation which previous methods failed to do. 2) They have used weighted rating factor to improve the effectiveness of recommend-ation	1) Other contextual information like social context etc. of user is not considered. 2) Performan-ce of the system can be improved by using knowledge graph	Temporal and spatial correlation, weighted rating effect for similarity computation.
Hao Wang [6]	Their proposed clustering algorithm converges fast.	1) Time complexity of their algorithm is square. 2) For large amount of data their clustering algorithm works slower	Multiview clustering
Weizhi Ma [7]	Their model performs good in case of noisy item knowledge graph that is created by linking item names to related entities	Creating rules for large number of items can make the system complex and can affect recommen-dation	Jointly learning rules,random walk, collaborative filtering and knowledge graph
Zhiheng Wu [8]	Used the concept of user reputations for validating the reputation of item or service	Their method gives more reputation value to real user and less value to malicious user.So, if this value is same for both types of users then their system fails to distinguish	User reputation calculation, collaborative filtering and context
		different users.	
Lan Zhang [9]	Considered user-event interactions, event-event interactions for better recommend-ation	For complex events their model may work slower.	User behavior analysis and knowledge graph
Zhixue Jiang [14]	Created efficient question answering system using concept like information extraction and knowledge fusion	1) Construction and retrieval speed of knowledge graph is not efficient. 2) Multi round dialogue and complex knowledge reasoning need to be improved.	Natural language processing, knowledge graph, Rule based matching techniques and string matching algorithms are used for classifying and querying the questions.

7. PROPOSED SYSTEM

7.1 Problem Statement

"To implement the recommendation system using context aware services, Dilated RNN based on the knowledge graph using machine learning"

7.2 Problem Elaboration

Nowadays recommendation systems are used in many domains and the challenge is to provide better recommendation to the user when we have large amount of data. So, We will be building recommendation system using knowledge graph as it have many advantages over traditional approaches. Also,we will be using machine learning for improving the performance of knowledge graph based recommendation system.

7.3 Proposed Methodology

Dilated RNN(Recurrent Neural Networks) is the latest embedding algorithm that can be used in the knowledge graph for improving the performance of the system. We will be comparing performance of three algorithms Dilated RNN(Recurrent Neural Networks),Dilated CNN(Convolutional Neural Networks) and LSTM(Long Short Term Memory).Out of these algorithms Dilated RNN gives better accuracy as compared to others. So, Machine learning algorithms play an important role in improving the performance of the system. We have used Yelp dataset for five domains (Movie, Travel, Health, Shopping and Restaurant) for creating recommendation systems. We

will do pre-processing of the dataset. Then training and testing of model is done by using three algorithm. And then classification of dataset is done by each of three algorithm. After that recommendation prediction part is implemented and then we are comparing the accuracy of three algorithms and the best algorithm is selected out of three algorithm and then we will be creating knowledge graph for each of the above mentioned domains.

