



Explainable and Bias-Aware LLM Based Resume Screening System for Fair Automated Recruitment

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Abstract - Traditional resume screening methods, which are time-consuming and prone to inconsistency and bias (due to human evaluators or keyword-based ATS), fail to understand the contextual meaning of candidate requirements. The purpose of this paper is to develop an Explainable and Bias-Aware Large Language Model (LLM)-Based Resume Screening System for evaluating candidates' qualifications and achieving better matching by incorporating NLU approaches with LLaMA 3 to understand candidate resumes and job descriptions contextually rather than relying on keyword-based similarities. This system will score candidates' skills, qualifications and experience with generation of explainable output, and the bias awareness mechanism is added to ensure fairness and transparency during recruitment processes. This system incorporates the functions of resume preprocessing, candidate job matching by semantically matching resumes with job descriptions, candidate scoring, explanation generation and candidate scoring display, and the system is implemented with an interactive Streamlit application interface. Experiments results shows an enhancement in contextual understanding and more accurate candidate-job matching.

Key Words: Resume Screening, Large Language Models, Explainable AI, Natural Language Processing, Bias Detection, Recruitment Automation, Semantic Matching, Candidate Evaluation



1.INTRODUCTION

In the modern job market, the sheer volume of resumes submitted for various job openings presents a daunting challenge for recruiters and hiring managers. Manual review processes are time-consuming and prone to human error, making it difficult to efficiently identify the most suitable candidates for a given role.[1] The evolution of LLM technology has been progressive, evolving from early statistical language models to today's neural network language models and pre-trained language models, each stage encapsulating the efforts and achievements of countless researchers.[2] AI technology can be used to search public data sources such as media profiles to get to know a candidate better; recruiters can use chatbots to interact with candidates in real time by asking questions to assess whether they match with the job requirements and provide feedback and suggestions; interviewers can use AI to assess the richness of candidates' vocabulary, speech rate and tone, and facial expressions to assess fit for the job; and recruitment software integrating algorithms can match people according to personality traits and predict sustainable working relationships. [3] Leveraging the power of Pyresparser, NLTK (Natural Language Toolkit), and MySQL, the system offers a comprehensive solution for parsing, analyzing, and extracting key information from resumes. The tool utilizes natural language processing techniques from NLTK and Pyresparser to extract vital details from resumes, such as contact information, work experience, education, skills, and certifications.[4]

In this era of dynamic technological evolution and intensifying competition for employment opportunities, the significance of efficient and accurate resume screening cannot be overstated. Traditional manual screening methods often lead to inefficiencies, overlooking potential candidates, and introducing human biases into the selection process.[5] Effective recruitment requires not only attracting suitable candidates but also accurately assessing and ranking them to align with organizational goals. [6]

Recruitment is one of the crucial functions in any organization; by selecting the right candidates, the organization could increase the level of productivity, innovation, and success. The increase in the job application volume and online recruiting platforms require the recruiters to examine a tremendous number of resumes within the limited period of time.

Conventional method of examining the resumes requires extensive use of manual effort resulting in a lengthy and inconsistent process with human bias. Therefore, many organizations employ Applicant Tracking Systems (ATS) that automate the screening process based on keyword matching to alleviate the manual burden, however these ATS cannot accurately determine the semantic meaning of candidate qualifications as it misses relevant candidates with varied word usage.

Recent developments in AI and Natural Language Processing (NLP) provide smarter solutions for analyzing textual information. Advanced language models such as LLaMA and GPT based models are capable of understanding semantic relationships between words, sentences, and phrases within the text. This can aid in intelligently analyzing resumes and job descriptions since they contain large amounts of unstructured and complex textual information. Compared to keyword based systems, LLM are well-suited for semantic candidate job matching as they are designed to analyze based on meaning rather than exact matching keywords.

However, some AI based recruitment systems fail to address aspects such as transparency and fairness of candidate evaluation. Most systems are a "black box" where candidates' performance scores are generated without proper justification leading to an undesirable lack of trust among recruiters and candidates. Moreover, there is the potential for AI systems to carry implicit biases due to hidden patterns in the data or consideration of irrelevant criteria in the evaluation. Consequently, there has been a recent interest in designing both explainable and bias-aware recruitment systems.

