



DEVELOPMENT OF AN AI-BASED INTERVIEW SYSTEM FOR REMOTE HIRING

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ABSTRACT

Recently applicant information services and interview-assistance services based on big data and AI technology are distributed rapidly worldwide to introduce an interview system that secures efficiency and fairness in the job interview market. Accordingly, this study presents an AI-based interview system developed based on deep-learning technology in which more than 100,000 evaluation data sets were derived from 400,000 interview image data sets. The resulting AI interview system has been applied to enterprises with a reliability of 0.88 Pearson score. Particularly, applying this system to 5 major public enterprises in Korea is presented in this paper. It turned out that the level of satisfaction with fairness and efficiency was as high as 85% in such aspects as evaluation processes, job fitness, and organization fitness. As the applicable range of AI-based solutions is expanding to the general area of personnel management with its time and cost efficiency, as well as reliability and fairness recognized, the deep learning-based job interview solution proposed by the present study needs to be applied widely to written examinations and personality and aptitude tests.

Key words: AI-based interview, AI interview system, Remote hiring, AI-based solution, Big data

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1. INTRODUCTION

As the 4th Industrial Revolution proceeds and society changes rapidly, talented individuals' importance is more emphasized than before. The growth and success of a society, organization, or enterprise depend on developing and securing talented individuals [1,2]. Enterprises' program of securing talented employees is an essential HR move compared to any other

employment step. The employment system aims to recruit and select talented human resources and assign them to a proper position according to reasonable and just procedures. For an enterprise to secure outstanding human resources, it is necessary to plan and manage how to select them and designate them to the appropriate department [3,4]. The primary step for employment is to select optimal individuals through such screenings as an examination. Interviews are also vital to evaluating individuals' capabilities, including document-based interviews, person-to-person interviews, and debate-based interviews [4].

Recently, applicant information services and interview-assistance services based on big data and AI technology have been distributed rapidly globally to introduce an interview system that secures efficiency and fairness in the job interview market. Mercer, a human resource consulting enterprise in the U.S., conducted a survey in 2018 among 7,300 business leaders and chief personnel managers of global enterprises. The survey results show that 36% of the participant enterprises used AI in the employment process to determine applicants' potential to show superior performance and remain in the enterprise longer [5].

In addition, AI-based employment platforms are widely distributed among many countries such as the U.S., Japan, and China. Each applicant takes various tests in a game form through the dedicated mobile app downloaded online. For applicants who agree to save their competency profiles, information on their job fitness, and information on enterprises and jobs they apply for, the recruiting enterprise accesses the database and conducts the interviews and employment process. Big data are utilized to analyze why the applicant chose an enterprise against competitors [6,7]. The percentage of enterprises using big data for this purpose has increased from 15% in 2018 to 25% in 2019. Particularly in the area of employment, AI is utilized actively. Such factors as job fitness, the possibility of advancement, fitness to organizational cultures, leaving the enterprise, and acceptability to changes are analyzed based on the collected information and referred to as a vital basis for decisions in the process of employment [8].

Accordingly, the present study examines technical trends related to AI-based interview services proliferating, presenting the results of AI-based interview system development and application to an employment process. Based on the results, this study clarifies the current status of AI-based job interview techniques and presents implications regarding how to establish an AI-based system at enterprises successfully.

2. AI-BASED EMPLOYMENT TYPES AND TRENDS

There are significant employment changes, specifically in trend analysis and future prediction in utilizing big data and AI. According to Midas IT, an agency specializing in AI analysis, the accuracy of determining talented applicants through AI interviews is as high as 82% as an official at an enterprise stated. This is an outstandingly high level considering that the personality/aptitude test validity is 30-40% and that the validity of nonstructural interviews is as low as 10% [9]. Employment aims to select the optimal workforce required for the organization at the right time and right place. It includes the recruitment step to inform potential applicants of the enterprise and the selection step to choose the optimal candidates among the applicants [9]. As AI technology is utilized for such recruiting systems, various activities are practiced to improve efficiency and fairness in various processes such as talent recommendation, application screening, job allotment, and employment examination [10,11].

AI-based recruiting is utilized mainly in the following areas: assessment before employment, documentation, interview-based assessment, and job allotment. As for evaluation before employment, applicants' problem-solving results are compared with significant data analysis results to analyze their inter-personal skills, collaboration and teamwork, motivation, and decision-making, among others, before interviews. Applicants' aptitudes, problem-solving

ability, ability to understand and apply information, and ability to learn new skills and think from a critical point of view are measured and used to grasp applicants' cognitive aptitudes. As for effective methods to be utilized, EI estimation can be practiced based on game-based exercises presented by AI, and psychological analysis and verification can be practiced through problems presented by AI [12,13].

