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DEPARTMENT OF MATHEMATICAL SCIENCES

A PROJECT REPORT ENTITLED

JOB MARKET ANALYSIS: BUILDING A RECOMMENDATION SYSTEM FOR IN-DEMAND SKILLS

BY

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SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF BACHELOR OF SCIENCE IN COMPUTER SCIENCE AND ENGINEERING

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SEPTEMBER, 2024

DECLARATION

I, GYAMFI JACOB KYEI BAFFOUR, declare that this project work is my own work. It is being submitted for the degree of Bachelor of Science in Computer Science and Engineering in the University of Mines and Technology (UMaT), Tarkwa. It has not been submitted for any degree or examination in any other University.

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(Signature of candidate)

.....day of .....(year) .....

ABSTRACT

This project focuses on developing a job market analysis and recommendation system that identifies in-demand skills and provides personalized recommendations to job seekers. By leveraging machine learning and natural language processing techniques, the system analyzes job posting data to highlight the skills most sought-after in the industry. The goal is to assist job seekers in enhancing their employability by offering targeted skill development advice and supporting employers in finding candidates with the necessary competencies. The project ultimately aims to contribute to a more informed and dynamic job market, helping both job seekers and employers navigate the evolving demands of the workforce.

DEDICATION

This project is a testament to the unwavering support, love, and inspiration propelling me. I extend my deepest gratitude to Dr. Osei Yaw Adutwum, MP, for his visionary leadership; to my father, Nana Gyampo-tua II, for his strength and wisdom; to my mother, Florence, for her boundless love; and to my siblings, for their constant companionship. Your collective presence in my life has made this achievement possible, and I dedicate this work to you with profound appreciation.

ACKNOWLEDGEMENT

I want to express my deepest gratitude to my project supervisor, Dr Vincent M. Nofong, for his invaluable guidance, constructive feedback, and continuous support throughout this project. His expertise and mentorship were crucial in shaping the direction of this work.

I am also grateful to the faculty of the Computer Science and Engineering Department at the University of Mines and Technology for providing the resources and knowledge that made this project possible. Special thanks to my friends and colleagues for their constant encouragement and insightful discussions.

Finally, I extend my heartfelt appreciation to my family for their unwavering love, patience, and understanding, which have been instrumental in the completion of this project.

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LIST OF ABBREVIATIONS

lr zxaaaa **SDG**	**S**ustainable **D**evelopment **G**oal
HDCF	**H**ybrid Deep **C**ollaborative **F**iltering
TF-IDF	**T**erm **F**requency – **I**nverse **D**ocument **F**requency
NLP	**N**atural **L**anguage **P**rocessing
CBF	**C**ontent-**B**ased **F**iltering
CF	**C**ollaborative **F**iltering
ML	**M**achine **L**earning
RMSE	**R**oot **M**ean **S**quare **E**rror
UPA	**U**ser **P**reference **A**nalysis
DCF	**D**eep **C**ollaborative **F**iltering
NSC	**N**eural **S**emantic **C**ontext
DMR	**D**ynamic **M**odel **R**anking
BiLSTM	**BI**directional **L**ong **S**hort-**T**erm **M**emory

CHAPTER 1

INTRODUCTION

1.1 Backgroung of Study

The dynamics of the labour market and the tasks with which jobs are being performed continuously evolve (Gutiérrez *et al.* (2019)). This trend has led to challenges in identifying the right skills and opportunities for both job seekers and employers. With the emergence of new occupations in the digitized landscape, the skills and competencies required for jobs are continuously changing (Kukreja (2020)).

Moreover, the COVID-19 pandemic has resulted in the displacement of over one-sixth of the global youth population from work, with those employed seeing their working hours cut by 23 per cent (Kukreja (2020)). To address these challenges, a job market analysis and recommendation system is essential.

This system would provide valuable insights into the current trends in the job market, identify the most in-demand skills and industries, and offer suggestions on the skills that job seekers need to develop to remain employable and the industries that offer the most opportunities for career growth.

According to the United Nations' Sustainable Development Goal 8, sustained, inclusive, sustainable economic growth, full and productive employment, and decent work are essential for promoting social and economic well-being.

The job market analysis and recommendation system can contribute to achieving this goal by promoting the creation of more job opportunities and supporting the development of a skilled and resilient workforce.

Furthermore, the system can help identify opportunities for career growth and support the economic and social well-being of society (The Global Goals (2015)).

1.2 Problem Statement

The World Economic Forum predicts that by 2022, at least 54% of all employees will require significant reskilling and upskilling (Forum (2018)). This statistic highlights the urgent need to identify the most in-demand skills and industries, ensuring that job seekers can adapt to the rapidly changing job market.

The Fourth Industrial Revolution, characterized by technological advancements and automation, is reshaping industries and transforming the nature of work (Schwab (2019)). As a result, job seekers and employers face the challenge of keeping up with the evolving skills and competencies required for jobs (Gutiérrez *et al.* (2019)). Without upskilling and reskilling, individuals risk being left behind in an increasingly competitive labour market.

The COVID-19 pandemic has further exacerbated this challenge by causing widespread job losses and economic disruption worldwide. According to the International Labour Organization (ILO), global working hours declined by an estimated 8.8% in 2020 compared to the fourth quarter of 2019, equivalent to 255 million full-time jobs (ILO (2021)).

The pandemic's impact has been particularly severe on specific industries, such as travel, hospitality, and retail, leading to significant job cuts and reduced working hours (WorldBank (2023)). As the labour market recovers, job seekers face the daunting task of reentering the workforce and finding employment in industries that are adapting to the post-pandemic landscape.

To address these pressing challenges, the development of a job market analysis and recommendation system becomes imperative. Such a system would utilize comprehensive job postings data from various sources to identify the most in-demand skills and industries. By leveraging data analytics and machine learning techniques, the system can provide personalized recommendations to job seekers, helping them navigate the evolving job market and make informed career decisions.

1.3 Objectives

1.3.1 General Objective

The main objective of this study is to develop a recommendation system that provides personalized skills recommendations to job seekers, analyze job market data and identify in-demand skills and industries.

1.3.2 Specific Objectives

The following are specific objectives outlined to enable the successful completion of the study:

1. Collect and clean job market data from various sources to ensure accuracy and reliability in the analysis.
2. Conduct exploratory data analysis using Python to identify trends and patterns in the job market data.
3. Use statistical methods in Python to analyze the most in-demand skills and industries based on the job postings data.
4. Develop and evaluate a recommendation system that provides personalized recommendations based on the skills and preferences of job seekers to assist in making informed career decisions.

1.4 Significance of the Study

The proposed job market analysis and recommendation system holds significant potential for various stakeholders, including job seekers, employers, and policymakers. By providing personalized recommendations, the system can help job seekers make informed career decisions, which can lead to better employment opportunities and career growth.

This is particularly important given the continuously evolving nature of the labour market, which has made it challenging to identify the right skills and opportunities for both job

seekers and employers (Gutiérrez *et al.* (2019) & Kukreja (2020)).

Employers can also benefit from the study's findings by using the system's information to identify the skills and competencies required for specific job positions, making the recruitment process more efficient and effective. Policymakers can use the results to inform policies that address the skills gap and promote economic growth, which is crucial for achieving the United Nations' Sustainable Development Goal 8.

The study's significance lies in its potential to provide valuable insights into the current job market, identify the most in-demand skills and industries, and offer suggestions on the skills that job seekers need to develop to remain employable and the industries that offer the most opportunities for career growth.

The findings of this study can help to promote the creation of more job opportunities and support the development of a skilled and resilient workforce, which is essential for achieving SDG 8.

1.5 Scope of the Study

The study focuses on the job market in the United States and covers the most in-demand skills and industries based on job postings data from various sources. The recommendation system will also be tailored to the US job market.

1.6 Organisation of the Study

The present study is structured into five chapters, which provide a comprehensive account of the research work conducted.

The first chapter, the introduction, provides the contextual background of the study, the problem statement, the main and specific objectives, and the significance and scope of the study.

The second chapter is a literature review, which presents the theoretical foundation and related concepts of the research topic. It also reviews the existing literature and related systems that inform the present study.

The third chapter delves into the methods and methodology employed in the research,

providing an in-depth discussion of the tools and processes used to build the models and the mobile application. It also elucidates the data types and collection methods employed in the study.

In chapter four, the results of the research are presented, outlining the findings from the tests conducted on the collected data and the efficacy of the developed application in real-life scenarios.

Finally, chapter five concludes the study by summarizing the entire research work, highlighting its contributions, and presenting recommendations for future studies. The reference list of the research materials utilized is appended to the end of chapter five.

CHAPTER 2

LITERATURE REVIEW

This chapter outlines the study's literature review and definition of concepts such as Recommendation Systems and In-Demand Jobs. The chapter concludes with a summary table of the related works.

2.1 Background Review

The job market is constantly evolving, driven by technological advancements, economic fluctuations, and shifting industry demands. As a result, individuals seeking employment face the challenge of identifying and acquiring the skills that are in high demand. In recent years, recommendation systems have emerged as valuable tools for guiding job seekers toward relevant opportunities by analyzing the job market and identifying in-demand skills. This literature review aims to explore the background, definition of concepts, and related works in the field of building recommendation systems for in-demand skills in the job market.

