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APPLICATION OF ARTIFICIAL INTELLIGENCE IN THE FORMATION OF A PROJECT TEAM IN THE FIELD OF AEROSPACE COMMUNICATIONS

The purpose of the study is to develop methodical support for team formation in aerospace projects. The use of modern information technologies will allow to automate the stages of selecting applicants for the team, to exclude the influence of the subjective factor. The article proposes a team formation method in aerospace communications projects. The process of selecting applicants, which takes into account the specifics of the industry, is considered, and the main stages of the method are defined. The developed method involves the use of artificial intelligence. Artificial intelligence tools are applied in the first step, machine learning is applied in the second step, while voice recognition algorithms and analysis are applied in the fourth and final step of the proposed method. The first step in this method involves an automated search for potential team members. In this part, the web application presented in this article searches several social networking websites such as LinkedIn and other websites where applicants can submit their resumes and communicate with other professionals and potential employees to find the best for determined by the criteria of candidates on the Internet. It also determines whether a candidate would hypothetically be interested in applying for a particular job. The second step consists of an automated test that will be distributed to all possible candidates through the app, the app will validate the tests and select candidates based on the automatic evaluation of the tests. In the third phase of the voice recognition interview, candidates will undergo a question and answer interview with the help of artificial intelligence. At the last, fourth stage of the method, which is called a live conversation, candidates are interviewed by company representatives. The peculiarities of the application of the proposed method were considered, and the prospects and limitations of its use were determined. The proposed methodical and instrumental support is of practical importance for the automation of applicant selection processes when forming a project team.

Key words: *artificial intelligence, team formation, project team, aerospace communications, algorithm.*

ЗАСТОСУВАННЯ ШТУЧНОГО ІНТЕЛЕКТУ ПРИ ФОРМУВАННІ ПРОЕКТНОЇ КОМАНДИ В ГАЛУЗІ АЕРОКОСМІЧНИХ КОМУНІКАЦІЙ

Метою дослідження є розробка методичного забезпечення формування команди в проєктах аерокосмічної галузі. Застосування сучасних інформаційних технологій дозволить автоматизувати етапи відбору претендентів у команду, виключити вплив суб'єктивного чиннику. В статті пропонується метод формування команди в проєктах аерокосмічних комунікацій. Розглянуто процес відбору претендентів, який враховує специфіку галузі, визначе-

но основні етапи методу. Розроблений метод передбачає використання штучного інтелекту. На першому етапі застосовуються інструментарій штучного інтелекту, машинне навчання застосовується на другому етапі, тоді як алгоритми розпізнавання голосу та аналіз застосовуються на четвертому та останньому кроці запропонованого методу. Перший крок у цьому методі передбачає автоматизований пошук потенційних членів команди. У цій частині веб-додаток, представлений у цій статті, здійснює пошук у кількох веб-сайтах соціальних мереж, таких як LinkedIn та інших веб-сайтах, де заявники можуть надсилати свої резюме та спілкуватися з іншими професіоналами та потенційними працівниками, щоб знайти найкращих за визначеними критеріями кандидатів в Інтернеті. Він також визначає, чи буде кандидат гіпотетично зацікавлений в тому, щоб претендувати на певну роботу. Другий крок складається з автоматизованого тесту, який розповсюджуватиметься всім можливим кандидатам через додаток, додаток перевірятиме тести та проводить відбір кандидатів на підставі автоматичного оцінювання тестів. На третьому етапі співбесіди з розпізнаванням голосу кандидати проходитимуть співбесіду із запитаннями та відповідями за допомогою штучного інтелекту. На останньому четвертому етапі методу, який називається живою розмовою, кандидати проходять співбесіду з представниками компанії. Розглянуто особливості застосування запропонованого методу та визначено перспективи та обмеження його використання. Запропоноване методичне та інструментальне забезпечення має практичне значення для автоматизації процесів відбору претендентів при формуванні команди проєктів.

Ключові слова: *штучний інтелект, формування команди, проектна команда, аерокосмічні комунікації, алгоритм.*

Introduction. Problem statement. The aerospace communications industry is known to have one the toughest requirements when it comes to forming a project team. The candidates, potential future teammates, have to undergo a thorough selection process which determines if they have the qualifications necessary to be a valuable part of the aerospace communications team. However, the method proposed in this article will not only determine the most qualified candidates to join such a team but also evaluate how well the candidates are expected to perform in a particular team based on the named team's dynamic.

