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USE OF LINKEDIN ENDORSEMENTS IN RECOMMENDER SYSTEMS

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Abstract

Social networks have become an important source of information, especially professional networks, where users share information about their academic and professional qualifications, skills and work experience. Nowadays, where the updating and development of professional skills is becoming more and more relevant for professionals, this information is of great interest, since it allows to know the trend of the labor market. In this regard, LinkedIn, in particular, has become one of the most widely used professional networks for this purpose, designed for professional networking and job search. From the professional profiles shared in this media, it is possible to retrieve relevant information for the labor sector, to know information about the professional profiles according to their competencies, as well as the most demanded competencies in the different job positions. This makes it possible to detect formation needs to improve or develop new skills. Additionally, LinkedIn has a particular element, the endorsements, through which it allows members of the network to acknowledge the skills of other members, which could provide information related to the level of development of a given skill. The analysis of this information, in addition to detecting training needs, can be used to adapt curricula to meet these needs, as well as in the field of human resources, to find the right candidates for the job. Currently, recommender systems have become a powerful tool for suggesting relevant articles to users. In the field of education, they have become very powerful, making it possible to link the training offer with the training needs of users, especially in the field of continuing education, in order to meet the need to develop professional skills. In a previous work, we have developed a recommendation system based on machine learning and ontology to recommend continuing education courses to LinkedIn users. As an extension of our work, we propose to incorporate the endorsement information to the user profiles to determine the improvement in the recommendations of our recommendation system. The results obtained showed an improvement in the recommendations, obtaining an accuracy of 94%.

Keywords: *LinkedIn, endorsements, recommendation systems, machine learning, ontology.*

1. Introduction

Nowadays, the use of Social Networks Sites (SNSs) has evolved in different fields, which has meant for users a means, par excellence, for interaction and communication in different areas of interest. They have become one of the main sources of information, generating a large amount of data, which once extracted, analyzed and treated, become an asset of great value in organizations. According to the work presented by (Urdaneta Ponte, Mendez Zorrilla and Oleagordia Ruiz 2022), organizations use social media in order to analyze their content and identify new opportunities.

Among the SNSs, the professional ones have positioned themselves in recent times. For (Urdaneta Ponte, Mendez Zorrilla and Oleagordia Ruiz 2022) these are used by different types of organizations to gather information on job positions, user profiles, identifying the most in-demand skills, labor market trends and adjusting academic programs. In this respect, (Wu, et. al., 2018) indicates that companies use this information in their recruitment processes to select the best candidates for their jobs.

According to (Wu, et. al., 2018), LinkedIn is considered to be the world's most important professional network, whose main objective is to match jobs with the right professionals. (Yan, et. al., 2019) and allows a user's skills to be endorsed by other users in the network.

The work presented by (Benkhedda, Azouaou and Abbar 2020) indicates that the data obtained from SNSs have become of great interest for the construction of user profiles used in applications such as personalized advertising and expert recommendation. Furthermore, it indicates that the analysis of SNSs and professional data has set a standard and, together with Recommender Systems (RS), can classify

profiles based on skills, endorsements or recommendations from colleagues, as well as analyze learning areas and provide possible corrections to study plans.

The RSs, which collect the information that links users to the articles and use it to make relevant and meaningful suggestions. According to (Bakhshinategh, et. al., 2017), RSs are based on the prediction of users' interests, on their explicit or implicit preferences.

For (Urdaneta Ponte, Mendez Zorrilla and Oleagordia Ruiz 2022), RSs manipulate a large amount of data that, due to the diversity of sources, such as the SNSs are characterized by their heterogeneity, so they make use of the semantic web to represent reality in a specific domain, in a way that is readable by machines. Additionally, they are combined with Machine Learning (ML) techniques, to exploit knowledge, update it and to infer new relationships between data. On the other hand, (Huang, et. al., 2019) indicates the use of ML as a means to study the relationship between SNSs entities. The combination of ontology-based recommender system with ML techniques has been used as an approach to improve the accuracy of recommendations.

Based on the above, it is proposed to use professional profile data extracted from LinkedIn, to build user profiles for a SR of Lifelong Learnig (LLL) courses, to develop and/or improve professional skills. An ontology is used to model employment sectors and knowledge areas to represent professional skills. The ontology is updated through events and using ML to group entities in order to make predictions about new data. An ontology is used to model employment sectors and knowledge areas to represent professional skills. The ontology is updated through events and using ML to group entities in order to make predictions about new data.

This article is structured as follows: Section 2 contains a review of related studies; Section 3 presents the SR proposal; Section 4 describes the evaluation of the proposal; and Section 5 presents conclusions and recommendations for future research.

2. Related studies

In accordance with (Obadă and Dabija 2022), the number of Internet users has grown significantly in recent years, with an estimated 4.62 billion active users of SNSs, which has generated the current information economy. To the extent that users of SNSs, the use of information shared in these media is used in different areas, generating great interest among researchers, due to the potential value of the information.