2.2 Concepts Definition

2.2.1 Recommendation System

Recommendation systems are algorithms or models designed to provide personalized suggestions, recommendations, or predictions based on user preferences, historical data, and other relevant information. In the context of the job market, recommendation systems can assist job seekers in identifying and acquiring the skills that are in high demand, thereby increasing their employability.

2.2.2 In-Demand Skills

In-demand skills refer to the abilities, competencies, or knowledge areas that are sought after by employers due to their relevance to the current job market needs. These skills may

vary across industries, job sectors, and geographical regions, reflecting the dynamic nature of the labour market.

2.3 Related Works

The field of building recommendation systems for in-demand skills in the job market has witnessed significant advancements in recent years. As the job market becomes more competitive and dynamic, the need to match job seekers with the right opportunities based on their skills and preferences has become increasingly crucial. This literature review aims to provide an overview of relevant works in this area, highlighting the approaches, methodologies, and findings of previous studies.

The study by Mhamdi *et al.* (2020) presents a job recommender system that utilizes natural language processing (NLP) to extract valuable insights from job offers and match candidates with suitable opportunities. By collecting job postings from various websites, the system extracts important attributes like job titles and technical skills. These offers are then clustered based on shared features, enabling effective matching between job seekers and suitable offers. The authors review existing works in automated recommendation and text clustering, highlighting the benefits of a hybrid approach that combines content-based filtering and collaborative filtering. They also discuss the use of Word2vec, a neural network-based model for text clustering, which represents words as contextual vectors. The proposed job recommender model aims to extract meaningful data from job postings using text clustering methods, with future work focusing on training and evaluating the model using Word2vec and k-means clustering algorithms. The authors anticipate that their system can assist job seekers in finding relevant positions while streamlining the recruitment process for recruiters.

Kirubahari and Miruna Joe Amali (2021) proposes a novel solution to address the challenges of the cold start problem and data sparsity in recommender systems. By integrating conventional collaborative filtering with deep neural networks, the authors present a weighted parallel deep hybrid collaborative filtering method based on singular value decomposition and restricted Boltzmann machines. The proposed approach achieves

superior prediction accuracy compared to other techniques, as demonstrated through experiments on movie lens datasets. The paper also explores related works such as deep collaborative filtering via marginalized denoising autoencoder and clustering-based approaches. The authors utilize a weighted hybridization technique to combine multiple recommendation approaches and generate new output recommendations. The research contributes to the field of recommender systems by integrating collaborative filtering and deep learning models, offering a promising solution to enhance recommendation accuracy and overcome common challenges.

Vista (2020) explores a data-driven approach to skill valuation by examining their transferability across different occupations. The article utilizes graph theory to analyze the connections between skills and occupations using the O*Net database. The main argument put forth is the importance of objectively quantifiable skills as a means for policymakers to prioritize 21st-century skills that offer the most value in specific contexts. The research involves computing various centrality metrics within the network, with a particular emphasis on the betweenness centrality metric. This metric measures the extent to which skills facilitate efficient transitions between occupations. The article suggests that this approach can effectively guide the targeted and efficient allocation of resources for re-skilling or upskilling initiatives within specific industries or even at the firm level.

In their study on job recommendation systems based on skill-set, Pramanik *et al.* (2024) presents a comprehensive overview of a system that employs machine learning algorithms to match users' skills with job descriptions. The research explores various components of the system, including the utilization of a job dataset file containing job names and descriptions, as well as user-collected resumes to capture individual skills. The study delves into the preprocessing techniques employed, such as Porter Stemmer and Stop words, followed by the application of tf-idf vectorization to create matrices for both the job dataset and user resumes. Cosine similarity is adopted as the similarity function to determine scores between job descriptions and resumes. The system's output is presented in a tabular format, showcasing top job recommendations, and their associated scores, and is complemented by visual representations in the form of pie charts. Furthermore, the study conducts an analysis

of the user's resume and the skill dataset to offer suggestions for areas of skill improvement. In their study on AI-based suitability measurement and prediction between job description and job seeker profiles, G. M. and Suganthi (2022) explore the development of an innovative approach to streamline the hiring process. The research focuses on the utilization of clustering techniques and Jaccard similarity to assess the compatibility of candidates with job descriptions. By employing natural language processing (NLP) and clustering techniques, they propose a method to effectively identify suitable candidates for various job profiles. Additionally, AI-based classifiers are implemented to predict the suitability of resumes for specific job positions. Notably, the XGBoost classifier demonstrates superior performance, achieving an impressive average classification rate of 95.14%. The findings highlight the potential of AI algorithms in automating and enhancing resume screening processes. The article further examines the real-time applications of AI in HR practices and suggests future directions, such as leveraging social media features for enhanced classification accuracy. This study contributes to the growing body of literature on AI-driven solutions in talent acquisition and offers insights into the potential benefits and advancements in the field.

In their study on the impact of artificial intelligence (AI) on the labor market, Eloundou *et al.* (2023) explore the potential risks and benefits associated with AI adoption. Their research delves into the implications for income distribution and wealth inequality, considering the use of AI across various industries and its potential to replace human workers. The study provides empirical data on the exposure to AI in different occupations and industries, shedding light on the relationship between productivity growth and AI exposure. The authors propose policy measures, such as education and training reforms, as well as changes to safety net programs, to address the potential consequences of AI. By examining these aspects comprehensively, the study offers valuable insights into the multifaceted impact of AI on the labor market and provides a foundation for informed policy decision-making.

The study by Kumar *et al.* (2022) provides an overview of job recommendations, discussing the fundamental steps in recommendation systems and examining relevant research papers and existing systems. It highlights the use of modern ML and DMBI techniques,

item-based collaborative filtering, and web scraping for data collection. The review proposes a new system that addresses previous limitations and focuses on delivering high-quality recommendations. The system includes a hybrid model for personalized job recommendations based on user profiles and interests, with real-time suggestions considering job popularity among users. The review emphasizes the importance of catering to users of all backgrounds and ages. Overall, it presents a comprehensive assessment of job recommendation research, emphasizing the need for an improved system that prioritizes quality and relevance in delivering recommendations to users.

Their paper Schlippe and Bothmer (2023) presents the AI-based recommendation system called Skill Scanner, which aims to provide skill-based recommendations for employers, job seekers, and educational institutions. The system leverages natural language processing techniques to extract, cluster, and compare skills, facilitating communication and collaboration among the three stakeholders. The authors provide a comprehensive description of the clustering techniques employed in Skill Scanner and offer visual representations through screenshots and interactive scatter plots accessible online. Furthermore, the paper includes the findings of a survey conducted with 108 representatives from employers, job seekers, and educational institutions. The survey results indicate that the majority of respondents perceive Skill Scanner as more effective, faster, fairer, more explainable, more autonomous, and better supported compared to existing processes. In future work, the authors propose extending the pipeline to other job positions and exploring the application of Skill Scanner in different domains to broaden its impact and usability.

The study by Ibrahim *et al.* (2023) presents HDCF (Hybrid Deep Collaborative Filtering), a novel model for recommendation systems. HDCF integrates User Preference Analysis (UPA), Deep Collaborative Filtering (DCF), Neural Semantic Context (NSC), and Dynamic Model Ranking (DMR) components to overcome limitations in existing systems. It employs Bidirectional Long Short-Term Memory (BiLSTM) for encoding reviews at the word and sentence level, capturing both contextual and sequential information. The interaction module extracts the interaction patterns between users and products, enhancing the recommendation process. A sentiment classifier is used to assign discrete sentiment

labels to reviews, providing a more fine-grained understanding of user preferences. DMR is computed by combining factors such as Votes, Stars, Likes, and Sentiment scores, providing a comprehensive measure of product popularity. Comparative analysis demonstrates the superior accuracy and reduced Root Mean Square Error (RMSE) of HDCF compared to previous models. By incorporating semantic information and emphasizing trust, HDCF enhances the overall performance and effectiveness of recommendation systems.

In their study, Brishti and Javed (2020) critically examines the opportunities and challenges associated with the integration of artificial intelligence (AI) in the recruitment process. The authors highlight the potential benefits of AI in recruitment, including the automation of candidate sourcing and selection, mitigation of biases, and improved efficiency. However, they also acknowledge the risks and challenges that accompany AI implementation, such as concerns regarding data quality, privacy issues, and ethical considerations. The review is structured around four key themes: the role of AI, the role of actors involved, potential risks, and adoption challenges. The authors emphasize the need for further research, particularly focusing on the candidate's perspective, to gain a comprehensive understanding of AI's impact on recruitment. The article concludes by providing a curated list of academic papers and studies that delve into the utilization of AI in recruitment and selection processes, offering valuable references for researchers and practitioners in the field.

In their study, Valverde-Rebaza *et al.* (2018) present a framework for job recommendation based on the professional skills of job seekers in the IT field. The authors collect a dataset of professional profiles and job offers from reputable platforms, utilizing text processing techniques to represent the data. The study evaluates two state-of-the-art methods, TF-IDF and Word2Vec with Skip-Gram, for their recommendation abilities. The findings demonstrate that Word2Vec with Skip-Gram outperforms TF-IDF, indicating its effectiveness in job recommendation. Additionally, the authors employ a weighted IT term dictionary to enhance the filtering process and ensure relevance to the IT field. The proposed framework holds potential for research and practical application design in the field of job recommendation, with future directions focusing on comprehensive evaluations of recommendation systems. Partial support from the São Paulo Research

Foundation (FAPESP) grants underscores the significance of this study in advancing job recommendation techniques.