The proposed work presents an Explainable and Bias-Aware Large Language Model Based Resume Screening System, which addresses the issues concerning the speed, transparency, and fairness of candidate evaluation. This system combines the capabilities of NLP and LLaMA 3 to achieve high semantic analysis and candidate-job matching while effectively providing explainable results for the evaluation score of a candidate based on skill, education and experience. Bias awareness mechanism is employed to facilitate the consideration of job-relevant features only while screening the candidates.

The proposed system comprises of various modules such as resume preprocessing, semantic analysis, candidate matching, scoring, explainability generation,



and result visualization. The results of the candidate evaluation are presented in a user-friendly manner via a Streamlit-based dashboard. The experimentations reveal a boost in the semantic understanding and candidate evaluation as compared to the traditional ATS based approach, resulting in an intelligent, scalable, and transparent solution.

2. LITERATURE REVIEW

The dynamic landscape of recruitment biases and AI continues to evolve, and recent literature reflects the ongoing quest to understand and address this critical issue. In the face of rapid technological advancements, the most current literature emphasizes the need to scrutinize AI-driven recruitment systems for emerging biases and explore innovative strategies to mitigate them.[7] As Artificial Intelligence (AI) technology rapidly evolves, its deployment in recruitment strategies has become increasingly prevalent, promising enhanced efficiency, decision-making capabilities, and talent acquisition optimization.[8] Moreover, Manual resume Data Extraction is still a time problematic, error prone task. To fill position during the recruitment process there is a big volume of resumes to be filtered, identified and analyzed to candidates' qualification, skills and experience. This typically delays and is inaccurate, so the ones that are critical information that identify the best candidates may go missing.[9] The studies employing NLP utilized various similarity measurements. It Automatized the resume screening system by applying NLP with Vector Space Model and Cosine similarity measures.[10]

In the past few years, Resume Screening and Automated Recruitment has been a popular research topic due to the huge volume of incoming applications and need of automated recruitment. Job screening process was primarily dependent on manually reading resume to pick up appropriate applicants, but this practice is very time consuming and inconsistent and can even bring in human biases. There has been a huge demand to create an automated recruitment system using AI and technologies such as Natural Language Processing (NLP) and Machine Learning (ML) for better applicant evaluation. Later researchers began to use and test Large Language Models (LLMs) to help automate the recruitment process for efficient working. Resume Screening systems started from Keyword based Application Tracking systems(ATS), the ATS simply searches for Keywords that appear in resume matches the keywords in job

description and returns a filtered output of suitable applicants. Although ATS reduced human work and speed up the selection of applicant the result yielded was very poor since there was no contextual meaning in the searched content, this method discarded even capable applicants if they did not mention their skills or experience with the words as specified in job description. Thus this method failed to consider semantic relationship between candidates skill and job requirement. Natural Language Processing techniques to extract relevant information from resume contents (unstructured) was proposed by researchers to overcome the issues with keyword based approach, the process included Text Pre-Processing, Tokenization, Named entity Recognition, skill Extraction and Semantic similarity between the matched text with skill identified. This increased ability of system to find candidates skills, and educational background as well compared to previously mentioned ATS system, but still many NLP based methods use hardcoded rules for searching and lacks deeper context understanding. The use of machine learning methods has proven beneficial for an automated recruit system, Machine learning classification methods like SVM, Naive Bayes, Logistic Regression, Random Forest classifier have been utilized for candidate evaluation and resume categorization. These models were able to predict more accurately based on historical recruitment data; however these traditional Machine Learning models requires manual extensive feature engineering and very large sized training datasets and lacks to understand deep context in data.

XAI also stands as an active area of research in recruitment systems. Most AI systems are 'black boxes' and do not communicate how and why certain decisions are made. In response to such a phenomenon researchers have put forward the explanation frameworks to increase transparency and trust in the automated decision making systems. Explainable recruitment systems present the reasoning behind candidate scores by showing what skills match what not and relevant qualities. Transparency in these decision systems can be considered crucial where decisions directly impact individuals and organizations.

