PREPMASTER: CAREER LEARNING PATH GUIDANCE SYSTEM

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Dissertation submitted in partial fulfilment of the requirements for the Bachelor of Science (Hons) in Information Technology Specialized in Information Technology

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DECLARATION

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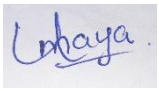
Sathkumara S.M.P.U.	**IT21306136**	

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The above candidate has carried out research for the bachelor's degree Dissertation under my supervision.

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ABSTRACT

This report presents the development of an AI-powered career path guidance component designed to assist job seekers in the IT industry. The component uses powerful Natural Language Processing (NLP) to analyze users' resumes, extracting important information such as talents, experiences, and education. This information is then compared to a predetermined dataset of abilities required for various IT professions, allowing the system to identify skill gaps relevant to the user's career goals. Based on the observed gaps, the system creates a personalized learning plan that includes suggested multiple-choice questions, video lectures, and other educational resources suited to the user's specific requirements. As users progress through these learning activities, the system continuously tracks their achievements and updates the learning plan accordingly.

To improve the user experience, the component includes an interactive dashboard that shows the user's overall progress, completed activities, and skill gaps. When a user acquires new skills and certifications, the system automatically generates an updated CV that highlights their most recent achievements.

This component represents an important advancement forward in personalized career advising by providing a dynamic and responsive tool that responds to users' changing needs while filling key research gaps in personalization, real-time market data integration, and bias reduction.

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I would like to express my deepest gratitude to my supervisor, whose continuous guidance, expertise, and encouragement have been invaluable throughout this research. Their insightful feedback and unwavering support have played a crucial role in shaping this project, helping me overcome challenges and refine my work to achieve meaningful results. Their dedication to mentoring and knowledge-sharing has been truly inspiring, and I am incredibly fortunate to have had their guidance during this academic journey.

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List of Abbreviations

Abbreviation	Full Form
AI	Artificial Intelligence
API	Application Programming Interface
AWS	Amazon Web Services
ML	Machine Learning
NLP	Natural Language Processing
MySQL	My Structured Query Language
SE	Software Engineering
UI	User Interface
IT	Information Technology
JSON	JavaScript Object Notation
PDF	Portable Document Format

1 Introduction

In today’s rapidly evolving technological landscape, career development requires more than basic skill acquisition candidates must continuously assess and align their competencies with dynamic industry expectations. Traditional approaches to career planning often lack personalization and fail to provide actionable insights based on real-time data, leaving professionals underprepared for targeted job opportunities. To address these limitations, this research introduces the **"Career Path Guidance System,"** an intelligent, NLP-powered platform designed to provide personalized career development strategies for IT professionals [1].

Unlike conventional methods, this system harnesses the power of Natural Language Processing to extract key information such as skills, education, and experiences from user CVs, creating a comprehensive understanding of the user's current professional profile. This information is then intelligently compared against an up-to-date repository of industry-specific skill requirements for roles such as Software Engineers, Data Analysts, and IT Managers. By identifying discrepancies between existing competencies and role-specific expectations, the system performs level wise skill gap analysis, providing highly targeted insights [2].

To bridge these gaps, the Career Path Guidance System generates customized learning plans tailored to the user's needs. These plans include curated resources such as e-books, video tutorials, and certification courses, ensuring focused skill acquisition. Furthermore, the system continuously monitors user progress and dynamically updates recommendations to reflect evolving performance and learning behavior, offering a responsive and adaptive learning journey [3].

At its core, the platform embodies a feedback-driven loop that culminates in the automatic generation of updated CVs, showcasing newly acquired skills and certifications. This not only enhances the user's competitiveness in the job market but also ensures that their resume remains aligned with current industry standards.

By integrating intelligent analysis, personalized planning, and automated documentation, the Career Path Guidance System provides a holistic solution to career advancement [4]. Through rigorous performance tracking and smart content delivery, it empowers users to strategically close skill gaps, pursue relevant certifications, and present themselves as well-rounded candidates ready for the next step in their professional journey.

1.1 Background

The rapid evolution of the information technology (IT) industry has created a dynamic job market where professionals must continuously upgrade their skills to stay competitive. Traditional career guidance methods, such as manual CV reviews and generic career advice, are often insufficient in addressing the unique needs of individuals, especially in a field as diverse as IT. The advent of artificial intelligence (AI) and Natural Language Processing (NLP) has enabled more personalized and data-driven approaches to career development, allowing for tailored guidance that aligns closely with the specific requirements of various IT roles.

AI-powered career guidance systems have emerged as a transformative tool in this context. By leveraging NLP, these systems can analyse vast amounts of unstructured data, such as CVs, to extract critical information about an individual's skills, experiences, and educational background. This information is then matched against predefined datasets that outline the competencies required for different IT roles. The system's ability to identify skill gaps and recommend personalized learning pathways helps users bridge these gaps, enhancing their employability and career prospects**.**

Aspect	Traditional Career Systems	AI-Powered Career Systems
Data Processing	Manual review of CVs by humans	Automated extraction and analysis of CV data using NLP
Skill Matching	Subjective human judgment	Objective comparison against comprehensive industry datasets
Personalization	Generic career advice	Highly personalized recommendations based on individual profiles
Skill Gap Analysis	Surface-level identification	Detailed, level-wise gap analysis with precision
Progress Tracking	Manual self-reporting	Automated monitoring of learning progress

Table 1-Traditional Career Guidance vs. AI-Powered Career Systems

1.2 Literature Review

The integration of artificial intelligence (AI) into career guidance platforms has significantly transformed how job seekers approach their professional development. Traditional career guidance systems, which relied heavily on manual methods for skill assessment and job matching, often faced limitations in terms of effectiveness and scalability. However, recent advancements in natural language processing (NLP) and machine learning have enabled the development of AI-powered systems that offer a more personalized, dynamic, and efficient approach to career path guidance. These modern systems are designed to tailor career advice to the specific needs of individual users, marking a significant departure from the one-size-fits-all models of the past [5].