This literature review provides an overview of advancements in job recommendation systems focused on in-demand skills in the competitive and dynamic job market. The studies reviewed explore various approaches, methodologies, and findings in the field. These studies collectively contribute to the development of more accurate and effective job recommendation systems, leveraging AI, machine learning, and NLP techniques to match job seekers with the right opportunities in an increasingly complex job market.

2.4 Summary of Related Works

Sn	Paper Title	Study Aim	Methodology	Evaluation of Matrix	Study Findings
1	Job recommendation based on job profile clustering and job seeker behaviour	To develop a job recommender system using NLP to extract insights from job offers and match candidates with suitable opportunities	-Data collection from job postings. -Attribute extraction (job titles, technical skills). -Clustering of job offers. -Matching job seekers to offers.	Accuracy of job matching. Precision and recall of recommendations.	The proposed system successfully extracts valuable data from job postings using NLP techniques and achieves accurate matching between candidates and job offers.
2	Job recommendation based on job seeker skills: An empirical study	Present a job recommendation framework based on professional skills in the IT field	Text processing, evaluation of TF-IDF and Word2Vec	Word2Vec with Skip-Gram outperformed TF-IDF	Effectiveness of Word2Vec in job recommendation for the IT
3	Data-Driven Identification of Skills for the Future: 21st-Century Skills for the 21st-Century Workforce	Utilize graph theory to analyze skill transferability across occupations	Graph theory analysis	Objective quantifiable skill importance for prioritizing 21st-century skills	Skills with high betweenness centrality facilitate efficient transitions between occupations

4	A Hybrid Deep Collaborative Filtering Approach for Recommender Systems	To propose a hybrid model that combines collaborative filtering and deep neural networks to enhance recommender system performance	-Integration of conventional collaborative filtering and deep neural networks. -Weighted parallel deep hybrid collaborative filtering based on singular value decomposition and restricted Boltzmann machines.	-Prediction accuracy. -Comparative analysis with other techniques.	The hybrid model outperforms other techniques in terms of prediction accuracy, showcasing the effectiveness of integrating collaborative filtering and deep learning approaches.
6	AI-based suitability measurement and prediction between job description and job seeker profiles	Explore an innovative approach using clustering techniques and Jaccard similarity for candidate-job compatibility assessment	Clustering techniques, Jaccard similarity, AI-based classifiers	XGBoost classifier achieved 95.14% average classification rate	Clustering and AI classifiers effectively assess candidate-job compatibility
6	Technical Job Recommenda-tion System Using APIs and Web Crawling.	To provide an overview of job recommenda-tions and highlight the need for an improved system in delivering high-quality recommenda-tions	-Literature review of job recommenda-tion research. -Analysis of existing systems and techniques.	-Quality of recommendations. -Relevance to user profiles and interests.	The review emphasizes the importance of prioritizing quality and relevance in job recommenda-tions and calls for advancements in the field to meet user expectations.

7	GPTs are GPTs: An Early Look at the Labor Market Impact Potential of Large Language Models	Examine the potential risks and benefits of AI adoption in the labour market	Empirical data analysis, policy proposals	Relationship between productivity growth and AI exposure	Policy measures and reforms needed to address potential consequences of AI adoption
8	Skill Scanner An AI-Based Recommendation System for Employers, Job Seekers and Educational Institutions	Present the AI-based recommendation system "Skill Scanner" for employers, job seekers, and educational institutions	Natural language processing, clustering techniques	Survey results from representatives, screenshots, interactive scatter plots	Skill Scanner perceived as more effective, faster, fairer, and better supported compared to existing processes
9	The viability of AI-based recruitment process. A systematic literature review	Critically examine the opportunities and challenges of AI integration in the recruitment process	Literature review	Potential benefits, risks, and challenges of AI implementation in recruitment	Need for further research and understanding of AI's impact on recruitment
10	Job Recommendation System Based on Skill Sets	Present a job recommendation system based on user skills and job descriptions	Machine learning algorithms, tf-idf vectorization, cosine similarity	Cosine similarity scores between job descriptions and resumes	Job recommendations based on user skills and job descriptions, areas of skill improvement suggestions

Table 2.1 Summary Of Related Works

CHAPTER 3

SYSTEM DESIGN AND METHODOLOGY

3.1 Overview

The job market analysis and the identification of in-demand skills play a crucial role in ensuring successful career pathways for individuals. This research project aims to develop a comprehensive recommendation system that assists individuals in navigating the job market by providing personalized recommendations for acquiring in-demand skills.

The system will leverage a range of data sources, including job postings, resumes, and online platforms, to gather relevant information. By employing advanced algorithms and techniques, the recommendation system will analyze and map skills to specific job roles or categories.

The methodology encompasses data collection, preprocessing, skills identification, and mapping, as well as the development and evaluation of the recommendation system. The outcome of this research will not only empower job seekers with targeted skill acquisition suggestions but also benefit employers in identifying suitable candidates.

This overview underscores the significance of the research project in addressing the needs of both job seekers and employers in today's dynamic job market.

3.2 Recommendation System Architecture

The architecture for the recommendation system of in-demand skills is designed to provide personalized skill recommendations to individuals in the job market. The system leverages a combination of data sources, algorithms, and technologies to generate accurate and relevant recommendations.

3.2.1 Data Source

The recommendation system utilizes multiple data sources to gather information about in-demand skills. These sources include job postings from online portals, resumes or profiles of job seekers, and relevant online platforms that provide insights into emerging job trends.

3.2.2 Data Processing

The collected data undergoes preprocessing to ensure quality and consistency. This involves cleaning the data, performing normalization and standardization, and preparing it for further analysis.

3.2.3 Recommendation Engine

Figure 3.1 illustrates a rule-based system utilizing Modus Ponens inference. Data entry triggers an event, which is processed and compared against rules in a rule base. If a rule is applicable (Yes), the results are presented. Otherwise (No), the process ends.

The recommendation engine as shown in Figure 3.1 is the core component of the system and generates skill recommendations based on individual profiles and job market analysis. It employs content-based filtering techniques, utilizing algorithms such as natural language processing (NLP) and similarity calculations. By considering factors like individual preferences, job requirements, and market trends, the recommendation engine provides accurate and personalized recommendations.

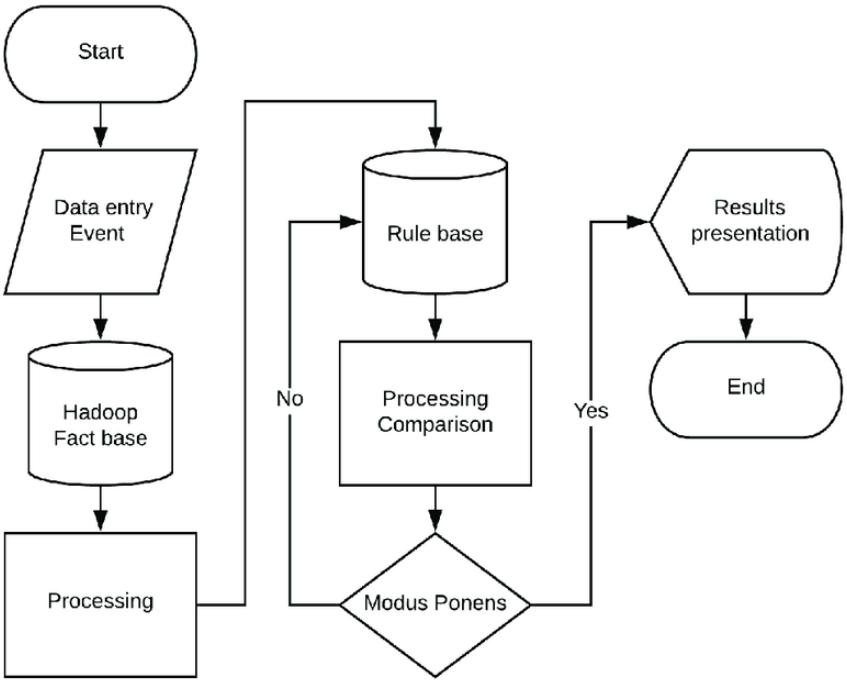
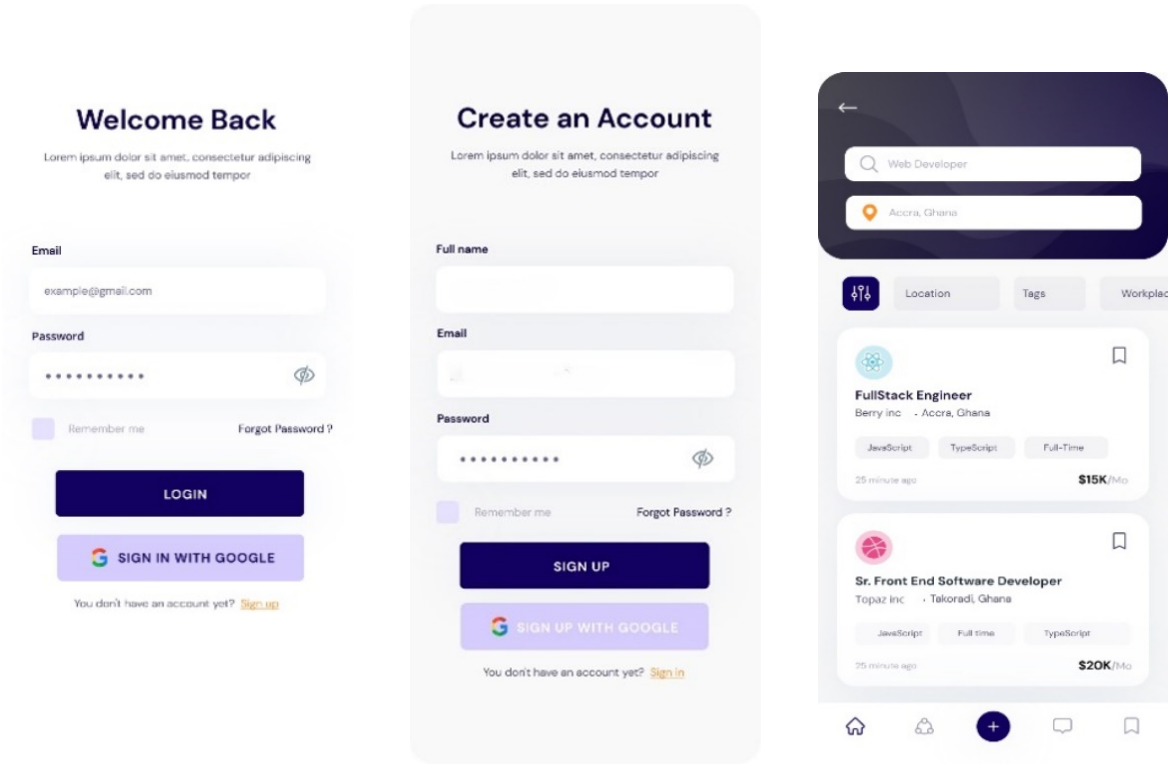


