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A context-aware researcher recommendation system for university-industry collaboration on R&D projects

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ABSTRACT

University-industry collaboration plays an important role in the success of R&D projects. One of the main challenges of university-industry collaboration is the identification of suitable partners. Due to the information asymmetry problem, it is difficult for companies to identify researchers from universities for collaboration on their R&D projects. Various expert recommendation systems (e.g., question responder recommenders and co-author recommenders) have been proposed, but they fail to characterize companies' needs in identifying suitable researchers. This paper proposes a context-aware researcher recommendation system to encourage university-industry collaboration on industrial R&D projects. The system has two modules: an offline preparation module and an online recommendation module. In the offline preparation module, candidate researchers are identified in advance to improve the efficiency of the context-aware recommendation. In the online recommendation module, contextual information (i.e., R&D projects) is captured from a social network platform, and then, candidate researchers are recommended based on a contextual trust analysis model, which combines the expertise relevance, quality, and trust relations of researchers to profile and evaluate candidate researchers for the R&D project collaboration. An offline experiment and a user study are conducted to evaluate the effectiveness of the proposed recommendation system. The results show that the proposed method achieves better performance than the baseline methods.

1. Introduction

University-industry collaboration is very important for research and innovation in a knowledge-based society [9,22,23]. Local governments have designed various policies to encourage open innovation and university-industry collaboration [11]. With industries' pressing needs for frontier technologies, university-industry collaboration on industrial R&D projects is widespread in practice and is significantly valuable to both parties [21]. However, it is a challenging task for companies to select suitable researchers as collaboration partners from universities because of the information asymmetry problem. For example, companies find it difficult to search for research output from different sources in order to understand a researcher. With the high potential risk of R&D projects, the information asymmetry problem could also lead to mistrust between researchers and companies, which further hinders university-industry collaboration.

Prior research has explored the incentives to encourage university-industry collaboration [6,8,9,14,21,22], but this paper studies university-industry collaboration from the perspective of partner selection with the support of an expert recommendation system. Expert recommendation systems have been widely explored for various applications, including responder recommendation systems in online Q&A communities [34], expert finding systems for knowledge management in organizations [37], researcher recommendation systems for co-author seeking [30] and reviewer assignment systems for project management [29]. However, current expert recommendation systems can hardly meet the need of recommending researchers for industrial R&D projects. The aforementioned recommendation systems mainly analyze the expertise and social relations of the experts available for recommendation, but they lack capacity to profile companies' need for experts and identify researchers for R&D project collaboration.

In this paper, a context-aware recommendation system is proposed to recommend researchers for industrial R&D projects. The proposed context-aware recommendation system captures contextual information from a social network platform, and then, proactively recommends researchers to inspire university-industry collaboration. We adopt a hybrid recommendation strategy and design two modules for the system. The offline preparation module provides two candidate selection

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strategies and selects candidate researchers at the backend to improve the efficiency of the context-aware recommendation. The online recommendation module captures companies' contexts and identifies suitable researchers from the corresponding candidate sets. In this paper, three important aspects of researchers, i.e., expertise relevance, quality, and trust relations, are introduced to profile and analyze researchers as collaboration partners [6,21,22]. A contextual trust analysis model is proposed to combine the three aspects and evaluate the candidate researchers for recommendation.

An offline experiment and a user study are conducted to evaluate the effectiveness of the proposed recommendation method in comparison with the baseline methods, i.e., the content-based method, the social network-based method, and the sum method (defined in Section 4.3). The experiment results show that the proposed method achieves higher recommendation accuracy than the content-based method and the sum method, and it also performs better than the social network-based method in terms of recommending collaborators who have not collaborated with the companies in the past (i.e., new collaborators). Researchers suggested by the proposed recommendation system have higher relevance and quality values than that selected by companies without recommendation systems. In addition, the results of the user study show that the proposed method obtains a higher average rating than the baseline methods.

The remainder of this paper is organized as follows. Section 2 reviews related work in recommendation systems and university-industry collaboration. Section 3 presents the framework of the proposed recommendation system. Section 4 introduces the experiment design for evaluation with an offline experiment and a user study and Section 5 provides the results. The contributions and limitations of the research are summarized in Section 6.