As of now, team formation in the aerospace communications industry is a long and difficult process, conducted primary with the use of the hiring or the "main" company's resources. The novel method proposed in this paper will, however, analyze that the current methods used in team formation can be greatly improved and propose a new method using artificial intelligence and machine learning. The proposed method is expected to greatly decrease the use of human resources and time consumption.

Analysis of the latest research. The current method used in the industry is a combined model to explore individual attributes, relational attributes, and previous structural ties as determinants of work partner choice [1]. In the current method of selecting team members, based on the data collected in [1], the selection process is based on a combination of individual and relationship traits. On the one hand, being in the same group, which is considered a structural trait, did not influence future work group member decisions much. Working with a person, which is referred to as a relational attribute, in the same group, considered a structural attribute, on the other hand, was a substantial predictor of future work group member preferences. In that sector, structural qualities appear to be essential to the extent that individuals are forced together and given the opportunity to establish stronger relationships. However, the current method as described in [2] does not include a fully automated team formation method which is proposed in this paper.

It is important to touch base on the different requirements for team formation specifically for aerospace communications. Artificial intelligence can be of great use in the process to save time and resources.

An example of formula design and explanation of its components:

$$x_{\text{opt}} = \mathbf{z}^{\text{t}}\mathbf{A}\mathbf{z} + \varepsilon, \tag{1}$$

where x_{opt} – clarification 1 (variable, denoted by a Latin letter, – italics; the abbreviation of the English word is used as an index – regular font);

$\mathbf{z}$ – clarification 2 (vector – bold; the superscript t denotes the transposition operation, that is, the abbreviation written in Latin letters);

$\mathbf{A}$ – clarification 3 (matrix – bold);

ε – clarification 4 (variable denoted by a lowercase Greek letter – italic).

Building a successful team entails more than just identifying expertise; it entails assembling a group of individuals who play various but complementary roles. Team members offer diverse experience, information, and social connections to the team, which benefits the team; nonetheless, persons must have a certain amount of overlapping knowledge and viewpoints to operate well together. If you bring together a group of specialists from various disciplines, but their perspectives are so far apart that they can't even discuss the topic due to different language or point of view, it will be difficult for them to establish common ground. On the other hand, bringing together a group of specialists who all agree with each other and have the same abilities and expertise might damage diversity of opinion and the capacity to confront unknown difficulties.

This research analyzes the origins and performance consequences of shared versus diversified information

using a unique data set of observed email content from 1382 executive recruitment teams and extensive accounting data on their productivity. A striking inverted-U shaped association is discovered between mutual information and team productivity. A large level of information overlap among team members is connected with improved performance, but extremes of too little or too much mutual information are detrimental to performance. The data shows that geographic dispersion and social network distance are important predictors of mutual knowledge failures in the data, although demographic dissimilarity and organizational distance do not.

We constrain ω such that in order to reflect the tradeoff between variety and mutual knowledge and to limit the values of the parameter that adjusts for their relative relevance across work settings,

$$0 < \omega < \frac{\pi\angle}{2}, \tag{2}$$

$$\text{Performance} = \kappa * \text{Cos}(\omega\angle) * \text{Sin}(\omega\angle) \tag{3}$$

The cosine term captures the advantage of mutual knowledge and scales it by a parameter ω that reflects how relevant mutual knowledge or information diversity is to team performance in a specific work context. The diversification advantage is reflected by the sine term and scaled by the same parameter. As grows, so does the importance of knowledge diversity in determining team effectiveness. Conversely, as declines, the importance of mutual knowledge for team success grows [3]. Based on the formulas above, the graph below, and the data provided in [1], the hypothesis is that when teams have too little information overlap, communication and cooperation are difficult, but when teams have too much mutual information, team members' contributions become redundant, diminishing problem solving efficiency and productivity.

The parameter κ simply measures the size of the influence of either information diversity or mutual knowledge on team performance to account for the likelihood that information distribution among team members is more relevant in certain settings than in others.

