

# JOB RECOMMENDER SYSTEM

## A DISSERTATION

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IN  
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I, Vaibhav Jain , Roll No. 2K18/CSE/502 student of M.Tech (Computer Science Engineering), hereby declare that the project Dissertation titled "JOB RECOMMENDER SYSTEM" which is submitted by me to the Department of Computer Science and Engineering, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Master of Technology, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of and Degree, Diploma Associateship, Fellowship or other similar title or recognition.

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**CERTIFICATE**

I hereby certify that the Project Dissertation titled “JOB RECOMMENDER SYSTEM” which is submitted by Vaibhav Jain , 2K18/CSE/502 Department of Computer Science Engineering, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Master of Technology, is a record of the project work carried out by the students under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

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## **Abstract**

Recruitment is one of the major tasks for the HR industry. As it offers numerous job opportunities at various locations, it is therefore very time taking and difficult to determine which user-job mapping is the most relevant one for a given user, on the basis of their skills and interests. In order to serve consumers, we propose an information recommendation engine that utilises an algorithm to match a user's interests and abilities with available jobs. To form recommendations, the system uses different text filtration and similarity measures. Testing the model using data from a major job offering agencies shows that topic models are relevant and effective. Therefore, this technique can be applied to several other industries..

## Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
<b>2</b>	<b>Background and Related Work</b>	<b>5</b>
<b>3</b>	<b>Problem Definition</b>	<b>12</b>
<b>4</b>	<b>Methodology</b>	<b>14</b>
<b>5</b>	<b>Results</b>	<b>18</b>
<b>6</b>	<b>Conclusion</b>	<b>21</b>

## List of Figures

1	General Model of Recommendation Engines . . . . .	5
2	Type of Recommendation Systems . . . . .	6
3	Content Based Recommendation . . . . .	7
4	User Based Collaborative Filtering . . . . .	8
5	Item Based Collaborative Filtering . . . . .	9
6	Proposed System Architecture . . . . .	14
7	Data Description from different domains . . . . .	16
8	Importance Vs Feature Characteristics . . . . .	19
9	Confusion Matrix using the proposed methodology . . . . .	20
10	Acceptance Letter . . . . .	26

## List of Tables

1	Featured Enhanced by Predictive Model . . . . .	18
2	Factors affecting accuracy in different domains . . . . .	19

# 1 Introduction

The management of situations involving a large number of jobs is one of the most challenging difficulties that individuals working in the field of human resource management must deal with. There is an issue with this situation. There are a variety of implications, both direct and indirect, that result from the employment of all of these methods, including not just the loss of time and money that is connected with them. As a consequence, scientists and professionals have concentrated their efforts on identifying methods of reducing the costs connected with such occurrences. Another facet of social capital that has a long history is the concern that candidates will not get a fair allocation of social capital throughout the election process. Someone spent many hours putting together a request, but never got a response explaining why the request was not approved. It is important to take a contractual position in order to fulfil the contract. In most cases, firms do not really communicate this information. Owing to the fact that the applicants will get just a modest advantage from completing this task, Even if we feel that if we don't allow for some automated operations, neither party will profit. For example, recruiting will gain from enhanced brand awareness, and rejected candidates will simply comprehend the process more thoroughly. The factors that influence recruiting choices, as well as creating recruiting choices that will lead to long-term success.

Talent acquisition has always been very complex, time taking and an important role of Human Resources (HR). Nowadays, with increasing Job Applications for a particular Job it has become very Challenging for the Human Resources(HR) to deal with it, lots of resources get wasted and a lot of time is spent on processing these job applications and finding a suitable candidate. The most problematic thing is that the CV of the candidates/ JobSeeker has no Standard format that makes the shortlisting of preferred candidates a lot more difficult. Also, to do so it requires a lot of domain knowledge but the roles in the industry are so diversified now that it has become near to impossible for a particular HR to have such a base of knowledge to shortlist candidates of all domains.

Researchers are working together to develop answers to this challenge. In this industry, it is often said that efficient remedies to a problem are required to be successful in business. Linking potential candidates and job offers in a standardised way may be able to alleviate some of the difficulties associated with the situation. The creation of new automated systems for enhancing re-



cruiting tactics as a result of this is an extremely time consuming endeavour. Furthermore, a computerised system of this kind is likely that recruitment agencies will find this method to be rather appealing in the long run. It is feasible that an automated analysis will be undertaken in conjunction with a number of educational institutions across the globe in order to decide which boot camps are required in order to increase the abilities and competencies of potential jobless individuals. In terms of the special requirements of a certain segment of the population, a major challenge is that the current strategies for comparing profiles and career opportunities are built on a language framework that is difficult to comprehend and use. According to this provision, if an employment opportunity becomes available, the current procedures will be followed in order to fill the position. to tally up the total number of parameters that are present in each of the candidates' profiles, and the most notable disadvantage of this strategy is that it does not take into account the labelling of each text expression in any manner whatsoever. The following are the necessary conditions:

- It will be necessary to use some level of experience or professionalism in order to get further information and ability in this field.
- Think about your own knowledge and experience while making decisions. There are just a few occurrences of this subject matter.
- Categorizations are a fantastic source of basic knowledge since they organise information, understanding for us how to use them to propose automated techniques best meet the businesses' actual hiring requirements

Lots of research has been carried out to solve this problem as already it has been said that HR does not do good to the candidates who have applied for the Job and have given their ample time for preparing an application. In contrast, there is an appreciable danger of losing out on relevant and qualified jobs or candidates because of the manual approach, and the process takes time. Also, there is a problem with not providing proper feedback on why the candidature was rejected for that Job [16]. On the other hand, Organisations also are not very interested to provide feedback to the candidates as it is of no profit to them and extra effort is also required from their side to do so.

