Towards an automated system for intelligent screening of candidates for recruitment using ontology mapping (EXPERT)

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Abstract: Many e-recruitment tools for recruiting candidates for jobs have significantly spread in recent years. Companies often receive resumes from candidates using e-recruitment tools or via job portal for each job posting and manually short list qualified applicants. The existing e-recruitment tools have been mainly used for the storage of applicant contact data. In this paper, we present EXPERT, an intelligent tool for screening candidates for recruitment using ontology mapping. EXPERT has three phases in screening candidates for recruitment. In first phase, the system collects candidates' resumes and constructs ontology document for the features of the candidates. Job openings/job requirements are represented as ontology in the second phase and in third phase, EXPERT maps the job requirement ontology onto the candidate ontology document and retrieves the eligible candidates. Experiment results show that this model improves the accuracy of matching candidates with job requirement.

Keywords: screening candidates; ontology; ontology mapping; intelligent e-recruitment.

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1 Introduction

The developments in the internet and communication technologies have brought radical changes in all facets of our life. They have changed the way we communicate, gather and disseminate information. They have also changed the traditional recruitment process by having job boards and corporate career web pages (De Meo et al., 2007). They offer several advantages over traditional approach by allowing Human Resources Agencies to target a very wide audience at a small cost. In traditional approach, HR agencies need to allocate human resources to manually scrutinise the candidate resumes and evaluates the applicants' suitability for the positions at hand. This is a time-consuming process. E-recruitment can automate the process of assessing the applicant profiles with maximum efficiency and small cost. This is already proved for SAT telecom (Pande, 2011). The finding of the study on SAT

telecom reported that 44% of cost savings and a drop in the average time needed to fill a vacancy from 70 to 37 days. There is no need to rely on recruitment consultants and search agents. The cost per hire has dropped drastically.

HR practitioners have long been under pressure to transform the HR function into one that is both efficient and can contribute to an organisation strategically (Parry and Tyson, 2009). E-recruitment tools for recruiting candidates have significantly spread in recent years. Corporate companies provide this feature in their homepages and job portals (e.g. www.noukri.com) have also available. Many corporate companies and the developments in job portal have driven the development in e-recruitment. While companies post job openings on these job portals and/or on their websites, job searchers use them to publish their profiles. Consequently, more job descriptions and candidate profiles are becoming accessible online. Although these vast amounts of digitally available candidate information represent a great opportunity for improving matching quality, this potential is largely unused since search functionality is currently mainly restricted to Boolean keyword search. Current practices as well as theoretical considerations show that this type of search is inadequate for achieving a good fit between the requirements of the job to be filled and the aptitudes of the candidates found.

1.1 Problem statement

The progress of internet and World Wide Web technology brings the movement of traditional recruitment process to web-based recruitment. Applying automatic screening of candidates will bring benefit to job recruiters. A few techniques could be applied in order to implement the screening of candidates such as fuzzy matching, semantic based and rule based. This research focused on using ontology mapping in screening candidates' problem to recommend the best mapped candidate resumes suitable for the job requirement using similarity measurement.

1.2 Motivation

Companies often receive resumes from candidates using e-recruitment tools or via job portal for each job posting. A large number of candidates may apply for the job opening and hence companies may be inundated with candidate resumes. Candidate screeners may be required to manually review a cumbersome amount of resumes to initially screen candidate resumes. It is a time-consuming one and requires more manpower and will result in inconsistencies due to candidate screeners basing resume screening decisions on subjective criteria resulting in fewer of more resumes reaching the recruiter than desired. EXPERT, an intelligent tool for screening of candidates can screen candidates semantically with score value for the job requirement and can solve the above problem and will be useful for employers.

This paper is organised as follows. Section 2 briefly describes some terminologies used. In Section 3, we give a brief overview about the related work. Section 4 discusses the overall architecture of the EXPERT and describes the EXPERT screening procedure using simulation. In Section 5, we give the experimental results and discussions, while in Section 6 we evaluate the system with real data. Finally, Section 7 concludes the paper and suggests future works.