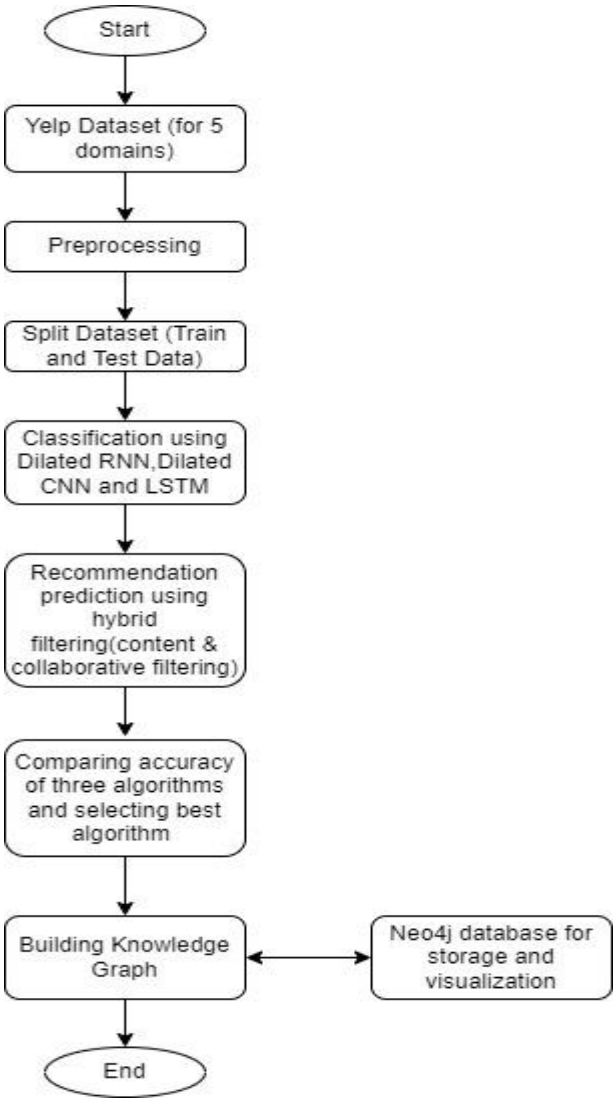

Fig 7.3 Workflow Diagram

1. Data Collection

We will collect data from Yelp dataset for five domains (Movie, Travel, Health, Shopping and Restaurant) for building recommendation systems. Each domain dataset will have relevant parameters required for it.

2. Training

Before starting the training of model we will first do pre-processing of the dataset. For training the model we will then split the dataset into training set and testing set. We will be using Dilated RNN, Dilated CNN and LSTM. Dilated RNN is also used here to convert the knowledge graph into low dimensional vector space and also for reducing the processing complexity of knowledge graph.

3. Testing

We will be testing our model on testing data and then we will be evaluating the performance of the system using certain metrics like accuracy, MRR(Mean Reciprocal Rank),Recall,Precision,F1 measure etc.

8. FUTURE SCOPE

In this section we will discuss some of the famous research approaches related to the recommendation system.

a) *Dynamic Recommendation:* We have seen that some knowledge graph based recommendation system with GNN or GCN architecture shows good performance but the training process is quite time consuming. The recommendation system using such models are called as static preference recommendation. However, nowadays recommendation system should also be deal with real time interests because nowadays user's preference can get affected by social media or friends also. So, in that scenario static preference model would not be sufficient. However for the purpose of capturing frequently changing user preference dynamic graph network can be used. The paper proposed by W.song [26] used this dynamic graph network for including long and short term interests from friends. Along with this, other side information can be used and knowledge graph for dynamic recommendation can be prepared.

b) *Multi-task Learning:* One of the most important task in creation of knowledge graph for recommendation purpose is the link prediction in the graph. So, there is a scope to improve the performance of graph based recommendation system. Some of the indirect links may get ignored because of user preference fact is missing which can ultimately impact the recommendation results. However, paper proposed by W.Cao [27] showed that it is effective to train the knowledge graph completion and recommendation module together for giving better recommendation. There are some other papers which have used multitask learning by training together task of recommendation module with knowledge graph embedding and item relation regulation task.

c) *Cross domain recommendation:* For dealing with the problem of long standing data sparsity in the recommendation system this cross domain recommendation is used. In this approach, we fully utilize the richer information from a richer domain for improving recommendation performance in a less richer

domain. The paper proposed by Zhang[28],created a matrix based method for cross domain recommendation. Also in some of the approaches user item graph contains only interaction relation and it does not consider any other relationships between users and items. For improving the cross domain recommendation we can include different types of users and items information in the graph.

d) Knowledge based enhanced language representation:

For the purpose of improving the performance of various natural language processing tasks, nowadays external knowledge is merged into the language representation model. So, language and text representation can be improved mutually. The paper proposed by Chen[29] created a model for short text classification and it utilizes previous knowledge from knowledge graphs for enhancing the semantic representation of the short texts.

9. CONCLUSION

In this survey paper, we have studied various methods used for filtering in recommendation system and also studied various traditional and recent knowledge graph based recommendation approaches. We have also seen approaches in which knowledge graph is used as additional information for giving better recommendations to the user. We observed that knowledge graph based recommendation are good for better and explainable recommendation.

In this paper, We have also introduced a method using knowledge and machine learning which we are going to experiment on existing knowledge graph based recommendation systems. After that, we will get the model having more average accuracy as compared to earlier model which will be able to give better recommended items or services to the user. With the help of this proposed system ,we will try to create more efficient and accurate model for the recommendation systems.

We hope that through this survey paper we have helped the readers to understand various works done in the recommendation field.

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