According to (Urdaneta Ponte, Méndez Zorrilla and Oleagordia Ruíz 2021) the use of SNSs has led many organizations to incorporate this new source of information in their selection processes, one of the most used being LinkedIn, where users share information in the labor field, such as employment, training and skills; characteristics to consider when proposing a learning itinerary to improve and/or develop professional competencies. For (Rapanta and Cantoni 2017) LinkedIn is the most influential web resource in terms of professional use, allowing members to endorse the skills of other members. Given this last feature of LinkedIn, some research has recently emerged around endorsements.

The research presented by (Yan, et. al., 2019) uses endorsements to measure the level of skills and thus estimate the expertise of LinkedIn members. The proposal of (Drakopoulos, et. al., 2020), uses endorsements to determine a user's skills and measure a candidate's reliability for startups. (Rapanta and Cantoni 2017) carries out an analysis on the reliability of endorsements, to identify the motivation behind LinkedIn usage behavior. The work of (Pérez-Rosés and Sebé 2017), uses endorsements to score a particular profile, according to the number and quality of these endorsements.
In the work proposed by (Constantinov, et. al., 2015), extract the skills from LinkedIn and determine their level according to the endorsements, and thus determine a set of competencies required by the market on which the curriculum should focus.

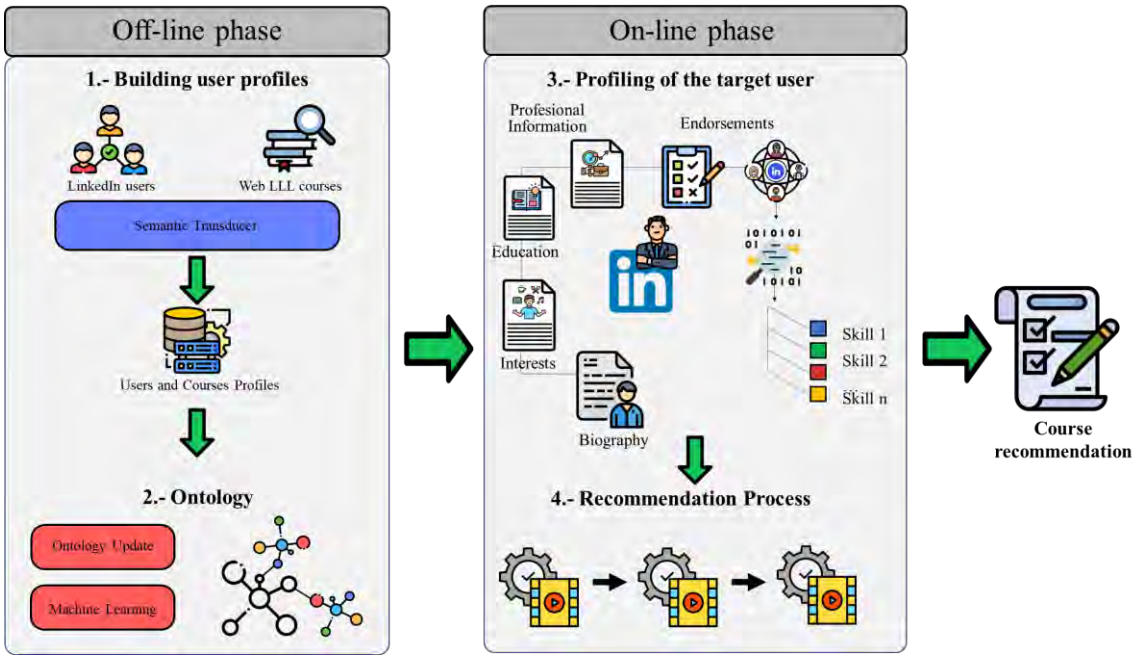
From this review, it is proposed to extract user profiles from LinkedIn to build user profiles for a semantic RS that recommends LLL courses to improve professional skills. The system will use the skills endorsements in order to validate the skills obtained in the user profile building stage to optimize the performance of the RS.

3. Material and methods

For the testing and evaluation of the proposal, data was extracted from LinkedIn professionals in software engineering. The information extracted for this purpose was: user ID, job title, location, summary, education, skills, interests, and endorsements. Similarly, information on LLL courses was retrieved from different websites.

The data, codified in the profiles, will be the input of the RS, which consists of multiple filtering techniques, and has as output an ordered list of LL courses for the improvement and/or development of the user's professional skills. Figure 1. shows the proposed processes for the SR.

Figure 1. Recommender System Processes.



The SR is executed in two phases, an off-line phase, consisting of the profile and ontology construction processes and the recommendation process, and an on-line phase, consisting of the target user profiling and the recommendation engine.