The issue of bias and fairness in the AI-based recruitment systems have become the focus in recent years. Studies showed that AI models tend to learn biased practices that are embedded within training data. Such discrimination can be caused by gender, educational background, writing style, demographic characteristics and so on



which are irrelevant for the jobs. Researchers developed fair-ware algorithms and methods for bias detection for the recruitment systems. In the context of ethical AI we evaluate candidates based on relevant skills, qualifications and experiences not based on the biases.

Recent works were also conducted on the combination of AI-based recruitment systems and user-friendly dashboards and visualization tools. Interactive dashboards support the users' work by presenting candidate score, matched skills, missing competencies, reasoning for the evaluations in an easily comprehensible format. Graphs, ranking tables, structured output and visualization techniques aid the decision makers' task, as well as interpretability of the system.

Though the progress achieved in recruitment automation is significant, limitations are still identified in current systems. ATS platforms mostly continue to rely on keyword matching and fail to present contextual knowledge while some ML models may need a lot of training data and complex feature engineering. Some other AI systems are not transparent and ignore the issue of fairness. Therefore, it is necessary to develop intelligent recruitment systems which integrate semantic understanding, explainability and fair evaluation framework.

2.1 Research Gap

Despite the growing interest in using ML, NLP and Applicant Tracking Systems for automated resume screening, many available systems are flawed in certain areas. Existing systems like conventional Applicant Tracking Systems primarily rely on keyword matching techniques which do not understand the contextual meaning of a candidate's competencies and are prone to false negatives. Conventional ML models need a large amount of feature engineering and labelled data. These factors make them difficult to use in practice.

Although the recently developed Large Language Models possess improved contextual reasoning abilities and a deeper semantic understanding, most existing recruitment systems still fail to explain why they have selected/ rejected candidates and maintain a black box operation. Hence, recruiters can never fully trust or rely on the decision making capability of these systems.

Another major deficiency noted in the previous work is the lack of awareness about bias during the recruitment process. Many automated systems have the tendency to indirectly embed biases due to unrecognized trends in

training data, resume format, candidate demographics, etc. The studies focus more on prediction accuracy without any focus on fair assessment and ethically intelligent practices.

Lastly, many of the available systems do not offer combined solution to semantic understanding, explanation, bias-awareness and visualized presentation together in one coherent framework, and each aspect is being focused individually.

Hence, this paper attempts to fill the above research gaps and proposes to develop an Explainable and Bias-Aware Large Language Model Based Resume Screening System for semantically assessing candidate competency, providing clear explanation, being less biased and offering structured visualization in a smart recruitment scenario.

3. METHODOLOGY

The developed methodology aims at constructing an Explainable and Bias-Aware Large Language Model (LLM)-Based Resume Screening System that enhances the evaluation of job applicants using semantics and intelligence-driven matching in a transparent framework. Current recruiting systems primarily involve manual evaluation or keyword-based Applicant Tracking Systems (ATS) which typically do not assess the relevance of resumes against the job descriptions based on their meaning. To address these drawbacks, this system is an incorporation of Natural Language Processing techniques, Large Language Models (LLM), explainability mechanisms, and bias-aware evaluation modules on an integrated recruitment system. The methodology involves a pipeline of different phases such as data collection, preprocessing, semantics, matching, scoring, explaining and visualizing results. First, the resume and job description are acquired and preprocessed through the required text extraction, cleaning, normalization and tokenization methods. The technical skills, academic qualifications, certifications and work experience information is extracted.

3.1 System Architecture Design

The presented system architecture is composed of modular and scalable components that contribute to intelligent resume screening and transparent candidate assessment. The architecture is made up of interconnected modules: pre-processing, semantic assessment, candidate matching and scoring, explanation

generation and visualization. Each module serves a distinct function within the recruitment pipeline while remaining communicative with the other system modules.

The workflow starts with the user interface layer, where the recruiters can upload resumes, provide job description, it was built using the streamlit platform. Uploaded resumes are then transmitted to the pre-processing module to extract and clean text, normalize it and segment it into tokens. Important candidate information such as skills, education, certifications, experience etc. is extracted and put into a structure.

