

Job Recommendation Systems for Enhancing E-recruitment Process

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Abstract - *The Internet caused a substantial impact on the recruitment process through the creation of e- recruiting platforms that become a primary recruitment channel in most companies. While companies established job positions on these portals, job-seeker uses them to publish their profiles. E-recruitment platforms accomplished clear advantages for both recruiters and job-seekers by reducing the recruitment time and advertisement cost. However, these platforms suffer from an inappropriateness of traditional information retrieval techniques like the Boolean search methods that caused many applicants missed the opportunity of recruiting. Recommender system technology aims to help users in finding items that match their preferences; it has a successful usage in a wide-range of applications to deal with problems related to information overload efficiently. In order to improve the e-recruiting functionality, many recommender system approaches have been proposed. This paper will analyze e-recruiting process and related issues for building personalized recommender systems of candidates/job matching.*

Keywords: Recommender systems; Collaborative filtering; Content-based filtering; Hybrid approach; e-recruiting; Similarity measure.

1 Introduction

With the increasing volume of information available online, recommender systems have become a daily tool for Internet users, providing them with desirable help in finding information. The recommender systems used to determine the interested items for a specific user by employing a variety of information resources that related to users and items. In the mid-1990s, the term recommender system was published for the first time in information system literature. Recommender systems are being broadly accepted in various applications to suggest products, services, and information items to latent customers. Many e-commerce applications joint recommender systems in order to expand customer services, increase selling rates and decrease customers search

time. For example, a wide range of companies such as the online book retailer Amazon.com [1], books [2], news articles [3]. Additionally, Microsoft provides users many recommendations such as the free download products, bug fixes and so forth [4]. All these companies have successfully set up commercial recommender systems and have increased web sales and improved customer fidelity.

For many years, information system supports in human resource management have been mainly restricted in storing and tracking applicants' data through the applicant management systems. These systems support the internal workflows and communication processes between the human resource management department and the other departments. Recently, the increased amount of digital information and the emergence of e-business reform the way companies conduct business in different aspects. Initially, simple solutions are applied such as posting the job ads on the career unit of the corporate website. Then, based on the experiences gained from these first implementations, the opportunities are realized establishing other changes and hence, implementing enhanced e-recruitment platforms.

The Internet-based online recruiting platform or e-recruitment platform is one of the most successful e-business changes, which changed the way companies employ candidates. These platforms spread in the recent years because the recruiting of the appropriate person is a challenge faced most companies, as well as the unavailability of certain candidates in some skill areas has long been identified as a major obstacle to companies success [5]. The online channels like Internet job portal, social media applications or a firm's career website have driven this development. While the companies established job positions on these portals, job-seeker uses them to publish their profiles. For each posted job, thousands of resumes received by companies. Consequently, a huge volume of job descriptions and candidate resumes are becoming available online. This vast volume of information gives a great opportunity for enhancing the matching quality; this potential is unused since search functionality in recruiting applications is mainly restricted to Boolean search method. The need increases for applying the recommender system

technologies that can help recruiters to handle this information efficiently [6] [7]. Many researches have been conducted to discuss different issues related to the recruiting problem as well as, the applying of recommender system technologies. However, job recommendation is still a challenging domain and a growing area of research. In order to support this research area, we conduct a comprehensive study for job recommendation. We will discuss the e-recruitment problem and present the different issues related to applying recommender systems in candidates/job matching.

This paper is organized as follows, in section 2 we present the recruiting process and its platforms. In section 3, we demonstrate the typical methods of various recommender system techniques. Section 4 illustrates the job recommendation related issues and presents a case study for applying recommender systems in candidates/job matching. Finally, we conclude this work in section 5.

2 The recruiting process

Recruiting process is a core function of human resource management treating the labor as one of the important factors of production [6]. The key objective of the recruiting process is to hire candidates who are valuable for the company [8]. Two viewpoints are distinguished: from recruiters and job seekers. The recruiters generate the job description by determining the set of requirements and constraints on skills, expertise levels, and degrees. The job-seeker, on the other hand, generates his/her CV by specifying the academic background, previous work experience and skills [9]. The IT support for the recruiting activities is ranging from attracting and finding talent to choose and retain candidates [10]. The degree of process integration represents the complexity of using e-recruitment solutions [11].

