Skill2vec: Machine Learning Approaches for Determining the Relevant Skill from Job Description

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Abstract — Un-supervise learned word embeddings have seen tremendous success in numerous Natural Language Processing (NLP) tasks in recent years. The main contribution of this paper is to develop a technique called Skill2vec, which applies machine learning techniques in recruitment to enhance the search strategy to find the candidates who possess the right skills. Skill2vec is a neural network architecture which inspired by Word2vec, developed by Mikolov et al. in 2013, to transform a skill to a new vector space. This vector space has the characteristics of calculation and present their relationship. We conducted an experiment using AB testing in a recruitment company to demonstrate the effectiveness of our approach.

Keyword — Word2vec, word embedding, neural network, talent management, recruitment, natural language processing, nlp.

I. Introduction

In the recruitment process, manually scanning the résumé or profile of a candidate takes a lot of time and efforts. Due to the limited of talent pool, and the experience of recruiters, automatic finding the right candidates becomes necessary. The relationship between different skills is the key ideas for enhancing the talent pool. For example, candidate who has OOP, and Python can possibly know Java. In the other hand, based on the different skill sets between job and candidates, we can provide the suitable training for employees effectively and efficiency. In NLP technique, Bag-of-Word (BoW) is a simple technique for present a word. In this model, a text is presented a bag of its words which disregarding grammar and even word order but keeping multiplicity. It is usually used in classification method where the frequency of occurrence of each word is used. However, using the frequency of words face many issues of common words like "a", "an", "the", "to", ... Term frequency - Inverse document frequency (tf-idf) can solve this issue. The idea of tf-idf is that a word is important if it happens many times in a document but not all documents. Cosine is a technique to find the similarity between vectors. In 2013, Mikolov⁵ developed a method, which called Word2vec to present word vectors. He proposed two models which are Continuous Bag-of-Words model, and Continuous Skip-gram model.

In this paper, we are trying to apply and develop a technique for the problem of automatically discovering the relationship between different skills from job post data. The job post data come from many hiring website like www.indeed.com, www.careerbuilder.com or www.dice.com. It contains millions of job posts with different formats. The rationale of our approach is to automatically parse the skills from the job posts and to bring them to train in neural network. To achieve this, we develop an approach, namely, Skill2vec, which is an artificial neural network technique⁶, inspired by Word2vec ideas. The output of Skill2vec constitutes a set of vectors, each of which is associated with a particular skill, in a new vector space. The new vector space allows the discovery of the relationship between skills by projecting the skills onto it. We conducted an experiment in a simple matching system which applied in a recruitment company to find out the effectiveness and efficiency of our approach using A-B testing.

II. Model Architecture

A. Pre-processing and feature engineering.

In Distributional Semantics² they are trying to find the meaning of a word based on the context of this word. The idea comes from the hypothesis: the words which have a similar context will have the similar meaning. In our problem, we propose the hypothesis that skills which are in the similar job post will be relevant. For example: "PHP" usually appears in the same context with "JS" and "CSS" and "JAVA" usually appears in the same context with "JS" and "CSS. Thus, "PHP" and "JAVA" can be relevant. In the other hand, if a candidate possesses "data science" skill, he/she will know "machine learning", "Python", or "R".
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With data from LinkedIn, we remove the irrelevant words and build a dictionary (Figure 2), then from other resources, we map the skills to this dictionary to build vectors in training data. Normally, a dictionary of words comes from the wordnet or other available resources. We built our dictionary by using data from LinkedIn. Moreover, parsing the un-structure text data from other recruitment website is a challenge. Thank to our dictionary, we are successful to parse the detail from job-description (Figure 3).
Table 1 Skills from Job description

| JD  | SKILL                        |
|-----|------------------------------|
| JD1 | Hadoop, Mapreduce, Java, Hive, SQL |
| JD2 | HTML5, CSS, PHP5, MySQL      |
| JD3 | HTML5, PHP5                  |
| JD4 | ......                        |

B. Training Model.

Skip-gram model in Word2vec has a better accuracy and performance than other models in semantic meaning of words. In this paper, for training the dataset, we use a neural network model with one hidden layer. The input and output data are presented by one-hot vectors (Figure 4). The purpose of this network is trying to predict other skills based on one input skill. Mapping between one-hot vectors to new vectors with higher dimensions through matrices $W_{VXN}$, $W'_{NXV}$ which present the distribution of skills with given input skill. Each row in matrix $W_{VXN}$ is presented as a skill vector. The distance between skills is calculated through Cosine distance.