However, if there exists any mechanism that automatically screen the applicants candidature, it will be helpful for both recruiter and the applicant

as recruiters can save their branding reputation and applicants would know the proper reason for the rejection and now they can focus on the areas they lag and prepare good for the next time on the same. Advances in technology and consumer expectations have created new and more tailored services for job seekers and recruiters, leading to an increased demand for predictive analytics that can pull the most appropriate information from various resources. Additionally, the same approach could be very useful for many educational organizations and employment agencies which could auto analyze the profiles of the unemployed people and suggest a suitable course or training required for them to improve their candidature which could give them an upper hand against the other people applying for the Job of the same domain.

Nonetheless, recommender systems have existed since the dawn of computing, but interest in the topic has grown in recent years as a result of increased exposure to social networks and e-commerce sites. To help people find suitable jobs, recruiters often utilise recommendation systems to recommend job information to various users [14]. This subject has received very little research because researchers are interested in employing content-based recommendation systems to help with recruitment agencies. Many algorithms/approaches already exist but the problem is they are mostly syntactic matching i.e. they will match the keywords of the job offer to that of the candidate's profile. The only problem with this kind of technique is that it fails to take into consideration the meaning that resides behind the text that intends to label the requirements. To improve this approach, there may be required some sort of expert knowledge and background into account.

In our work, there is a solution to this problem, there is a mechanism that maps the Job with the JobSeeker profiles based on the skills of the candidate that he has mentioned in the CV and the skills mentioned in the Job Description and uses an approach that automatically matches the job offers to the suitable candidates profile. The information retrieval algorithms mentioned in this paper are used to augment the various recruitment strategies of job search, testing, and short listing of the right talent. It reduces the amount of time and effort that goes into the entire process, at the same time, providing interesting and precise information filtration. Latent features are applied to the text to increase the accuracy of outcomes.

Our work goes on to elaborate, and describes the rest of the process. The very next section is concerned with the background and related work in the field, it aims to brief what other researchers have done so far in this area.

The followed section aims to define the actual problem followed by defining the methodology that has been used to carry out research, post that results are discussed and finally the work is concluded with discussions.

## 2 Background and Related Work

To extract the appropriate data from web databases has become increasingly time-consuming in today's recruitment sector [17]. There is a heavy reliance on precise data filtering systems within the market. Job postings and employment portals have witnessed a decrease in quality and performance as a result of this data surge. Now that everyone has access to more job information and job objectives, both job identifiers and recruitment teams must complete a massive pool of job postings and jobs advertised information in order to arrive at the result [23]. Every year there is an increase in the number of people who apply for a job, with this for a particular job a lot of applicants are there and many of the profiles are deserving ones. It is a big challenge for the HR person to shortlist the most suitable candidate's profile from the bag of applicants. The process of matching a Job with the desired Job Seeker profile is the same as a recommendation system as we are recommending candidates for a particular Job Posting.