2 Terminology

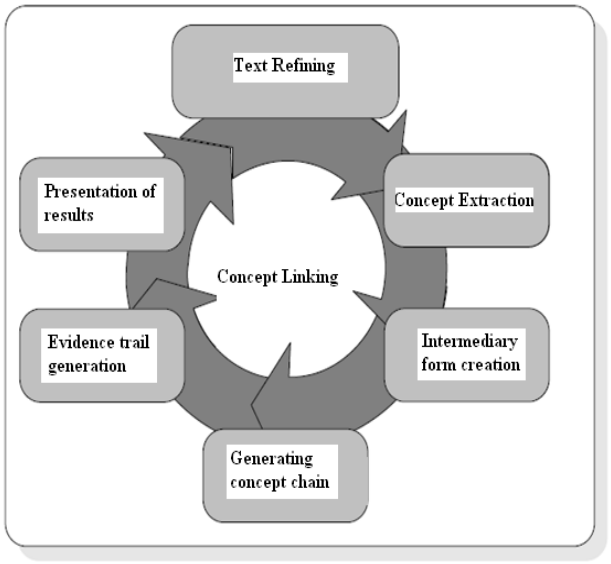
The most important terminologies used in the paper are defined in this section.

2.1 Concept linking

Concept linking is the process of connecting related data/documents by identifying their commonly shared concepts based on their co-occurrence and closeness within the document. Concept is an event/record/object which has high relevance in that context.

Figure 1 gives a brief overview of concept linking. The process is basically repetitive, that is, the entire process is repeated until satisfactory results are obtained.

Figure 1 Overview of concept linking



2.2 Ontology

The underlying data models in our process are ontologies. Guarino (2009) names several research fields in computer science that have embraced ontologies, including knowledge engineering, knowledge representation, qualitative modelling, language engineering, database design, information retrieval and extraction, and knowledge management and organisation. It is possible to define ontology with a sextet in the form (Gruber, 1995):

$$O = [C, P, R^C, R^P, A, I]$$

where C is the concepts, P is the properties, R^C and R^P are the relations between concepts and relation between properties, A is the set of axioms and I is the instance of

concepts and properties. Standard languages like RDF and OWL are used to create the ontology documents.

2.3 Ontology mapping

Ontology mapping seeks to find semantic correspondences between similar elements of different ontologies. We describe our understanding of the term 'mapping': given two ontologies O1 and O2, mapping one ontology onto another means that for each entity (concept C, relation R or instance I) in ontology O1, we try to find a corresponding entity, which has the same intended meaning, in ontology O2. The mapping between two ontologies (M) can be defined as follows:

$$M = [C1, C2, R, S]$$

where C1 is a concept in O1, C2 is a concept in O2, R is the relation between C1 and C2 and S is the similarity between C1 and C2. So, ontology mapping is the creation of a mapping function M.

3 Related work

To find relevant literature on e-recruiting in general, and resume design in specific, a systematic search method was applied. We have reviewed the related work in e-recruiting and in ontology mapping and carefully selected the articles that are most relevant to our research. Many e-recruitment tools for recruiting candidates for job have significantly spread in recent years. All these tools suffer from inadequate matching of candidates with job requirements (Bizer et al., 2005). Basic theory and mathematical tools are already available; however, the most complicated part in job matching process is the matching between the candidate's information and employers' requirement. Matching algorithm is used to balance the employers' and candidate's preferences, but still flexible to offer priority to either employers or candidates (Terzis and Economides, 2005). Job matching process involved the calculation of similarity between candidate profile and job requirement specified by the employers. Recent developments in recruitment practices show that job applicants, as well as professional recruiters and organisations in need of personnel, are increasingly using the internet to advertise job postings and search applicant pools (Gueutal and Stone, 2005; Ross and Young, 2005). In the last decade, e-recruiting spread around the globe and many attempts were made to automate the recruitment process (Lee, 2007).

