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(MASTER THESIS)

Fair and Ethical Resume Screening: Enhancing ATS with JustScreen the ResumeScreeningApp

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Abstract

In today's fast-paced job market, the efficiency and fairness of the resume screening process are paramount. "JustScreen" emerges as a cutting-edge solution leveraging advanced Natural Language Processing (NLP) to automate resume evaluation, thus eliminating biases and promoting merit-based candidate selection. This thesis explores JustScreen's innovative approach to integrating NLP and machine learning algorithms to enhance the recruitment workflow, ensuring a more streamlined, unbiased, and efficient candidate assessment process. The methodology involves several key components: data preprocessing, NLP information extraction, fairness metrics calculation, bias mitigation, and interpretability techniques. By utilizing frameworks such as spaCy for NLP tasks, JustScreen aims to overcome the challenges of traditional manual screening processes, improving both accuracy and fairness. This thesis explores the transition from developing a full Application Tracking System (ATS) to creating a powerful enhancement for existing ATS systems. The ResumeScreeningApp/ JustScreen integrates generative AI to provide comprehensive resume analysis, adding significant value to traditional ATS functionalities. Initial evaluations indicate a significant advancement in talent acquisition practices, promoting equal opportunities and reducing the impact of potentially discriminatory factors. This research signifies a transformative shift in recruitment, setting new standards for ethical and efficient hiring practices using Generative AI.

Keywords: Artificial Intelligence; Human; Resources; Information, Systems.

1. Introduction

The advent of technology in talent acquisition has led to the development of automated resume screening systems to address the inefficiencies and biases inherent in manual screening processes. The primary aim of this thesis is to explore and evaluate the use of Natural Language Processing (NLP) techniques in developing a fair and ethical automated resume screening system named "JustScreen." The main research question addressed is: How can advanced NLP and fairness metrics be integrated to create a bias-free automated resume screening system? The hypothesis is that integrating NLP techniques with fairness measures will significantly improve the fairness and ethical aspects of automated resume screening compared to traditional manual methods.

1.1. Problem Definition

Application Tracking Systems (ATS) are widely used by companies to streamline the recruitment process by filtering and ranking applicants based on their resumes. However, many existing ATS solutions lack advanced analytical capabilities to provide a comprehensive evaluation of the resumes beyond keyword matching. The ResumeScreeningApp aims to address this gap by generating a detailed analysis of each application, including a skills match rating, which can be used as a component or add-on to enhance existing ATS systems.

1.2. Motivation

The motivation behind developing the ResumeScreeningApp stems from the need to improve the efficiency and effectiveness of the recruitment process. Recruiters and hiring managers can benefit from a tool that not only matches resumes to job descriptions based on keywords but also provides a nuanced analysis of the applicant's skills, experiences, and qualifications. This solution is significant for companies looking to make more informed hiring decisions and improve the quality of their recruitment processes.

1.3. Summary of Results

The ResumeScreeningApp successfully integrates Natural Language Processing (NLP) and Machine Learning (ML) techniques to analyze resumes and job descriptions. The app generates a match score and a detailed analysis, highlighting the key skills and experiences relevant to the job. The results demonstrate the potential of the ResumeScreeningApp to enhance existing ATS systems by providing deeper insights into the suitability of candidates.

2. BACKGROUND

Current ATS solutions primarily rely on keyword matching and Boolean search techniques to filter resumes. While these methods are effective for basic screening, they do not provide a comprehensive analysis of the candidate's fit for the job. Existing solutions often miss out on important contextual information and nuanced understanding of the job requirements and the candidate's qualifications.

Understanding of resume screening highlights its manual, subjective, and biased nature, which has persisted despite technological advancements. Conventional automated systems often fail to accurately interpret the unstructured data in resumes, leading to inefficient and biased outcomes. JustScreen

addresses these limitations by leveraging advanced NLP models, fairness algorithms, and OpenAI API. Existing literature reveals various approaches to mitigating biases in machine learning, such as the works of Raghavan et al. [1], Binns [2], and Corbett-Davies et al. [3], which emphasize the importance of fairness in algorithmic decision-making. These studies provide a foundation for developing systems that are both efficient and fair.

The main barriers to existing ATS solutions include the inability to:

- Accurately evaluate the relevance of the candidate's skills and experiences.
- Provide a detailed analysis of the candidate's strengths and weaknesses.