Färber et al. [6] demonstrated in their proposed model the relationship between recruiting tasks and divided the recruiting process into two main phases: The attraction phase and the selection phase, both phases contain a planning and an execution part. The planning part determines the overall strategy and actual measures to attract valuable employees as well as, the explicit selection methods. The execution part comprises the employer branding activities that include all long-term marketing measures that attracting qualified candidates. The attraction phase aims to generate a description for open job positions. The selection phase starts with the pre-screening of resumes and other submitted materials. Then, the final selection of candidates is conducted by comparing the remaining set of candidates that has not been filtered out in the screening phase. Finally, the applicant management serves as a secondary function; it consists of the contact of applicants, the management of applicant data and associated processes such as directing applications to organization's members that involved in the

selection decision. Figure1 represents the recruiting process that adapted from [12]. Additionally, Carroll et al. [13] presented four phases of the recruiting process: an assessment of job position that needs to be filled, a description job profile, the construction of a job description and a candidate specification. Moreover, Breugh and Starke composed the recruiting process into five main tasks: short-term and long-term candidate attraction, applicant management, pre-selection as well as the final selection of candidates. Short-term and long-term marketing measures are establishing the attractive employer image that intended to attract qualified candidates [14].

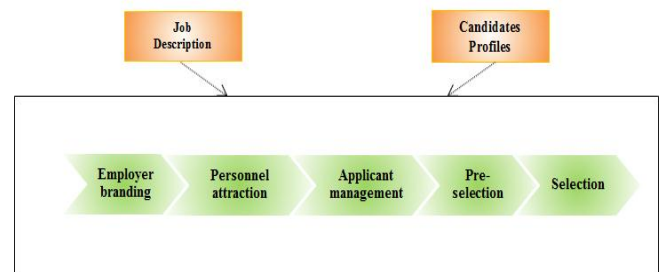


Figure 1: Recruiting process

2.1 E-recruitment platforms

The e-recruitment is a system for quickly reaching a large set of potential job-seekers. E-recruiting has attractive growth since the late 1990s when the rapid economy changes produced a high demands for qualified candidates that the labor market could not fully satisfy. The e-recruiting platforms such as corporate homepages and job portals (e.g. monster.com) have driven this development. The International Association of Employment websites¹ mention that there are more than 40,000 employment sites helping job-seekers and recruiters worldwide [9]. While companies send open job positions on these portals, job-seekers use them to publish their profiles, this caused a vast amount of job descriptions and candidates' profiles are becoming available online. However, the adoption of these e-recruiting platforms accomplishing cost savings, effectiveness, and suitability for both recruiters and job-seekers [15]. Many online recruiting platforms suffer from an inappropriateness of Boolean search methods for matching applicants with job requirements. Consequently, a large number of candidates missed the opportunity of recruiting [12]. Actual practices and theoretical thoughts show that this search type is insufficient for achieving a good fit between candidate aptitudes and job requirements [6]. Researchers have identified different reasons why organizations implement e-recruiting platforms; they discussed several challenges that faced the organizations when implementing IT support for

¹ <http://www.employmentwebsites.org/>

their recruiting activities. Lang et al. [12] presented detailed information about drivers, challenges and consequences of e-recruiting platforms.

2.2 Categories of e-recruitment platforms

In order to give the reader a better understanding of the e-recruiting platforms, we present the six categories of e-recruiting sources that presented by Lee [15]: (1) General-purpose job boards (e.g. Monster.com; HotJobs.com) that provide complete online recruiting functions. While job-seekers search jobs by category such as experience, location, education or any combination of these attributes, recruiters search applicants databases by skills, experience, preference, education, salary or any combination of keywords. (2) Niche job boards (e.g. Dice.com; Erexchange.com) serve the specialized markets such as a particular occupation, industry, education or any combination of specialties. (3) E-recruiting application service providers (e.g. RecruitUSA; PeopleClick) present a collection of services such as recruitment software, recruitment process management, education and training. (4) Hybrid recruiting service providers (e.g. magazines and Journals) are the traditional means that provide e-recruiting services. (5) E-recruiting consortium (e.g. DirectEmployers.com; NACElink.com) is a search engine drives traffic directly to a member's career website. (6) Corporate career website is an employment source most commonly used by Fortune 500 companies where the use of the corporate career website is a regular extension of e-business applications.