Shvaiko and Euzenat (2013) demonstrated the ontology matching. In fact, e-recruiting is one of the leading e-commerce applications as a method for quickly reaching a large pool of potential job seekers. Major advantages cited as related to the rapid and successful adoption of e-recruiting methods include cost savings, efficiency and convenience for both recruiters and job seekers (Cappelli, 2001).

There are many approaches for automating the recruitment process and used various techniques. Laumer and Eckhardt (2009) used collaborative filtering to match the candidate for the given job. Then collaborative filtering combined with content-based similarity to recommend a candidate. Relevance models were used by Yi et al. (2007) to match resumes and jobs. Muderedzwa and Nyakwende (2010) assessed the effectiveness of online background screening. It was discovered that online screening is effective though it presents some problem.

Hu et al. (2011) present an SMS-based recommendation system for campus recruitment in China, which helps college placement office to match the companies and students with higher precision at lower cost. They are mainly focusing on profile matching and preference-list-based two-sided matching for further recommendation. Singh et al. (2010) proposed PROSPECT, a system for screening candidates for recruitment. They mine resumes to extract salient aspects of candidate profiles like skills, experience in each skill, education details and past experience, and mined details are presented in the form of facets. They also rank the candidates for a given job.

Weathington and Bechtel (2012) used personal information available on networking websites such as Facebook and LinkedIn to evaluate the applicants and on selection decision making.

Wright and Domogalski (2011) investigate and suggest the revised resume format that includes candidate personality assessment information for improving the effectiveness of candidate screening and selection. Recommendations for resume design theory and practice are proposed and developed a resume field framework by Haitsma (2009). Job Site Evaluation Framework (JSEF), an easy to use and comprehensive evaluation framework for job sites was proposed by Terzis and Economides (2005). They evaluated the job sites across four categories: (a) job market, (b) technical, (c) usability, and (d) social. Each category has different weights. Each category is divided into sub-categories.

There are many e-recruitment systems that have been proposed with an objective to cut cost and to speed-up and increase the efficiency of the recruitment process. In order to find the suitable candidates for job positions, these systems use different approaches like relevance feedback (Kessler et al., 2007; Yi et al., 2007), semantic matching (Mochol et la., 2007), machine learning (Faliagka et al., 2012), natural language processing (Amdouni and Ben Abdessalem Karaa, 2010) and analytic hierarchy process (Faliagka et al., 2011) to automatically represent CVs in a standard format.

4 Phases of expert

EXPERT is an intelligent tool for screening candidates for recruitment using ontology mapping. EXPERT has three phases in screening candidates for recruitment. In first phase, the system collects candidates' resumes and

constructs ontology document for the features of the candidates like personal information, current employment, past employments, education, skill, interest and their goal. Job openings/job requirements are represented as ontology in the second phase, and in third phase, EXPERT maps the job requirement ontology onto the candidate ontology document and retrieves the eligible candidates. Phases of EXPERT are given in Figure 2.

The architecture of EXPERT is given in Figure 3.

Phase 1: candidate ontology generation

The resumes submitted by the candidates are stored. The collected resumes will be in various formats. In our previous work (Senthil Kumaran and Sankar, 2012), we used concept linking approach to collect all the relevant information from the resumes and constructed ontology document. We used our previous work to construct candidate ontology from the collected resumes. The schema of the constructed ontology is given in Figure 7. First the input from the data store is validated and converted into a common machine usable one. Concept extractor involves tokenising, POSTagging of the preprocessed text. It then recognises the named entities and normalises. The normalised text is then parsed to semantically extract categorised details. Concept linker finds out relationship between the concepts extracted by the concept extractor. Then ontology is constructed (Senthil Kumaran and Sankar, 2012).

