Early-identification of Human Resource Trends and Innovations through Web-scraping Technology

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Abstract: The paper presents an innovation management approach within the human resources (HR) management area. The approach provides possibilities to search and scrape HR trends and the joint global evaluation of those trends by an expert community. We developed a platform that scrapes human resources websites and parses the documents based on pre-defined keywords to support the innovation management approach and to identify the innovations that are applicable to the HR domain. It is based on the analysis of term occurrence frequency change during a period. The evaluations of innovations are done by HR Process Owners and the global HR Expert Community. For project staffing, innovation-specific requirements are matched with employee skill profiles.

1 INTRODUCTION

Keeping up with state-of-the-art trends in the area of Human Resource (HR) management is important for several reasons. First, the reasonable use of innovations increases the efficiency of HR services operating within the company. Second, the use of modern technologies attracts potential employees who are at the edge of technology development, which is important for a company that pays significant attention to innovations.

The current innovation search process is centered around several experts who spend a significant part of their working time studying what is currently going on in the field, what technologies are in use, what trends take place, and what can be potentially used in the future (Figure 1, left part). The discovered trends a then discussed and a group of experts decides, which innovations can be potentially useful for the company and initiate corresponding projects. As one can see, all these processes (especially trend discovering that takes a significant working time) are currently manual.

The main research contribution of the paper is the novel automated innovation management approach that enables scraping and analysis of new HR trends as well as joint evaluation of the trends by an expert community. In the scope of the proposed approach, we seek ways to automate parts of the processes where human activity could be replaced through technology in order to focus more on value-creation along the process that cannot be taken over by technology. As a result, a platform has been built with the workflow shown in Figure 1 (right part). First, the platform analyses new articles in the pre-defined websites: it discovers new terms that currently gaining popularity. Then, the list of potential innovations is presented to an expert (a member of the HR Process Owner community) who can decide if they are really innovations or not. When a certain amount of innovations is collected or a certain time has passed, a group of experts is formed from the global HR Expert Community

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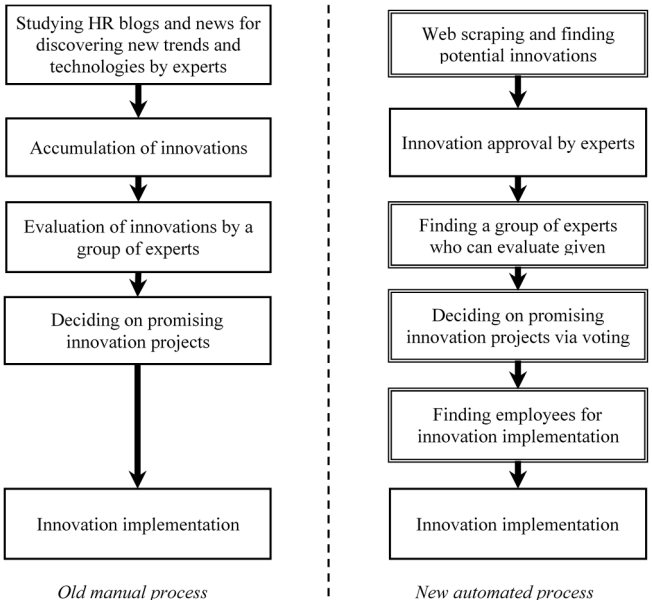

Figure 1: Current and proposed innovation management process (automated operations are indicated by the double border).

Such group is based on matching expert competencies against innovation descriptions. Experts evaluate discovered innovations and decide their priorities. In addition, every six months, a global community of HR Experts evaluates innovations by using the crowd-funding approach in order to identify local and global innovation requirements. The most promising innovations are implemented in pilot processes by teams, which are also found via skill matching. Once the innovations for pilot projects are selected, innovation-specific skill requirements are matched against a skill profile database of employees to find out who has the best skill for the pilot project.

Since the platform is based on the earlier described competence management platform (Petrov and Kashevnik 2018), the skill matching stages are not considered here in detail. All other steps are described below. The paper is structured as follows. First, the state of the art in the area of HR management is presented. Then, the innovation search and analysis approach is described. It is followed by the trend and innovation evaluation procedure. Section IV presents the implementation details and some platform interface examples. The main results and future work are discussed in the conclusion.