The pre-processed candidates' data are then fed to the Large Language Model integration layer. The LLAMA 3 model is used to perform semantic analysis and contextual understanding of candidate and job descriptions; thus differs from traditional systems that only rely on keyword search by the system for semantic comparison between job descriptions and skills.

The candidate matching and scoring engine performs job requirements analysis, determines the fitness level of each candidate, produces relevant suitability scores based on the following aspects; skills, education and experience. Human-understandable explanations that describe the assigned scores along with identified skills and missed competencies in candidate responses are also generated using the explainability module. A bias-aware evaluation mechanism is also embedded to make it clear to recruiters that candidate assessment would be done only on skills and attributes that are related to the jobs.

In the end, output visualization layer is integrated to present the assessment outcomes and it is visualized using an interactive dashboard where recruiters are presented with the candidate score, skill matching, missing skills, explainability results and structural outputs in a user-friendly interface. The modular system is easily scalable, maintainable and upgradeable.

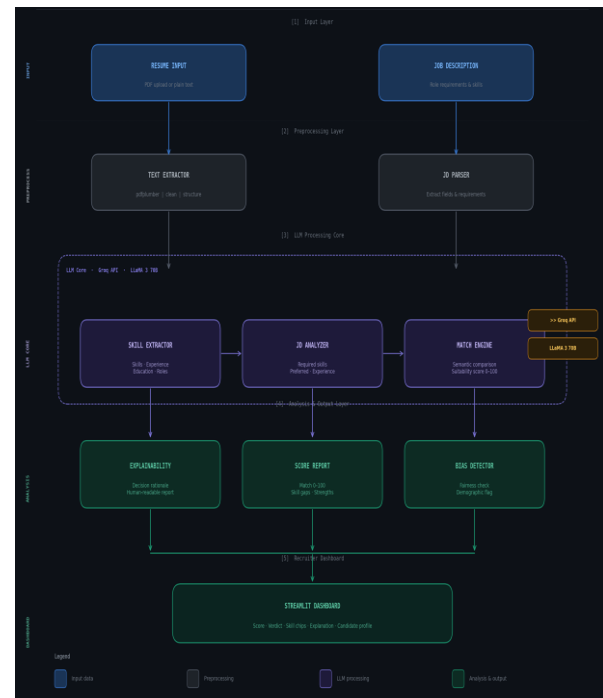


Figure 1: System Architecture

3.2 System Workflow

The workflow of the proposed Explainable and Bias-Aware Resume Screening System is designed to be a streamlined pipeline for efficient processing and intelligent candidate evaluation. The workflow begins with the resume and job description upload where the recruiter uploads candidate resumes (in PDF or text) along with the job description.

The uploaded resumes first go through the preprocessing stage. This stage consists of text extraction, text cleaning, text normalization, and text tokenization where any irrelevant data is filtered out and texts are made coherent. Important candidate data like skills, education, certifications and work experience are extracted in a structured way.

Once the resume is preprocessed and structured, it is passed to the LLM integration layer along with the job description. The LLM model like LLaMA 3 performs semantic understanding and context assessment of the candidate's resume and job description. The model searches for semantic similarity, matched skills, related skills and abilities that may not be present in the job description exactly.

The candidate matching and scoring stage where the compatibility between resumes and job description is measured with weighted scoring mechanism. In this



stage candidates are scored on the factors such as relevance of their skills to job, education, certifications, and work experience. Missing and additional skill and competencies of candidates are identified.

Once the candidates are evaluated by the system then the explainability module generates clear, human-readable explanations that articulate the justification behind the score of a candidate. It highlights candidate's strengths, weaknesses, matching skills, and missing skills to make recruiters trust the automated decisions.

Finally, the results are presented on an interactive Streamlit dashboard where the recruiter can see the ranking of the candidates, score and skill compatibility report, explainability of the score and visualizations of the outputs in structured manner. The workflow ensures that the candidates can be evaluated in an accurate, transparent, and automated manner.