Phase 2: constructing job criteria ontology

In the second phase, we constructed the job criteria ontology for the job opening/job requirement. Some requirement can take multiple values and some requirement will be mandatory and some will be optional. For example, the qualification requirement will have BE or MCA or MSc as its value. To make some requirements as mandatory, we give weight for each requirement. The weight will be in the range of 0–1 with 1 for mandatory. The other value denotes the level of importance of that requirement.

Figure 2 Phases of EXPERT

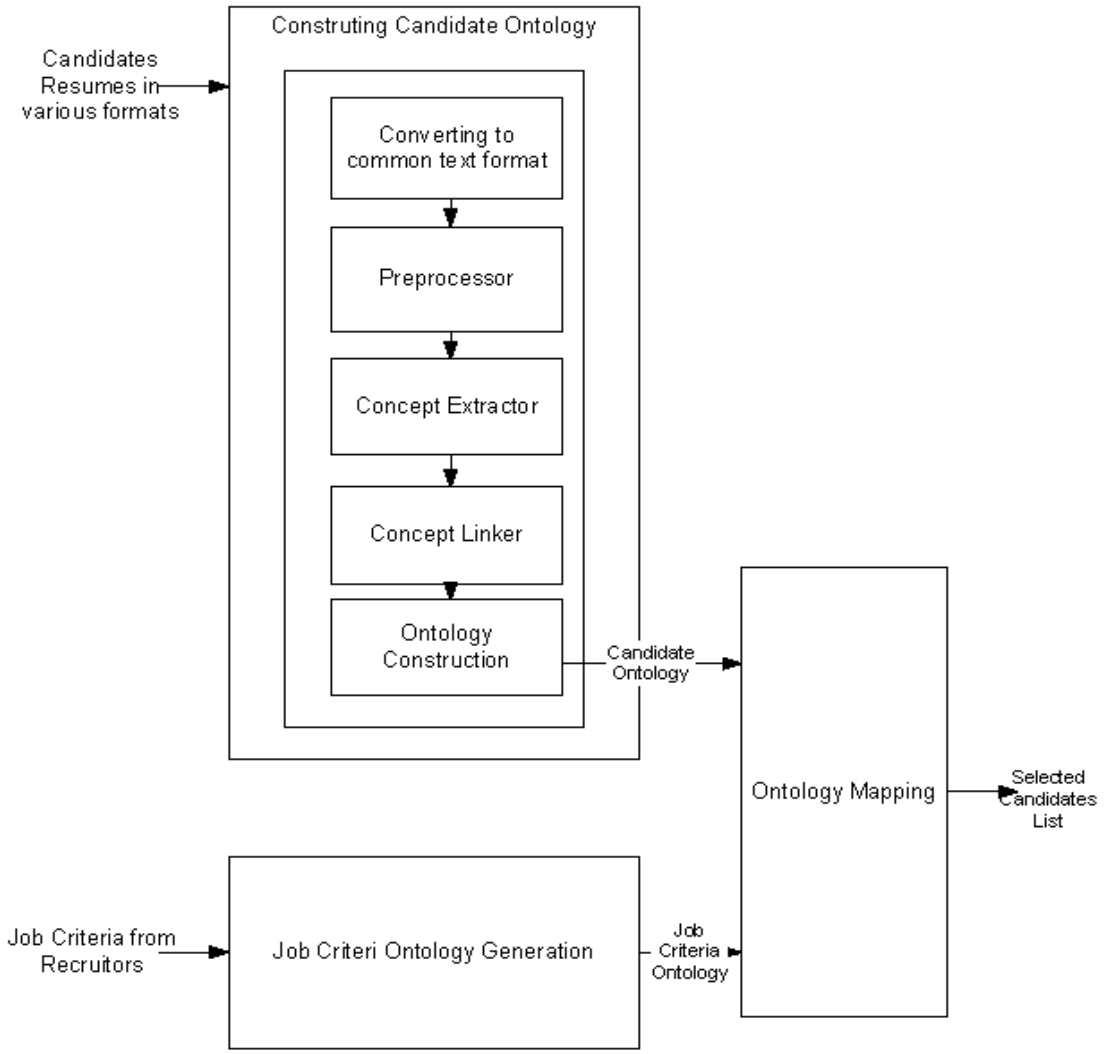
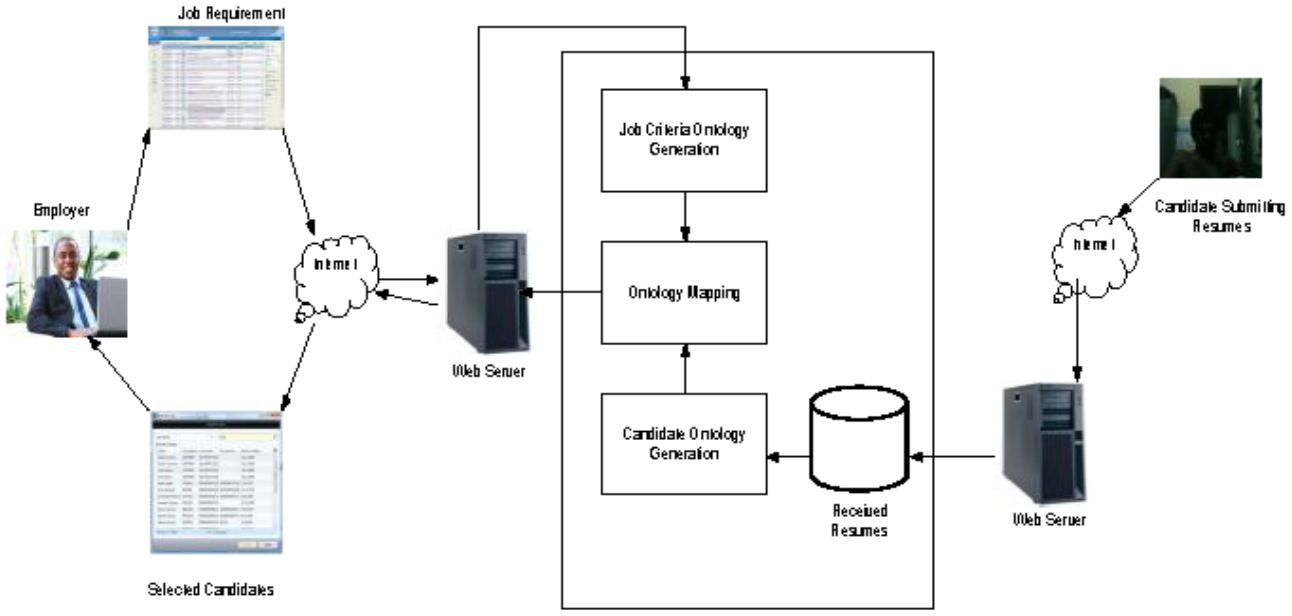