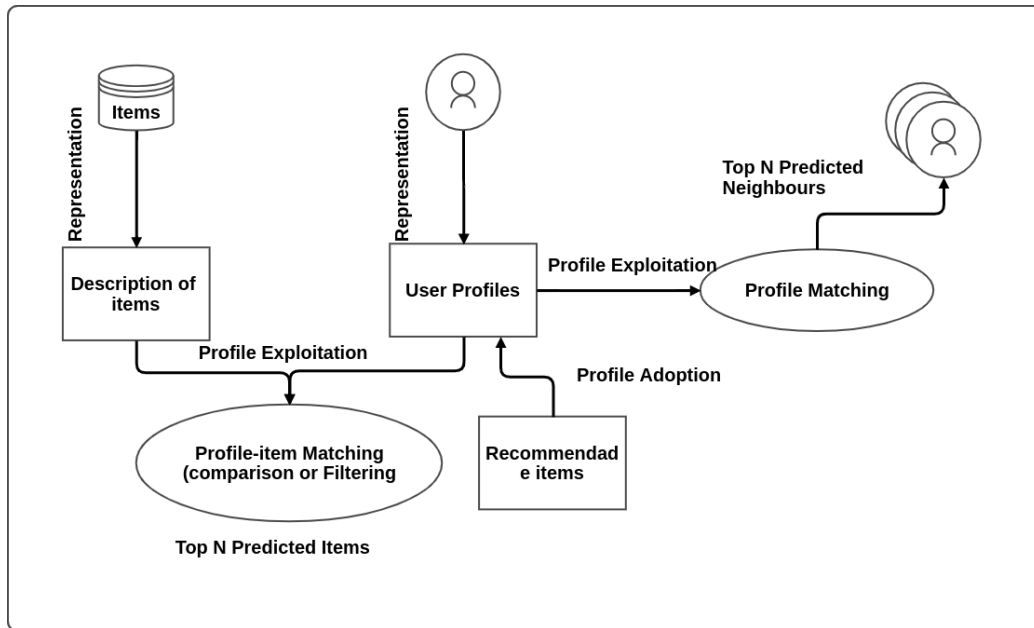


Figure 1: General Model of Recommendation Engines

Figure 1 shows a general flow of how recommendation works. It's typically a model that takes item representation (i.e products/News Articles/Jobs etc) as input along with the user feature vector, it does the profile item matching/filtering and finally returns the recommended items. These returned items are generally ranked on the scale of 10, and the same are recommended accordingly.

The matching techniques vary for various domains like movie recommendation may use some different matching technique to news recommendation. Below are the few techniques used to match/ filter out the profile-item similarity [2]

- Content Based Filtering.
- Collaborative Filtering
- Demographics Filtering
- Knowledge based
- Hybrid

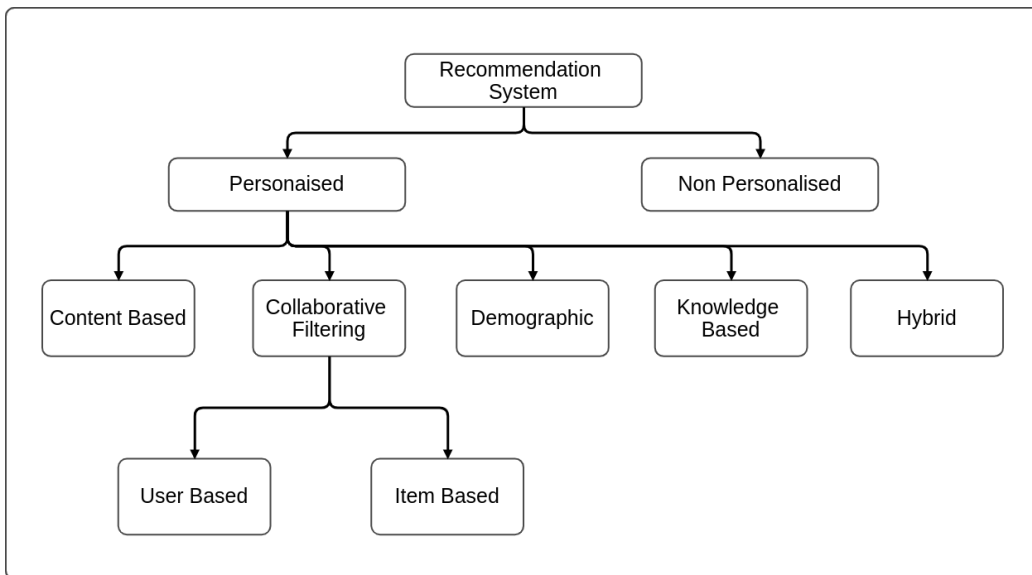


Figure 2: Type of Recommendation Systems

### (A) Content Based Filtering

These algorithms are based on the likeliness of the users. I.e. They aim to examine user interest on the basis of their past liking of the product. This algorithm compares the products which are similar to the products liked by the user and recommends similar kinds of products. As the below figure indicates a user liked an Hotel and the system recommended another Hotel which has the same features as of what was liked by the user.