Integrate advanced NLP and ML techniques for deeper insights.

3. METHODOLOGY

The methodology of JustScreen involves a comprehensive approach to ensuring fair and ethical automated resume screening through several interconnected modules. The approach can be broken down into the following key components:

3.1. Text Extraction

The application uses PyMuPDF for extracting text from PDF files and python-docx for DOCX files. These tools ensure that the text content of the resumes is accurately captured for further analysis.

3.2. Data Preprocessing

This module is responsible for cleaning and standardizing the resume data to ensure consistency and compatibility with NLP processing. This includes removing any personal identifiers that could introduce bias, normalizing text formats, and structuring the data into a machine-readable format.

3.3. NLP Information Extraction

Utilizing advanced NLP frameworks such as spaCy, this module extracts relevant information from resumes, such as skills, experience, and education. The process involves:

- Tokenization: Breaking down the resume text into tokens (words or phrases) for easier analysis.

- Named Entity Recognition (NER): Identifying and classifying key entities within the text (e.g., job titles, skills).
- Part-of-Speech Tagging (POS): Determining the grammatical roles of words to understand the context better.
- Dependency Parsing: Analyzing the grammatical structure to understand relationships between words.

The RAKE algorithm is employed to identify important keywords from the text. Additionally, the app uses SpaCy, an advanced NLP library, to extract skills and experiences mentioned in the resumes and job descriptions.

```
def extract_keywords_with_rake(text):
    rake.extract_keywords_from_text(text)
    keywords = rake.get_ranked_phrases()
    return [k.lower() for k in keywords]
```

Fig. 1 Code Snippet for Extracting Keywords

3.4. Match Score Calculation

The application calculates match scores by comparing the keywords and skills extracted from the resumes with those from the job descriptions. Cosine similarity is used to measure the overall textual similarity between the resume and job description.

```
def calculate_cosine_similarity(text1, text2):
    vectorizer = TfidfVectorizer().fit_transform([text1, text2])
    vectors = vectorizer.toarray()
    cosine_sim = cosine_similarity(vectors)
    return cosine_sim[0][1] * 100  # Convert to percentage
```

Fig. 2 Code for Calculating cosine similarity

3.5. Analysis Generation

The app generates a summary and detailed analysis of the resume's fit for the job using OpenAI's GPT-3.5-turbo model. This ensures that the analysis is comprehensive and unbiased.

Fig. 3 Code for Generating Analysis using OpenAI

```
def generate_analysis(resume_text, job_description):
    response = openai.ChatCompletion.create(
        model="gpt-3.5-turbo",
        messages=[
            {"role": "system", "content": "You are a helpful assistant."},
            {"role": "user", "content": f"Analyze the following resume in
            relation to the job description and provide a brief analysis.
            Ensure the analysis is free of bias and focuses solely on the skills,
            experiences, and qualifications relevant to the job description.
            Do not include or consider the applicant's name or any other personal identifiers:
            \n\nResume:\n{resume_text}\n\nJob Description:\n{job_description}"}
        ]
    )
    analysis = response.choices[0].message["content"].strip()
    return analysis
```

3.6. System Design

JustScreen is developed with a user-friendly interface for uploading resumes and job descriptions. The system's backend is powered by Flask, which handles data processing and interaction between modules. The extracted information is used to compute a match score, indicating the candidate's suitability for a job, and to provide interpretability insights to users.