Figure 3.1 Recommendation Engine Flow(credit: Research Gate)

3.2.4 Frontend

The frontend of the system as shown in Figure 3.2 is developed using the Flutter framework, providing a user-friendly interface. Through this interface, users can input their profiles, preferences, and desired career paths. The interface displays the recommended skills based on individual profiles and job market analysis.

The Figure 3.2 presents the user interface of an application with Figure3.2a a login screen for existing users, Figure3.2b a sign-up screen for new user registration, and Figure3.2c a home screen displaying job listings with search and filter options.



(a) Login Screen **(b) Sign-up Screen** **(c) Home Screen**

Figure 3.2 Frontend

3.2.5 Backend

The backend of the system is implemented using the FastAPI Python web framework, providing a robust and efficient solution for handling backend operations and API endpoints. It acts as the intermediary between the front and backend, facilitating seamless communication and data exchange. Leveraging the SQLite database, the backend

manages the retrieval and storage of user data, including skills, experience, education, and other relevant data. Integrating SQLAlchemy within FastAPI, it ensures efficient and secure access to the database, utilizing ORM techniques for seamless data manipulation. The backend incorporates a content-based filtering algorithm to generate personalized skill recommendations for users. It also implements authentication and authorization mechanisms to enforce access controls, ensuring the security and confidentiality of user information. Overall, the backend component plays a critical role in managing data exchange, recommendation generation, and enforcing security measures, contributing to the seamless functioning of the system.

3.2.6 Database

The system database as shown in Figure 3.3 utilizes the SQLite database management system to store and retrieve user data, including skills, experience, education, and other relevant information. SQLite, being lightweight and suitable for mobile applications, efficiently manages user profiles and skill data.

The Figure 3.3 depicts an Entity-Relationship Diagram (ERD) of a database for the system. It shows the relationships between various entities like users (job seekers and employers), jobs, skills, courses, and experiences. Each entity has attributes with corresponding data types, primary keys, and foreign keys to establish relationships.

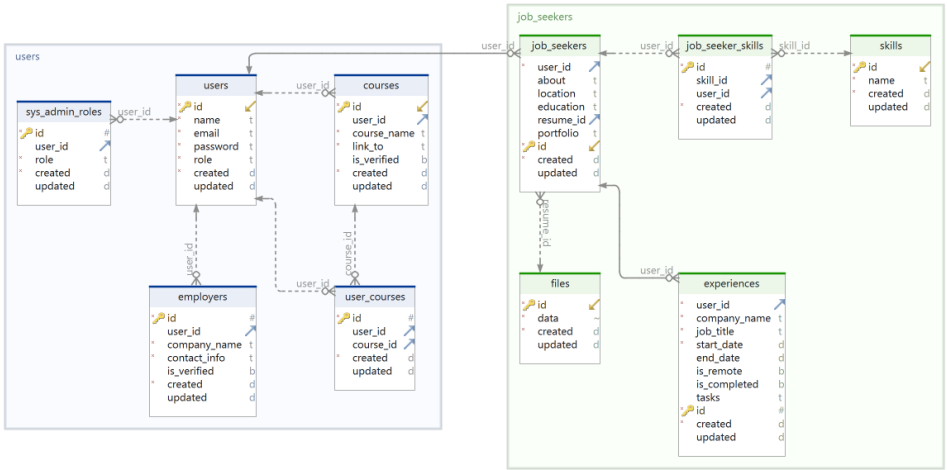


Figure 3.3 UML Database Schema

3.2.7 Integration with External System

The recommendation system integrates with external systems such as learning management platforms or online training providers. This integration enables users to access recommended training resources or courses for skill enhancement directly from the system.

3.2.8 System Security and Authentication

The recommendation system incorporates robust security features and implements a user authentication process to ensure the protection of user data and prevent unauthorized access. User registration is required, where users provide their personal information such as name, email address, and password. A strong encryption algorithm, such as bcrypt or SHA-256, is employed to safeguard user passwords, ensuring that passwords are not stored in plain text. Additionally, the system can implement two-factor authentication, requiring users to provide an additional verification factor during the login process. Access control mechanisms are in place, granting different levels of access to users based on their roles or privileges. Secure communication protocols, such as HTTPS, are utilized to encrypt data transmitted between components. Regular security audits, including penetration testing and vulnerability assessments, are conducted to identify and address potential vulnerabilities. By implementing these security measures, the recommendation system ensures the confidentiality, integrity, and availability of user data, establishing user trust and complying with data privacy regulations.

3.3 System Interactions

The recommendation system's interactions involve several entities, including job seekers, system administrators, employers, and skill development providers. Each entity plays a distinct role in the system and interacts with it through specific functionalities and features. This illustrates the interactions between different user groups and the system would enhance the understanding of the system's dynamics. These diagrams could visually represent the flow of information and actions between users and the system, providing a clearer picture of

how each user group engages with the system's functionalities. Additionally, elaborating on the user interface design and the specific features available to each user group would provide a more comprehensive understanding of the system's interactive capabilities.

3.3.1 Job Seeker Interaction

Job seekers as shown in Figure 3.4 are the primary users of the system who are seeking employment opportunities. They interact with the system to access various features, such as registering and creating their profiles, logging into their accounts, updating their profiles with skills, experience, and education information, searching for job opportunities based on their preferences, receiving personalized skill recommendations, and managing their applications and job-related activities.

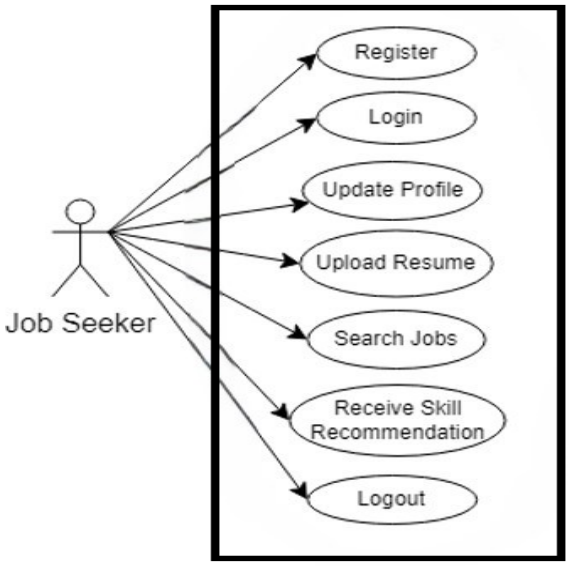


Figure 3.4 Skills/Job Seeker Interaction with the System

3.3.2 System Administrator

System administrators as shown in Figure 3.5 are responsible for managing and maintaining the overall operation of the recommendation system. It illustrates the various ways a System Administrator can interact with the system. These interactions include registering new user accounts, logging in to the system, managing existing user accounts (potentially including creating, deleting, and modifying them), maintaining the system through activities like

updates and backups, and logging out of the system. They have privileged access and perform administrative tasks, such as user management, system configuration, monitoring system performance, ensuring data integrity and security, and handling any technical issues or concerns that may arise.