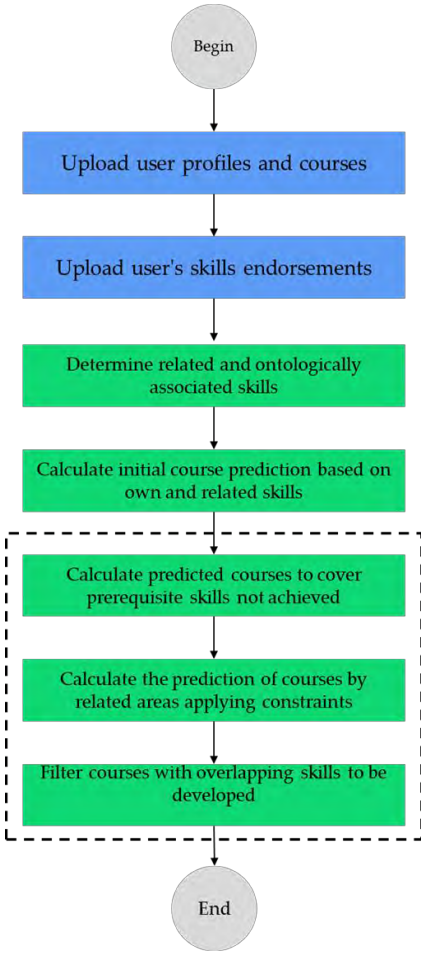
1.- Profile creation. Profiles are created using a semantic process based on ontology, making use of taxonomies, which were used to represent the areas of knowledge associated with skills, and employment information. For each user, the skills related to the work performance sector and position are stored, with their respective attributes. For course profiles, the skills to be developed. This made it possible to relate user information with course information.

2.- Ontology. The ontology is used to store the relationship between the positions and the areas of knowledge, which is given by the skills with attributes, as well as the number of times that this skill is present, the average level of specialization and its degree of updating. Clustering algorithms are used on the ontology to group similar positions, these groupings are based on the similarity of the skills associated with the positions, with the objective of inferring new information. This information can be used to determine the set of jobs related to a particular position, or a set of skills of a particular user.

3.- Profiling of the target user. The coding algorithms use heuristics that consider the relative frequency of the number of users that endorse the skill for the level of specialization and degree of updating for the user profile.

4.- Recommendation process. For the recommendation process, it is necessary to determine the user's skills to be improved. The process is implemented in three stages. The first stage corresponds to a semantic filtering to determine own, related, and ontological skills; a second filtering based on content, for the initial prediction of courses, and finally, filtering and sorting heuristics are applied for the final recommendation of LL courses for the improvement and/or development of professional skills based on a user's record.

Figure 2. General Recommendation Algorithm.



4. Results

In order to evaluate the SR, different metrics were calculated to measure the performance of the RS. Tests were performed for the different system configurations with the different data sets: training, test and total. The configurations are the result of combining the different similarity functions with the different clustering algorithms. The best results were obtained with the configuration using semantic filtering using rules to determine related job performance sectors and related skills (S1) and with the configuration using semantic filtering using DBSCAN clustering to determine related job performance sectors and semantic rules to determine related skills (S2). The results obtained are presented in Table 1, together with those obtained in our previous work (Urdaneta Ponte, Méndez Zorrilla and Oleagordia Ruíz 2021).

Table 1. Result of Evaluation Metrics of the Recommendation System.

Setting	Data	MAE	RMSE	Coverage	Precision	Recall	Novelty	Serendipity
S1	(Urdaneta Ponte, Méndez Zorrilla and Oleagordia Ruíz 2021)	0,25	4,44	0,91	0,83	0,82	0,46	0,07
	Author´s proposal	**0,24**	**4,14**	**0,91**	**0,85**	**0,82**	**0,46**	**0,07**
S2	(Urdaneta Ponte, Méndez Zorrilla and Oleagordia Ruíz 2021)	0,18	2,92	0,91	0,91	0,80	0,52	0,07
	Author´s proposal	**0,16**	**2,58**	**0,91**	**0,94**	**0,80**	**0,52**	**0,07**

5. Discussion and conclusions

SNSs sites provide significant information when building user profiles. Endorsements offer the possibility of determining their level of specialization.

When evaluating the incorporation of the endorsements in the creation of the user profiles, an improvement in the performance of the RS was observed in the configuration that makes use of the DBSCAN algorithm, improving the values of the root mean square error (RMSE) and mean absolute error (MAE), as well as in the metrics of precision, novelty, and coverage. With the incorporation of the endorsements, it was possible to obtain more information on the user profile, which made it possible to incorporate skills that were not evident in the data related to current employment, which were useful when refining the recommendation of courses.

Below are some guidelines for future work and further progress in this area:

Implement methods to determine the veracity of the endorsements.

In order to evaluate the behavior of the system for multiple domains, updating the ontology with new instances associated to new domains. As well as to evaluate the use of ontologies already built, new forms of representation of knowledge areas and occupational sectors of performance.

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