3 Background of recommender systems

The recommender system approaches are classified into the following main four categories: Collaborative filtering, Content-based filtering, Knowledge-based and Hybrid approaches [16]. The descriptions of different techniques are presented in the following paragraphs.

(1) Collaborative Filtering (CF) is one of the most successful approaches for building recommender systems. It applies the known preferences of a set of users to predicate the unknown preferences for new users. The fundamental assumption of CF is that if users x and y rate n items similarly, or have similar behaviors. Hence, they will rate other items similarly [17]. CF approaches have the capability of working in domains where items contents are difficult to obtain or cannot be parsed automatically.

(2) Content-Based Filtering (CBF) is treated as information retrieval problem or machine learning problem. In information retrieval problem, the document representations have to be matched to user representations on textual similarity while, in machine learning problem, the textual content of the representations are combined as feature vectors, which are used for training a prediction algorithm [16]. The CBF recommends items whose content is similar to

the content that the user has previously viewed or selected [2]. There are two main tasks related to CBF recommender systems, the User profiling and the Item representation. User profiling is one of most challenging tasks in CBF recommender systems that deal with acquiring, extracting and representing the features of users. User's profile may contain different types of information such as the selected items, ratings of items, and user's demographic data, etc. [18]. Item representation is also an important issue in CBF recommender systems. Items can be a structural data represented by the same set of attributes, and there are specific values that the attributes may have. Several approaches for learning a structural data used such as machine learning techniques. Additionally, unstructured data may occur in some applications such as unrestricted texts in news articles. In this type, there are no attribute names with well-defined values. A common approach to deal with free text fields is to exchange the text to a structured representation [19].

(3) Knowledge-Based Approach, this type of recommender systems attempts to suggest objects based on inferences about user's needs and preferences [20]. This approach assists users in the determination of suitable solutions from complex product and service assortments. These solutions based on exploiting deep knowledge about the product domain to figure out the best wishes of the customer [21]. They can use rules and patterns to recommend items based on functional knowledge of how a specific item meets a particular user need [20].

(4) Hybrid Approach, all recommendation approaches that mentioned above have characteristics and challenges. To get better performance and overcome challenges, these approaches have been combined. In general, collaborative filtering is integrated with other techniques in an attempt to avoid these challenges [20]. Authors of [20] and [22] presented different ways to integrate collaborative filtering, content-based filtering and knowledge-based approaches into a hybrid recommender system.

4 Job recommendation systems

Recent researches show that the increasing demands of Information System technologies for human resource management in general and recruiting processes in particular. Most companies put the focus on their own e-recruiting platforms as primary recruitment channels. Job ads are published automatically on the job portal as soon as they are entered into the system. On the other hand, the applicant creates a profile to apply it for one of the listed job positions. The user profile is stored in the system, letting the applicant reuse it for other job position. The last functionality gives the companies possibility to create the applicants pool. Thus, the companies achieved a uniform view for all applicants' data in one candidate pool. This pool is used by the recruitment department to find the applicant documents.

Appropriate applicants' documents are directed to the human resource departments for more processing. In addition, the system supports all required communication processes as well as tracks applicant status inside the application process [11].

As mentioned previously, the e-recruiting platforms are usually based on Boolean search and filtering techniques that cannot sufficiently capture the complexity of a person-job fit as selection decisions [23]. Many literatures have been applied the recommender system concept into the job problem. Malinowski et al. [24] determined that, we must consider unary attributes such as individual skills, mental abilities and personality that control the fit between the individual and the tasks to be accomplished, as well as the relational attributes that determine the fit between the individual and the upcoming team members. In this context literatures usually distinguish between (1) person-job, (2) person-team and (3) person-organization fits [25]. Thus, the recruitment approach must cover all these aspects. Keim argues that transferring recommender system approach to search for persons is a challenging but promising goal [26]. Therefore, many recommendation approaches applied for matching candidates and jobs to overcome the previous challenges of holistic e-recruiting platforms [8].

4.1 System requirements for candidates/job recommendation

There are major requirements presented in literatures that should be derived when recommending candidates for a specific job [23] [26] [24].

1. The matching of individuals to job depends on skills and abilities that individuals should have.
2. Recommending people is a bidirectional process that needs to take into account the preferences not only of the recruiter but also of the candidate.
3. Recommendations should be based on the candidate attributes, as well as the relational aspects that determine the fit between the person and the team members with whom the person will be collaborated.
4. Individual is considered to be unique; we cannot choose a single person several times such as a movie or book.