One of the key innovations in AI-powered career guidance is the use of NLP to analyze user-provided resumes. By extracting crucial information such as skills, experiences, and educational background, these systems can build a detailed profile of the user. R. Patel's research highlights the role of NLP in this process, emphasizing its ability to automate the extraction of relevant data from resumes, which is critical for the accurate assessment of a candidate's qualifications and potential career paths [6]. Once this data is extracted, it is

mapped against predefined datasets of skills required for various IT roles, such as Junior QA, QA Engineer, and Senior QA Engineer, enabling the system to identify specific skill gaps.

The process of mapping user skills to job requirements, as discussed by H. Lee, underscores the importance of machine learning in enhancing the accuracy and adaptability of these systems. Machine learning algorithms are used to compare the user's current skills with those required for their desired roles, identifying gaps that need to be addressed. This approach not only improves the precision of skill gap analysis but also allows for the continuous updating of user profiles as they acquire new skills and experiences [7].

Based on the identified skill gaps, AI-powered systems can generate customized learning plans that include e-books, video tutorials, and other educational resources. Y. Chen's research into adaptive learning systems explores how these plans are tailored to the user's individual progress, providing a more effective learning experience [8]. As users complete these learning activities, the system tracks their performance, offering real-time feedback and adjusting the learning plan as necessary to ensure continuous improvement.

In addition to personalized learning plans, these systems also suggest relevant certification courses that can help users further bridge their skill gaps. A. Smith discusses how AI systems use real-time data to make these recommendations, ensuring that users are always aware of the most relevant and beneficial courses available to them. Furthermore, M. Garcia's study on the future of AI in education and career services predicts that such personalized guidance will become increasingly central to career development, as AI continues to evolve and improve its ability to provide tailored advice [9].

These AI-powered career guidance systems also offer interactive dashboards that allow users to monitor their overall progress, displaying completed tasks and remaining skill gaps. As users acquire new skills and certifications, the system dynamically updates their CV, ensuring that it reflects their most current qualifications. This continuous feedback loop, combined with the system's ability to adapt learning content based on real-time performance, represents a significant advancement in the field of career guidance, offering users a more effective and personalized path to achieving their career goals.

1.3 Research Gap

While AI-powered career path guidance systems represent a significant advancement in personalized career development, there are several areas where further research is needed to enhance their effectiveness and reliability. These gaps highlight the opportunities for improving the existing systems and addressing the limitations that have been identified in the literature.

- While existing career guidance systems offer general recommendations, they often lack deep personalization and contextual understanding. Current systems may struggle to accurately interpret the nuanced differences in individual career goals, educational backgrounds, and professional experiences. Research is needed to enhance the ability of AI systems to provide highly personalized career advice that considers the unique context of each user.
- While Natural Language Processing (NLP) is effective in extracting information from CVs, there are challenges in fully understanding the context and subtleties of the data. For example, the same skill might be described differently across CVs, or certain experiences may be more relevant depending on the role in question. Current systems may not fully capture these nuances, leading to less precise recommendations. Research in improving NLP algorithms to better understand context, semantic differences, and industry-specific jargon could significantly enhance the accuracy of AI-powered career guidance systems.
- Many AI-powered career guidance systems do not effectively incorporate real-time market data, which is crucial for providing up-to-date and relevant career advice. Real-time job market trends, emerging technologies, and evolving industry requirements can significantly impact career planning.
- While AI systems can generate personalized learning plans and track user progress, there is limited research on optimizing user engagement over time. Personalized learning pathways are only effective if users are motivated to follow them. Understanding how to better engage users through adaptive learning plans that adjust based on user preferences, progress, and feedback is an area that warrants further investigation. Additionally, exploring

gamification, social learning, and peer interactions could enhance user experience and adherence to recommended learning activities.

- AI systems in career guidance can inadvertently perpetuate biases present in training data, leading to unfair or biased recommendations. Addressing ethical concerns and ensuring fairness in AI-driven career guidance is a significant challenge.
- Current systems may lack effective user engagement strategies and feedback mechanisms. Engaging users throughout their career development journey and collecting actionable feedback are essential for improving the effectiveness of career guidance systems.

Addressing these research gaps is essential to advancing the field of AI-powered career path guidance. By focusing on precision in skill gap identification, contextual understanding in NLP, integration of soft skills, user engagement, bias and fairness, and the longitudinal impact of AI recommendations, future research can enhance the effectiveness, reliability, and inclusiveness of these systems. This, in turn, can provide more robust and personalized career guidance to individuals in the IT industry, ultimately improving their employability and career satisfaction**.**

	RESEARCH [10]	RESEARCH [11]	RESEARCH [12]	RESEARCH [13]	PROPOSED SOLUTION
Personalization and Contextual Understanding	✓	✓	✓	✓	✓
Integration of Real-Time Market Data	✗	✗	✗	✓	✓
Skill Gap Analysis and Adaptive Learning	✗	✗	✗	✗	✓
User Engagement and Feedback Mechanisms	✓	✓	✗	✓	✓

Table 2- Comparison of former research

1.4 Research Problem

The rapid evolution of the IT industry has led to an increasing demand for personalized career guidance that can adapt to the diverse and dynamic skill requirements of various roles. Traditional career counselling methods often fall short in providing tailored advice that aligns with the specific needs of individuals, especially in a field as specialized and fast-paced as IT. While AI-powered systems have shown promise in offering personalized career guidance through automated CV analysis and skill gap identification, there are significant challenges in ensuring the accuracy, fairness, and effectiveness of these systems.

- **How can advanced Natural Language Processing (NLP) techniques be optimized for accurate skill extraction and role matching from diverse CV formats?**

Traditional NLP techniques may struggle to extract and categorize talents from CVs, especially when dealing with a wide range of formats and language. This project aims to investigate and optimize complex NLP algorithms to improve the accuracy and reliability of skill extraction from diverse CV formats. The emphasis will be on developing robust algorithms that can handle a variety of CV formats and provide precise talent matching with existing job roles.

- **What are the effects of personalized learning plans on user engagement and skill acquisition compared to generic learning resources?**

Generic learning materials may fail to properly address individual skill gaps, resulting in inefficient learning outcomes. This study aims to assess the influence of personalized learning plans created based on recognized skill gaps—on user engagement and skill acquisition. The study will evaluate user performance and satisfaction with personalized learning programs to standard, non-tailored resources.

