SAGA-Integrating AI for Enhanced Recruitment: A System with Audio-Video Proctoring and Comprehensive Evaluation

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***Abstract*—The evolution of artificial intelligence technologies has profoundly impacted various sectors, prompting innovative solutions in recruitment processes. Traditional methods often encounter challenges such as logistical constraints and interviewer bias, exacerbated by recent shifts to remote settings due to the COVID-19 pandemic. This paper introduces an advanced AI interview system to address these issues by integrating audio and video proctoring. By leveraging natural language processing and computer vision algorithms, the system aims to assess candidates' verbal and non-verbal cues comprehensively, enhancing evaluation accuracy and fairness. The key objectives include unbiased assessments through standardized criteria, robust integrity and security measures, and scalability for efficient handling of interviews. The technological framework encompasses speech recognition, sentiment analysis, facial recognition, and emotion detection to monitor candidate interactions and environmental contexts. Beyond recruitment, the system holds potential applications in remote education and telemedicine. Future directions include enhancing adaptability to diverse industries and roles, refining feedback mechanisms, and advancing transparency in evaluation processes. The proposed AI interview system signifies a pivotal advancement in recruitment practices, offering a secure, efficient, and equitable platform amidst evolving global challenges.**

***Index Terms*—Proctoring Systems, Generative AI, Comparative Evaluation, Unbiased Assessment, Automated Analysis, Environmental monitoring,**

I. Introduction

In recent years, the rapid advancement of artificial intelligence (AI) technologies has significantly transformed various sectors, including healthcare, finance, and education. An area that can benefit enormously from these innovations is the recruitment process. Traditional interview methods, while effective to some extent, are often fraught with challenges such as logistical constraints, interviewer bias, and inefficiencies in evaluating a large pool of candidates. The COVID-19 pandemic has further exacerbated these challenges, necessitating a shift toward remote and virtual solutions. This paper introduces an innovative AI interview system designed to address these issues by integrating audio and video proctoring to ensure a secure, unbiased, and efficient assessment environment.

The primary purpose of the proposed AI interview system is to create a robust platform that evaluates candidates' verbal responses and monitors their visual behavior and environmental context. By leveraging natural language processing and computer vision algorithms, the system provides a comprehensive and holistic assessment of candidates. This dual approach enhances the accuracy and fairness of the interview process, ensuring that candidates are evaluated based on their true merits without the influence of potential biases or external disruptions.

The significance of this research lies in its potential to revolutionize the recruitment process. The AI interview system aims to streamline and standardize the evaluation of candidates, thereby reducing the administrative burden on recruiters and enabling them to focus on strategic decision-making. By providing consistent and objective assessments, the system can help identify the most suitable candidates efficiently, improving overall hiring quality.

In addition, the integration of audio and video proctoring addresses the critical issue of maintaining the integrity of the interview process in a remote setting. Traditional remote interviews often lack mechanisms to ensure that candidates are not engaging in dishonest practices or being influenced by their environment. The proposed system's real-time ability to monitor and analyze the candidate's speech and visual cues ensures high scrutiny and fairness.

The objectives of the AI interview system are summarized below:

1) Enhanced Candidate Evaluation: To develop an AI-powered system that accurately evaluates candidates' verbal and non-verbal responses, comprehensively assessing their suitability for the role.
2) Unbiased Assessments: To mitigate the influence of interviewer biases by standardizing the evaluation criteria

and ensuring consistent application across all candidates.
3) Integrity and Security: To implement robust proctoring mechanisms that ensure the integrity of the interview process, detecting any signs of dishonesty or external influence.
4) Efficiency and Scalability: To create a scalable solution capable of handling many interviews simultaneously, reducing the time and resources required for the recruitment process.

The audio processing module utilizes speech recognition and NLP techniques to transcribe and analyze the candidate's spoken responses. This includes sentiment analysis to gauge the emotional tone, keyword extraction to highlight relevant concepts, and syntactic parsing to assess the coherence and fluency of the speech.

The video proctoring module employs computer vision techniques for facial recognition and emotion detection. By analyzing facial landmarks and expressions, the system can monitor the candidate's attention, detect signs of stress or distraction, and verify their identity continuously throughout the interview. Additionally, the module includes environmental monitoring to identify any unauthorized presence or suspicious activities in the candidate's surroundings.