Figure 3 Architecture of EXPERT (see online version for colours)



Phase 3: mapping candidate ontology and job criteria ontology

We used ontology instant mapping approach to map the job criteria ontology with all the instances in the candidate ontology. The mapping between the job criteria ontology (i_2) and an instant in candidate ontology (i_1) is calculated as follows:

$$M(i_1, i_2) = \frac{\sum_{k=1}^{n} Sim(p_k^{i1}, p_k^{i2}) * W_k^{i2}}{\sum_{k=1}^{n} W_k^{i2}}$$

where p_k^{i1} is the k-th property in i_1 and p_k^{i2} is the k-th property in i_2 and W_k^{i2} is the weight given by the employer for the property p_k^{i2}.

The similarity function Sim(p1, p2) is defined as follows:

$$Sim(p1, p2) = \begin{cases} 1, & if\ similarity\ of\ p1\ and\ p2 \geq t \\ 0, & otherwise \end{cases}$$

Sim(p1, p2) is either 1 or 0 and is calculated according to the following rules.

- Rule 1: if p1 and p2 are properties with multiple values, similarity is calculated with subset matching. For example, qualification property in i_2 can have multiple values like BE or MCA or MSc which will be mapped to either BE or MCA or MSc in the corresponding property in i_1.
- Rule 2: if p1 and p2 are properties with integer values, similarity is calculated as follows: if value of p1 is greater than or equal to values of p2, then similarity is 1 otherwise 0. For example, if year of experience property in i_2 is 4, similarity function will return 1 for all i_1 in which year of experience property has value ≥4 otherwise 0 will be returned.

The $M(i_1, i_2)$ is a value in the range of [0, 1] with 1 for exact mapping and 0 for not mapping. The mapping value is calculated for all the candidates and returns all candidates with M value more than a threshold value as the eligible candidates.

We illustrate the notions of EXPERT by using more than 800 resumes. To illustrate the notions, let us consider a part of this resumes that consists of ten randomly selected resumes. The most important properties retrieved from these ten resumes are given in Table 1.

Table 1 Properties as retrieved from ten resumes

ID	*Qualification*	*CGPA*	*Total experience*	*Skills*
S1	MCA	6	3	Java, C++
S2	BE	7.5	4.5	Java, .Net, PHP
S3	MSc	6.5	7	.Net, C, C++
S4	MSc	8	7	.Net
S5	BE	9	4	Perl, Python, C++
S6	BE	8	5	Python, Java
S7	MCA	7	6	C++, Java
S8	BE	6.5	5	PHP, Perl
S9	MCA	8.5	5.5	Java, Perl, C++
S10	BE	9.25	2	Java, jScript, .Net

Consider the following job criteria given in Table 2.

Table 3 shows the calculated M value for each candidate.

Suppose, if we want to select the candidates with exact matching, S2, S6, S7 and S9 will be selected as they have M value 1. If the threshold value is 0.8, S2, S6, S7, S9 and S10 will be selected as eligible candidates as they have the M value more than 0.8.

Table 2 Job criteria

Attribute	*Expected value*	*Weight*
Qualification	BE/MCA	1
CGPA	7 and more	0.5
Experience	4 and more	0.5
Skill	Java	1

Table 3 Calculated M values

ID	*M (i1, i2)*
S1	0.67
S2	1.0
S3	0.17
S4	0.33
S5	0.67
S6	1.0
S7	1.0
S8	0.5
S9	1.0
S10	0.83

5 Experimental results and discussion

In this section, we discuss the experimental results of EXPERT and also the effectiveness of our system. The most important phase of EXPERT is the mapping function, which gives the mapping value for each candidate. The survey conducted by Ross and Young (2005) shows that an objective statement is very important to filter the candidates. Cole et al. (2007) concluded that education would decide the suitability of the candidate for a particular job. They also mentioned the importance of reputation of school/colleges attended, length of duration of study of the candidate. Hutchinson and Brefka (1984) state that GPA (Grade Point Average) and class rank are not important to filter a candidate. But Roth and Bobko (2000) highlighted that GPA reflects the candidates' intelligence. Ross and Young (2005) have also pointed out the importance of using work experience and job achievements to filter the candidates. Cole et al. (2007) found that extracurricular activities as another important resume field to filter the candidate.

But using one or two resume fields to filter the candidate will end up with more number of unwanted candidates and/or eligible candidates will be missed out. Hence, in EXPERT, we consider all possible resume fields as desired by the recruiters to filter the candidates. In EXPERT, the recruiters can give their requirement with not only all resume fields required but also the importance for the field in terms of weight. Since all required resume fields and weight for each field are considered, EXPERT will give only the desired candidates. Based on the number of candidates filtered, we can change the threshold value to increase/decrease the number of selected candidates. Consider the example given in Section 4. With threshold value 1, four candidates are selected, and with threshold value 0.8, five candidates are selected. Figure 4 shows the partial list of candidates that matches the recruiter's request with their mapping value.