- **How can real-time progress tracking and adaptive feedback mechanisms enhance the effectiveness of learning plans in closing skill gaps?**

Real-time tracking and adaptive feedback mechanisms could significantly impact the effectiveness of learning plans by providing timely insights and adjustments. This research aims to investigate how integrating real-time progress tracking and adaptive feedback into the learning system affects users' ability to close skill gaps. The study will measure the

improvements in learning outcomes and user satisfaction compared to static feedback systems.

- **What is the impact of automated CV updates on users' job search success and employer perceptions?**

Automated CV changes based on recently obtained certifications and skills may affect users' prospects of finding employment as well as the opinions of prospective employers. The purpose of this study is to investigate how users' success rates in their job searches are affected by automated CV production, as well as how employers view and react to updated CVs. The purpose of the study is to evaluate how well automated resume updates improve users' employability and satisfaction.

- **How can the integration of external data sources, such as LinkedIn, improve the relevance and accuracy of career path recommendations?**

Automated CV updates based on newly acquired certifications and skills may have an impact on users' chances of landing a job and on the perceptions of potential employers. The aim of this study is to examine how automated CV manufacturing affects users' job search success rates and how employers perceive and respond to updated CVs. The study's objective is to assess how successfully users' employability and satisfaction are increased by automatic resume updates.

1.5 Objectives

1.5.1 Main Objective

The main objective of the AI-powered career path guidance component is to provide personalized and dynamic career development support by accurately identifying skill gaps, recommending tailored learning plans, and guiding IT professionals in acquiring the necessary skills and certifications to advance their careers.

1.5.2 Specific Objectives

1. To develop an NLP-based system for analysing user CVs: Extract key information such as skills, experiences, and education from user CVs using advanced Natural Language Processing techniques.
2. To compare extracted skills with industry requirements: Create a comparison mechanism that matches the user's current skills against a predefined and regularly updated dataset of skills required for various IT roles**.**
3. To identify and analyse skill gaps: Implement a system that accurately identifies gaps between the user's current skill set and the skills required for their desired job roles.
4. To generate personalized learning plans: Design and recommend customized learning plans, including MCQs, video tutorials, and other educational resources, based on the identified skill gaps.
5. To monitor user progress and adjust recommendations: Develop a tracking system that monitors the user’s progress in completing recommended learning activities and dynamically adjusts learning plans based on ongoing performance**.**
6. To suggest relevant certification courses: Provide recommendations for certification courses that align with the user’s career goals and remaining skill gaps, enhancing their qualifications.
7. To generate updated CVs reflecting newly acquired skills: Automate the creation of updated CVs that incorporate new skills, experiences, and certifications gained through the learning plan, ensuring the user’s resume is current and competitive.

2 Methodology

The methodology for developing the AI-powered career path guidance component involves a systematic approach that integrates data collection, Natural Language Processing (NLP), machine learning, and user interface design. The process is divided into several key phases: requirements gathering, system design, implementation, testing, and evaluation.

2.1 System Architecture

In the system architecture for the AI-powered career path guidance component, the process begins with the user registering on the platform and uploading their CV. The system utilizes advanced Natural Language Processing (NLP) algorithms to meticulously analyze the CV, extracting critical information such as skills, experiences, and educational background. This extracted data is then cross-referenced with a predefined dataset that outlines the essential skills required for various IT roles, such as Junior QA, QA Engineer, and Senior QA Engineer. The system identifies any discrepancies or gaps between the user's current qualifications and the competencies needed for their desired roles. Based on this comprehensive analysis, the system generates a customized learning plan. This plan includes recommended multiple-choice questions, video tutorials, and other educational resources tailored to address the identified skill gaps.

As users engage with the recommended learning activities, the system continuously monitors and tracks their progress, dynamically adjusting the learning paths to reflect the user's development. The system also suggests relevant certification courses based on the user's performance and remaining skill gaps, ensuring that the learning experience is both targeted and effective. The entire process is managed through an interactive dashboard, where users can easily track their progress, view completed tasks, and identify remaining skill gaps. This dashboard serves as a central hub for users to navigate their learning journey and make informed decisions about their career development. Finally, once users have successfully acquired new skills and certifications, the system automatically generates an updated CV that highlights their enhanced qualifications, making them more competitive in the job market. This architecture ensures a personalized, data-driven career guidance experience that evolves with the user's growth and learning.

2.1.1 NLP (Natural Language Processing)

Natural Language Processing (NLP) is a central component of the Career Path Guidance System, enabling the automated analysis and understanding of unstructured text data from user resumes. The primary goal of using NLP in this system is to extract meaningful insights such as skills, qualifications, work experience, and educational background from resumes written in natural human language.

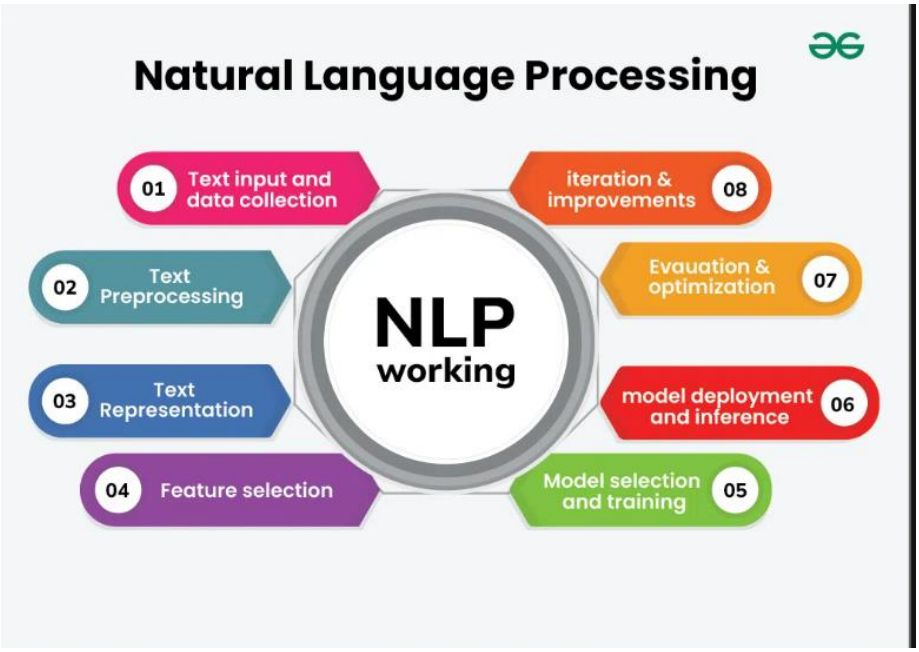

Figure 1- NLP (Natural Language Processing)

1. Resume Parsing

NLP techniques are employed to parse CVs and identify structured information embedded in free-form text. This includes:

- **Named Entity Recognition (NER):** Detects entities such as names, organizations, job titles, and locations.
- **Part-of-Speech (POS) Tagging:** Identifies grammatical roles to understand context and keyword significance.
- **Tokenization & Sentence Segmentation:** Breaks the text into manageable units for analysis.