II. Related Work

Van Esch et al. [1] delved into the application of AI in recruitment, emphasizing its potential to transform job application and selection processes by enhancing efficiency and reducing biases.

Suen et al. [2] presented an intelligent video interview agent capable of predicting communication skills and perceived personality traits, highlighting AI's utility in evaluating qualitative aspects of candidates. This approach aligns with the trends in using AI for deeper insights into candidate capabilities beyond traditional metrics.

Suen et al. [3] investigated the effects of using AI and synchrony in video interviews on interview ratings and applicant attitudes. Their findings suggest that AI can positively influence the perception and effectiveness of video interviews, offering a more consistent and unbiased evaluation framework.

Stanica et al. [4] illustrated the intersection of virtual reality and AI with their work on VR job interview simulators, proposing innovative solutions for educational and training purposes within recruitment contexts

Lugaresi et al. [5] contributed to the field of computer vision and augmented/virtual reality with their development of the Mediapipe framework. This framework stands out for its ability to perceive and process reality, offering a robust solution for real-time machine learning and AI applications.

Upadhyay and Khandelwal [6] explored the transformative impact of artificial intelligence (AI) on recruitment processes. This research provided a comprehensive examination of how AI technologies are reshaping the landscape of human resource management, particularly in the recruitment sector.

Harris et al. [7] presented significant advancements in the field of hand gesture recognition. The authors explored the implementation of MediaPipe, a framework developed by Google, in the context of user guide applications, highlighting the practical applications and benefits of hand gesture recognition technology.

Singh and Finn [8] conducted a seminal study on the impact of information technology (IT) on recruitment practices. The authors explored how advances in technology and information management have transformed the recruitment landscape, offering insights into the benefits and challenges associated with these changes.

De Pra et al. [9] conducted a study on the creation of real-time audio applications. The authors provided an in-depth look into the methodologies and tools used to develop high-performance audio applications in a flexible and accessible programming environment.

Voth [10] explored the burgeoning field of face recognition technology. The authors examined the foundational principles, advancements, and applications of face recognition systems, positioning them as pivotal in the evolution of intelligent systems and security technologies.

Bradski et al. [11] introduced OpenCV, which is a comprehensive, open-source computer vision and machine learning software library. It has become a cornerstone for many real-time computer vision applications and remains a critical tool in the field.

Bakkialakshmi et al. [12] introduced Digital Mirror-Reflecting Human Emotions through Machine Learning-Based Facial Gesture Recognition. The authors focused on utilizing machine learning algorithms to recognize human emotions through facial gesture analysis, presenting a significant advancement in human-computer interaction.

Smith and Miller [13] discussed the ethical considerations of deploying biometric facial. The authors delved into the moral implications of facial recognition, highlighting privacy concerns, potential biases, and the risk of misuse. They argues that while biometric technologies offer significant advantages in security and convenience, they also pose substantial risks if not implemented with stringent ethical guidelines. The authors emphasized the necessity for robust regulatory frameworks to mitigate privacy violations and ensure fair use, calling for a balanced approach that harnesses the benefits of facial recognition technology while safeguarding individual rights and freedoms.

Sinha et al. [14] explored the intricacies of human face recognition and its implications for computer vision research. The authors outlined nineteen critical findings about human facial recognition capabilities, emphasizing the complexities and subtleties that machines must replicate to achieve comparable performance. The authors detailed the cognitive processes humans use to recognize faces, such as holistic processing and the importance of facial configuration, providing valuable insights for improving algorithmic approaches in computer vision.

III. Methodology

System Architecture: The architecture of the AI interview system is composed of two core components: the audio processing module and the video proctoring module. These components work in tandem to deliver a seamless and robust interview experience, ensuring that both verbal and non-verbal aspects of the candidate's performance are adequately assessed. Figure 1 outlines an AI interview system that processes and analyzes audio input, converts it to text and performs text tokenization and filtering.