Figure 4 Partial list of selected candidates with M value (see online version for colours)

EXPERT

List of Selected Candidates

Total Number of Candidates : 854
Number of Candidates selected : 135

Threshold Value : 0.8 Submit

S.No.	Name of the Candidate	Gender	Age	Qualification	CGPA	Skills	Total Experience	M Value
1	Dhilip Kumaran S	M	30	MCA	6	Java, C++	3	1
2	Kamaraj K	M	30	BE	7.5	Java, .NET, PHP	4.5	1
3	Ramya E	F	28	M.Sc	6.5	.Net, C, C++	7	1
4	Kirthiga M	F	24	M.Sc	8	.NET	7	1
5	Rajam L	F	26	BE	9	Perl, Pythan, C++	4	1
6	Gokul Raj D	M	25	BE	8	Pythan, Java	5	1
7	Aparna K	F	26	MCA	7	C++, Java	6	1
8	Arun N	M	26	BE	6.5	PHP, Perl	5	1
9	Sujitha S	F	27	MCA	8.5	Java, Perl, C++	5.5	1
10	Rubella Mary T	F	27	BE	8.5	Java, Perl, C++	4	1
11	Sabari A	M	28	MCA	9	C++, Java	4	1

6 System evaluation

EXPERT was evaluated using the real data downloaded from two different online portals http://www.amrood.com/resumelisting/listallresume.htm and http://www.iconjob.com/resume_search_by_location_in_india/ default1. asp (downloaded on 9 January 2013). iconjob.com provides the candidates' CV in the form of excel sheet for 228 candidates (Figure 6) and amrood.com provides the candidates resume in doc format (collected 250 CVs) (Figure 5).

We call iconjob.com CVs as CVSET1 and amrood.com CVs as CVSET2. We have assumed our own job criteria and evaluated our system using both the CV sets.

The attributes of CVSET1 is given in Table 4.

Figure 5 Screen shot of amrood.com CVs (see online version for colours)

Embedded Systems 3+ Years of Exp
Posted on : 18th Sep 12
Location: Others
Download Resume
Contact : Hadi Babaei, Ph. +989126798310
Send Email
To Download CV in DOC format
Description
Sorry no description is given - Check "Download Resume" option
Go back

Figure 6 Screenshot of iconjob.com CVs (see online version for colours)