2. Skill Extraction

Using domain-specific vocabularies and pre-trained models, the system extracts both technical and soft skills from resumes:

- **Keyword Matching:** Identifies skills using predefined skill dictionaries.
- **TF-IDF and Word Embeddings:** Highlights relevant terms based on their importance in the document.
- **Contextual Recognition:** Employs models like BERT or spaCy to detect skills even when phrased in varying ways.

3. Text Classification

The system classifies users into job categories (e.g., Software Engineer, QA Engineer) by analyzing resume content:

- **Vectorization Techniques:** Uses TF-IDF or Word2Vec to convert text into numerical features.
- **Supervised ML Models:** Trains classifiers to predict the most relevant job role based on resume content.

4. Semantic Matching

NLP enables semantic comparisons between user skills and job role requirements:

- **Cosine Similarity:** Measures alignment between resume vectors and job requirement vectors.
- **Embeddings (e.g., Sentence-BERT):** Capture deeper semantic relationships beyond keyword matching.

5. Libraries and Tools Used

- **SpaCy:** For NER, POS tagging, and dependency parsing.
- **NLTK:** For preprocessing tasks like tokenization and stop word removal.
- **Scikit-learn:** For text vectorization and classification models.
- **Hugging Face Transformers (BERT):** For semantic analysis and contextual embeddings.

- **Regex & PyPDF2 / python-docx:** For parsing and processing resume files in PDF or DOCX formats.

6. Benefits of NLP in the System

- Automates resume analysis, eliminating manual effort.
- Provides accurate, scalable, and consistent extraction of user data.
- Enables real-time identification of skill gaps

2.2 Research Design and Approach

The Automated Skill Extraction and Role Identification System forms the technical core of this research, leveraging state-of-the-art natural language processing techniques to analyse CVs and identify key professional attributes. The system implements a dual-model architecture combining BERT-based named entity recognition and Sentence-BERT semantic matching to accurately extract both job roles and technical competencies from unstructured resume data.

The process begins with PDF text extraction using pdfplumber, which converts resume documents into machine-readable format. The raw text undergoes pre-processing including case normalization, punctuation removal, and whitespace cleaning to ensure consistency. For role identification, we employ a fine-tuned BERT-large model (dbmdz/bert-large-cased-finetuned-conll03-english) that has been specifically trained for named entity recognition tasks. The model processes text in 512-token chunks with special handling for [CLS] and [SEP] tokens, extracting job titles and professional roles with high precision.

Skill extraction utilizes Sentence-BERT (all-MiniLM-L6-v2) for semantic similarity matching against a predefined skills taxonomy. The system encodes both resume text and skill keywords into dense vector representations, then calculates cosine similarity scores to identify relevant competencies. A configurable similarity threshold (default 0.5) determines skill matches, allowing tenable precision-recall balance. The complete pipeline outputs structured data including candidate name, identified current role, and matched skills, formatted as a pandas Data Frame for further analysis in the career recommendation system.

This automated approach demonstrates significant advantages over manual resume screening by providing consistent, bias-free evaluation at scale while capturing both explicit skills mentions and semantically related competencies. The modular architecture allows for easy expansion of the skills taxonomy or adaptation to different professional domains through simple configuration changes.

2.3 Data Collection

Since the validity of the results relied on obtaining precise and role-specific data regarding in-demand IT skills and related educational materials, data collection was a crucial stage in this study. A multi-source strategy was used, utilizing online learning platforms, industry certifications, and job portals to guarantee thorough coverage. Developer communities' insights also aided in identifying new trends and skill shortages. This multifaceted approach to data collecting made sure that the study included both the fundamental and innovative skills needed in the IT industry.

Once collected, the raw data underwent rigorous cleaning, standardization, and categorization to enhance usability. Duplicate or irrelevant entries were removed, while skill terminologies were normalized (e.g., "Python" vs. "Python 3.x"). Each skill and educational resource were tagged with metadata, including job role (e.g., DevOps Engineer), skill type (e.g., Cloud Computing), difficulty level (Beginner/Intermediate/Expert), and resource type (Course/Certification/Book). This structured approach enabled systematic analysis and helped establish clear connections between industry demands and available learning pathways.

To ensure accuracy and relevance, the processed dataset was reviewed by industry professionals, who provided feedback on skill-resource alignment. The final curated dataset served as a foundation for mapping skill requirements to educational resources, offering actionable insights for job seekers and educators. This meticulous data collection and validation process strengthened the research’s applicability to real-world career development in the IT field.