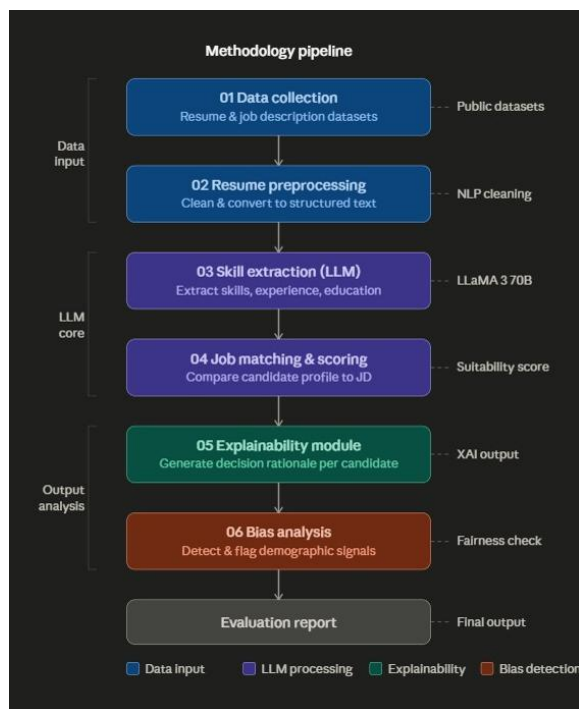


Figure 2: Pipeline

4. RESULTS AND DISCUSSION

4.1 Overall Discussion and System Performance

The proposed system "Explainable and Bias-Aware Large Language Model Based Resume Screening System" was developed and evaluated for smart candidate evaluation and semantic resume screening. The system was able to integrate NLP approaches, LLMs, explainability and bias-aware evaluation into one recruiting pipeline. Through extensive experiments, the

proposed system performed much better on semantic understanding and candidate-job fit than keyword-based ATS. The proposed system processed resumes and job description through stages like preprocessing, semantic evaluation, candidate matching and scoring, result visualization and explainability of the output. Candidate's skills, education, certifications, experience was interpreted using LLaMA 3 LLM in a contextual manner. In contrast to keyword-based ATS that heavily depended on exact keyword matching for skills, the system used semantic related skills and context for effective matching between candidate and job requirements. The candidate matching and scoring module effectively performed evaluation on multiple candidates on several aspects such as technical skill sets, educational background, and professional experience. A weighted scoring mechanism resulted in better candidacy suitability score based on the candidates and the job description. It was also possible to identify matched skills, gaps and strengths of candidates that further made it effective. The experiments revealed that semantically similar skills of candidates were effectively matched even in absence of exact keywords. The second core contribution of the system is the explanation mechanism integrated in the evaluation process, providing human interpretable reasoning on why specific candidates get the score and classification (e.g., unsuitable, suitable etc.), thereby improving trust. The candidate matching and scoring module not only focused on job related parameters, but also excluded biased information that would impact the scoring of the candidate. The final experiments were run with traditional and the proposed system on different criteria. The proposed system excelled over the keyword based method in the context of accuracy, precision, recall and F1 score. Large Language Models significantly improved the context understanding and result ranking quality. The use of the Streamlit dashboard for displaying results in a structured form of visualizations and explanation report improved user experience.

4.2 System Interface and Visualization Results

The system architecture proposed integrates an interactive user-interface, built using Streamlit, to increase usability and engagement for recruiters. Users (recruiters) will be able to upload resumes, input job descriptions, and obtain intelligent candidate evaluation reports from the organized dashboard. Recruiters can then interpret evaluation outputs through the various visualizations for candidate scores, matched skills, absent skills, and an explainability report.



The dashboard provides several evaluation results including a suitability score, a skill match score, education, and work experience analysis. Additional visualization sections, such as missing vs matched skills, candidate strengths, and a semantic analysis report, are also present. JSON outputs are provided as well to enhance transparency and provide ease for integration with other recruiting platforms.

The UI makes the system easier to access and the process of recruitment much simpler by organizing information into readily understandable visualizations. This type of application (semantic analysis with interactive visualization) can be practical in an active recruiting environment because it facilitates efficient decision-making for recruiters.