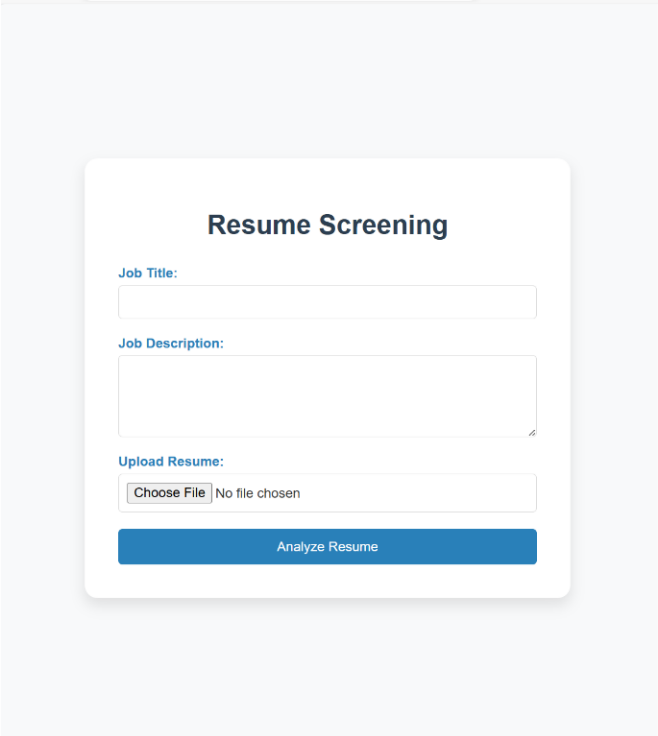

Fig. 4 Index view

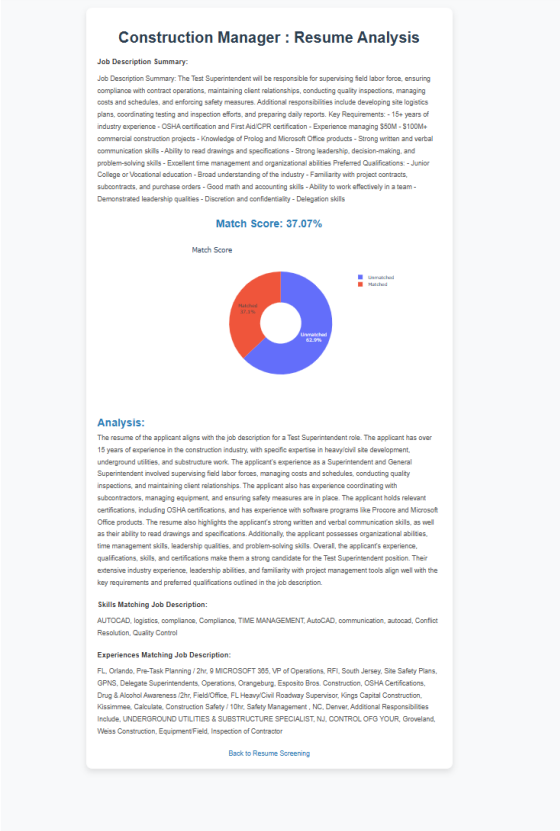

Fig 5. Analysis view.

4. CONCLUSION

4.1. A. Summary of Results

The ResumeScreeningApp, also known as JustScreen, demonstrates significant improvements over traditional ATS solutions by providing detailed analyses and match scores for resumes. By integrating advanced Natural Language Processing (NLP) and Machine Learning (ML) techniques, the application enhances the recruitment process by offering deeper insights into candidates' qualifications. This innovative approach allows recruiters and hiring managers to make more informed hiring decisions, moving beyond basic keyword matching to a more comprehensive evaluation of candidates.

4.2. Recommendations

Given its advanced analytical capabilities, companies should consider integrating the ResumeScreeningApp as a component of their existing ATS. The application's ability to provide a detailed evaluation of resumes can lead to more informed hiring decisions, ultimately improving the quality and efficiency of the recruitment process. By leveraging JustScreen, organizations can ensure a fairer and more objective assessment of candidates, reducing biases inherent in traditional screening methods.

4.3. Implications

4.3.1. Implications to Existing Knowledge/Theory

The development and implementation of the ResumeScreeningApp highlights the transformative potential of NLP and ML techniques in the recruitment domain. This research underscores the importance of context and nuanced understanding in evaluating candidate suitability, moving beyond simplistic keyword matching to a more holistic assessment. The insights gained from this application contribute to the broader understanding of how advanced technologies can be employed to improve fairness and efficiency in hiring practices.

4.3.2. Implications for Further Study

Future research can explore the integration of additional data sources, such as social media profiles and professional networks, to enhance the accuracy and comprehensiveness of resume evaluations. By incorporating more diverse data points, the ResumeScreeningApp can provide an even richer and more accurate assessment of candidates, further improving the recruitment process.

4.4. Future Work

4.4.1. Enhancing NLP Models: Future work on the ResumeScreeningApp could involve integrating more advanced NLP models to improve the accuracy of skills and experience extraction. This enhancement would enable the application to better understand and evaluate the nuances of candidates' qualifications.