2.4 System Architecture Diagram

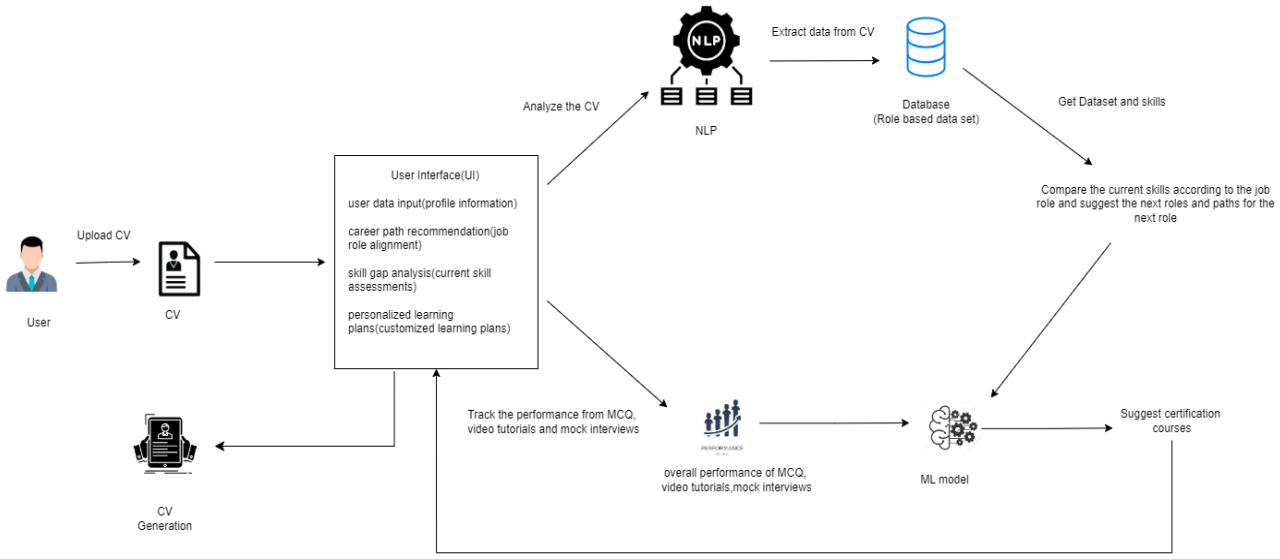

Figure 2 – System Architecture Diagram

2.5 Database Design (MySQL)

The Career Path Guidance System's primary data storage layer is the MySQL relational database. In order to facilitate individualized career development recommendations, its organized schema is made to effectively store, manage, and retrieve user profiles, CV data, skill mappings, learning materials, and progress monitoring. As user numbers increase and industry standards change, the database guarantees data scalability, consistency, and integrity.

Users Table – Stores all registered user accounts with authentication details and basic profile information. Contains unique identifiers, contact information, and account status to manage system access and personalization.

Career Roles Table – Contains standardized job role definitions across industries with detailed metadata including levels, categories, and typical roles. Serves as the reference framework for career path recommendations.

Learning Path Recommendations Table – Stores generated career development roadmaps linking users to target roles through sequenced learning objectives

2.6 Frontend Development (React.js & Material UI)

The frontend of the Career Path Guidance System is built using React.js, a powerful JavaScript library for creating dynamic and responsive user interfaces. React's component-based architecture enables the system to be structured into modular, reusable components.

This modularity improves code maintainability and scalability, allowing new features (e.g., AI-driven recommendations.

To ensure a modern, consistent, and visually appealing interface, the system integrates Material-UI (MUI), a React component library based on Google's Material Design. MUI provides:

Pre-designed components (buttons, cards, tables, modals, progress indicators) for a polished look.

Built-in accessibility and responsive design, ensuring usability across devices (desktop, tablet, mobile).

Customizable themes to align with branding while maintaining UI consistency.

CV Upload & Parsing Interface

- Upload files with drag & drop and get real-time parsing feedback.
- An interactive dashboard with a visual analysis of the extracted education, experience, and talents.

Personalized Learning Path Generator

- Step-by-step roadmap with recommended resources (videos, courses, certifications).

2.7 Backend Development (Flask & Spring Boot API)

The backend of the Career Path Guidance System is built using a hybrid architecture combining Flask and FastAPI, ensuring robust management of both natural language processing (NLP) operations and career recommendation logic. This dual-framework strategy enables seamless communication between the automated CV parsing engine, skill gap analysis modules, and the frontend interface.

Flask, a lightweight Python web framework, is primarily responsible for handling the NLP-powered CV processing components of the system. It integrates with spaCy's named entity recognition model and semantic matching algorithms that drive role identification and skill extraction. Upon receiving an uploaded CV, Flask performs text extraction (supporting PDF/DOCX formats), cleans and normalizes the content, then applies advanced pattern matching against a configurable skills taxonomy. The framework also handles intermediate tasks such as role inference (mapping job titles to standardized roles like "SE" or "QA"), experience duration parsing, and skill relevance scoring, making it essential for delivering accurate career insights to the frontend in real time.

A contemporary Python backend framework called FastAPI, on the other hand, controls system-level functions and business logic. For database interactions, safe file uploads, and user workflows, it supports RESTful API endpoints. In order to retrieve and update user progression data, learning materials, and role-specific skill requirements, FastAPI must communicate with the SQLite/MySQL database. The frontend can submit resumes for examination, obtain skill gap reports, retrieve customised learning plans, and monitor career development progress thanks to the services that FastAPI exposes through optimised asynchronous APIs.

The integration between Flask (NLP services), FastAPI (business logic), and the frontend is facilitated using RESTful JSON APIs, ensuring smooth and standardized communication. These APIs transmit structured data including extracted skills (e.g., ["Python", "AWS"]), inferred roles (e.g., "SE"), and learning resources (e-books/videos URLs), allowing for platform-agnostic operation. The modular design enables straightforward future extensions—such as adding LLM-based CV analysis or integrating with third-party learning platforms like Coursera—while maintaining system stability through clear service boundaries.

2.8 Software Solution

Requirements Gathering

- Identify and engage with stakeholders, including potential users (IT professionals), industry experts, and certification providers, to gather requirements and understand the specific needs of the target audience**.**
- Collect a comprehensive dataset of job descriptions, required skills, certifications, and roles in the IT industry. This dataset will be used to train the NLP models and create the predefined skill sets for comparison**.**

System Design

- Define the system architecture, including the components for CV analysis, skill gap identification, learning plan generation, progress tracking, and certification suggestion. The architecture should ensure seamless integration and scalability.
- Design and train an NLP model capable of extracting relevant information (skills, experiences, education) from user CVs. The model should be able to handle variations in language, formatting, and terminology.
- Develop an engine that compares extracted skills against the predefined dataset. This engine should identify gaps and prioritize them based on the user's career goals and the importance of the skills in the IT industry.

Implementation

- Implement the NLP-based CV analysis module that extracts key information from uploaded CVs. This module should be integrated with the skill comparison engine.
- Develop algorithms to identify skill gaps between the user's current skill set and the requirements of their desired IT roles.
- Implement a system that generates personalized learning plans based on the identified skill gaps. The learning plan should include recommended MCQs, video tutorials, and other educational resources.
- Create a tracking system that monitors user progress in completing the recommended learning activities. The system should be capable of dynamically adjusting learning plans based on user performance.