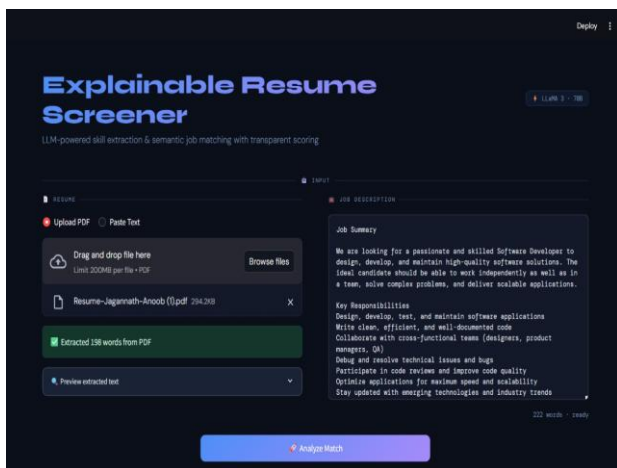


Figure 3: System Interface 1

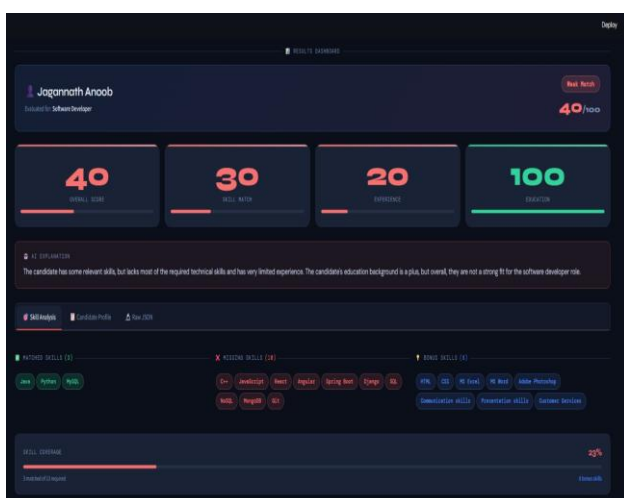


Figure 4: System Interface 2

4.3 Comparative Performance Analysis

The efficiency of the Explainable and Bias-Aware Resume Screening System was compared to a keyword-based ATS and a simple semantic matching model. Through experimental analysis, the proposed LLM-based system had superior semantic matching and candidates evaluation performance, as it took context into account when analyzing resume. Traditional ATS primarily depends on exact matching and cannot find semantically similar skill. On the other hand, the proposed system detected semantic relevancy between resume and the job description thereby enhancing candidate ranking performance. It can effectively infer candidates' competency and skillset due to the advanced language understanding of LLM even with the difference in terms. Through various performance evaluation metrics such as precision, recall, accuracy and F1-score, experimental results indicated that the proposed system demonstrated higher performance than conventional models in all aspect. By providing natural language based explanation for the scores and candidate evaluation, the system can be made more interpretable. Through the comparative analysis, it can be proved that integrating LLMs with an explainable framework and a bias-aware decision-making procedure leads to enhanced recruitment automation and better evaluation for candidates.

4.4 Error Analysis and Limitations

While the system proved to have a robust semantic understanding and candidacy evaluation, it is evident that there are a few limitations and mistakes we observed during testing and analysis. The variety of resumes is a major issue; resumes, by nature, are an unstructured document, involving different font types, styles, table, layouts and writing styles that can lead to inaccurate text extraction and preprocessing of the resumes.

Semantic ambiguities between descriptions of candidates are another issue; certain technical terms and projects may have various interpretations based on the context of their application leading to mistaken candidate skill detection and candidate scoring discrepancies. Also, depending on the quality of both the candidate resume and job description inputs to Large Language Model, it is possible for certain aspects to be missed, and hence influence the outcome.

The large Language Model also introduces heavy computation costs, leading to the need for large



computational power in case of processing thousands of resumes for large-scale recruitment; scalability and a cloud-based system for Large Language Models would then be essential. Even though bias-aware mechanisms were integrated into the system, it is inherently very difficult to fully eliminate bias from AI systems, as language models themselves can still exhibit implicit bias from their training data.