Job recommendation problem is bidirectional recommendation between job seeker and job. The recommendation process can be divided into two parts: job recommendation and job-seeker recommendation. The design idea of these two parts is the same roughly [27] [23]. For a job-seeker, the job with higher matching degree should be recommended to him. Similarly, for a job, the job-seeker with higher matching degree should be recommended to it [27]. In general, the ranking items either are the top n candidates that best fit the job in consideration or the top n job profiles that best fit the candidates' preferences. Additionally, Fazel-Zarandi and Fox mentioned that skills requirements matching need to distinguish between must-

have and nice-to-have requirements in the matching process. Must-have requirements are constraints that should be possessed by the applicant, whereas nice-to-have requirements are preferences that are taken into consideration when ranking applicants [9]. Figure 2 summarizes the job recommendation requirements in a unified model.

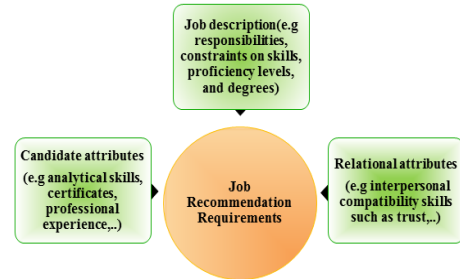


Figure 2: Model of system requirements for candidates/job recommendation

4.2 Job recommendation information

Candidates and jobs should be matched based on certain criteria that used as indicators of performance on the job. In selection theory, the available information at a certain time of the decision selection is called predictor data which comprises the individual attributes. The actual selection method is called predictor. The prediction process is referred to the assessment of the criteria using the predictor data and a method-specific way of data combination [6]. However, to construct candidate profiles, the meta-data extracted from existing resumes. Rafter and Smyth proposed a system that builds user profile in recruitment environment directly from analyzing the behaviors of web users. In this system, user profiles are constructed by passively detecting the click-stream and read-time behavior of users [28]. Malinowski et al. used an input data for their CV-recommender: demographic data, educational data, job experience, language skills and IT skills, awards, publications, others [23]. In general, candidate's profile is composed of three sections.

1. Personal information about the employee, such as the first name, last name, and location.
2. Information about the current and past professional positions held by the candidate. This section may contain company names, positions, company descriptions, job start dates, and job finish dates. The company description field may further contain information about the company (e.g., the number of employees and industry).
3. Information about educational experiences, such as university names, degrees, fields of education, start and finish dates [29].

Additionally, for collaboration measures, candidate may be asked to rate the job profiles using 5 point scale ranging from 1 to 5. Candidates were asked to evaluate whether the profiles interested to them with respect to their career perspectives and planning [23]. From these meta-data, a number of

features can be extracted to train and test recommendation [29]. On the other hand, the job profile should be constructed to describe the requirements and listing of all relevant skills that an employee for this job should have [8]. Moreover, the quality of the recommendation system can be assessed using statistical accuracy metrics such as the Mean Absolute Error (MAE), Root Mean Squared Error (RMSE) or Correlation calculations [30] [23] [17].

4.3 Job recommendation architecture

Laumer and Eckhardt [8] proposed system architecture that aligns recommender systems with the recruiting process based on the preceding holistic e-recruiting architecture provided by Lee [15]. They added new processes that supporting the development of job profiles and automated recommendation approaches. In his architecture proposal, Lee presented a workflow management subsystem linked to a

database management subsystem as the central component. All information related to recruiting activities is stored in the database. Any subsystem can have access to data stored by another subsystem and processes can include other processes or execute them. The integrated architecture for employee recruitment and recommender systems is built on the workflow management subsystem and database to manage the information flow and storage. For the integration of recommender systems, they added two important parts: First, a process to build job profiles that describing the job requirements and listing all related skills an employee for this profile should have. Second, they integrated a person-job recommender in the recruitment process as a process step in the selection phase. Finally, matching candidate and jobs can be managed by automated recommendation approaches [8]. Figure 3 illustrates the integrated system architecture for job recommendation.