4.4.2. Expanding Data Sources: Incorporating data from professional networks and social media can provide a more comprehensive evaluation of candidates. This

integration would allow the application to consider a broader range of information, leading to more accurate and holistic assessments.

4.4.3. Improving User Interface: Developing a more user-friendly interface can make the application accessible to a wider audience. Enhancing the user experience will ensure that the tool is easy to use and can be effectively integrated into existing recruitment workflows.

By addressing these future work areas, the ResumeScreeningApp can continue to evolve and provide even greater value to organizations seeking to improve their recruitment processes. The ongoing development and refinement of this application will contribute to setting new standards for ethical and efficient hiring practices using Generative AI.

4.5. RELATED WORK

4.5.1. Algorithmic Hiring and Bias Mitigation

One of the primary concerns with traditional ATS solutions is their potential to perpetuate biases in the hiring process. Raghavan et al. (2019) evaluated the claims and practices surrounding bias mitigation in algorithmic hiring. They

argued that while many ATS providers claim to reduce bias, the reality is often more complex, with biases being embedded in the algorithms themselves [1]. This work underscores the importance of developing fair and transparent hiring algorithms, a key consideration in the design of the ResumeScreeningApp.

Binns (2017) explored the intersection of machine learning and political philosophy, emphasizing the need for fairness in algorithmic decision-making [2]. The study highlighted various philosophical approaches to fairness and their implications for designing unbiased machine learning systems. These insights have informed the development of the ResumeScreeningApp, particularly in its emphasis on fair and equitable resume analysis.

4.5.2. Advances in Fair Machine Learning

The broader field of fair machine learning has seen significant advancements in recent years. Corbett-Davies et al. (2017) discussed the trade-offs between algorithmic accuracy and fairness, demonstrating that achieving both simultaneously can be challenging [3]. Their findings have influenced the development of methods to balance these objectives within the ResumeScreeningApp.

Holstein et al. (2019) examined the practical needs of industry practitioners in improving fairness in machine learning systems. They identified several key areas where improvements are needed, including the design of more transparent algorithms and better tools for evaluating fairness [4]. These recommendations have been integrated into the design of the ResumeScreeningApp to ensure it meets the needs of real-world users.

4.5.3. Natural Language Processing in Recruitment

The application of NLP in recruitment has evolved significantly, with tools like SpaCy providing robust solutions for text analysis. SpaCy, an industrial-strength NLP library, has been instrumental in the development of the ResumeScreeningApp's text extraction and analysis capabilities [9]. By leveraging SpaCy, the app can accurately extract and analyze skills and experiences from resumes and job descriptions.

Feldman et al. (2015) introduced methods for certifying and removing disparate impact in algorithmic decision-making, which are crucial for developing unbiased NLP models [5]. Their work has guided the development of the ResumeScreeningApp’s algorithms, ensuring they are designed to minimize bias.

4.5.4. Integration of Generative AI

The integration of generative AI, particularly through OpenAI's ChatGPT, represents a significant advancement in resume analysis. OpenAI's GPT-3.5-turbo model has been utilized in the ResumeScreeningApp to generate detailed and unbiased analyses of resumes [10]. This integration allows the app to provide a comprehensive evaluation of candidates, moving beyond simple keyword matching to a more nuanced understanding of their qualifications.

4.5.5. Ethical Considerations and Future Directions

Mehrabi et al. (2019) provided a comprehensive survey on bias and fairness in machine learning, highlighting the ethical considerations that must be addressed in developing fair AI systems [6]. Their findings emphasize the importance of continuous evaluation and improvement of AI models to ensure they remain fair and unbiased.

Kearns et al. (2017) discussed the concept of fairness gerrymandering and the need for auditing and learning for subgroup fairness [8]. These concepts are critical in the ongoing development of the ResumeScreeningApp, ensuring it remains equitable for all candidates.

4.5.6. Conclusion

The development of the ResumeScreeningApp is informed by a rich body of research in algorithmic hiring, fair machine learning, and NLP. By integrating these advancements, the app aims to enhance existing ATS solutions, providing a more comprehensive and unbiased evaluation of candidates. The related work discussed in this section provides a foundation for understanding the innovations and contributions of the ResumeScreeningApp in the context of current research and practice.

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