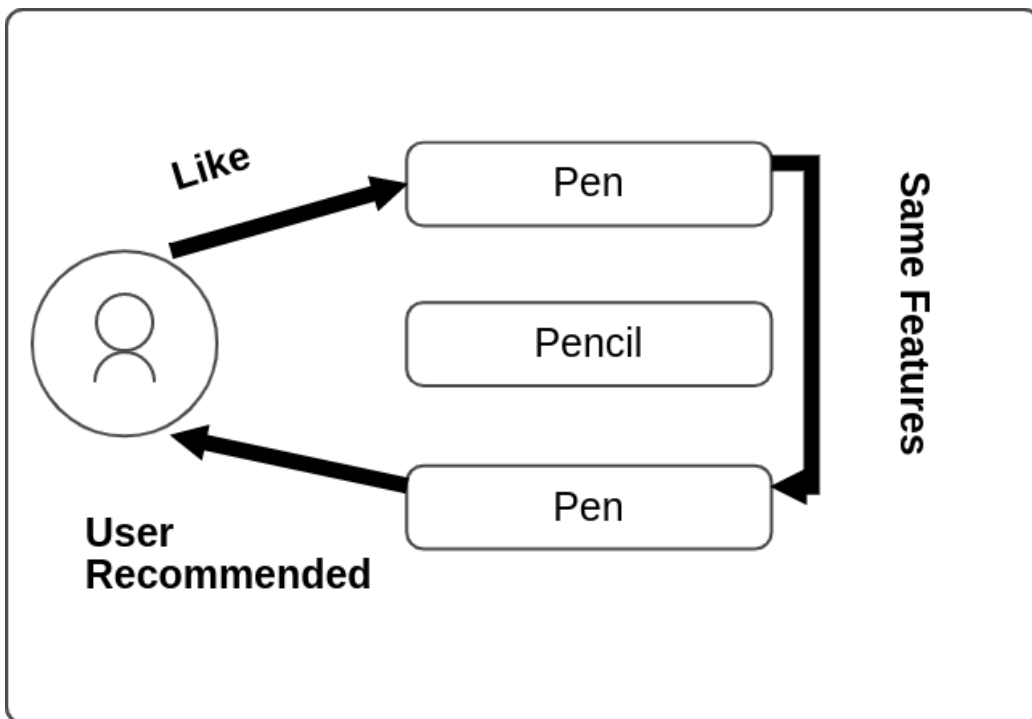


Figure 3: Content Based Recommendation

#### Advantages :-

- It's scalable as only that users data is considered for which recommendation is to be generated.
- It's based on the user's liking so there are more chances that the user would like the suggested item and it does resolve the cold start problem as well.

**Disadvantages :-**

- Future likeliness of the user can not be predicted as it works on the current integers of the user.
- Item features need to be analysed by an expert before making any recommendations to match the item similarity.

**(B) Collaborative Filtering**

Collaborative filtering is further categorised into two :-

(a) User Based

In this users with common interest are identified and then the item is recommended on the basis of the items liked by the common interest users and not yet seen by the user for which recommendation is to be generated.

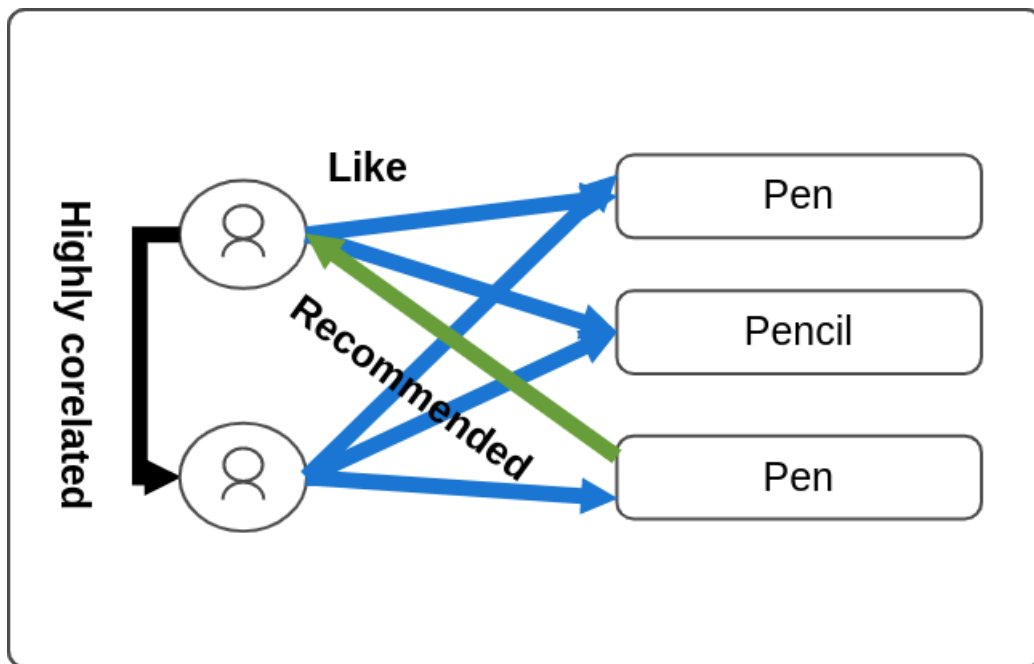


Figure 4: User Based Collaborative Filtering

(b) Item Based

In this technique similar items of the user interest are recommended to the user. Ie. If a user likes one item then the item similar to that is recommended to the user. User historical data is not needed for this.