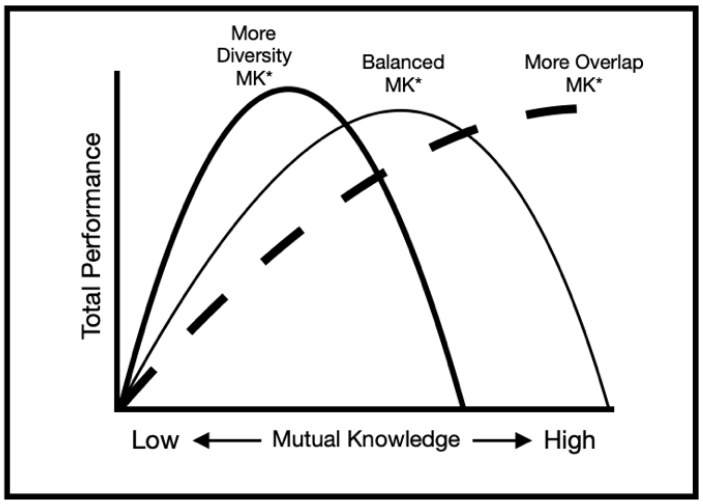

Fig. 1. An inverted U-shaped connection demonstrates the value of mutual knowledge in team effectiveness

Figure 1 graph depicts the composite advantages of (information overlap) * (information diversity), which are characterized as Cos[<]*Sin[<] for the angle between knowledge profiles. This type of connection suggests optimal information overlap in teams (MK*), in which best performing teams have neither too little nor too much mutual information among team members [4]. The appropriate degree of knowledge overlap in teams may vary depending on the work setting. The ideal information overlap (MK*) shifts to the left as the relevance of information variety for team performance grows (rising), showing that higher diversity is better. The optimal information overlap (MK*) moves to the right as the importance of mutual information for team performance increases (decreases), implying that greater mutual knowledge is beneficial. These many settings illustrate the link between mutual knowledge and team performance in typical team situations such as innovation teams, regular operations and production teams, and so on [5]. From this figure it can be seen that information diversity may be more significant for teams whose success is linked to creativity and invention, whereas mutual knowledge may be more important for teams whose performance is linked to effective exploitation of known organizational processes or tasks.

Search expansion. Expanding the potential aerospace communications team members to the international

market can be challenging when done manually but becomes possible while utilizing the artificial intelligence method described in this paper. Based on the evidence provided in [6], such international market search expansion can be very useful and even contribute to better team bonding in the future projects of an aerospace company. An experiment in team capstone design education conducted in [6] that began with the addition of engineering freshmen to standard senior design groups has grown to include freshmen, sophomores, juniors, and seniors in a big, interdisciplinary design team. The project has been expanded to incorporate an international design experience, with American design students collaborating with counterparts from European schools. This interdisciplinary, worldwide design approach has resulted in a useful experience for its participants, who are considerably more equipped for today's team environment in industry and for global aerospace programs.

Article purpose. All the above aspects of the search for the most suitable team members can be significantly improved by applying the described below method of artificial intelligence.

Step 1: Automated potential team members' search. In this step, a web-based application proposed in this paper's method finds the most suitable candidates online by searching different social media websites such as LinkedIn and other websites where candidates can post their resumes and interact with other professionals and prospective employees. As this method implements machine learning, every time this method is applied in the search, the web-based application learns how to conduct the search better using AI [7]. For example, in the first round of applying this method, the proposed application would search the future team members based only on their resumes, education, and work experience, posted on the Internet. However, in the second round, the application would not only do that, but also analyze the potential team member interactions on social media such as LinkedIn and other websites, thus helping determine if the communication style of the candidate is suitable for the team. As mentioned prior, work qualifications are not the only things that matter how a person would fit in a particular team matters as well. The proposed artificial intelligence method hopes to expand on that and find the most suitable candidates all around.

Future team member interest. The next point of interest in the proposed method is to determine whether a potential candidate is interested in the job. There could be some caveats here, but since the application does not use human resources to conduct this process, it can be run in the background without requiring any attention from the current company stuff. Thus, if after searching the Internet, the application finds a number of candidates, for instance one hundred people, who the application believes can be a good fit for the job indicated, the application will then attempt to predict if the candidate would be interested in applying for and acquiring the said job. If the application determines that yes, the candidate would be interested, the application will then reach out to the candidate with the job details and ask the candidate to complete a fifteen-to-thirty-minute test which can be completed remotely.