As for documentation evaluation, answers in received applications are analyzed on the combined basis of AI and NLP (natural language processing) to determine their fitness. As such, AI is used to select outstanding individuals suitable for corporate strategies. The image of the right people for the enterprise is decided through AI learning, and then the curricula vitae that best correspond to it are selected. One primary method is AI deep learning: AI analyzes application forms previously submitted by competent employees for learning and compares them with the curricula vitae of new and experienced applicants to determine the similarities. Additionally, such methods as Natural Language Processing (NLP), Morphological Analysis, and Syntactic Analysis are used [14,15].

For AI-based interview evaluation, neuroscience-based games are played for about 20 minutes to verify whether applicants' personalities fit specific duties and are likely to embrace or avoid risks. AI then conducts interviews through a video conference by using pre-set questions, measuring the applicants' facial expressions, detecting their feelings, and assessing their personality characteristics. Effective methods to be utilized include neuroscience-based games to evaluate personalities, AI-based video conference interviews, and reference data (facial expression, body language, and keywords). These methods are used to find applicants who best correspond to collected reference data [16].

As for AI-based job placement, job requirements are defined regarding the related position, tasks, and expected performance. AI then generates requirements automatically based on such definitions. The role classification of each department where the positions belong is analyzed to understand each position's task activities and characteristics. Personnel information on the individuals to be appointed is also analyzed, including such factors as appointment history, competency evaluation, and performance, so that the basic requirements for each position are met. AI then combines various information sets of applicants such as job experience, capacity assessment, and performance and recommends candidates who are expected to perform for the allotted job best. Effective methods to be utilized include deep learning on tasks to be handled after employment, competencies required for given tasks, and requirements. About the combined data of the applicant's career, competency evaluation, and performance, AI recommends candidates expected to show satisfactory performance on given tasks [17].

3. TECHNOLOGY UTILIZATION AND PRINCIPLES

As for major AI technologies used in job interviews, domestic interviewers' evaluations on applicants answering given questions as shown in [Figure 1] are collected, significant features are extracted, and then exemplary interviewers' judgment mechanisms are learned by way of machine learning.

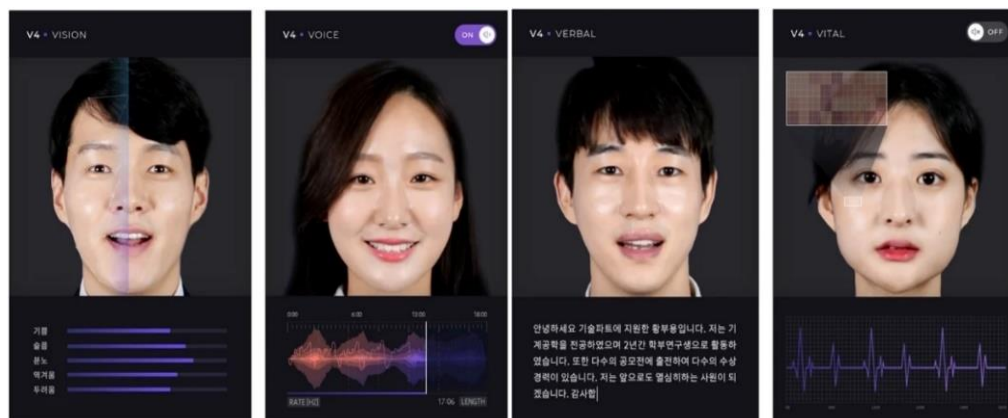
V4 is the method to extract significant features. This is an AI technology to recognize and process the four types of information: Visual, Vocal, Verbal, and Vital. Based on video and voice information, it is possible to measure the applicant's external characteristics (see Table 1). Each applicant's competencies are evaluated based on the results, including performance competency, relationship competency, organizational fitness, fitness to the official position, communication ability, emotional expression ability, and favorability. Second, As V4 learns experts' senses and know-how, applicants' real-time reactions are analyzed and judged [18].

Table 1 AI technology factors used in job interviews

Classification	Technology	Technology applicable	AI evaluation technology
Visual	Technology to recognize video information	Imitation of human vision	The facial expression, emotional expression, eye movement, facial movement
Vocal	Technology to recognize voice information	Imitation of human auditory sense	Voice tone, volume change, speed, pause, pronunciation, and the like.
Verbal	Technology to recognize linguistic information	Imitation of human linguistic functions	Speech to Text (STT), word semantics, vocabulary, and the like.
Vital	Biological data analysis technology	Application of video information processing technology	Delicate changes of facial muscles and complexions are detected to estimate the pulse.