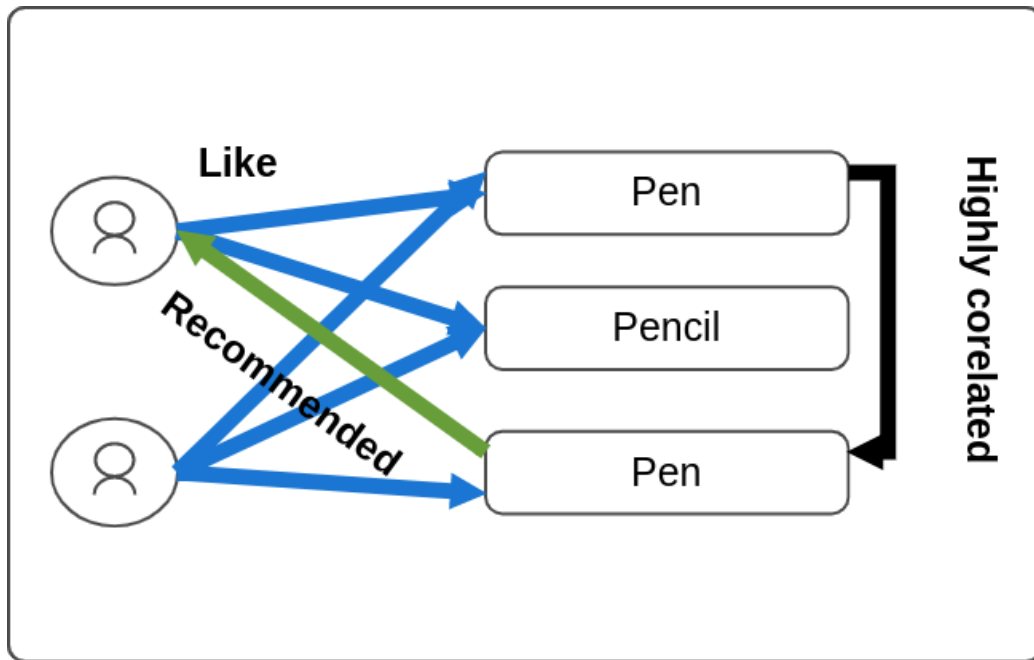


Figure 5: Item Based Collaborative Filtering

**Advantages :-**

- Easy to implement

**Disadvantages :-**

- Cold start problem for new item/user.

**(C) Demographic Filtering**

In demographic filtering demographics of the user(age, location, gender etc.) are considered. Let's say if there is a highly liked item by the users of the same demographics then if a new user enters into the system with the same features then that item is recommended to that user.

**Advantages :-**



- It works on all domains, i.e. it fits for all use cases(News, product,Movie etc)

#### **Disadvantages :-**

- Demographic data collection could arise privacy issue

#### **(D) Knowledge Based Recommendation System**

These are the systems that are built for complex cases. They are used where collaborative Filtering and Content based filtering fails to outperform. Like in the case of investment or like buying a car, where the user is sure about some of the constraints like budget. So this kind of system is used to recommend the item based on user preferences.

#### **(E) Hybrid Recommendation System**

In this technique two or more recommendation techniques are combined to obtain the recommendations. It is used to reduce the disadvantages of one algorithm and boost the strengths of the other. For instance, we can combine collaborative filtering with content based filtering to obtain good recommendations and also it takes over the disadvantage of cold start and start generating the recommendation from the very first instance of the item/user.

[14] published a survey detailing the applications that are using the recommender systems and the approaches adopted by them to build the recommendations. Recommendation systems are broadly classified into four types i.e. Collaborative filtering, Content-based filtering, Knowledge-based and Hybrid as per various researchers. [19] published a survey detailing recommendations systems of Job. They detailed out all the steps involved in the recruitment process like the factors that may lead to the selection of candidates to how e-recruitment is helping the companies to ease down the recruitment process.

[9] proposed a recommendation system that recommends personalized career paths using similarities across education and experience. Skill extraction has also become a very popular topic and has grabbed much attention. [11] [21] [4] [7] [6] [5] proposed a mechanism that extracts skills from the documents focusing on hiring candidates for an organization. The initial work computes the similarities between a document that is provided and the

Wikipedia pages text and then uses an algorithm to associate the input document with the skills [24][7][4] propose a system to extract skills from user profiles in a social network context.

Most of the approaches till now are based on Information retrieval method i.e keyword based search is performed on both Job offer and the Job seeker profiles. The same kind of approach is used by [3], [22] and [10]. There is also a lot of work that has been conducted on job recommender systems [8], [15], [12], [13], [20] [19] and [11] which match job descriptions with that of user profile. These strategies undoubtedly work pretty well also they are easy to implement as raw data is not required to be converted into any kind of structure and then to process it further but the problem with this method is that it is error prone as manual entry of the similar keys is required to be done. As the job market is very dynamic and flexible, therefore the skills and thus the keywords keep on changing. Alternatively there are approaches that are sector specific which helps in screening the profile of applicant and the job specification. For example, StackOverflow website contains huge information about the IT sector skills that a programmer may possess.

The mentioned frameworks such as ICED, ESCO, and DISCO [18], are there to capture concepts of skill and do not use the advantages of ontologies and the description logics [1], these frameworks currently support taxonomies. So the challenge is to use the capabilities of description logics and to get some useful facts, For ex. Experience and last use of the particular skill. In general, any approach that tries the problem of Job matching address one of the below research problem :-

- Ranking the Applicant for a certain job Posting.
- Ranking the jobs for a particular candidate.
- Identify the Gaps between the candidate's profile and the Job Posting.
- Identify the proper skill/training needed for a Job Seeker to be eligible to apply for a particular Job.

### 3 Problem Definition

The actual problem lies in ranking the jobs according to profiles of the Job Seekers according to the most relevant/ fit according to the profile. So there has to be a system that takes the profile of the candidates and Job description as an input and provides the rank of the Job as an output. Also, there has to be a knowledge base that acts as a database which is basically a super set of all the skills that a Job Seeker may possess and that holds all the skill base that is mentioned in the Job Description. Our job is to map the skills mentioned in the Job description with the Job Seeker skills using our knowledge base and define a function such that the ranking of the Job Seekers profile who applied for the Job is generated automatically by the inputs provided. Also, the other factors like function of the job and industry of both jobseeker and job, the experience of the jobseeker etc are to be considered to provide a relevant pool of jobs to jobseekers. These factors could be used as a filter to the recommendations made but for matching there must exist a function that does the job.