Step 2: Automated test. The proposed test may be developed by both artificial intelligence and humans, albeit it is recommended that the test be monitored in the first few rounds of testing the application for a specific company. The test would be given to all potential candidates via the application and, after the applicants answer the test's questions, the application would then review the tests in order to determine which candidates passed the test and which did not. The passing of the test would be determined on a percentage scale as further discussed in Fig. 2. The first priority would be given to candidates who scored in the top 10^{th} percentile; for those candidates who scored in the $85\text{-}90^{th}$ percentile, a shorter second test would be given. Those who score in the top 5^{th} percentile on the second test would be given the second priority level and will also move up to the next team building round.

An example of automated testing was applied in high school students where after a series of tests, the application system recommended which high school students should be accepted to which university [6]. This example shows a hybrid neural network and decision tree classifier model that acts as the foundation for a university entrance recommender system. In addition to the high forecast accuracy rate, the system's flexibility allows it to anticipate potential universities that match the students' profiles as well as relevant techniques via which the students should enter. Based on the students' histories, the recommender may be extended to make other types of predictions.

Based on the instance above, automated testing with artificial intelligence analysis can be applied while searching for the best candidates in the aerospace communications industry. As seen in Fig. 2, the testing process can be fully automated with the help of the application proposed in this paper. From a pool of potential candidate, the application would estimate what score would each candidate get on this future test based on each candidate's history. Such history can include but is not limited to: education, work experience, volunteer experience, previous employers reviews, indicated candidate's interests. This extra step is needed so that the application could, in the future, conduct a more optimal search in the first step of this proposed method [8].

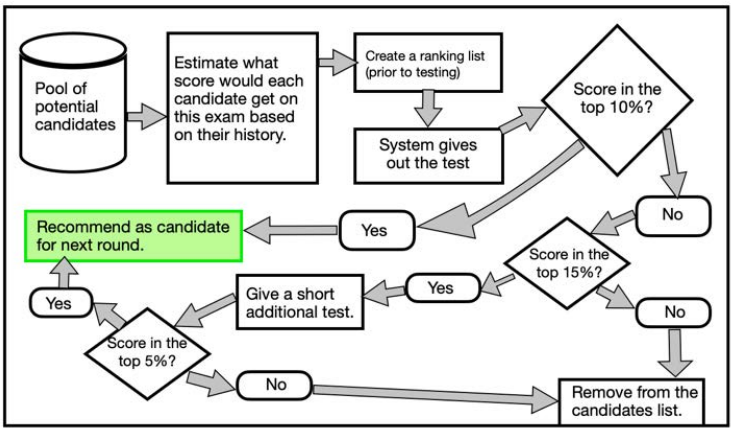

Fig. 2. The passing of the automated test algorithm

Test grading. The newly proposed method would create a ranking list that would rank all candidates right away, even before giving out the test. Short after that, however, the test is given out to candidates; this process is fully automated with humans only monitoring the process in the early versions of the application. Depending on the individuals scores, they can either move up in the team formation process, be disqualified from the process, or get a second chance on another, shorter, test. The percentages of correct answers are what gives the people their scores. The second chance test is given out as another opportunity to make sure every candidate is being vetted thoroughly and no excellent candidates are missed by the application. It is worth noting that because of the automatic nature of this test, there would be no discrimination and no human factors, as there are no humans involved in the test except for the actual candidates attempting to pass the test.

Step 3. Voice recognition interview. This method proposes using artificial intelligence to collect data and analyze it in order to increase the speed of the team building process, decrease the use of human and financial resources, and to avoid discrimination. However, question answering (QA) is perhaps one of the most difficult jobs in natural language processing. It necessitates search engines capable of retrieving succinct, precise text fragments containing an answer to a question provided by the user. The addition of voice interfaces to QA systems gives these systems a more natural and engaging perspective [9].

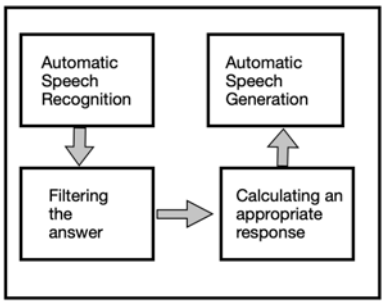

Fig. 3. Process of the proposed question-answer system

As described in Fig. 3, the proposed question-answer system would have 4 main steps. The first step would be the speech recognition. The application would determine if the candidate actually answered the given question. In the second step, the application will research options on what to say next [10]. Thus, it will compare the answer given by a candidate with a few most suitable options of what to say back. In the third step, the application would calculate an appropriate response by deciding which answer option is most appropriate to say. In the fourth and final step, the application will produce the response out loud, thus concluding the cycle of generating a reply. In Fig. 3, the system tries to answer a spoken question correctly by first filtering out the many possible ill-formed questions from the word lattice, and if that fails, it performs lexical and semantic alternations on the remaining questions in the reduced word lattice. If the solution cannot be identified by employing keyword variations, the questions will be answered using an interactive Questions & Answer approach [9].