Figure 3: The integrated architecture for job recommender system

4.4 Case study: an example of recommending candidates for specific job

In order to understand the job recommendation problem, we present a simple and concrete example for matching candidate with job requirements. We focus on measurable skills possessed by human resources. This example applies a content-based recommendation approach that used the attributes related to both job and candidates. As mentioned before in content-based approach in section 3, we must construct a profile for each item, which is a record representing the important features of that item. In job case, the candidate's profile consists of some features that required for a specific job. Similarly, the job's profile consists of the

job requirements that should be possess by candidates. For simplicity, we consider only few features that might be relevant to a recommendation system. The task of a job recommender system is to retrieve a list of candidates' CVs for a new job position. We conduct this example using one job description and list of 5 prospective candidates CVs. The job description was downloaded from Careers portal website²:

- Job title: Computer System Administrator.
- Job description: the prospective employee will monitor, operate and supervise the internal computer systems of an organization.

² www.careersportal.ie

- Qualifications required: BSc certificate in Software Engineering, Computer Programming or IT and four years of experience in IT sector, especially as Systems Analyst or System Programmer.

- Skills: English language skill (1-low, 2-medium, 3-excellent) and Oracle developer skill.

The candidates' CVs were downloaded from BSR site³. As mentioned above, the first step to determine the best fit between candidates and job description is building the job profile and the prospective employees' profiles. We extract some features from employee resumes and job description to build both profiles. Then, we estimate the model parameters by creating a rating matrix $R_{x,y}$, where x represents the job and y represents the candidate CVs.

$$R_{x,y} = \begin{cases} 1 \text{ (TRUE = "Exist")} & \text{'If the target attribute is existed} \\ 0 \text{ (FALSE = "not Exist")} & \text{'If the target attribute isn't existed} \\ \text{"Value"} & \text{'For quantity attributes} \end{cases}$$

The rating matrix $R_{x,y}$ transformed by treating the values of candidate's attributes as ratings of all the attributes extracted from the resumes using any similarity measures. That means the job profile as well as the candidates' profiles represented as vectors. We applied three measures in this example: Cosine Similarity, Euclidean Distance [31] and New Jaccard Measure [32].

The profiles vectors are constructed as the following: 0 (MSc not required), 1(BSc required), 1(if one of these majors: Software Engineering, Computer Programming or IT), 1(if he/she worked in IT sector), 1(if the candidate's experience more than 4 years), 1-3 (for English skill levels), 1(if the candidate has Oracle developer skill).

The resultant job's vector is [0 1 1 1 1 3 1] and the resultant candidates' vectors are: 1st person: [0 0 1 0 0 2 1], 2nd person: [0 1 0 1 1 3 0], 3rd person: [0 1 1 1 1 2 1], 4th person: [0 1 0 1 1 2 0], and 5th person: [1 1 0 1 1 1 0]. The candidates' ranking after applying the Cosine Similarity, Euclidean Distance and new Jaccard Measure is presented in table 1.

Table 1: Ranking of candidates for the job position using three similarity measures.

Cosine Similarity	Euclidean Distance	New Jaccard Measure
3 rd person 0.99	3 rd person 1.0	3 rd person 0.94
2 nd person 0.82	2 nd person 1.41	2 nd person 0.83
4 th person 0.81	4 th person 1.7	4 th person 0.78
1 st person 0.70	1 st person 2.0	1 st person 0.61
5 th person 0.67	5 th person 2.65	5 th person 0.48

This example aims to find a candidate who fits best to the requirements of job profile [0 1 1 1 1 3 1]. Based on the three similarity measures, 3rd person is the best candidate who fits job requirements, followed by 2nd person and 4th person. The 1st person and 5th person are the least appropriate candidates for the job requirements.

5 Conclusion and future works

In this paper, we used a literature analysis of many journals and proceedings related to the recruiting process and the job recommendation researches. We have seen from our literature review and from the challenges that faced the holistic e-recruiting platforms, an increased need for enhancing the quality of candidates/job matching. The recommender system technologies accomplished significant success in a broad range of applications and potentially a powerful searching and recommending techniques. Consequently, there is a great opportunity for applying these technologies in recruitment environment to improve the matching quality. This paper analyzed the e-recruiting process and the different aspects related to applying the recommender systems in candidates/job matching problem. Additionally, in order to give a clear understanding for job recommendation problem, a case study of applying three measures for matching candidates with job position was presented. Finally, we plan as a continuation of this work to present a survey of job recommendation approaches that have been proposed to produce the best fit between jobs and candidates. We will introduce state of the art of job recommendation as well as, a comparative study for its approaches.

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³ www.bestsampleresume

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