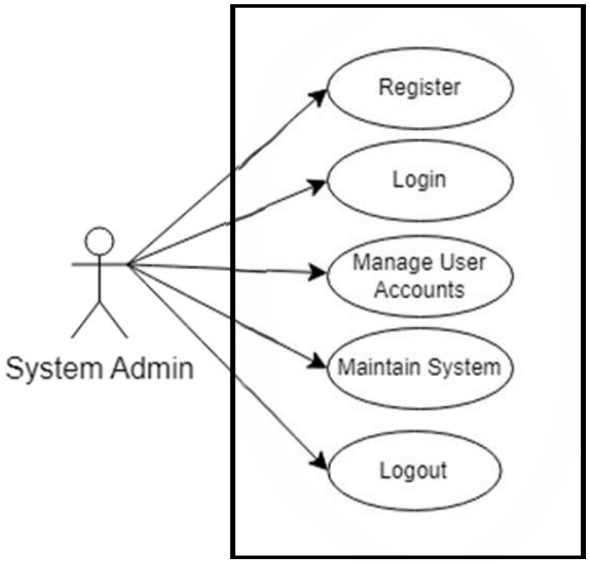


Figure 3.5 System Administrator Interaction with the System

3.3.3 Employer Interaction

Employers as shown in Figure 3.6 represent organizations or companies that offer job opportunities to job seekers. They interact with the system to register their accounts, login to access their employer dashboard, post job openings by providing relevant details such as job title, description, requirements, and location, search and browse through job seeker profiles to identify potential candidates, and manage the hiring process by reviewing applications and conducting interviews. Employers can also utilize additional features provided by the system, such as filtering and sorting candidates based on specific criteria, communicating with job seekers, and tracking the progress of their hiring activities. Once their tasks are completed, employers can logout from their accounts.

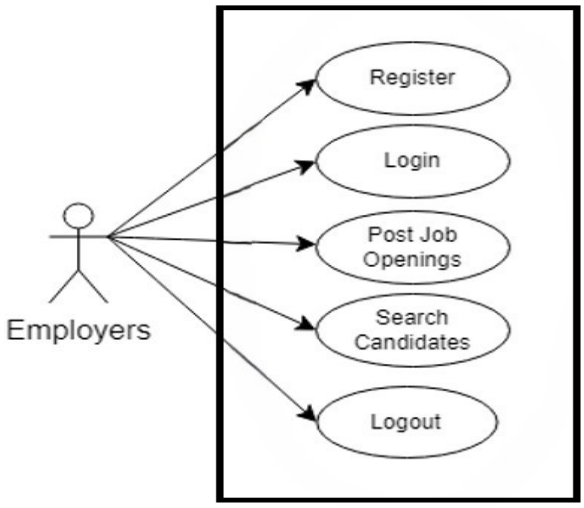


Figure 3.6 Employer Interaction with the System

3.3.4 Skills Development Provider

Skill development as shown in Figure 3.7 providers are entities that offer courses, training programs, or resources to enhance job seekers' skills and competencies. They interact with the system to create and manage their profiles, showcase their courses or training programs, provide relevant information about the skills they specialize in, and collaborate with job seekers and employers to bridge the skill gap.

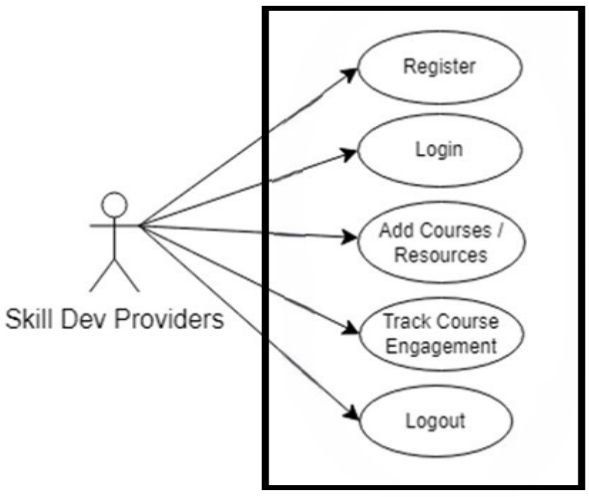


Figure 3.7 Skill Development Providers Interaction with the System

3.4 Methods Used

This section describes the methods employed in the development of the recommendation system for tech jobs.

3.4.1 Data Collection

The dataset used for the analysis and recommendation system was obtained from Kaggle. Specifically, the dataset consisted of job postings data from Dice, a popular job board in the United States, focusing specifically on tech jobs. The dataset included over 2200 records of tech job postings, providing a comprehensive sample of the tech job market. This dataset served as the foundation for understanding the specific requirements and characteristics of tech jobs for the recommendation system.

3.4.2 System Design and Development

The system design and development process involved the use of Visual Studio Code (VSCode) as the primary integrated development environment (IDE). VSCode provided a robust set of tools and features for coding and debugging, making it well-suited for the development of the job market analysis and recommendation system. The system was implemented using the FastAPI framework, which facilitated the creation of RESTful APIs for handling data retrieval, processing, and recommendation functionalities. This architecture allowed for efficient communication between the frontend and backend components of the system.

3.4.3 Data Processing and Storage

To ensure the accuracy and effectiveness of the recommendation system, the dataset was preprocessed and transformed. Relevant information such as job titles, skills, experience requirements, and company details were extracted from the dataset. Data cleaning techniques were applied to remove inconsistencies and ensure data quality. The processed data was then stored in an SQLite database, which efficiently managed and organized the

job postings data. SQLite, being a lightweight and versatile database management system, was well-suited for the storage and retrieval of job data.

3.4.4 Iterative Design

The development process followed an iterative approach, allowing for continuous refinement and improvement of the system based on user feedback and requirements. Regular testing and debugging were conducted to ensure the proper functioning of the system, and necessary optimizations were implemented to enhance performance. This iterative development cycle ensured that the job market analysis and recommendation system evolved and adapted to the changing needs of the users and the job market. By employing these methods, the job market analysis and recommendation system for tech jobs were effectively designed, developed, and refined, providing valuable insights and recommendations for job seekers in the tech industry.

CHAPTER 4

SYSTEM TESTING AND RESULTS DISCUSSION

4.1 Overview

Here is the development of a job market analysis and recommendation system designed to assist job seekers in navigating the evolving landscape of the job market. The system focuses on providing personalized skill and job recommendations by analyzing job market data and identifying in-demand skills and industries. The primary goal is to empower job seekers to make informed career decisions and enhance their employability.

The system utilizes Python for data analysis and the Flutter framework for creating a user-friendly interface. It collects and processes job market data from various sources, conducts exploratory data analysis, and employs statistical methods to identify trends and patterns. The core of the system is a recommendation engine that leverages content-based filtering techniques, natural language processing (NLP), and similarity calculations to generate personalized skill recommendations based on individual preferences and job market insights.

The project emphasizes the significance of addressing the challenges faced by job seekers in a dynamic labour market. By providing personalized skill recommendations, the system aims to bridge the gap between job seekers' skills and the requirements of the job market. The project also highlights the potential benefits for employers in identifying suitable candidates with the necessary skills.

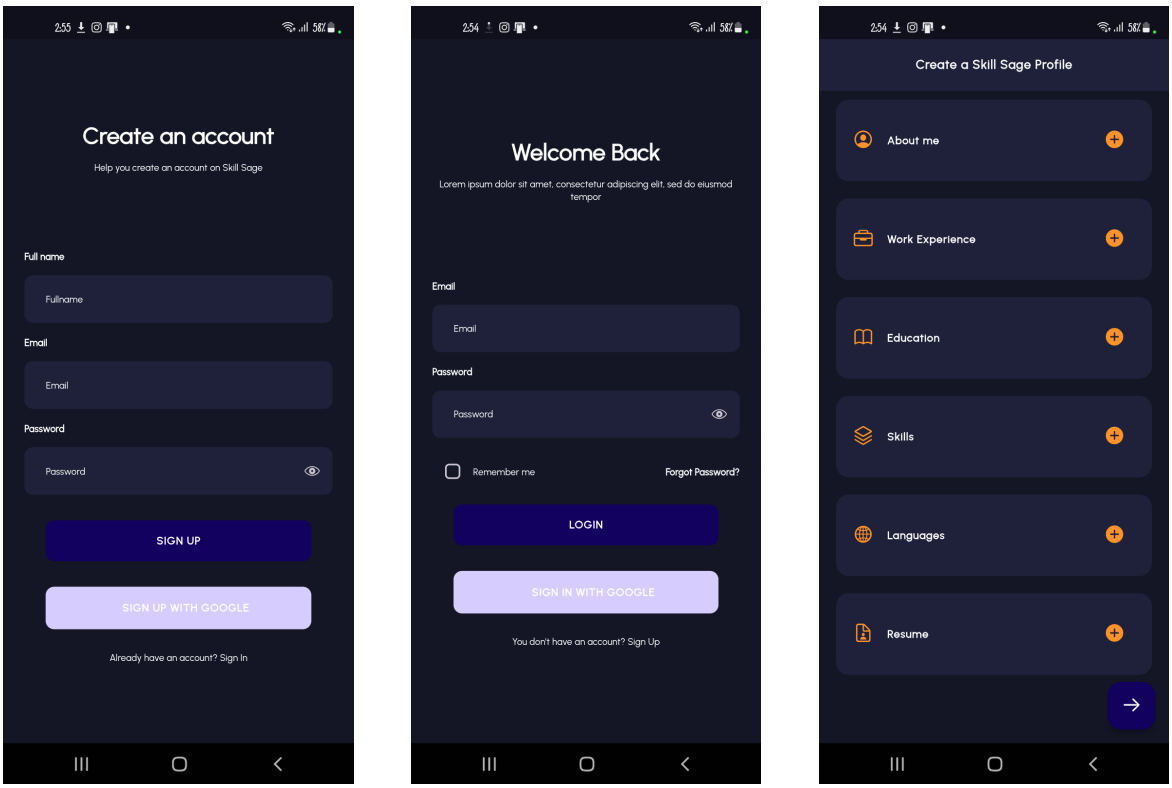
The project presents a comprehensive view of the development of a job market analysis and recommendation system. The system's focus on personalized skill recommendations and its utilization of advanced techniques demonstrate its potential to empower job seekers and contribute to a more efficient and effective job market. The project's emphasis on addressing the challenges of a dynamic labour market and its potential benefits for both job seekers and employers underscore its significance in the field of career development and human resources management.