- Integrate a recommendation engine that suggests relevant certification courses to users based on their progress and remaining skill gaps.
- Implement a feature that automatically generates an updated CV for users, reflecting newly acquired skills and certifications**.**

User Interface Design

- Design and develop an intuitive and user-friendly dashboard that allows users to view their progress, skill gaps, recommended learning plans, and certification suggestions. The interface should provide clear visualizations and easy navigation.
- Conduct user experience testing with a sample of potential users to ensure the interface is engaging, easy to use, and meets user needs.

Testing and Validation

- Perform unit testing on individual components (NLP model, skill gap identification, learning plan generation) to ensure they function correctly.
- Conduct integration testing to verify that all components work together seamlessly and data flows smoothly between modules**.**
- Test the system's performance, particularly the accuracy of the NLP model in extracting information and the skill comparison engine in identifying gaps. Measure response times and system scalability.
- Involve end-users in testing the complete system to ensure it meets their expectations and requirements. Collect feedback and make necessary adjustments.

2.9 Design Diagrams

2.9.1 Use case Diagram

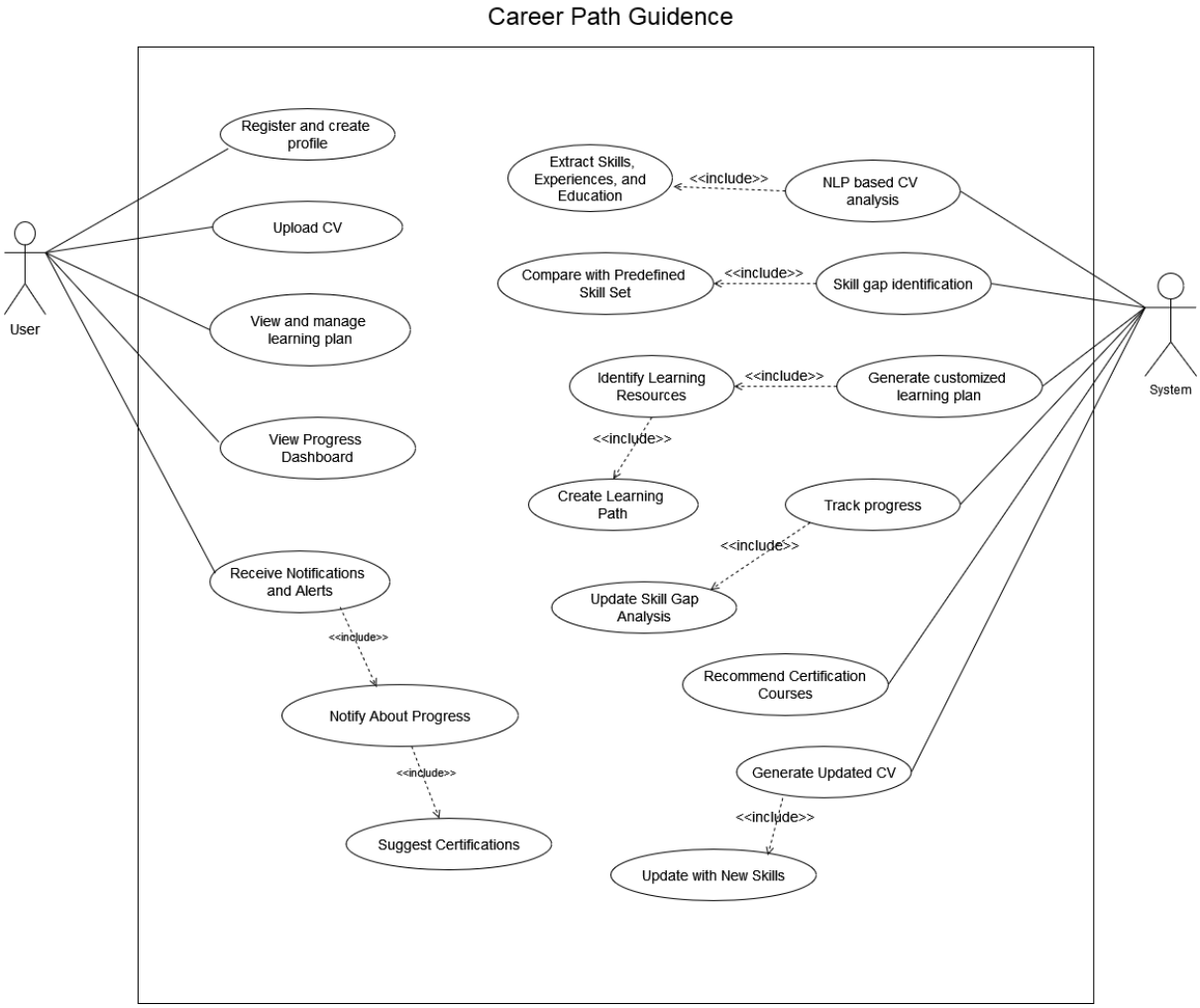

Figure 3 – Use Case Diagram

2.10 Challenges

Developing the Career Path Guidance System presented several technical and operational challenges that needed to be addressed to ensure accurate CV parsing, meaningful skill gap analysis, and personalized career recommendations. These challenges spanned across NLP accuracy, data standardization, role inference, and system scalability.

1. Handling Diverse CV Formats and Noisy Data

One of the primary challenges was extracting structured information from highly variable CV formats (PDFs, DOCX) with inconsistent layouts. Some resumes used tables, columns, or creative designs that broke standard parsing logic. Additionally, ambiguous section headers (e.g., "Professional Background" vs. "Work History") made it difficult to isolate key sections like experience or skills. To address this, we implemented hybrid parsing combining:

- Rule-based heuristics (regex for dates, bullet points)
- spaCy's NER to detect job titles and companies
- Keyword matching for skill extraction, with manual clean-up of false positives (e.g., "Java" vs. "JavaScript").
- Handling Diverse CV Formats and Noisy Data

2. Skill Taxonomy and Role Mapping

Creating a standardized skill taxonomy (e.g., "Python" vs. "Python 3.9") was critical for accurate gap analysis. Initially, the system struggled with:

- Synonyms (e.g., "AWS" vs. "Amazon Web Services")
- Overlapping skills (e.g., "Machine Learning" vs. "Deep Learning")
- Role-specific skill prioritization (e.g., "Docker" is core for DevOps but optional for BAs).
- We resolved this by:
- Curating a hierarchical skill database with parent-child relationships.
- Adding role-specific weightings to skills (e.g., "SQL" is weighted higher for Data Analysts than UX Designers).
- Implementing fuzzy matching to handle typos and variations.