2. Related work

This study designs a researcher recommendation system to promote university-industry collaboration. We review recommendation systems with a focus on expert recommendations, and investigate university-industry collaboration research to define the evaluation criteria for researcher recommendation.

2.1. Recommendation systems

Recommendation systems are widely used in online platforms to help users identify items of interest, e.g., products, courses, services, experts and so on [24]. Lu et al. made a comprehensive review of the applications of recommendation systems and the related techniques used in different application contexts [19]. In addition to recommendation systems for individual users (e.g., tourism service recommendation systems [1]), group recommendation systems are designed to recommend items for a group of users [35]. For expert recommendation systems, current recommendation methods can be classified into three types, i.e., content-based methods, collaborative filtering methods and hybrid methods.

Content-based (CB) methods employ text-mining techniques to extract keywords from associated documents (e.g., browsed articles and published articles) and use the extracted keywords as features to define the expertise of users [17,29,30,34]. The vector space model is widely used to profile the expertise of experts by a list of keywords with importance weights [29,34]. However, content-based methods usually suffer from a high calculation cost when there are enormous documents to be analyzed for profiling and the vector space is getting large.

Collaborative filtering (CF) methods construct a user-item rating matrix based on users' browsing, viewing, and searching behaviors [4]. Similar users are identified for recommendations according to their past behaviors instead of analyzing the content of the associated documents. With the wide use of social networks, social relations are employed in recommendation systems to ease the data sparsity problem [20]. Social network-based recommendation systems recommend users who have strong social relations (e.g., friendship and co-authorship) with the target user based on the assumption that users with social proximity have similar interests [7,28]. Liben-Nowell and Kleinberg conducted an experiment to compare several proximity measures in a co-author network, where Katz's approach performs best in co-authorship prediction [18]. However, one critical concern about CF and social network-based methods is that they could identify irrelevant experts in different domains.

Hybrid methods are proposed to make use of the advantages of content-based methods and collaborative filtering methods. Wang et al. proposed a new algorithm to identify suitable responders for unsolved questions in online Q&A communities [34]. The new algorithm combines content-based expertise analysis and social network-based authority analysis to make suggestions. Li et al. combined semantic similarity and social relations for recommendations to improve knowledge sharing in online forum communities [16]. A research analytical framework (RAF) was proposed to recommend researchers for project selection [29]. The RAF extends the content-based approach and social network approach with the extension of quality analysis, and it also has been applied for expert identification in scientific communities [30]. Previous hybrid methods mainly combine content-based methods and social network methods by using weighted aggregation techniques. In this paper, we use a hybrid recommendation strategy and propose a contextual trust analysis model for the context-aware researcher recommendation system.

2.2. University-industry collaboration

University-industry collaboration is a challenging topic not only academically but also practically. Universities are requested to transfer knowledge to local industries, and industries are under pressure to upgrade their technologies to become competent in global markets [10]. Current research focuses on the influence of university-industry collaboration [10,11], the motivations and incentives of researchers for collaboration with industries [8,14], collaboration channels and their differences [9], and factors that influence the collaboration engagement and collaboration performance [3,21].

This paper concentrates on the factors that influence the engagement and performance of university-industry collaboration, especially with a focus on researcher partner selection. Influence factors determine the possibility that a researcher could work with companies. De Fuentes and Dutrénit summarized the influence factors from multiple perspectives. They found that the characteristics of researchers (e.g., age, work experience, research fields and academia status) have an influence on their engagement with industries [9]. Perkmann et al. found that the researcher quality is an important factor that influences the involvement of industries in collaboration with researchers [21]. Perkmann et al. summarized the determinants of researchers in collaborating with industries from individual, organization and institution levels [22]. They found that researchers' productivity and success in academic articles and research projects positively affect their engagement with the industries. Success factors influence the collaboration performance, which in turn affect the collaborator selection of companies for future collaboration. Barnes et al. explored the success factors of university-industry collaboration and identified several important characteristics of collaboration partners, including trust, good personal relationships and collaborative experiences [3]. Prior collaboration experiences and trust can reduce the barriers of collaboration, e.g., differences in the orientation and conflicts over the intellectual property [6].

The research findings provide solid foundations to define the criteria for researcher recommendation, i.e., expertise relevance, quality and trust relations. In this paper, the expertise relevance of researchers to R&D projects is analyzed based on the domain of the projects and the expertise of the researchers. The quality of researchers is defined

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