2 RELATED WORK

The human resources literature over the past 50 years has been reviewed by (Cascio and Boudreau 2016) to identify trends and analyze the evolution of human resource and talent management. They reviewed the history of international human resource management and talent management and identified key topics that were relevant at various times.

Discussion about the organization of the interaction between employees and management is described by (Černe, Batistič, and Kenda 2018). The paper also considers the use of human resource management systems to stimulate the generation of ideas and innovation. They describe various combinations of different styles and what consequences they will lead to.

The factors that influence individual and team creative ideas are investigated in (Amabile and Pratt 2016). According to their research, the generation and management of innovations are dynamic processes that are influenced by internal and external factors.

The impact of various parameters of human resource flexibility on the effectiveness of research and absorptive capacity of new knowledge is tested by (Martínez-Sánchez, Vicente-Oliva, and Pérez-Pérez 2020). Their findings point to the positive impact of outsourcing, training core employees, and applying innovation.

The impact of innovation and sustainable human resource management practices on customer satisfaction in hotels is investigated by (Wikhamn 2019). The paper shows how applying sustainable HR practices drives innovation and leads to positive results.

The role of big data in intuition-based human resource management is examined by (J. Kim et al.

2021). They analyzed data on baseball league clubs to determine which is more important in human resource management: intuition and experience or big data analysis. Their results show that big data reduces the bias associated with intuitive HR decision making. However, these benefits are diminished by making decisions based only on data analysis.

The factors that contribute to the transformation of innovative aspirations into real results are explored by (De Clercq, Thongpapanl, and Dimov 2011). Their results show that high levels of organizational autonomy, trust, and commitment strengthen the link between innovation and organizational performance.

The impact of artificial intelligence progress on the process of finding and managing innovation is studied by (Haefner et al. 2021). The authors conclude that the use of artificial intelligence helps to improve information processing and new trend detection.

The impact of digitalization on innovation organizations and their strategy is considered by (Niewöhner et al. 2020). They show that innovation organizations, culture, and strategy are influenced by the changes in world trends.

Principles that are specific to innovation organizations are discussed by (Solaimani, Haghighi Talab, and van der Rhee 2019). They declare that such organizations should have people and technical equipment involved in innovation processes.

The conditions required for the effective management of Big Data considered by (Caputo et al. 2020). Their results show that applying innovation and employing staff trained to manage innovation increases the profitability of companies in this area.

A flexible approach to project and innovation management is offered by (Brandl, Kagerer, and Reinhart 2018). It shows possible development options and tasks that need to be solved.

The presented literature review showed that the analysis of trends and existing practices for the search and generation of innovations in HR is a relevant topic (Cascio and Boudreau 2016). Human resource management systems should support the generation and implementation of ideas and innovations by employees and management (Černe, Batistič, and Kenda 2018). Stimulating creativity in innovation is facilitated by clear goal setting, explicit interest in innovation, the provision of resources, and a reasonable time frame (Amabile and Pratt 2016). The use of external sources of knowledge has a positive effect on the development and dissemination of knowledge in the organization (Martínez-Sánchez, Vicente-Oliva, and Pérez-Pérez 2020). However, innovation itself is not sufficient. The style and HR practices used should be focused on the search and application of innovations (Wikhamn 2019). Relying only on big data or intuition is not enough for resource management. A combination of approaches is more effective (J. Kim et al. 2021). To successfully implement innovations and get positive effects from them, structural and relational mechanisms for cross-functional exchange of ideas are required. Functional managers who are responsible for finding and applying innovations should have autonomy and trust from management in decision-making (De Clercq, Thongpapanl, and Dimov 2011). The development of information technology and digitalization affect the processes of searching and managing innovation and improves their efficiency (Haefner et al. 2021; Niewöhner et al. 2020). At the same time, it is important to be able to combine everyday processes and the development of new areas (Niewöhner et al. 2020). The use of technology and trained personnel to search for innovations should be one of the basic principles of a successful modern innovative organization (Caputo et al. 2020; Solaimani, Haghighi Talab, and van der Rhee 2019). Such technologies should show possible options and their requirements (Brandl, Kagerer, and Reinhart 2018).

3 INNOVATION MANAGEMENT APPROACH

In the paper, we proposed an approach to innovation management that is aimed at innovation identification in the HR area, the voting procedure of different experts, and the project creation based on the innovation.