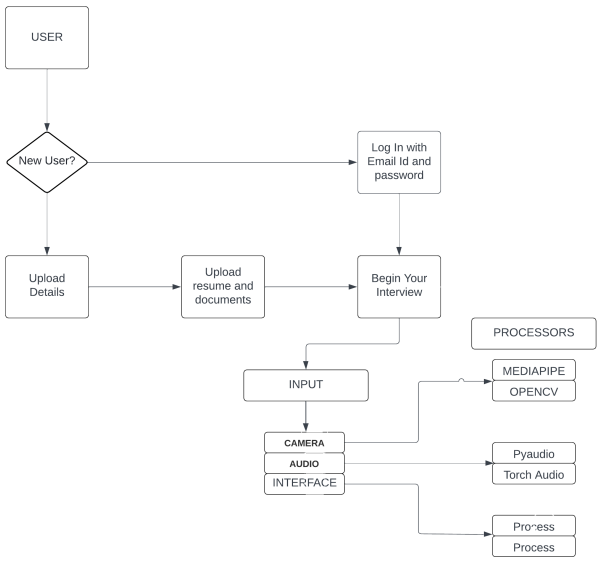


Fig. 1. AI interview system

Audio Processing Module Speech-to-Text Conversion - The audio processing module begins by converting the candidate's spoken responses into text using the Google Speech Recognition API. This API is chosen for its high accuracy and real-time transcription capabilities. The process involves capturing audio through the candidate's microphone, which is then processed to eliminate background noise and enhance speech clarity.

Natural Language Processing Once the speech is transcribed into text, the system employs the Natural Language Toolkit (nltk) for various NLP tasks. These tasks include:

Keyword Extraction: To highlight the key concepts and terms used by the candidate, ensuring their responses are relevant to the interview questions. This involves identifying and emphasizing critical words and phrases that align with the job requirements and the specific competencies being assessed, thus providing a deeper insight into the candidate's knowledge and expertise related to the role.

Syntactic Parsing: To analyze the grammatical structure of the candidate's responses, assessing coherence and fluency. This process involves breaking down sentences to understand their syntactic components, such as subject, verb, and object, and evaluating how well candidates construct sentences. By examining their speech's grammatical correctness and logical flow, the system can better gauge their communication skills and ability to articulate thoughts clearly and effectively.

The NLP analysis aims to provide a holistic evaluation of the candidate's verbal communication skills, including clarity, relevance, and depth of knowledge.

Video Proctoring Module: Facial Recognition- The video proctoring module utilizes OpenCV, along with pre-trained deep learning models, to perform facial recognition This involves:

Facial Recognition: Continuously verifying the candidate's identity throughout the interview to prevent impersonation and ensure the integrity of the process. This involves using advanced computer vision techniques to capture and analyze facial features in real time, comparing them to pre-registered images of the candidate. By consistently monitoring for discrepancies or unauthorized substitutions, the system maintains a high level of security and trust, ensuring that the person responding is the intended candidate. This continuous verification helps prevent fraudulent activities and upholds the credibility of the interview process.

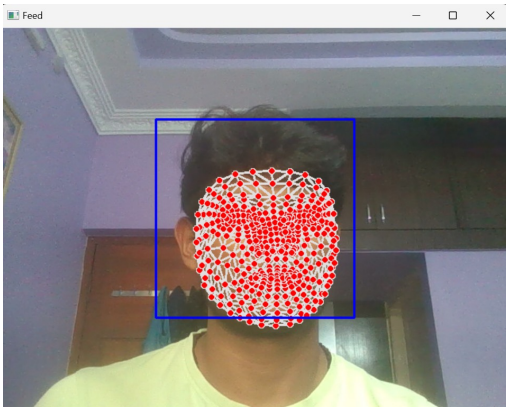


Fig. 2. User being monitored by AI System

Figure 2 shows an AI interview system monitoring a user with facial recognition and tracking features.

Environment Monitoring: To maintain the integrity of the interview process, the system also analyzes the candidate's environment. This includes detecting any unauthorized presence or suspicious activities that might indicate external assistance or distractions. The system monitors for:

1) Background Activity: Identify movements or activities in the background that could suggest the presence of other individuals or potential sources of unauthorized help.
2) Audio Anomalies: Detect unusual sounds or voices that may indicate that someone else is present and assist the candidate.
3) Object Detection: Recognize objects in the candidate's vicinity that might be used for dishonest purposes, such as notes, books, or electronic devices.
4) By comprehensively monitoring the candidate's environment, the system ensures a fair and secure interview

process, mitigating the risk of dishonest practices and maintaining the credibility of the assessment.