Visual technology extracts 68 points from each applicant's face, analyzes each facial part's delicate movements, and extracts necessary data from the video information, including the applicant's emotional state, eye movement, facial movement, and head rotation. Based on the extracted data of facial changes, the applicant's feelings are analyzed, such as joy, sadness, anger, distaste, fear, and tension [19].

As for auditory and vocal technology, the vocal method extracts applicants' vocal waves to analyze vocal factors such as utterance time, speed, and volume. In addition, each applicant's answers are analyzed in terms of temporal change to collect vocal spectrum data in real-time. As for verbal technology, voice data are extracted just as in the case of vocal technology. Each applicant's linguistic habits, times of using a particular word, and the like are analyzed to grasp his/her linguistic behaviors and tendencies [20]. Finally, vital (biological) data are collected to grasp applicants' emotional state and dishonesty based on the fact that the current biological state is related to his/her blood flow and pulse (see Figure 1).

**Figure 1** Vocal analysis samples of an applicant's face

4. AI-BASED INTERVIEW SOLUTION DEVELOPMENT

4.1 System Architecture and Development Environment

Figure 2 shows the natural language processing engine of the platform for AI-based interview systems. Voice data in videos are converted into text form utilizing Google STT API. The converted self-introduction data are analyzed in morphemes, phrases, and semantics through the self-developed natural language processing engine. The analyzed self-introduction data are compared with the reference data (the excellent self-introduction data and competency dictionary) to derive the final results.

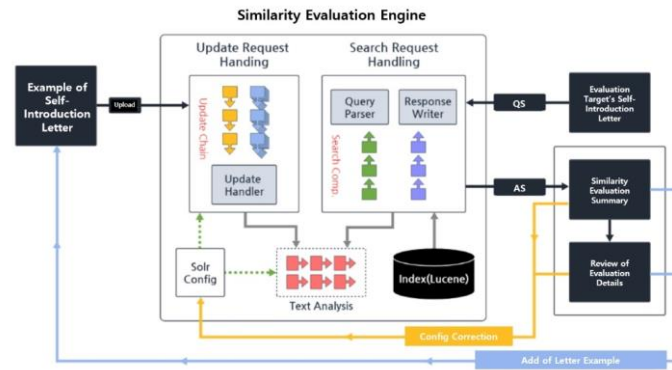


Figure 2 System architecture

The development environment may be divided mainly into the WAS area and Deep Learning area. As shown in Table 2, the development environment is designed and embodied in each specific role. First, the WAS area is based on Linux Ubuntu OS. As for the DBMS, MongoDB of NoSQL, which is commonly used recently, is adopted for more flexible expansion. To embody the asynchronous Single-page Application (SPA) service, Javascript-based VUE web programming technology was applied. GraphQL API is also used for faster and more efficient operations. Second, the Deep Learning area is based on Linux CentOS. As for the DBMS, the relational database MySQL is adopted to apply the JAVA web programming method.

Table 2 System development environment

Section	Front-end	Back-end	Deep learning
OS	Ubuntu	Ubuntu	Cent
DBMS	-	Mongo DB	MySQL
Language	HTML5, CSS3, Vue.js, Vuetify.js	Python	JAVA
Framework	Nuxt.js	Node.js	Spring
Script	JavaScript, GraphQL		JavaScript, ES6
Server	Node Express	NginX	Tomcat

4.2 System Web Service Configuration

Figure 3 shows how website users use such services through a web browser. The WAS area and Deep Learning area exchange data systematically through the JSON protocol, and then the analysis results are provided to users through RESTful API or the API services provided to other solutions.

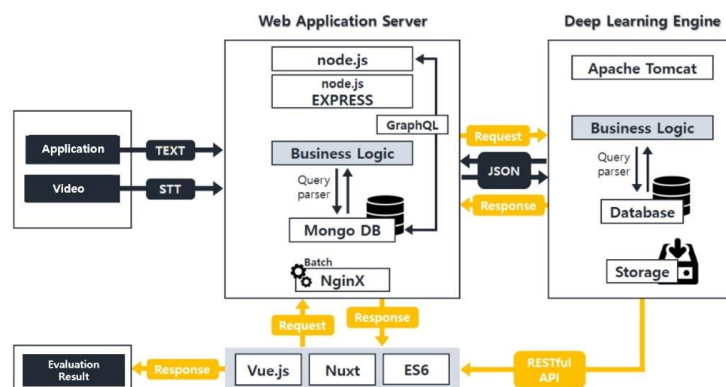


Figure 3 Design of web service structure

4.3 Deep-learning Process

The AI interviewer analyzes applicants' biological signals and answers data while communicating with them online and then allots assignments to judge competencies required for given tasks. To this end, the method to determine an applicant's external and internal elements is also applied. First of all, the applicant's face, voice, vocabulary, and pulse, are measured to determine his/her emotions and genuineness. Based on the 68 muscle points of the applicant's face, the AI interviewer reads facial expressions and emotions. The tone color and interval between answers are also used as a basis for judgment. Answers are then converted into text form in real-time in order to analyze the used words.