3.1 HR Trend and Innovation Search and Analysis

The preliminary research on HR trend and innovation search and analysis has been reported in (Shilov and Teslia 2020). In accordance with its results, the innovation is characterized by (i) radical novelty relating the notion of emergence to a certain period of time, and (ii) relatively fast growth assuming that the attention paid to the innovation during the emergence period growth significantly (Rotolo, Hicks, and Martin 2015; Xu et al. 2019).

Finding innovations has been attracting the attention of researchers for a while. In 2001 an approach to emerging topic tracking via evaluation of the Proportional Document Frequency measure (TF*PDF) metric was proposed by (Bun and Ishizuka 2001). In the work presented by (K.-Y. Chen,

Luesukprasert, and Chou 2007) another metric called "Energy" was proposed that evaluates the "importance" of a topic over different periods. These two metrics have later been applied in different domains (Ma 2011; Nguyen, Byung-Joo Shin, and Seong Joon Yoo 2016).

Other approaches considered not only frequency of term appearance but also references to the analyzed documents (Y. Chen et al. 2013; Takahashi, Tomioka, and Yamanishi 2014; Wang 2018) and document clustering (Glänzel and Thijs 2012; Kasiviswanathan et al. 2011; Small, Boyack, and Klavans 2014). Whereas all the above techniques either apply certain thresholds to separate emerging or new topics or use the "Top N" approach, some works are aimed at the application of machine learning techniques to analyze the pre-computed metrics (D. Kim et al. 2019; Xu et al. 2019).

Unfortunately, the latter techniques are most applicable to significant innovations that form their own fields during few years, since the innovation has to be "invented" and proposed first, then noted by others and cited in their publications. For the topic to become noticeable, this cycle has to be repeated several times that would take some years. In the case of innovation search, this period is too long, so we will have to rely only on the former metrics (Shilov and Teslia 2020).

The methodology used was inspired by (Xu et al. 2019) and is shown in Figure 2. Firstly, the articles related to the HR topics are scraped from the Web. The relevance of the articles is evaluated by identifying proper sources by the HR experts. Usually, these are news sites and blogs related such as:

- HBR (http://hbr.org),
- Josh Bersin (http://joshbersin.com),
- Deloitte (https://www2.deloitte.com),
- HR Dive (https://www.hrdive.com),
- HR Morning (https://www.hrmorning.com),
- re:Work (https://rework.withgoogle.com),
- and etc.

Then, the tokenization procedure is applied, which selects "tokens" ("words") in the text based on the predefined rules. In this particular work, we eliminate all non-letter symbols (they are replaced with spaces) and identify single words, bi-grams, and tri-grams as tokens. As a result, for example, we can get such terms as "chatbot", "talent marketplace", or "novel coronavirus pandemic".

The resulting tokens are stemmed: the words are reduced to their base form, and the stopwords (words that are not significant for the analysis, such as articles ("a", "an", "the"), prepositions ("in", "on", etc.), conjunctions ("and", "or", etc.), pronouns ("we", "it", etc.) and other) are filtered out and removed.

The above procedures result in vectors of meaningful words for each article. After this, each token (word or sequence of two or three words) is considered as terms and a matrix is built, with rows being articles, columns being terms, and values being term occurrence numbers in the documents. This matrix accompanied by article metadata (such as publication date) is stored as an index.

As one can see even though the articles analyzed are scraped from thematic Websites, not all of them are related to HR innovations and a significant amount of terms can be found that are not interesting for innovation search (e.g., "novel coronavirus pandemic" mentioned above). To filter out the articles potentially related to innovations, the following two aspects are considered.

On the one hand, the article should be related to the appropriate current megatrends of the Gartner Hype Cycle (e.g., connectivity, neo-ecology, individualization). On the other hand, it has to be related to HR categories (e.g., strategy and planning, recruitment, talent management). The relationship of an article to a megatrend or a category is evaluated through the presence of keywords predefined by experts for each megatrend and category.

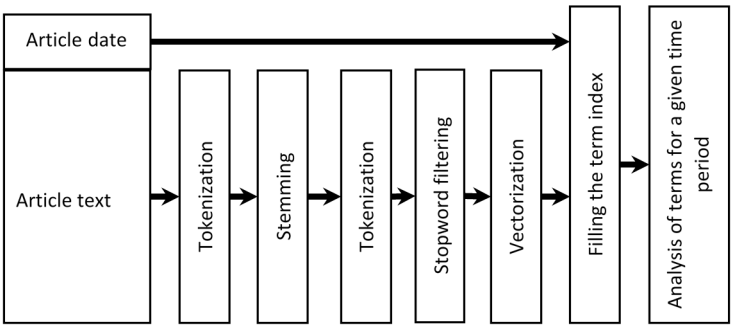

Figure 2: The methodology of searching for HR innovations.