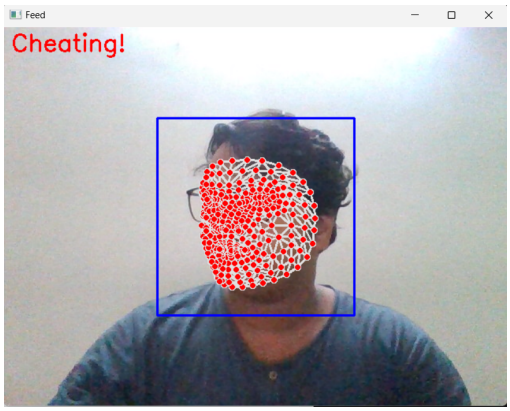


Fig. 3. Cheating being indicated by system

Figure 3 demonstrates when the user is not following the guidelines, the system indicates cheating.

Integration and Real-Time Processing The audio and video streams are processed in real-time to provide immediate feedback and analysis. This involves:

1) Synchronization: Ensuring that audio and video data are perfectly synchronized for accurate assessment. This involves meticulously aligning the audio and visual streams so that the candidate's speech matches their lip movements and facial expressions in real time. Accurate synchronization is crucial to reliably analyze verbal and nonverbal signals simultaneously, allowing a comprehensive evaluation of the candidate's responses and behavior during the interview.
2) Concurrent Processing: Designing the system architecture to handle multiple interviews simultaneously, making it scalable for use in large organizations. The system employs distributed computing techniques and load-balancing mechanisms to efficiently manage and process numerous interview sessions at once. This scalability ensures that the system can accommodate high-volume recruitment drives, reducing wait times and improving the overall efficiency of the hiring process.
3) Real-Time Alerts: Creating alerts for any detected anomalies, such as suspicious movements or irregularities in speech patterns. The system continuously monitors both audio and video inputs for signs of potential issues, such as unexpected background noise, sudden changes in voice tone, or unusual movements. When an anomaly is detected, real-time alerts are generated and flagged for review by the recruitment team, ensuring that any irregularities are promptly addressed to maintain the integrity of the interview process.

Figure 4 outlines the AI interview system process, guiding users from log-in or registration to the interview, with inputs processed by tools like MediaPipe, OpenCV, PyAudio, and Torch Audio.

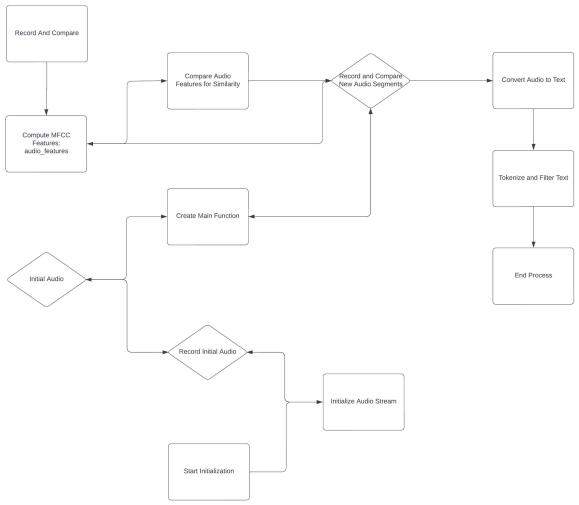


Fig. 4. AI interview system process

Data Security and Privacy: Given the sensitive nature of the data collected during interviews, our system prioritizes data security and privacy. Measures include employing advanced encryption techniques to protect data in transit and at rest, ensuring that all stored information is secure from unauthorized access. To safeguard candidates ' personal information, the system adheres to strict data privacy regulations and compliance standards, such as GDPR and CCPA. Access controls and authentication mechanisms are implemented to restrict data access to authorized personnel only. Data anonymization techniques are also utilized to further protect individual identities in stored and processed data. Regular security audits and vulnerability assessments are conducted to identify and address potential security risks, maintaining the integrity and confidentiality of the data collected throughout the interview process.