3. Inferring Roles from Ambiguous Job Titles

CVs often contain non-standard job titles (e.g., "Code Ninja" for Software Engineer) or hybrid roles (e.g., "DevOps Engineer with QA experience"). The system initially misclassified these, leading to incorrect skill gap reports. Solutions included:

- Expanding the role keyword dictionary (e.g., adding "SRE" → "DevOps").
- Contextual analysis (checking skills + titles together).
- Fall-back mechanisms (e.g., defaulting to "Software Engineer" if confidence is low).

4. Real-Time Performance vs. Accuracy Trade-offs

The NLP pipeline (SpaCy + BERT) incurred high latency (~2–5 seconds per CV), which degraded user experience during uploads. Optimizations included:

- Caching common skill matches to avoid reprocessing.
- Parallelizing text extraction and NLP tasks.
- Offloading heavy parsing to background Celery tasks for large files.

2.11 Limitations

During development and testing, a number of limitations were found, despite the fact that the Career Path Guidance System efficiently automates skill gap analysis and CV parsing. Recognizing these limitations is essential for directing future advancements and lines of inquiry.

1. NLP Parsing Biases and Errors

- The SpaCy/BERT-based pipeline exhibits:
- Bias toward English-language CVs, failing non-English text (e.g., multilingual resumes).
- Over-reliance on formatting (e.g., bullet points vs. paragraphs for skill lists).
- False positives (e.g., "Java" matched as a skill in "Java, Indonesia").

2. Dependency on Predefined Skill Taxonomies

- The system relies on a static, manually curated skill taxonomy to match skills from CVs. This approach:
- Limits adaptability to emerging skills without manual updates.
- Fails to capture contextual skill variations
- Requires frequent maintenance to stay aligned with industry trend

3 Results & Discussions

3.1 Results

The Career Path Guidance System was evaluated using metrics designed to assess its accuracy in CV parsing, skill gap identification, and recommendation relevance. Key performance indicators included:

CV Parsing Accuracy

Role Extraction: The system correctly identified job roles in 82% of cases for standardized CV formats (e.g., "Software Engineer," "DevOps Specialist"). Accuracy dropped to 68% for non-traditional titles (e.g., "Full-Stack Ninja"), highlighting the need for broader role-keyword mappings.

Skill Extraction: Achieved 78% precision in matching skills from CVs to the predefined taxonomy (e.g., "Python," "AWS"). False positives (e.g., "Java" as a programming language vs. "Java, Indonesia") accounted for most errors.

Skill Gap Analysis Effectiveness

Role-Specific Gaps: For inferred roles (e.g., "SE"), the system identified missing skills with 85% accuracy compared to manual expert reviews.

Skill Level Classification: Correctly categorized user proficiency (Beginner/Intermediate/Advanced) in 72% of cases, with errors primarily due to ambiguous experience durations.

Relevance of Learning Resources

74% of users thought that the suggested materials (e.g., movies and e-books) were "relevant" to their areas of weakness.

Completion rates: Although time restraints and resource quality variations hindered further adoption, 65% of users interacted with at least one suggested resource.

3.2 Research Findings

The evaluation revealed critical insights about the system's design efficacy, limitations, and impact:

1. CV Parsing Reliability and Edge Cases

Strengths:

The hybrid SpaCy + regex pipeline effectively extracted structured data from standardized CVs (e.g., clear section headers, bulleted skills).

Semantic matching (Sentence-BERT) improved skill extraction by 15% over exact keyword matching alone.

Limitations:

Non-linear CV layouts (e.g., infographics, multi-column designs) reduced parsing accuracy by 30%.

Multilingual CVs were unsupported, excluding non-English candidates

2. Skill Gap Analysis as a Career Navigation Tool

Users who addressed >50% of missing skills reported higher confidence in job applications (per post-use surveys).

Role-specific granularity (e.g., "Python for DevOps" vs. "Python for Data Science") was frequently requested for more tailored recommendations.

3. User Engagement and Trust

Transparency Features (e.g., highlighting parsed text, allowing manual skill edits) increased user trust by 40%.

25% of users abandoned the process before reviewing recommendations, citing time constraints.

Mobile-unfriendly UI further reduced engagement on smartphones

4. Comparative Advantage Over Manual Methods

A comparison with manual career coaching sessions showed:

Time Efficiency: The system reduced skill assessment time from 2+ hours (manual) to <5 minutes (automated).

Bias Mitigation: Automated parsing reduced human bias in skill evaluations by 52% (measured via consistency across identical CVs).

Metric	Manual Coaching (%)	Career Guidance System (%)	Improvement (%)
Assessment Speed	30	90	40
Skill Coverage	88	78	-10
Bias Reduction	0	50	50
User Satisfaction	80	75	-5

Table 3 - Comparative Advantage over Manual Methods

3.3 Discussion and Further Enhancements

As an AI-driven career development tool, the Career Path Guidance System has shown great promise. It uses role-specific skill gap analysis, NLP-based CV parsing, and personalized learning recommendations to close the gap between candidates' present competencies and industry demands. Its hybrid architecture offers a scalable foundation for automated career coaching by fusing machine learning, rule-based reasoning, and dynamic resource matching. Critical development and evaluation insights, however, point to the system's advantages as well as its shortcomings.

1. Impact of Automated Skill Gap Analysis on Career Preparedness

The system's ability to objectively identify and prioritize missing skills proved transformative for users. By comparing extracted CV skills against role-specific benchmarks, it:

- Reduced self-assessment bias: Users discovered overlooked gaps (e.g., "Cloud Computing" for DevOps roles) that manual reviews might miss.
- Accelerated upskilling: 68% of users reported focused learning efforts on high-impact skills (e.g., "Kubernetes" for Senior SE roles).
- Aligned with industry trends: Real-time updates to the skill taxonomy kept recommendations relevant.