Step 4. Live conversation. In-person or online in real time final interview. In the final fourth step of the method called a live conversation, the candidates would be interviews by humans with the assistance of the

application. Even though this interview is conducted by a real person, its audio and video are recorded by the application and analyzed at a later time so that the application can learn how to conduct the interviews and, in the future, even the fourth step can be conducted by the application. The fact that step 4 is the only step in this application life cycle requiring human intervention significantly saves human time and resources. With the hope of automating even the fourth step in the future as more versions of the proposed application come out, humans in the team building aerospace communications company will only need to supervise the process.

Conclusions. Discussion. The novel method proposed in this paper analyzed that the current methods used in team formation can be greatly improved and proposed a new method using artificial intelligence and machine learning. The results confirm that the method proposed in this article will not only determine the most qualified candidates to join such a team but also evaluate how well the candidates are expected to perform in a particular team based on the named team's dynamic. The method's initial stage involves searching several social media networks for the most qualified persons online. The second phase is administering an automated test to all potential candidates via the application, and after the applicants answer the test's questions, the application examines the tests to determine who passed and who did not. Candidates would go through an artificial intelligence question-answer discussion in the third phase of a voice recognition interview, which would be totally automated by the application presented in this research. The applicants would be interviewed by humans with the aid of the application in the last part of the procedure, known as a live conversation. The conclusions about the usability and benefits of this method have been made, based on saving human and financial resources. The hope is that in the future versions of the application, all steps will be done with artificial intelligence with minimum human intervention.

Bibliography:

1. Арал, Сінан і Бриньольфссон, Ерік і Ван Алстайн, Маршалл В., Передумови та наслідки взаємного знання в командах (10 листопада 2008 р.), http://dx.doi.org/10.2139/ssrn.1299260.

2. Організаційна поведінка та процеси прийняття людських рішень Том. 81, № 2, березень, стор. 226–251, 2000 doi:10.1006/obhd.1999.2875, https://www.heinz.cmu.edu/faculty-research/profiles/krackhardt-davidm/_files/2000-choosing-workgroup-members.pdf.

3. Асатурян, Гарен; Марамот, Кінгслі; Рейес, Діана Мехія; Сейф, Джавад. Проблема формування мультидисциплінарної команди для проектів в аерокосмічній промисловості. Щорічна конференція MIO. провадження; Норкрос (2021): 914-919. https://www.proquest.com/openview/defde9ceabafbcc9e124a5d00b84134a/1?pq-origsite=gscholar&cbl=51908

4. Раченко Ю., Доценко Н. (січень 2021). «Використання комп'ютеризованої системи для визначення більшості Відповідні професійні навички для аерокосмічної промисловості». 6-а Міжнародна науково-практична конференція; Бостон, США, BoScience Publisher, pp. 69-72, https://sci-conf.com.ua/wpcontent/uploads/2021/01/FUNDAMENTAL-AND-APPLIED-RESEARCH-IN-THE-MODERN-WORLD-20 -22 січня 2021.pdf

5. Oihab Allal-Chérif, Alba Yela Aránega, Rafael Castaño Sánchez, Intelligent recruitment: How to identify, select, and retain talents from around the world using artificial intelligence, Technological Forecasting and Social Change, Том 169, 2021, 120822, ISSN 0040 -1625, https://doi.org/10.1016/j.techfore.2021.120822.

6. Саймон Фонг і Роберт П. Б'юк-Агай. Автоматизований консультант щодо вступу до університету Система для учнів середньої школи. 6-та Міжнародна конференція з інформаційних технологій та додатків (ICITA 2009).

7. Юрій Кубрак, Дмитро Плечистий, Ігор Толстой. Формування комплексної системи моніторингу сучасних БПЛА на базі штучного інтелекту. Наукові праці Кременчуцького національного університету імені Михайла Остроградського. Кременчук: КРНУ, 2022. Випуск 2(133), https://doi.org/10.32782/1995-0519.2022.2.5.