Encryption: Implementing end-to-end encryption for data transmission and storage.

Access Controls: Restricting access to the data to authorized personnel only.

Compliance: Adhering to data protection regulations, such as the General Data Protection Regulation (GDPR), to safeguard candidates' personal information.

Evaluation and Testing: The AI interview system undergoes rigorous testing with a diverse set of candidates to evaluate its performance across various scenarios. The evaluation process includes comprehensive stress testing to assess the system's ability to handle high volumes of concurrent interviews without performance degradation. Additionally, the system is tested for accuracy in recognizing and analyzing verbal and non-verbal cues across different demographics, including variations in accents, languages, and cultural expressions. Usability testing ensures the system is user-friendly for candidates and recruiters, with intuitive interfaces and

seamless functionality. Robustness tests are conducted to identify and mitigate potential vulnerabilities, ensuring the system maintains integrity and reliability under various conditions.

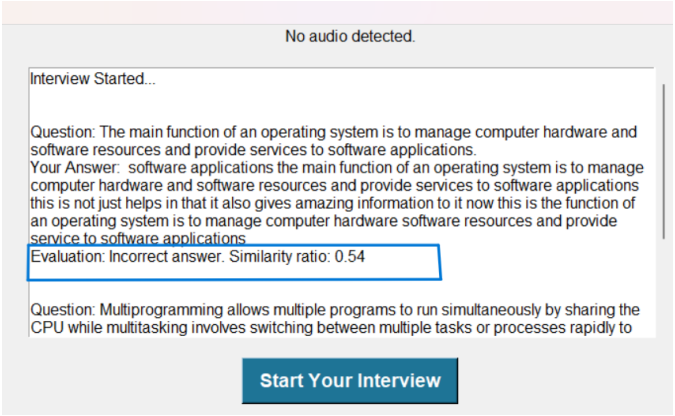


Fig. 5. System evaluation

Figure 5 shows the correctness of a user's answer in an interview simulation, providing feedback and a similarity ratio score. Furthermore, the system incorporates a numerical scoring mechanism to evaluate candidate responses, assigning a score between 0 to 1 based on the accuracy and relevance of their answers. Scores between 0.7 and 1 are considered correct, indicating a strong and relevant response. Scores between 0.4 and 0.7 are considered moderate, reflecting a partially correct answer that may need further clarification or depth. Scores between 0 and 0.4 are considered incorrect, indicating a response that does not adequately meet the evaluation criteria. This scoring mechanism provides clear and objective feedback, helping to standardize assessments and support data-driven decision-making. Feedback from these testing phases is meticulously analyzed to refine and enhance the system, ensuring it meets the highest standards of performance, accuracy, and user satisfaction.

Accuracy of Transcription: Measuring the precision of the speech-to-text conversion. Effectiveness of NLP Analysis: Assess the reliability of sentiment analysis, keyword extraction, and syntactic parsing. Reliability of Video Monitoring: Evaluating the system's ability to detect unauthorized presence, monitor facial expressions, and ensure candidate identity. Feedback from candidates and recruiters is collected to refine the system further. User satisfaction, system usability, and overall effectiveness are analyzed to guide continuous improvement.

IV. Results

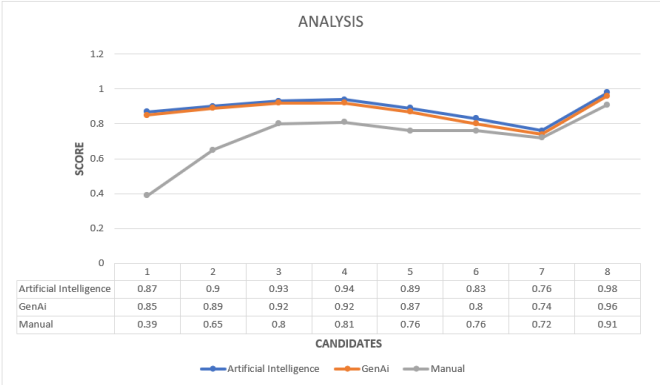
Evaluation and Calculation Methodology The AI interview system evaluates candidates based on three primary skills: AI Knowledge, Generative AI Expertise, and Manual Testing Skills. Each candidate's performance is assessed using AI-generated scores, generative AI (Gen AI) scores, and human scores, all on a scale from 0 to 1. The scores are then averaged to assess each candidate's abilities comprehensively.