The algorithm is described in the following steps:

a. Building the training dataset from job posts using one-hot vectors. For example:
b. Initialize the parameters: Choose the number of hidden nodes, and matrix. Using stochastic gradient descent method with the learning rate is equal to 0.01.

c. Parsing the input vector to hidden layer.

d. Calculate the error function and update the $W'$ and $W$ sequentially using Stochastic Gradient Descent.

e. Continue the process until meeting the global optimization.

III. Result

A. Performance.

We experiment with different baseline method: Latent Semantic Analysis (LSA) and Skill2vec model. The performance of Skill2vec model is significant better than LSA model (~300 times). The more data we train, the better result we have. The reason maybe from the sparsity of data, and LSA has to deal with a huge of computational from matrix, while Skill2vec is optimized from Gensim package (Python).

Table 2: Overall performance between LSA and Skill2vec

|                     | LSA                         | Skill2vec                   |
|---------------------|-----------------------------|-----------------------------|
| Data                | 1,438,906 job description; 113,256 skills |                             |
| Training time       | 14 hour 49 minute 17 second (53,357 second) | 2 minute 57 second (177 second) |

(*) Deployed parallel in the server with 110GB RAM, 32 cores

B. Result.
Using the AB testing based on the domain knowledge of recruiters, with seven jobs: Web Development, Software Development Engineer, Technical Program Manager, Senior Data Scientist, Sales Coordinators, Data Engineer, DevOps Engineer.

For each job, we have the list of skills required. Using the above model, we extract the relationship between skills. Using the domain knowledge from recruiters, 76% of top 10 most relevant skills is truly relevant with the original skills.

For Example:
- Top 5 skills relevant with HTML5 skill: CSS3 (0.926); UI (0.912); Bootstrap (0.912); Javascript (0.893); Web_tool (0.886).
- Top 5 skills relevant with Java skill: Core_Java (0.812); SOAP (0.776); Eclipse (0.752); Maven (0.750); Jboss (0.743).

IV. Conclusion

In this paper, we developed a relationship network between skills in recruitment domain by using the neural net inspired by Word2vec model. We observed that it is possible to train high quality word vectors using very simple model architectures due to lower cost of computation. Moreover, it is possible to compute very accurate high dimensional word vectors from a much larger dataset. Using Skip-gram architecture and an advanced technique for preprocessing data, the result seems to be impressive. The result of our work can contribute to building the matching system between candidates and job post. In the other hand, candidates can find the gap between the job post requirements and their ability, so they can find the suitable trainings.

V. Future work

After the initial version of this paper was written, we publish the Python code for pre-processing and building the Skill2vec model. We intend to build the ultimate matching system based on our result. Moreover, many directions can follow like: adding domain in training model, for example: Between Python, Java, and R, in Data Science domain, Python and R are more relevant than Java, however in Back End domain, Python and Java are more relevant than R.

VI. References

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Skill2vec: Phương pháp máy học cho việc xác định mối liên hệ giữa những kỹ năng nghề nghiệp

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Phương pháp học không giám sát trong mạng神经网络 embedding đã được phát triển rộng rãi trong xử lý ngôn ngữ tự nhiên với những năm gần đây. Bằng báo động góp một vòng dùng được gọi là Skill2vec, được áp dụng từ thuật toán máy học để tăng việc truy tìm những ứng viên tiềm năng trong ngành tuyển dụng. Skill2vec được phát triển từ mạng nơ ron, sử dụng mô hình Word2vec, được phát triển bởi Mikolov 2013. Đồng thời với việc này, công việc để rút trích được những kỹ năng phù hợp qua đó dùng mô hình Skip-Gram để tìm ra được mô hình quan hệ giữa các kỹ năng với nhau trong ngành tuyển dụng.