8. П. Россо, Л. -Ф. Хуртадо, Е. Сегарра та Е. Санчіс, «Про голосові відповіді на запитання», у IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews), vol. 42, вип. 1, стор. 75-85, січень 2012 р., doi: 10.1109/TSMCC.2010.2089620, https://ieeexplore.ieee.org/abstract/document/5672612.

9. Раченко Єлизавета. «Чи варто нам використовувати штучний інтелект для найму співробітників в аерокосмічній галузі». VII Міжнародна науково-практична конференція. Велика Британія, Лондон. 2021. https://scholar.google.com/scholar?hl=en&as_sdt=0,5&cluster=4148719248741376041

10. С. Харабагіу, Д. Молдован, Я. Піконе. Відповіді на запитання з голосовою активацією відкритого домену. Матеріали 19-ї міжнародної конференції з комп'ютерної лінгвістики, том 1, серпень 2002 р., сторінки 1–7 https://doi.org/10.3115/1072228.10723

References:

1. Aral, Sinan and Brynjolfsson, Erik and Van Alstyne, Marshall W., Antecedents and Consequences of Mutual Knowledge in Teams (November, 10 2008), http://dx.doi.org/10.2139/ssrn.1299260.

2. Organizational Behavior and Human Decision Processes Vol. 81, No. 2, March, pp. 226–251, 2000 doi:10.1006/obhd.1999.2875, https://www.heinz.cmu.edu/faculty-research/profiles/krackhardt-davidm/_files/2000-choosing-workgroup-members.pdf.

3. Asatourian, Garen; Maramot, Kingsley; Reyes, Diana Mejia; Seif, Javad. A Multidisciplinary Team Formation Problem for Projects in the Aerospace Industry. IIE Annual Conference. Proceedings; Norcross (2021): 914-919. https://www.proquest.com/openview/defde9ceabafbcc9e124a5d00b84134a/1?pq-origsite=gscholar&cbl=51908

4. Rachenko, Y., Dotsenko N. (January 2021). “Using a Computerized System to Determine the Most Suitable Job Skills for Aerospace Industry.” 6th International Scientific and Practical Conference; Boston, USA, BoScience Publisher, pp. 69-72, https://sci-conf.com.ua/wpcontent/uploads/2021/01/FUNDAMENTAL-AND-APPLIED-RESEARCH-IN-THE-MODERN-WORLD-20-22jan2021.pdf

5. Oihab Allal-Chérif, Alba Yela Aránega, Rafael Castaño Sánchez, Intelligent recruitment: How to identify, select, and retain talents from around the world using artificial intelligence, Technological Forecasting and Social Change, Volume 169, 2021, 120822, ISSN 0040-1625, https://doi.org/10.1016/j.techfore.2021.120822.

6. Simon Fong and Robert P. Biuk-Aghai. An Automated University Admission Recommender System for Secondary School Students. The 6th International Conference on Information Technology and Applications (ICITA 2009).

7. Yuri Kubrak, Dmytro Plechystyy, Ihor Tolstoi. Formation Of A Complex System For Monitoring Modern Uavs Based On Artificial Intelligence. Transactions Of Kremenchuk Mykhailo Ostrohradskyi National University. – Kremenchuk: KRNU, 2022. – Issue 2(133), https://doi.org/10.32782/1995-0519.2022.2.5.

8. P. Rosso, L. -F. Hurtado, E. Segarra and E. Sanchis, "On the Voice-Activated Question Answering," in IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews), vol. 42, no. 1, pp. 75-85, Jan. 2012, doi: 10.1109/TSMCC.2010.2089620, https://ieeexplore.ieee.org/abstract/document/5672612.

9. Rachenko, Yelyzaveta. "Should we use artificial intelligence to recruit employees in the aerospace industry." VII International Scientific and Practical Conference. United Kingdom, London. 2021. https://scholar.google.com/scholar?hl=en&as_sdt=0,5&cluster=4148719248741376041

10. S. Harabagiu, D. Moldovan, J. Picone. Open-Domain Voice-Activated Question Answering. Proceedings of the 19th international conference on Computational linguistics, Volume 1, August 2002, Pages 1–7 https://doi.org/10.3115/1072228.1072397.