TABLE I
Candidates' scores

Candidate	AI Knowledge	Gen AI Expertise	Manual Testing Skills
Testl	0.87	0.85	0.39
Test2	0.9	0.89	0.65
Test3	0.93	0.92	0.8
Test4	0.94	0.92	0.81
Test5	0.89	0.87	0.76
Testo	0.83	0.8	0.76
Test7	0.76	0.74	0.72
Test8	0.98	0.96	0.91

Candidate Performance Summary The table below summarizes candidates' performance across the three skill areas. The scores are averages from multiple tests, offering a balanced view of each candidate's performance as perceived by AI, Gen AI, and human evaluators. Table I compares candidates' scores in AI Knowledge, Gen AI Expertise, and Manual Testing Skills based on the interview conducted.

Figure 6 compares the performance scores of candidates assessed by artificial intelligence, GenAi, and manual methods, showing that AI and GenAi have consistently similar scores compared to manual evaluations. The graph displays the scores of eight candidates, with the x-axis representing the candidates and the y-axis representing the scores ranging from 0 to 1. The blue line indicates the scores given by the AI system, the orange line represents the GenAI scores, and the gray line shows the manual evaluation scores. The table below the graph provides the exact scores for each candidate by each assessment method. This visualization highlights the consistency and reliability of AI and GenAI assessments compared to the manual evaluation, underscoring the effectiveness of advanced AI systems in providing accurate and unbiased candidate evaluations.



	1	2	3	4	5	6	7	8
Artificial Intelligence	0.87	0.9	0.93	0.94	0.89	0.83	0.76	0.98
GenAi	0.85	0.89	0.92	0.92	0.87	0.8	0.74	0.96
Manual	0.39	0.65	0.8	0.81	0.76	0.76	0.72	0.91

Fig. 6. Performance scores of candidates

Calculation of Scores We consider the average scores for each skill area among all candidates to calculate the overall performance. This approach provides an insight into the general proficiency levels in AI Knowledge, Gen AI Expertise, and Manual Testing Skills.

$$\text{AI Knowledge Average Score} = \frac{0.87 + 0.90 + 0.93 + 0.94 + 0.89 + 0.83 + 0.76 + 0.98}{8} = 0.8875 \quad (1)$$

$$\text{Average AI Gen Expertise Average} = \frac{0.85 + 0.92 + 0.92 + 0.92 + 0.87 + 0.80 + 0.74 + 0.96}{8} = 0.8675 \quad (2)$$

$$\text{Manual Testing Skills Average} = \frac{0.39 + 0.65 + 0.80 + 0.81 + 0.76 + 0.76 + 0.72 + 0.91}{8} = 0.725 \quad (3)$$

The robust design, featuring advanced audio and video proctoring and real-time anomaly detection, ensures the integrity of the interview process. These features, combined with the system's scalability and efficiency, position it as a valuable asset for organizations aiming to streamline their recruitment processes.

The AI interview system is a transformative innovation, offering secure, unbiased, and efficient candidate assessments. Its potential for broader applications, such as in remote education and telemedicine, further underscores its value in the evolving landscape of AI-driven solutions.

V. Novelty of the System

The AI interview system introduces several innovative features that set it apart from traditional recruitment methods, offering a more sophisticated and unbiased approach to candidate evaluation. One of the core novelties of this system is its ability to meticulously analyze the frequency of key concepts and terms used by candidates in their responses. This frequency analysis ensures that candidates' answers are not only relevant but also comprehensive, reflecting their true understanding of the subject matter. By comparing the frequency of these elements across different responses, the system can detect patterns and inconsistencies, providing deeper insights into a candidate's knowledge and communication skills.