Say, We consider  $jd$  as job description and  $js$  as JobSeeker profiles list for which we should have a score list say  $y \in \mathbb{R}$  where each job is ranked according to the jobseeker profile. Now our goal is to determine a function  $f(jd, js) \approx y$  that fits for every Job applicant. It is also necessary that a JobSeeker profile has to be a set which holds components that are there in a knowledge base (e.g. ICED, ESCO or DISCO etc) [17]. Therefore, there is a job to score the eligibility of a number of possible jobs for a particular candidate, taking the following facts into consideration:

- The elements that appear in either job offered or the applicant's profile may be of any order, as ordering does not play any key role and different order may not hamper anything and is not relevant in our case.
- The size of the set of elements of the Job offer and applicant's profile may differ as the applicant may possess more or less skills required for the Job offered and it may affect the ranking later.
- The elements present in the set  $jd$  can be replaced by the elements present in  $js$  at a certain cost to it. For example:- a person who possesses SVN as a skill may not face much difficulty in working on GIT but there is a certain cost that is attached to it as it can take time to switch to a familiar technology as well.

- The Job function mentioned in the jd must match the mapped function list of js.
- The Job sector/ industry/ domain plays a vital role and if the jd and js sector matches then it's an additional benefit.

## 4 Methodology

There is no single solution to this problem as every domain expert has different opinions and a different way to deal with the problem and that may give different results altogether. A model has to be trained first for each organization or user who wants to use the model to know their preferences [Martinez-Gil et al.[1]]. We have closely looked into the various parameters that affect the matching of jobs to the Candidates profile, validated the same manually and talked to many HR domain experts and considered many factors affecting the candidates opinion to opt for a particular job.

- The Architecture

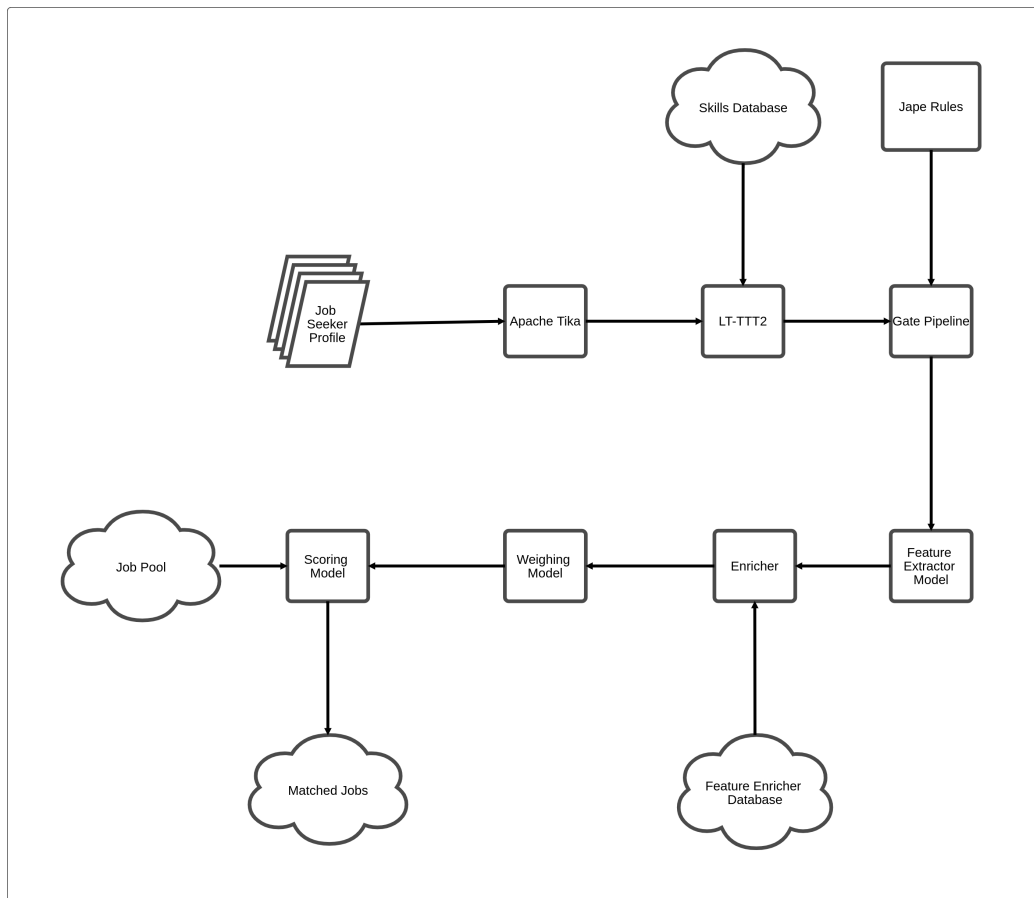


Figure 6: Proposed System Architecture

Figure 6 shows the overall process and the architecture of the approach adopted for the whole process. There are many data preprocessing that has to be done before the mentioned process which is also mentioned in the section below.