Since the amount of articles is rather big and scraping and building an index is a time-consuming operation, it is done on a nightly basis. At the moment of paper writing, the database has information about 7000 articles, 1.2 million terms, and the index table has nearly 3.5 million entries.

When the index is built, the system can propose potential HR innovations and an expert can decide if the suggested term is innovation or not. For this purpose, the analysis of the dynamics of mentioning the term in the articles related to HR innovations (estimated via TF*PDF and Energy metrics) is done. Based on the innovation features (radical novelty and relatively fast growth) the dynamics of the mentioning of the innovation should be similar to one shown in Figure 3. One can see that before May 2019 this term almost had not been mentioned (corresponding to the "radical novelty" feature), however, after that its popularity has been growing up significantly (corresponding to the "fast growth" feature). Identified HR innovations are suggested by the system to experts.

3.2 Trend and Innovation Evaluation

An objective importance and impact evaluation of the trends and innovations is ensured through the involvement of a global HR Expert Community. HR Process Owner evaluates all innovations in the first step. In a second and global step, the whole HR Community votes on the top innovations. The set of selected innovations and experts determines the voting session, limited by the dates set by HR Process Owners (see Figure 4). All experts participating in the voting session have a virtual budget specified by the HR Process Owners. They should distribute it among the innovations selected for this session, according to their importance and impact.

It is considered that the more value the expert assigned to the innovation, the more important it is in her/his opinion. The final result is determined for each innovation selected for the session as the sum of all values determined by the experts participating in the session for this innovation. HR Process Owners can use these results to determine the importance and impact of innovation. An example of such results and how they are displayed is shown in Section IV.

Information about innovations is stored in innovation profiles. These profiles contain categories and trends to which innovations belong, the terms associated with them, and their impacts. Information about the categories and impacts of the innovations is displayed on the trend radar. An example of the trend radar is shown in Section IV.

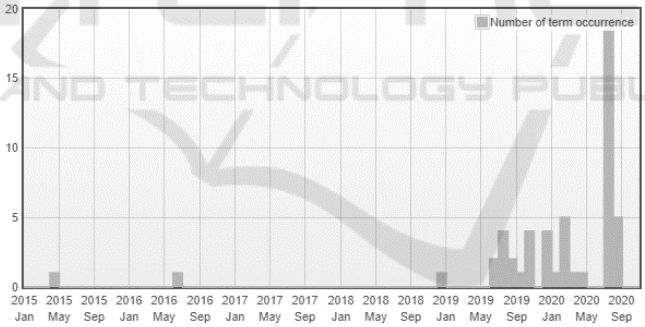

Figure 3: Dynamic of occurrence of the term "talent marketplace".

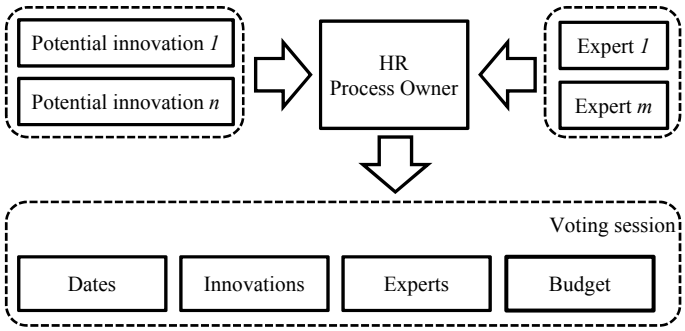

Figure 4: General scheme of trend and innovation evaluation.

Figure 5: Innovation search workflow and hot terms identification.

3.3 Innovation Project Staffing

To find the group experts that have enough competencies for innovation project estimation the (Petrov and Kashevnik 2018) method has been developed. The method allows finding the following group types: most effective, most experienced group, most available group. Based on the method HR process owner has the possibility to find an effective expert group to decide which innovation project should be started.