4.2 Results

4.2.1 Sign-Up, Log-In and Landing Page

Sign-Up Page

The Sign-Up Page shown in Figure 4.1a is straightforward, asking for basic information like full name, email, and password, with an option to sign up via Google for convenience. The layout is simple and intuitive, with password visibility toggle enhancing user experience. Accessibility is considered, with distinct and clear buttons that differentiate between primary (Sign-Up) and secondary (Google Sign-Up) actions. The design ensures the process is fast and easy, providing a seamless registration experience for new users.



(a) Sign UP Page **(b) Login Page** **(c) Landing Page**

Figure 4.1 Sign-Up, Log-In and Landing Page

Log-In Page

The Log-In Page shown in Figure 4.1b welcomes returning users with a friendly "Welcome Back" message and provides options to log in via email and password or Google. The page

maintains consistency with the overall design, featuring the same dark background and light-coloured buttons. The inclusion of a "Forgot Password?" option adds a layer of convenience and support for users. Overall, the login process is simple and efficient, continuing the user-friendly experience established by the previous pages.

Landing Page

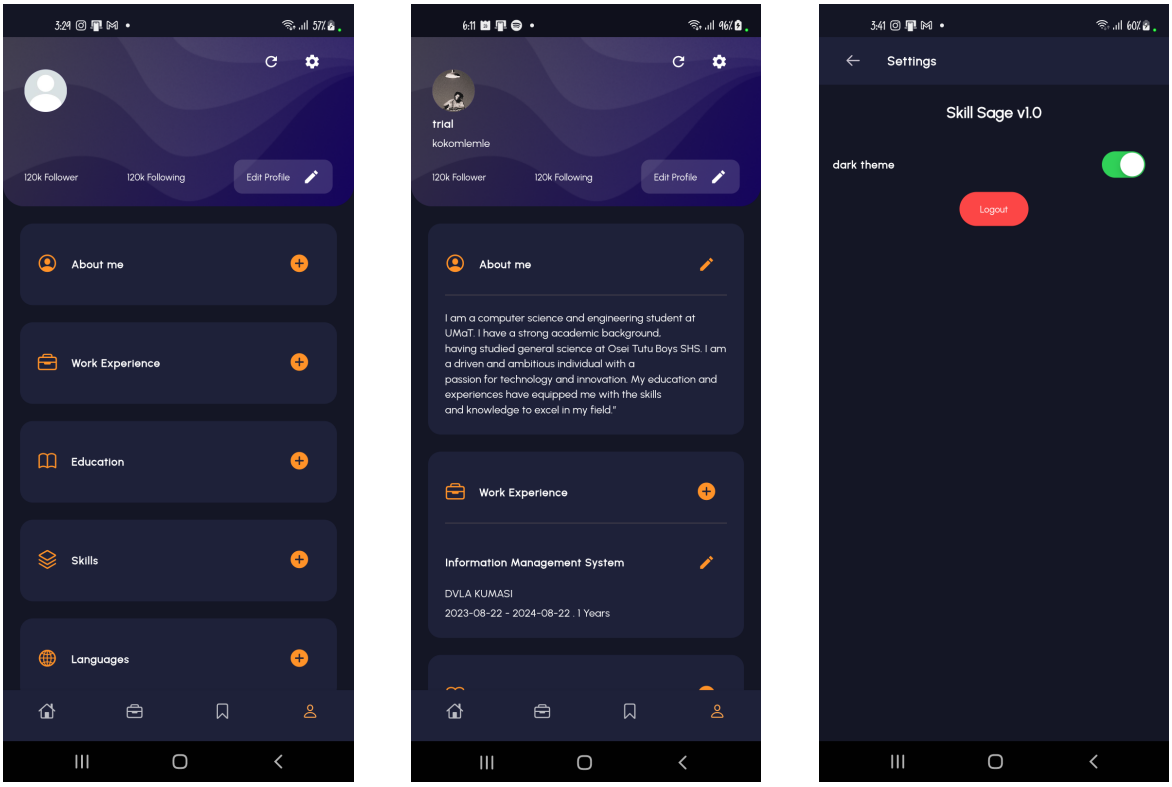
The Landing Page shown in Figure 4.1c introduces users to the platform and guides them in creating a Skill Sage profile. It is divided into sections like "About Me," "Work Experience," "Education," "Skills," "Languages," and "Resume." Each section is marked with icons and a plus sign, making it easy for users to navigate. The minimalist design, featuring a dark background with bright orange accents, keeps the focus on content and action buttons. The clear call to action, a forward arrow button, subtly directs users to proceed, creating a user-friendly and engaging start.

Across all three pages, visual consistency is maintained through the use of a dark theme and light-coloured action buttons, creating a sleek and modern look. The mobile-friendly design ensures users can easily navigate and interact with the platform across different devices. The flow from landing on the page to signing up or logging in is seamless, with a minimalistic approach that reduces distractions and improves user focus, ensuring an overall smooth and engaging experience.

4.2.2 Profile and Settings Page

Profile Page

The profile page shown in Figure 4.2a is just like the landing page, where a user can update the information provided on the landing page. The information provided on the landing page is displayed on the user profile page. This page also has sections like "About Me", "Work Experience", "Education", "Skills", "Languages", and "Resume" just like on the landing page. It also has sections like "User Profile Picture", "User Name, Portfolio and Location Display", and "Settings".



(a) Profile Page **(b) Profile Page With Data** **(c) Settings Page**

Figure 4.2 Profile and Settings Page

Settings Page

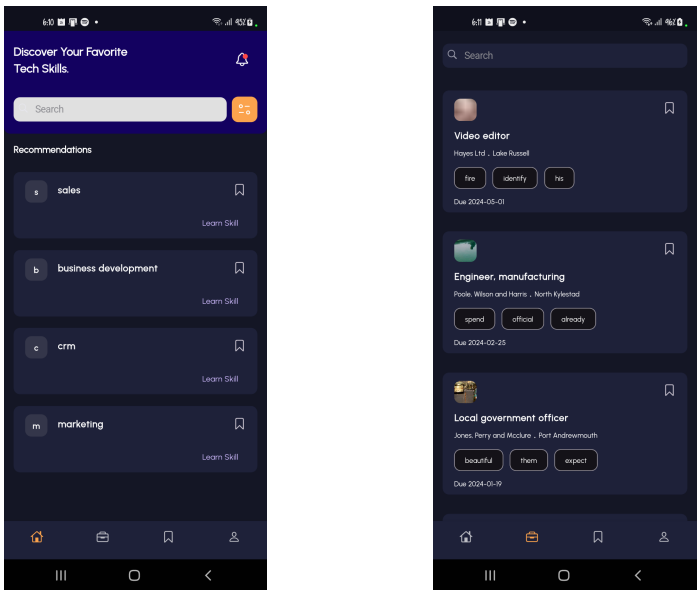
The settings page, as shown in Figure 4.2c, presents a minimalistic design with a focus on core functionalities. A toggle switch for enabling/disabling dark themes is provided, allowing users to customize their visual experience. The prominent "Logout" button ensures easy access to terminate the session. The overall layout is clean and uncluttered, promoting ease of use. However, user testing revealed that some participants desired additional settings options, such as the ability to change their profile information or manage notifications. Future iterations of the app could incorporate these features to enhance user control and personalization.

4.2.3 Skills, Job Search and Recommendation Page

Skills Recommendation Page

The skills recommendations page shown in Figure 4.3a is focused on helping users improve their skill sets by suggesting popular or in-demand skills, such as "Sales," "CRM," and

"Marketing." Each skill is displayed in a simple card layout with the option to “Learn Skill” directly from the page. The design is minimal yet functional, with a search bar and filter icon to assist users in finding relevant skills. The page’s straightforward approach makes it easy for users to navigate and focus on skill development. However, adding more context or information about why each skill is recommended would make the suggestions more valuable to users.



(a) Skills Page **(b) Job Page**

Figure 4.3 Skills, Job Search and Recommendation Page

Job Recommendation Page

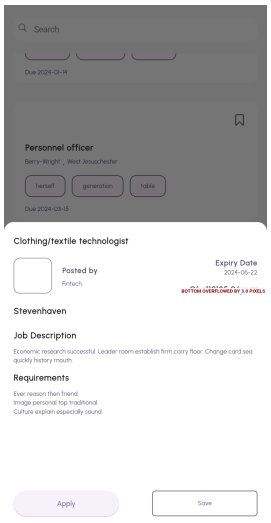
The job recommendations page shown in Figure 4.3b features a clean and minimalist design with a dark theme, showcasing a list of job openings. Each job card provides essential details like the job title (e.g., "Video Editor" or "Engineer, Manufacturing"), company name, location, and the application deadline, allowing users to quickly assess their options. Additionally, each job card includes keywords and a bookmark icon, letting users save jobs for future reference. However, some keywords seem arbitrary, which could confuse users. The search bar at the top helps users find specific jobs, making the page easy to navigate. Overall, the page’s design is visually appealing and user-friendly, but refining the relevance of the keywords would enhance its effectiveness. Both pages offer a user-

friendly interface with a consistent dark theme that enhances readability and focus. The job recommendations page efficiently presents job opportunities, while the skills page promotes learning and development. However, there is room for improvement in providing more relevant keywords on the job page and offering deeper insights into skill recommendations. These enhancements would help users make more informed decisions about their careers.