As shown in Figure 6 for finally ranking the jobs and to find suitable matched jobs, the profile of the jobseeker goes through various stages listed below.

- (A) **Tika** :- here Apache tika is used to parse the job seeker profile and to provide a unified form of data. It basically consumes multiple formats i.e. doc, pdf and provides the profile as a text file.
- (B) **LT-TTT2** :- It takes the text file as an input along with the skills database and tags all the skills present in the jobseeker profile
- (C) **Gate Pipeline** :- it's combination Jape rules and other machine leaning library that identifies the various aspects from jobseeker profile. For eg. experience of a particular skill, number of projects done by applicant, number of organisations he has worked with etc.
- (D) **Feature Extractor model** :- It's a model which extracts all the identified features of the Applicant/Job seeker.
- (E) **Enicher** :- it's a model that enriches the extracted features from the Jobseeker profile. Like adding synonyms, broadening the skills horizon, identifying and expanding the Job function etc.For this a enricher DB is required to be ingested along with the profile.
- (F) **Weighing Model** :- This is the model that gives the weighted feature matrix from the jobseeker profile.
- (G) **Scoring Model** :- Finally after the weighting matrix is obtained the scoring model gets the weighted feature matrix and the job pool as the input and provides the matched ranked jobs that are best suited according to the jobseeker profile.

- **Dataset Description**

For Skills enrichment DBpedia database has been used. The data is extracted and loaded as a graphical Dataset and the connected nodes are considered for the skill cloud. After several attempts and tuning

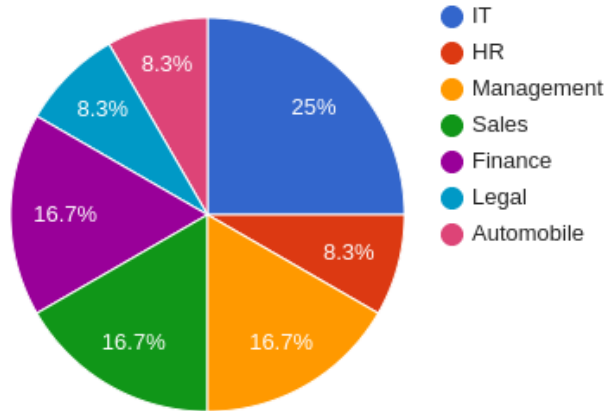


Figure 7: Data Description from different domains

we have reached to a conclusion that the nodes that are connected to maximum five level hoppings are the only ones which are useful, post that the data gets diluted and the results are not so good. The rest of the data was downloaded from Kaggle and through a classified job portal. The data is converted to an excel file having five columns, i.e Id, Function, Category, location and Resume. The number of instances for the different domain can be seen from Figure 7

- Preprocessing
  - (A) **Skills Database** :- Skills database is prepared by parsing data from DBpedia and storing the same in graph, the inter-relation between the skills were identified and finally stored as a flat structure to be used for the further processing purpose
  - (B) **Jape Rules** :- Lot of profiles were examined and different profile structure were studied to write Jape rule to identify various Jobseeker Information

- (C) **Feature Enricher Database** :- Function prediction model was used and Function Cloud was obtained after studying the Job-seeker data. Skill cloud was also used to enrich Skills. Various synonym dictionaries were used to map synonyms as well.
- (D) **Job Pool** :- Job data was already predefined and well structured like Job Title, Skills to be required, location, function, industry etc.



## 5 Results

In this section, we will present the actual results obtained while working with the real data from the recruitment agency. Also, we have only considered the data that was most relevant to us and personal data like photo, reference etc was not taken into consideration. We have worked on 7 major domains that we got data for : IT, HR, Sale, Marketing, Finance, Legal, Automobile.

We are interested in forecasting the contextual factors for an employee who is presently working in one organization .If the precision factor is high enough, we may be able to utilise our model for employees looking for a new job profile. We created a prediction model using supervised machine learning. In our learning model, an instance is equivalent to a member who is employed in an institution.

S No.	Feature	Range
1.	Skills	List;String
2.	Designation	String
3.	Total Experience	Int
4.	Job Function	List;String
5.	Period of Working	Date

Table 1: Featured Enhanced by Predictive Model

The system is more of a ranking system and ranks all the jobs present in the system according to the Job Seeker profile. So it may be considered that the last job recommended might be the job that is most irrelevant to the job seeker. So for our experiment purpose we considered the top 50 recommendations for a particular domain that the system has recommended. Also, various factors mentioned have been used to filter the recommended Jobs post recommendation was made. Figure 8 , shows the importance vs feature characteristics graph to show how relevant the factor is for the recommendation the system is generating.