4 CASE STUDY

In this section, we consider the use of the platform by the innovation manager. The manager's goal is to search for innovations, identify the most important ones, and assign a project team to implement the selected innovations.

The innovation search is carried out on the basis of terms found in articles obtained from various sources. The most relevant recent terms (hot topics) are extracted fro m the articles as it is described in Section III (Subsection A). These terms are shown for each category (see Figure 5) and updated nightly. The manager can choose a category or subcategory by clicking on them. In this case, only terms that belong to the selected category or subcategory will be shown.

If information about the specific term is required, the manager can find it using an innovation search or by clicking on that term. If the expert has not found an innovation that he thinks needs to be added, he can add it by clicking the "Add" button. The innovations found and saved earlier are shown under the innovation search.

The manager can view statistics for any of the suggested hot topics or any found term (see Figure 6). The graphs and the table show the absolute and relative number of mentions of the term in the last few months. This statistic shows how often the term has been used in different periods (last 30 days, last 3 months, last year, or a number of occurrences for each month in the last 5 years), and shows the articles in which the term appears most frequently. The manager can use this information to become more familiar with the term and to understand how innovative it is. If the manager has decided that some term is innovation, he/she can create an innovation project (see Figure 7). The manager should fill the required fields and save the project. Some fields of the new project (such as name, associated terms, and due date) are filled in automatically and can be changed by the manager. The innovation project contains information about the innovation and associated terms, as well as its impact. In addition, experts can participate in the discussion of the project.

When several innovation projects have been created, an innovation voting session is started to decide which of them will be implemented. The manager can select innovation projects and experts to attend the session, and set a budget for the experts. After the voting session is over, the manager uses the voting results to identify the most important innovations. The manager can select the required session and see the distribution of votes for various

Figure 6: Term occurrence statistics in the HR documents (to identify its novelty).

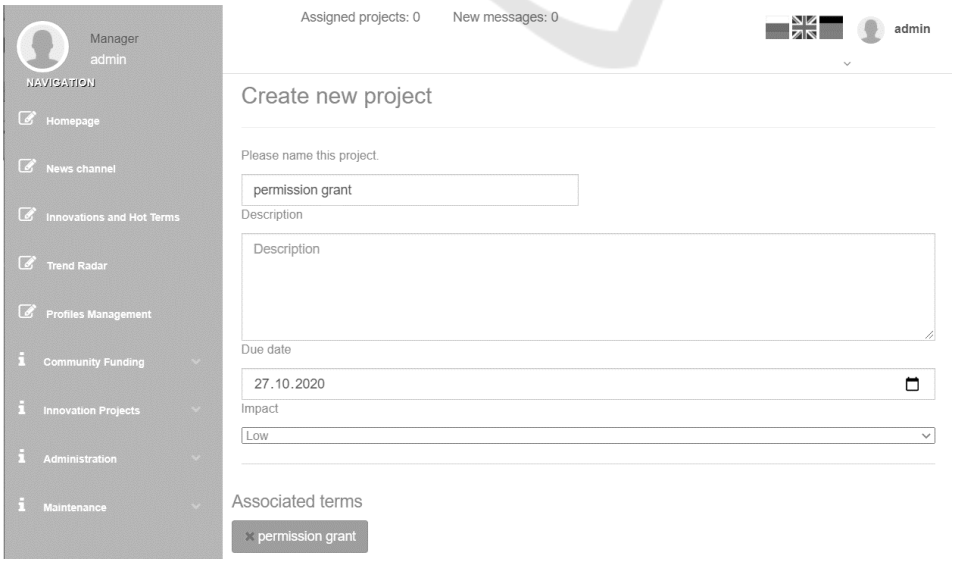

Figure 7: An innovation project creation workflow.

innovations in the form of a diagram or table (see Figure 8). The most important innovations in different categories are displayed on the trend radar (see Figure 9). The trend radar is divided into several sectors corresponding to different categories. Each sector contains innovations (in the form of points) that belong to the corresponding category. The greater the impact of an innovation, the closer it is to the center.

Trend radar is used to identify innovation projects to be implemented. The closer the project is to the center, the more important it is. Consequently, such projects are more likely to be selected. When an innovation project is selected for implementation, a project team must be assigned. For this purpose, the requirements for the competencies of team members should be determined. When the requirements are determined, experts who have the required competencies are automatically matched (see Figure 10).