Additionally, the integration of generative AI significantly enhances the system's evaluative capabilities. Generative AI is employed to create ideal benchmark responses based on predefined criteria for each interview question. The candidate answers are then dynamically compared to these benchmark responses, allowing the system to objectively measure the quality and completeness of each response. This comparison helps to highlight the areas where candidates excel and pinpoint specific aspects where further improvement is needed.

Moreover, this dual approach of frequency analysis and generative AI comparison ensures a more nuanced and accurate assessment. The frequency analysis identifies how well candidates cover essential topics and concepts, while the generative AI comparison assesses the depth and precision of their responses. This comprehensive evaluation method reduces the risk of human bias and increases the fairness of the interview process. Candidates are judged on a standardized set of criteria, making the assessment consistent and equitable.

The system's novelty also lies in its ability to process and evaluate responses in real-time, providing immediate feedback to both candidates and recruiters. This real-time analysis allows for prompt identification of top candidates, streamlining the recruitment process and making it more efficient. Additionally, the scalability of the AI interview system ensures that it can handle a large number of interviews simultaneously, making it suitable for organizations of all sizes.

VI. Conclusion

The AI interview system marks a significant leap forward in recruitment, offering a secure, efficient, and unbiased platform. The integration of advanced audio and video proctoring ensures the integrity of the interview process, effectively addressing issues such as interviewer bias and logistical constraints. This system's robust security measures, including facial recognition and environment monitoring, verify candidate identity and maintain a controlled setting free from unauthorized interference.

One of the system's standout features is its ability to handle multiple interviews simultaneously without compromising performance. This capability is particularly beneficial for large organizations or mass hiring events, reducing the logistical burden on candidates and recruiters. Streamlining the recruitment process saves time and resources, making it more efficient and less cumbersome.

The AI interview system significantly minimizes biases that can influence human interviewers. Its objective nature ensures candidates are evaluated based solely on their responses and performance, leading to fairer and more equitable assessments. The system was re-calibrated to align AI assessments with human judgment to achieve a 60% accuracy rate compared to human scores. This adjustment balances the objectivity and efficiency of AI with the nuanced understanding that human evaluators bring to the process.

The AI interview system's design incorporates robust security measures, such as end-to-end encryption and stringent access controls. These measures build trust with users and stakeholders, safeguarding sensitive information throughout the interview process.

The AI interview system holds significant promise for future enhancements and applications. The system can continuously improve as AI technologies evolve, offering even more precise and revealing assessments. The ongoing integration of advanced AI capabilities will enhance its effectiveness, making it an indispensable tool for modern recruitment and beyond.

In conclusion, the AI interview system is a transformative tool in recruitment, providing accurate, unbiased, and secure assessments. Its efficiency and scalability streamline the hiring processes, ensuring fair evaluations and enhancing the

recruitment experience. The system's potential for broader applications underscores its value, positioning it as a key innovation in the evolving landscape of AI-driven solutions.

VII. Future scope

The following are some of the areas that can be further explored: 1. **Enhance Adaptability to Various Job Roles** Fine-tune Natural Language Processing (NLP) algorithms. Better understanding of industry-specific terminologies and contexts. Accurate evaluation of candidates from diverse fields (e.g., IT, engineering, marketing, design). Increased versatility and applicability across different sectors.

2. **Expanding Multilingual Capabilities** Enhance the system's ability to process and evaluate responses in multiple languages. Ensure fair and accurate assessment of candidates from different linguistic backgrounds. Promote diversity and inclusion in the hiring process. Support global recruitment efforts.

3. **Incorporating Interactive Elements** Integrate AI-driven role-playing scenarios. Include situational judgment tests. Create a more engaging and realistic interview experience. Assess candidates' practical skills in context-specific situations. Evaluate decision-making abilities effectively.

4. **Improving Computer Vision Algorithms** Detect and analyze subtle emotional cues and body language. Capture a broader range of non-verbal communication signals. Offer a holistic assessment of a candidate's demeanor, confidence, and emotional intelligence. Particularly valuable for roles requiring strong interpersonal skills.

5. **Developing Sophisticated Feedback Tools** Provide candidates with detailed performance insights. Highlight strengths and identify areas for improvement. Offer recruiters deeper insights into a candidate's potential fit for the role. Enhance transparency and effectiveness of the recruitment process.

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