Regardless of these limitations, the system can bring much more improved resume semantics analysis, explainability and transparency to recruitment than traditional ATS systems. Future improvements with greater amounts of data, enhanced bias- auditing and optimized deployment can help us further achieve improved performance.

5. CONCLUSION

The presented Explainable and Bias-Aware Large Language Model Based Resume Screening System proves that AI and NLP can make modern recruitment more efficient. Conventional resumes screening practices are time-consuming and inconsistently rely on human input or keyword based Applicant Tracking Systems (ATS). Furthermore, conventional screening methods often lack an ability to understand a relation between resume contents and the job description, hence the candidate could be falsely judged. The designed system attempts to solve this issue through Large Language Models (LLM) in combination with semantic analyses to implement an intelligent candidate-job match.

In summary, the implemented system preprocesses resumes, extracts semantic skills from them, scores candidates, generate explanations, and assesses candidates in a bias-aware manner all in one environment. LLaMA 3 in combination with NLP features the ability to process and understand the contextual relevance rather than just looking for a exact match between keywords, which significantly increases candidate evaluation accuracy and effectively identifies well-matched candidates. With the explainability module integrated into the system, the recruiter can view human readable reasons behind the candidate score, thereby fostering a better understanding of the recruitment evaluation.

A significant benefit of the implemented system is also that the system includes bias-aware screening methods to not take non-job relevant criteria (for example,

candidate's ethnicity, gender, etc) into consideration while making candidate evaluations. The proposed system aims to analyze only the job-relevant criteria (skills, education and experience). It helps enhance the fairness and ethics of modern recruitment as well as the reliability of an AI based recruitment process.

The implemented approach has better semantic understanding, better candidate match, and more transparent decision making compared to traditional ATS-based methods. An interactive Streamlit-based interface allows for an easy view of candidate evaluation results in an understandable and systematic manner. All in all, this AI based system can be a smart, scalable, explainable, and fair alternative to conventional recruitment process.

5.1 Recommendations and Future Work

Given the results and findings acquired through the development of the proposed Explainable and Bias-Aware Large Language Model Based Resume Screening System, several recommendations and potential enhancements are suggested which could boost the efficiency, scalability and practicality of the system. Although the developed model showed better capabilities of understanding semantics, providing explanations and candidate evaluating accuracy, further development would contribute to a more efficient, reliable, and practical system suitable for actual enterprise recruitment scenarios.

It is recommended to use a much larger and diverse set of resume datasets of different industries, technical domains, educational backgrounds etc to help the model with a better capability of generalizing candidate evaluation and to get more accurate outcomes in different scenarios. Moreover, input resumes with different writing styles and formats could further assist with a better understanding of preprocessing and semantics module.

Another strong recommendation is integrating the system into the actual Applicant Tracking Systems and Human Resource Management platforms. By such integration, an organization would be able to achieve higher level of recruitment process automation and minimize manual work and processing time. Customizable scoring parameters would be necessary as well to assist organization with their specific requirements and criteria.



With regards to further enhancement on the explainability framework, we suggest generation of more detailed evaluation report and interactive visualization analyses such as skill gap analysis, candidate comparison dashboard, ranking etc. Such a generation would significantly enhance the recruiters' decision-making process and the overall trust to AI generated results. Also, the model is possible to achieve the same by some cutting-edge explainability techniques.

The fairness audit and bias detection can be further strengthened in the system. As current study is only focused on relevant job information, some advanced fairness audit approaches can be explored to deal with irrelevant attributes. Continuous auditing and monitoring will be necessary in the real system to ensure ethical usage.

Another promising extension can be in supporting multiple languages. In this system, English resumes and job descriptions are currently handled only. Thus, expanding the model into other languages can significantly promote its usage and capability. For specific domains such as technical fields, a fine-tuning for a more comprehensive semantic understanding can be beneficial.

For the scalability of the system, as Large Language Models have computational overhead, exploration on efficient inference techniques and further development on cloud platform support and lightweight model structures could significantly boost performance and achieve better usability for large-scale recruitment needs. Moreover, an integration with real time recruitment analytics and prediction systems can create an even higher value.

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