During the question and answer session, the AI interviewer gives each applicant questions according to the general contents and employment purposes. During the self-introduction session, pressuring interview questions are used to analyze the applicant's disposition and expected performance. Every interview is recorded. After the interview ends, AI evaluation sheets are completed and provided to personnel managers as a basis for judgment. The AI-based interview system's deep-learning process is designed to detect significant features autonomously in reflecting the score that experts gave based on interview videos (see Figure 5). AI learns from more than 400,000 interview videos and derives and analyzes more than 100,000 evaluation data sets. With the given scores as the basis, AI generates many mathematical dimensions and changes parameters to reduce errors continually. To this end, the same interview videos are allotted to evaluators periodically to verify the reliability. As the evaluation reliability was estimated statistically based on the results, it was as high as 0.88 Pearson.

5. AI-BASED INTERVIEW SOLUTION SIMULATION

5.1. Simulation Subject Selection and Solution Configuration

In order to apply the solution practically to organizations, 5 major public enterprises in Korea were selected: SR, Mine Reclamation Corp. (MIRECO), Korea South-East Power Co. Ltd., Credit Guarantee Foundation (SCGF), and Korea Expressway Corporation (see Table 3,4).

Table 3 Application overview

Company	Selected persons	Applicants number	Inter-viewees	AI-based interview service
SR	74	5,995	374	374
Mine Reclamation Corp	27	2,190	135	135
Korea South-East Power Co., Ltd.	890	32,090	2,670	2,670
Credit Guarantee Foundation	45	3,659	225	225
Korea Expressway Corporation	690	29,085	2,070	2,070

Table 4 Corporate's purpose of the AI interview adoption

Company	Purpose
SR	To secure fairness To exclude biased views To prevent interviewers' errors Preference to untact interviews To save workforce and time
Mine Reclamation Corp	To exclude biased views To secure fairness Preference to untact interviews To save time To prevent interviewers' errors
Korea South-East Power Co., Ltd.	To secure fairness To exclude biased views Preference to untact interviews To prevent interviewers' errors To save workforce and time To address difficulties in finding a proper place Time-saving in self-introduction reviews Cost-saving (down to 1/5)
Credit Guarantee Foundation	To exclude biased views To secure fairness Preference to untact interviews To prevent interviewers' errors

Korea Expressway Corporation	To secure fairness Objective evaluation Preference to untact interviews To prevent interviewers' errors To save workforce and time To address difficulties in finding a proper place for interviews Time-saving in self-introduction Cost-saving (down to 1/5)
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However, since ethics for civil service and specific characteristics of performance are emphasized when it comes to employment at public organizations, AI-based interviews are applied not for the entire interview process but in the form of the simulated interview before the second personal interviews in order to assist personal interviews (see Table 5).

Table 5 Evaluation items for AI-based interviews

Classification	AI-based interview	Personal interview (by human interviewers)
Evaluation step	1st: AI-based interview	2nd: Personal interview
Evaluation method	Facial expression analysis, voice analysis, language analysis, STT analysis, vital information. Deep-learning model for recommendation	Q&A-based evaluation
Evaluation system	Consisting of computers, microphones, and webcams	Personal interview
Evaluation questions	AI development	Corporate development and commission to external organizations
Evaluation details	Performance competency index, relationship competency index, organizational fitness index, index of fitness to the official position, strategic thinking, growth competency	Basic vocational ability, work performance, performance creating, interpersonal relationship, communication, fitness to the organization, ethics for civil service
Comparison items*	Performance competency, relationship competency, organizational fitness, fitness to the official position,	Performance creating, interpersonal relationship, organizational fitness, ethics for civil service
Evaluation time	50 minutes (online)	40 minutes (personal)
Evaluator (interviewer)	AI	3 professional interviewers + 2 managers at an institution concerned
Applicant	1	1

* Comparison of everyday evaluation items used in both AI-based and personal interviews.

The AI-based job interview model applied the classification algorithm to judge whether successful applicants were predicted correctly and whether disqualified applicants were predicted. The relevance between the two variables was grasped through the correlation analysis (see Figure 4).