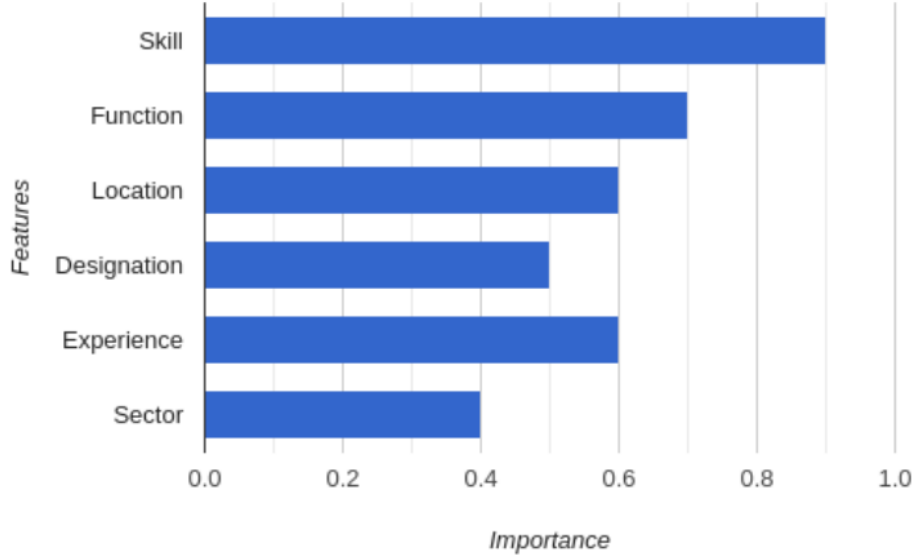


Figure 8: Importance Vs Feature Characteristics

The below Table shows different result accuracy rate on adding the different features. The experiment is performed for each domain on successively adding different feature vectors and the same was recorded as shown in Table 2.

	Skills	Function	Sector	Designation	Experience
HR	60%	75%	79%	80%	83%
Management	55%	72%	75%	80%	82%
Sales	58%	70%	74%	76%	78%
Finance	65%	75%	78%	81%	85%
Legal	60%	69%	77%	78%	80%
Automobile	60%	65%	72%	74%	77%

Table 2: Factors affecting accuracy in different domains

The model design is best suited for the first level of screening of the job by the Jobseeker. This would help the Jobseeker to classify the Jobs as per the requirements and easily identify the Jobs that are the best match to their profile. Also, it would help many recruitment agencies to recommend

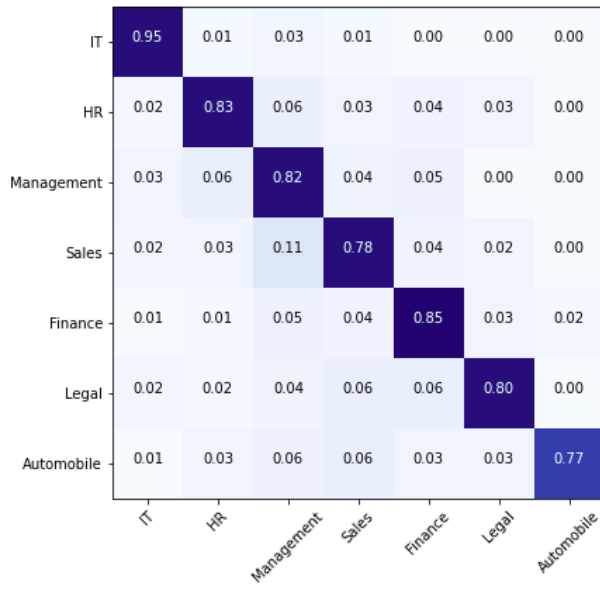


Figure 9: Confusion Matrix using the proposed methodology

better jobs to the candidates and save a lot of time in manually screening the jobs for a particular candidate, it would in turn also increase their reliability for the Job seeker. The recommendations made by the model are currently for the varied industries but the model can be further enhanced to target specific industries which would make it more effective, and give better recommendations.

## 6 Conclusion

A recruitment consultancy/ agency works really hard to match jobs with the candidates profile and increasing both jobseekers and jobs makes it very difficult to do the matching process manually, thus there is a need for a system which can do the matching task automatically. The proposed system does the same and helps finding the relevant jobs for the Jobseekers of different domains. The proposed approach gave the accuracy of upto 95% for the IT domain. Though the results for other domains could not match the results of the IT domain, they are equally good. The proposed solution heavily relies on the skills database and we were able to get maximum data for the IT domain and hence the results validates our proposed approach. The model could grow if the taxonomy of the other domains could be collected from other data sources which has to be curated well with the help of HR/ Domain experts.

The experimental results showed that the proposed model showed high accuracy except for the jobs where the taxonomy database was weak. In future we plan to improve the system by extending the taxonomy, which is presently inclined more towards the IT domain.

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# Publication

The manuscript entitled "A Novel Approach to Rank Jobs for a Job-seeker" is accepted for Publication in "Turkish Online Journal of Qualitative Inquiry; E-ISSN: 1309-6591; Indexing: Scopus;  
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## Acceptance Letter

Dear Author(s): Shailender Kumar, Vaibhav Jain

Paper ID	TOJQI_2152
Paper Title	A Novel Approach to Rank Jobs for a Jobseeker

This is to enlighten you that above manuscript reviewed and appraised by the review committee members of **IFERP** and it is accepted for the purpose of publication in “**Turkish Online Journal of Qualitative Inquiry**”.

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Figure 10: Acceptance Letter