Table 4 Attributes in CVSET1

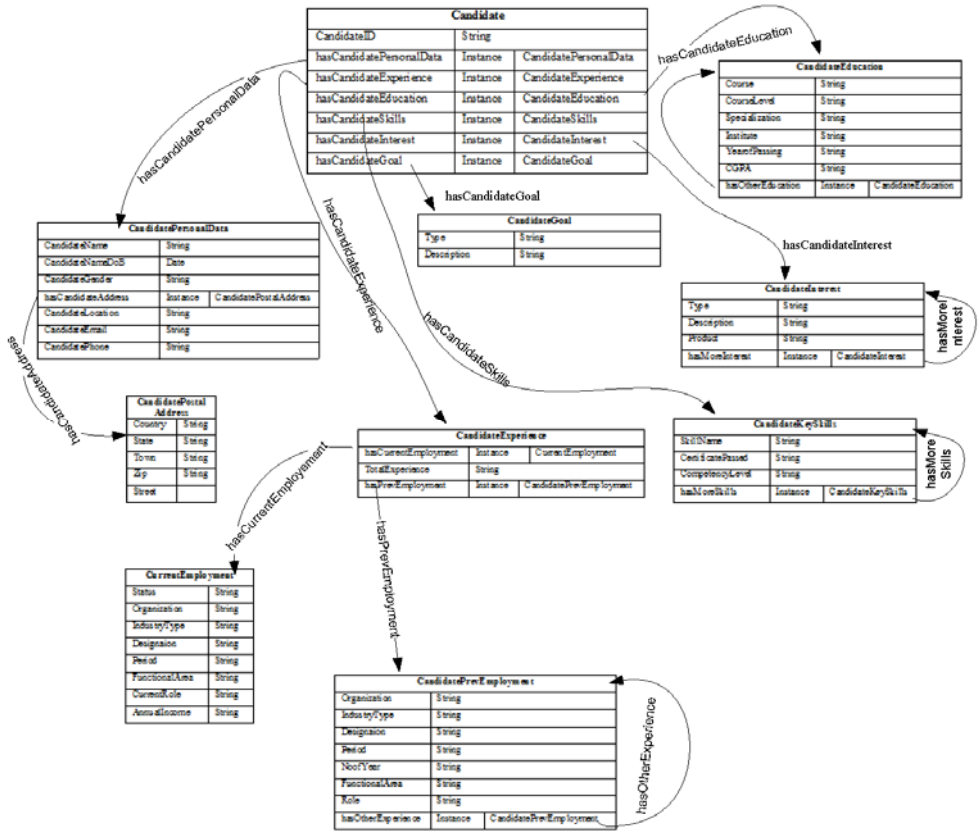
S.No.	*Attribute name*
1	Resume ID
2	Name
3	City
4	Title
5	Key Skill
6	EXP
7	Current Employer
8	Current Salary
9	Phone
10	Mobile
11	Email
12	Highest Education
13	Preferred Location
14	Address

We have generated the ontology for both CVSET1 and CVSET2. Ontology construction for CVSET1 is direct since it is already structured. We have constructed ontology for CVSET2 using concept linking method (Senthil Kumaran and Sankar, 2012). The schema for ontology constructed for CVSET2 is given in Figure 7. The EXPERT was implemented on both data sets and measured the recall, precision and F-measure to find the accuracy of EXPERT. These measures are given in Table 5. A high recall indicates that suitable candidates are not missed out and a high precision indicates that all returned candidates were relevant, and F-measure combines exactness (precision) and completeness (recall).

Table 5 Performance measures of EXPERT

	CVSET1	*CVSET2*
Recall	0.85	0.93
Precision	0.91	0.89
F-measure	0.82	0.87

Figure 7 Schema for candidate ontology



The CVSET1 does not have many attributes like qualification, CGPA, goals, interest, filed experience. Hence it gives less recall and F-measure than for CVSET2. In CVSET2, we extracted all information from the CV and hence it exhibits more recall, precision and F-measure.

7 Concluding remarks and future works

In this paper, we presented an intelligent tool for screening of candidates, EXPERT to screen candidates semantically with score value for the job requirement and evaluated using real data. This research focused on using ontology mapping in screening candidates' problem to recommend the best mapped candidate resumes suitable for the job requirement using similarity measurement. It will overcome the limitations of manual screening process. The application of our approach revealed that it is more efficient and accurate in screening the job applicants' CV and ranking them accordingly. The performance measure shows that EXPERT can screen the candidates with more than 90% accuracy.

The main future direction is to improve the mapping methods along with higher precision. Obtaining a precision higher than the earlier ones is a typical and an efficient result of any automatic ontology mapping system. In EXPERT, screening candidates for the particular job criteria is based on the CV data. In future, EXPERT will be extended to consider the candidates' participation in social network sites, contribution in technical forums, contribution in research, social activities of the candidates and Friend List. From the participation in social network sites, it is possible to find the social behaviour and personal characteristics of the candidate and from forum data and research contribution technical involvement of the candidate can be judged. There is a proverb 'tell about your friend I will tell about you'. To judge about the candidate we can find his friend whom he/she moves with.

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