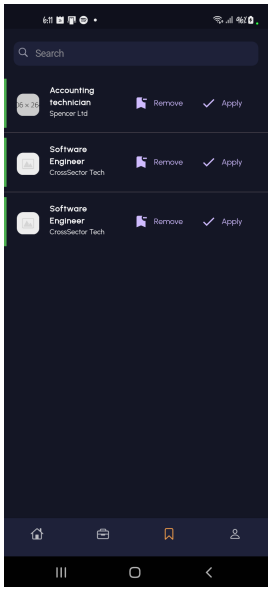
4.2.4 Job Description Pop-Up and Saved Jobs Page

Job Description

The job description pop-up shown in Figure 4.4a, appears when a user selects a job. It provides detailed information about the job, including the title, company name, job description, requirements, and the job's expiry date. The layout is clean and well-organized, with an "Apply" button at the bottom for users to take immediate action and a "Save" button for those wanting to bookmark the job for later. The job description is brief but informative, and the expiry date helps users prioritize their applications. This pop-up balances providing essential details without overwhelming the user, ensuring a smooth experience.



(a) Job Description Pop-Up



(b) Saved Job Page

Figure 4.4 Job Description Pop-Up and Saved Jobs Page

Saved Job Page

The saved jobs page shown in Figure 4.4b, shows a list of jobs that users have saved for later review or application. It has a simple, user-friendly design with a dark background and contrasting light text. Each job entry displays the job title, company name, and options to remove the job from the list or apply directly. This layout makes it easy for users to manage their saved jobs and take quick action when ready. The search bar at the top allows users to filter through their saved jobs. Overall, this page focuses on convenience, giving users control over their job search and making the process more streamlined.

4.2.5 Filter Page

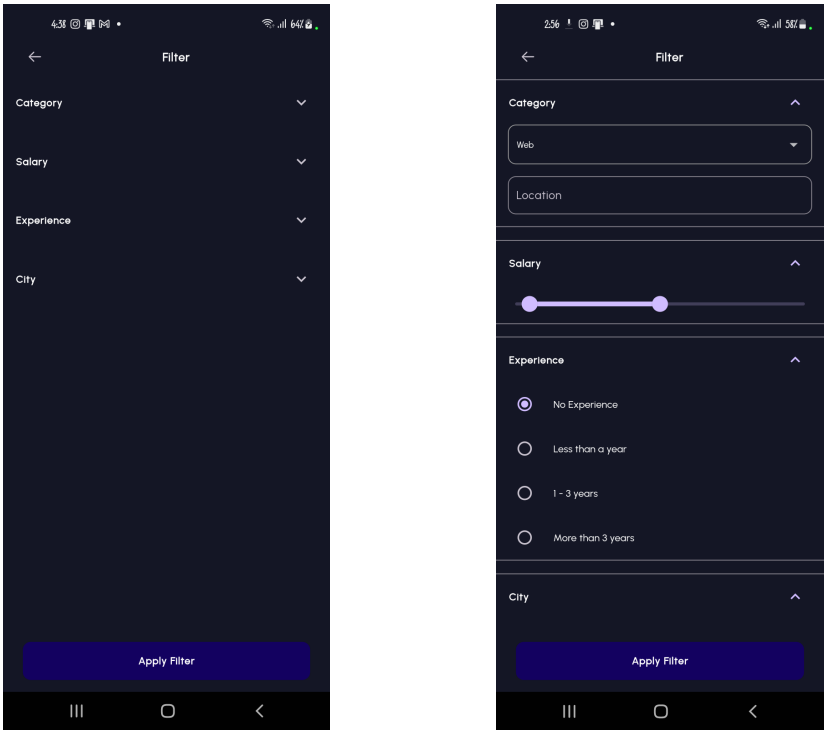
Filter Page

The filter page interface shown in Figure 4.5 offers a clean and user-friendly design, allowing users to filter job search results by Category, Salary, Experience, and City. The minimalist layout presents dropdown menus, sliders, and radio buttons, making it easy to navigate and set preferences. Key features include a sliding salary scale for flexible salary range selection, radio buttons for different experience levels, and dropdowns for job categories and cities. The prominent "Apply Filter" button ensures users can quickly apply their chosen filters. This design focuses on simplicity and efficiency, helping users refine their searches without confusion. The collapsible filter sections keep the interface organized, avoiding clutter. The dark background with light text enhances readability, and the interactive elements improve engagement. Overall, this well-structured filter page provides a streamlined and intuitive experience for users to customize their job search.

4.2.6 Notification and Edit Profile Page

Notification Page

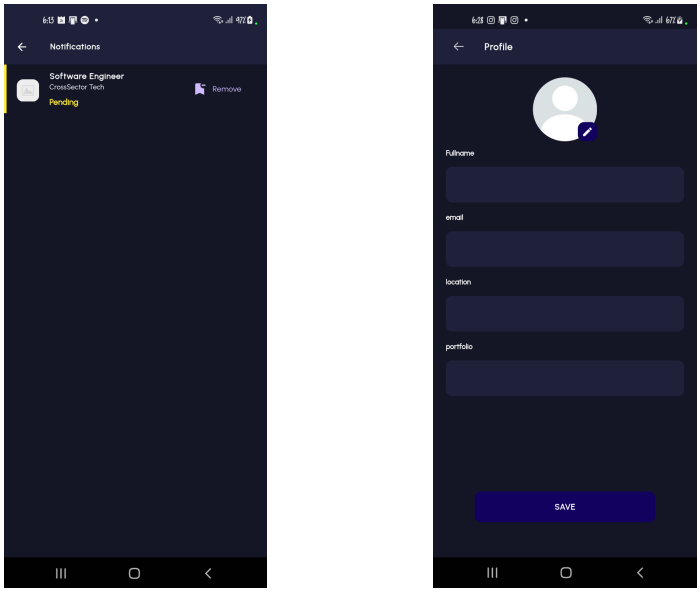
The notification page in Figure 4.6a shows a clean and minimal interface focused on job application updates. In this specific example, a notification is shown for a "Software Engineer" position at "CrossSector Tech," with a status marked as "Pending" in yellow,



(a) Filter Page **(b) Filter Page Expanded**

Figure 4.5 Filter Page

which clearly indicates that the application is still under review. The layout includes a company name and job title, along with an option to "Remove" the notification via a simple clickable icon.



(a) Notification Page **(b) Edit Profile**

Figure 4.6 Notification and Edit Profile Page

Edit Profile Page

The "Edit Profile" page, as shown in Figure 4.6b allows users to update their personal information, enhancing user penalisation and account management features. This page features a user interface where profile fields like "Fullname," "email," "location," and "portfolio" can be filled or edited. At the top, a user avatar placeholder is displayed with an edit button, signifying that users can also update their profile picture. This simplistic, clean design makes the interface intuitive for users by clearly defining input fields for personal details.

The minimalist design of the Profile page aligns with the app's overall aesthetic. User testing indicated that participants found the page intuitive to navigate. However, some expressed a desire for additional profile customisation options, such as adding a short bio or linking social media accounts. Furthermore, the absence of real-time feedback during input (e.g., email validation) was noted as a potential area for improvement. Future iterations of the app may benefit from incorporating these suggestions to enhance user engagement and provide a more comprehensive profile management experience.

4.2.7 Admin Dashboard

The Admin Dashboard displayed in Figure 4.7 presents the login screen of what appears to be an admin dashboard named "Skill Sage." The interface is minimalistic, featuring only the essential elements for user authentication: an email input field, a password field, and a "Log in" button.

The Admin Dashboard displayed in Figure 4.8 provides a clear and structured interface that allows administrators to manage various functionalities related to job postings. The dashboard is divided into multiple sections, accessible through a sidebar with options such as "Job," "Applicants," "Course," and "Analytics." The primary section shown in the figure is the "Job" section, which lists all available job postings in a tabular format.