The level of relevance between the 'AI-based job interview score' and 'actual score in the job interview evaluation process' was determined as high when the applicant given a high score in the AI-based interview obtained a high score in the actual job interview as well. Likewise, as a candidate given a low score in the AI-based job interview is given a low score in the actual job interview, the AI-based job interview was evaluated as valid. This static correlation was utilized as a significant index that indicates the AI-based job interview model's validity. The correlation between the AI-based job interview score and the actual job interview score is about 0.4. As the correlation analysis was conducted for each evaluation item, it turned out that the correlation coefficient of organizational fitness was the highest (0.41), and the correlation coefficient of relationship competency was 0.40.

As each evaluation item's classification accuracy was analyzed for the AI-based job interview evaluation model, the accuracy was as high as 70% in every evaluation item.

Specifically, the accuracy rate of performance competency was 75%, relationship competency 72%, organizational fitness 70.2%, and fitness to the official position 82% (see Figure 4).

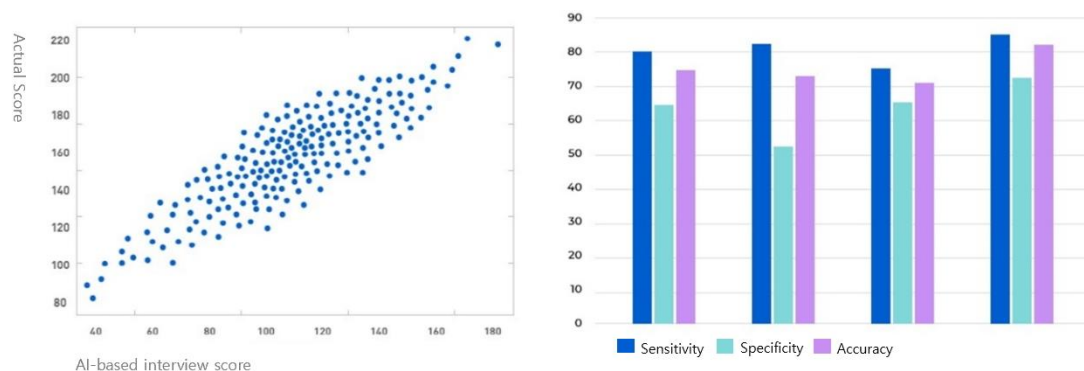


Figure 4 Correlation analysis result and classification accuracy of the model

5.2 Application Results

As shown in Table 6, the satisfaction with the evaluation process in applying the suggested solution was compared with the satisfaction with evaluating successful applicants (5-point scale survey results were converted into the percentage score). As a result, the level of satisfaction was 85.5% on average, and the highest score (92) was given to the item of efficiency in the evaluation process.

Table 6 Result of AI-based interview service introduction

Company	Successful applicants	Satisfaction with the evaluation process		Satisfaction with the evaluation result		Average
		Fairness	Efficiency	Job fitness	Organizational fitness	
SR	74	84	89	85	80	84.5
Mine Reclamation Corp	27	88	92	82	82	86
Korea South-East Power Co., Ltd.	890	85	93	86	85	87.25
Credit Guarantee Foundation	45	82	95	80	84	85.25
Korea Expressway Corporation	690	82	91	84	81	84.5
Total of Satisfaction Scores		84.2	92	83.4	82.4	85.5

6. CONCLUSION

The present study examines technical trends related to AI-based interview services that are growing rapidly and presents the results of AI-based interview system development and application to an employment process. This study is significant because it contributes to enterprises, job seekers, and the society. Specifically, regarding each of these three perspectives, first in the perspective of enterprises, it provides a high validity method that improves the limitations and problems of the existing employment methods. It also saves time and expenses for offline interviews, provides more applicants with interview opportunities, and improves interviews' effectiveness, with bias reduced.

Second, from the job seekers' perspective, sufficient opportunities are given to all job seekers with the sense of relative deprivation addressed. In addition, such online interviews in a video conference format can be conducted with no limitation of time and place and save time/expense while the focus is on applicants' competencies. Finally, in the perspective of

society, as the existing custom of employment that focuses on documentation-based qualifications is changing into the practice of performance-based employment, social costs are reduced in the preparation and activity of employment for both enterprises and job seekers. In addition, fair opportunities and evaluations are secured.

AI-based job interviews were developed to support the reasonable selection of outstanding candidates and the decision-making aspect in the employment process. It is expected that the design specifications and solution application results presented by the present study can be utilized widely in support of the existing document screening process that estimates applicants' future performance based on each applicant's resume and self-introduction but with only limited validity, written examinations whose relevance to actual performance is relatively low, and aptitude tests as well.

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