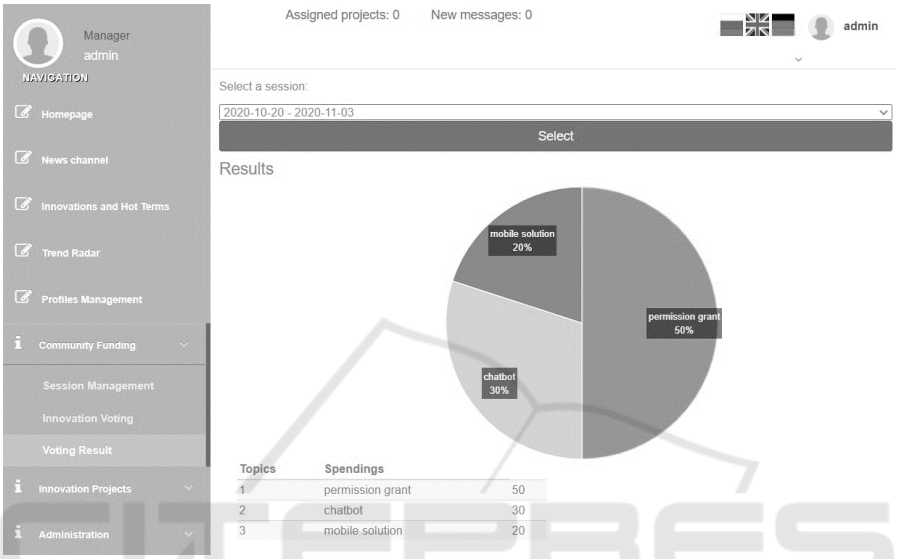

Figure 8: Innovations voting results.

Figure 9: The trend radar visualization.

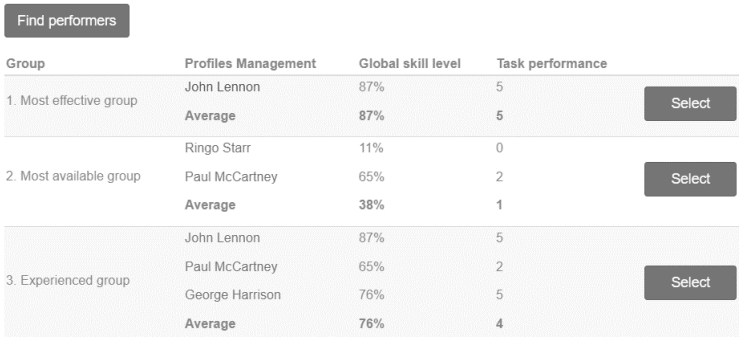

Figure 10: Innovation project performers search.

They are presented in the form of groups that managers can compare with each other and choose the most suitable for current goals. Each group contains information about its participants, their availability, and efficiency. Also, the manager can see the number of tasks performed by each participant at the moment in order to assess their workload.

The developed system has been evaluated for the HR department of Festo company. Several users integrated the system workflow into their everyday business processes. During the 5 month experience, the following results have been tracked:

- Manual effort of searching for interesting articles related to HR innovation topic has been decreased by 80%;
- The effort for reading, validating, and prioritizing innovation ideas has been decreased by 40%;
- The time of selecting relevant employees to innovation projects has been decreased by 90%;
- Actual HR trends database has been created in the company;
- HR trends and statistics are being used in the HR Quarterly Review;
- The global HR community is highly involved in evaluating and implementing pilot projects;
- The company has clear transparency of the HR Community skills and gaps in the skills.

5 CONCLUSION

The paper presents an approach and case study to HR trends and innovations identification through web-scraping technology. We propose the method for trend and innovation search that allows experts to analyze them. Then the workflow is proposed to implement the community voting for identification of the trend innovativeness. We identify the following assumptions: HR trends and innovations are always related to the appropriate current megatrends of the Gartner Hype Cycle and to HR Categories; the content of the crawled web sites is of high quality and consistent; the number of experts registered in the system is enough for voting and team formation. Also, we identify the following limitations for the developed system: found by the system HR trends and innovations strongly depend on the crawled documents and sometimes do not meet experts' expectations.

The approach has been developed in the scope of the joint research project with Festo SE & Co. KG. Our goal was to automate the company processes for trends and innovation search. The project was successfully implemented and evaluated by the HR department of Festo company.

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