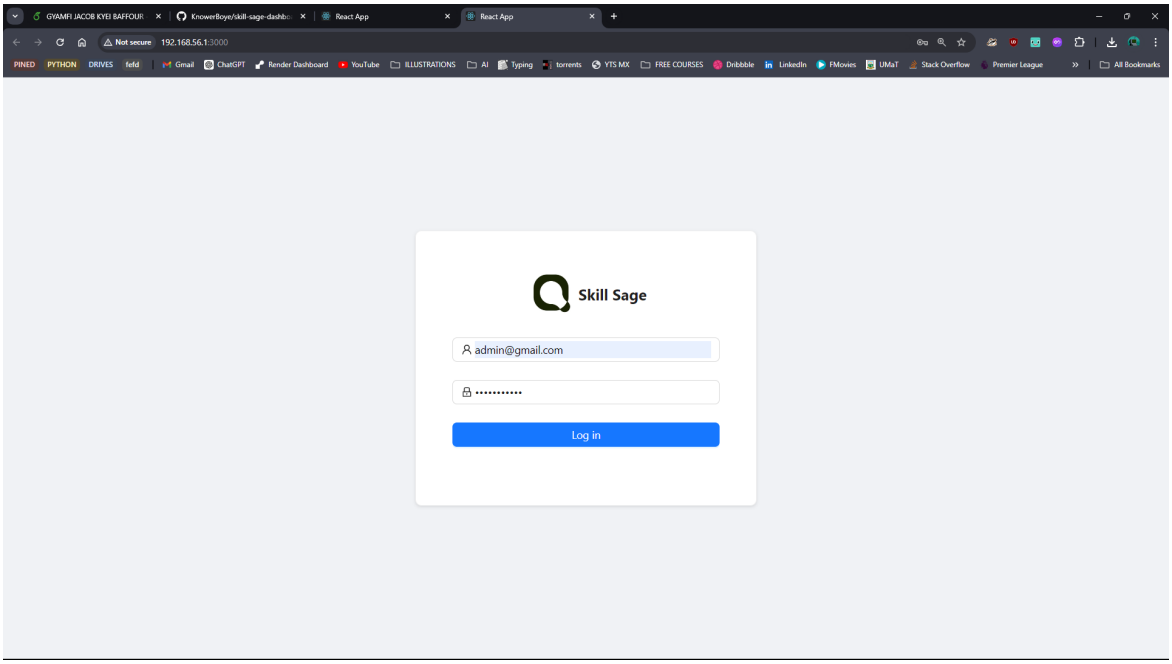


Figure 4.7 Admin Dashboard Login

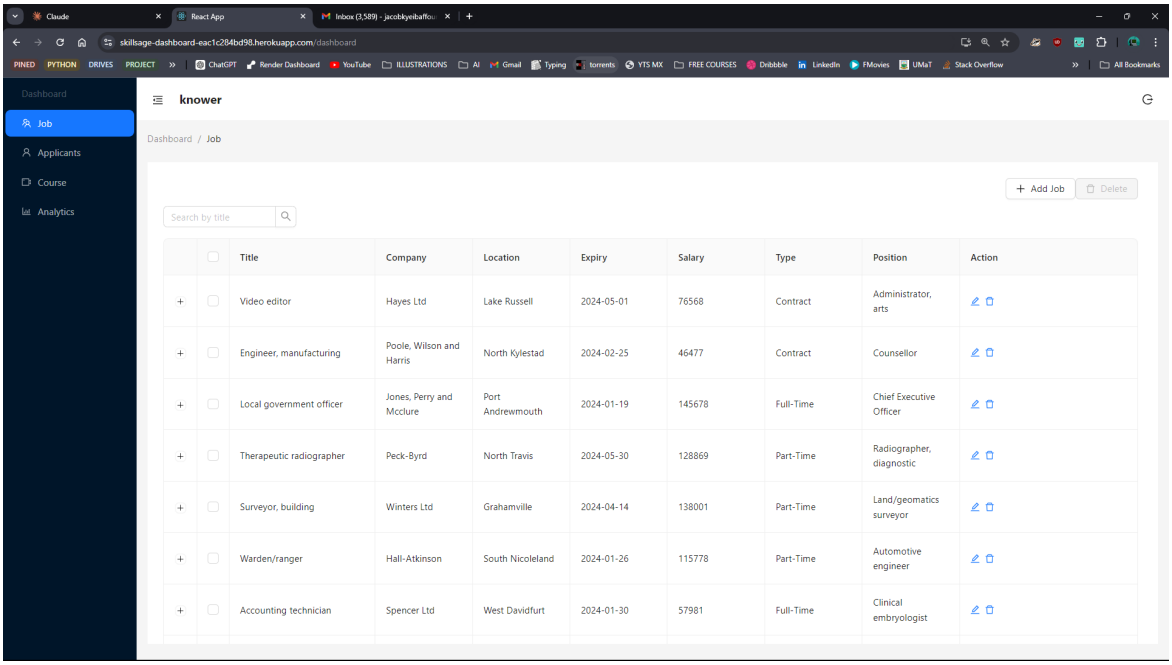


Figure 4.8 Admin Dashboard

Structure and Navigation

The dashboard layout is intuitive, ensuring ease of navigation for the administrator. The sidebar on the left provides quick access to major functionalities, while the header bar indicates the current page, in this case, "Dashboard / Job." The top-right corner includes buttons for refreshing the page or adding new job entries, while the table itself is neatly

organized with columns such as:

1. **Title:** The name of the job role.
2. **Company:** The company offering the position.
3. **Location:** The job's geographical location.
4. **Expiry:** The expiry date for the job posting.
5. **Salary:** The salary associated with the job.
6. **Type:** The employment type (e.g., Contract, Full-Time, Part-Time).
7. **Position:** The specific role being offered.

Each job entry includes options for editing or deleting the listing, represented by pencil and trash can icons under the Action column, providing quick access for updating or removing job details.

Usability

The job listings include essential information, making it easy for the admin to manage postings at a glance. The interface is clean, with no clutter or unnecessary elements, and the table includes a search bar at the top, allowing admins to filter job titles quickly. This functionality ensures that administrators can easily find specific job postings among potentially long lists.

The plus sign (+) in front of each job listing suggests that more detailed information or additional actions may be accessible by expanding each row, a feature that enhances usability by keeping the interface minimal yet informative.

Visual Design

The design of the dashboard is modern and professional, with a focus on usability. The colour scheme is simple yet effective, with a dark sidebar contrasting against the white background of the main content area, making the job table stand out. The blue accents on

the action icons and buttons align with the overall aesthetic of the platform, ensuring visual consistency across different sections.

Functionality

From a functional perspective, the dashboard allows for streamlined job management. The administrator can view, add, update, and delete job listings with minimal effort. Each job entry provides quick access to key details, while additional features, such as sorting by salary, expiry date, or location, could further enhance the usability of the dashboard. The design also suggests potential for scaling, as the table structure would likely handle large numbers of job listings without losing clarity or usability.

4.3 Discusion

The system testing and results discussion chapter of the project report focuses on evaluating the developed job market analysis and recommendation system. The system's primary goal is to empower job seekers by providing personalized skills and job recommendations based on an analysis of job market data. The system utilizes Python for data analysis and the Flutter framework for the user interface.

The chapter highlights the system's ability to collect and process job market data, conduct exploratory data analysis, and employ statistical methods to identify trends and patterns. The core of the system lies in its recommendation engine, which leverages content-based filtering techniques, natural language processing (NLP), and similarity calculations to generate personalized skill recommendations tailored to individual preferences and job market insights.

The evaluation of the system involved assessing various aspects, including the sign-up, login, and landing pages, profile and settings pages, skills and job recommendation pages, job description pop-ups, saved jobs page, filter page, notification and edit profile pages, and the admin dashboard. The results indicate that the system offers a user-friendly interface with a consistent design and intuitive navigation. The job recommendations page effectively presents job opportunities, while the skills page promotes learning and development. The

filter page allows users to refine their job searches based on specific criteria, and the notification page provides timely updates on job applications. The admin dashboard enables administrators to efficiently manage job postings and user data.

However, the evaluation also identified areas for improvement. Some users expressed a desire for additional settings options and profile customization features. The relevance of keywords on the job recommendations page could be refined, and deeper insights into skill recommendations could be provided. Additionally, the system's reliance on a limited dataset and the absence of user-specific career goals in the recommendation algorithm were noted as limitations.

CHAPTER 5

LIMITATION, CONCLUSION AND RECOMMENDATION

5.1 Limitation

The project, while innovative and promising, encountered certain limitations that could be addressed in future research. The primary constraint was the scope of the dataset, which predominantly focused on tech jobs within the United States. This limited the generalizability of the recommendations to other industries and geographical regions. The system's reliance on job postings as the primary data source also presented challenges, as it may not fully capture the nuances of the actual skills required in the workplace. Additionally, the recommendation algorithm did not explicitly incorporate user-specific career goals or long-term aspirations, potentially limiting its ability to provide tailored guidance for career development. The absence of real-time updates to the job market data and skill trends could also affect the system's ability to stay current with the rapidly evolving demands of the industry. Finally, the system's evaluation primarily focused on technical aspects and further research is needed to assess its impact on user satisfaction and actual career outcomes.

5.2 Conclusion

The project successfully developed a functional recommendation system that leverages job posting data to provide personalized skill recommendations to job seekers in the tech industry. The utilization of machine learning and natural language processing techniques enabled the system to analyze job requirements effectively and offer targeted skill suggestions, thereby empowering individuals to enhance their employability and navigate the evolving tech landscape. The project's outcomes underscore the potential of data-driven approaches in bridging the gap between job seekers' skills and the demands of the job market, ultimately contributing to a more efficient and skilled workforce.

5.3 Recommendatio

To further enhance the system's impact and applicability, future work should focus on expanding the dataset to encompass a wider range of industries and geographical locations, enabling the system to cater to a more diverse user base. Additionally, incorporating user-specific career goals and preferences into the recommendation algorithm would allow for a more personalized and strategic approach to skill development.

The integration of real-time labour market trends and emerging technologies would also ensure that the system remains adaptive and continues to provide relevant recommendations in an ever-changing job market. By addressing these areas, the recommendation system can evolve into an even more powerful tool for empowering job seekers and facilitating a more efficient and skilled workforce across various industries and regions.

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