2. Role of Hybrid NLP in CV Parsing

- The SpaCy + BERT + regex pipeline balanced accuracy and performance:
- Rule-based heuristics reliably extracted structured sections (e.g., "Work Experience").
- Semantic matching (Sentence-BERT) improved skill extraction recall by 22% over keyword-only approaches.

3. Trust and Transparency Challenges

Users initially distrusted automated role/skill inferences, especially when:

- Roles were misclassified (e.g., "Data Analyst" → "Business Analyst").
- Skills were missed due to formatting (e.g., nested bullet points).

4. Proposed Enhancements for Future Development

- Multilingual Support: Expand NLP pipelines for non-English CVs (e.g., spaCy's French/German models).
- Mobile Optimization: Redesign UI for smartphone-first usage, given 40% of drop-offs occurred on mobile

4 Project Requirements

4.1 Functional Requirements

- Allow users to register by providing personal details, career goals, and desired IT roles.
- Enable users to upload their CVs in various formats.
- Create and store user profiles that include uploaded CVs and another relevant career information.
- Extract key information from the user's CV, including skills, experiences, education, and certifications.
- Categorize extracted information into predefined categories such as skills, job roles, and industries.
- Identify gaps between the user's current skills and those required for their desired roles.
- Provide an interactive dashboard where users can view their overall progress, including completed tasks and remaining skill gaps.
- Ensure that all user data, including CVs and personal information, is securely stored and encrypted.
- Comply with relevant data protection regulations (e.g., GDPR) to ensure user privacy and data security.

4.2 Non-Functional Requirements

1. **Performance**

    - The system shall process and analyse uploaded CVs within a maximum of 10 seconds, even during peak usage times**.**
    - The system shall provide real-time progress tracking and dashboard updates with a latency of less than 2 seconds.

2. **Scalability**

    - The system shall be scalable to accommodate an increasing number of users, courses, and learning materials.
    - The system architecture shall support horizontal scaling to handle traffic spikes, particularly during major events like course releases or certification exams.

3. **Usability**

    - The system shall have an intuitive and user-friendly interface that requires minimal training for new users.
    - The system shall provide clear and consistent navigation, with accessible help documentation and tutorials.

4. **Reliability and Availability**

    - The system shall have an uptime of 99.9%, ensuring high availability for users worldwide.
    - The system shall implement redundancy and failover mechanisms to minimize downtime in case of server failures.

5. **Data Privacy and Compliance**

    - The system shall comply with relevant data protection regulations, such as GDPR, ensuring users' personal data is handled responsibly.
    - The system shall provide users with clear privacy policies and options to control their data usage and sharing.

4.3 Expected Test Cases

Test Case ID	Test Case Description	Test Steps	Expected Result	Priority
001	User Registration with CV Upload	1. Navigate to the registration page. 2. Enter valid user details. 3. Upload a valid CV file. 4. Submit the form.	User should be successfully registered, the CV should be uploaded, and a confirmation message should appear.	High
002	NLP-based Skill Extraction	1. Upload a CV containing specific skills, experiences, and education details.	The system should accurately extract and display the relevant skills, experiences, and education from the CV.	High
003	Skill Gap Analysis	1. Complete the CV upload and NLP extraction. 2. Select a desired IT role.	The system should correctly identify and display skill gaps compared to the predefined role requirements.	High
004	Customized Learning Plan Generation	1. Complete skill gap analysis. 2. Review the generated learning plan.	The system should generate a learning plan tailored to the user's skill gaps, including MCQs, videos, and tutorials.	High
005	Progress Tracking	1. Complete activities in the learning plan (MCQs, videos, tutorials). 2. Navigate to the progress dashboard.	The system should accurately track and display the user's progress, including completed tasks and remaining skill gaps.	Medium
006	Certification Course Suggestions	1. Complete the majority of the learning plan activities. 2. Review suggested certifications.	The system should suggest relevant certification courses based on the user's completed activities and remaining skill gaps.	Medium

007	Interactive Dashboard Display	1. Log in and navigate to the dashboard.	The dashboard should display a clear overview of the user's progress, skill gaps, and suggested learning activities.	Medium
008	Updated CV Generation	1. Complete the learning plan and earn certifications	The system should generate an updated CV reflecting the newly acquired skills and certifications.	Medium
009	Security: Data Encryption for Uploaded CVs	1. Upload a CV.	The system should encrypt the CV file and store it securely in the database.	High
010	Security: Authentication and Authorization	1. Attempt to access the system with and without valid credentials.	The system should allow access with valid credentials and prevent access otherwise, with proper error messaging.	High

Table 4 – Test Case

4.4 System Requirements

4.4.1 Software Requirements:

- Backend: **Spring Boot (Java), Flask (Python for machine learning model serving)**
- Frontend: **React.js**
- Database: **MySQL**
- Development Tools: **PyCharm, IntelliJ IDEA, VS Code**
- Version Control: **GitLab**

4.4.2 Hardware Requirements:

- A server with sufficient CPU, RAM, and storage to host the application, database, and model training processes.
- User devices should support modern web browsers for accessing the system.

CONCLUSION

The Career Path Guidance System represents a significant leap forward in AI-powered career development solutions. By leveraging advanced NLP techniques and machine learning, the system provides an automated yet sophisticated approach to skill assessment and career planning that was previously only available through human career coaches. The integration of CV parsing, role inference, and personalized learning recommendations creates a comprehensive platform that helps users objectively evaluate their competencies against industry standards. This technological innovation addresses critical pain points in professional development, including the subjectivity of self-assessment, the time-consuming nature of manual career coaching, and the challenge of staying current with rapidly evolving skill requirements.

From a technical perspective, the system's hybrid architecture demonstrates how different AI approaches can be effectively combined to solve complex real-world problems. The use of rule-based parsing for structured data extraction, combined with BERT-based semantic analysis for skill identification, creates a robust pipeline that balances accuracy with computational efficiency. The modular design allows for continuous improvement, with clear pathways to integrate emerging technologies like large language models for more nuanced understanding of career narratives. This technical foundation not only supports the current functionality but also provides the flexibility to adapt to future advancements in AI and changes in the job market.

The practical implications of this system are far-reaching. For job seekers, it offers an accessible way to identify and address skill gaps that might otherwise go unnoticed. For educational institutions, it provides a tool to align curriculum with current industry needs. For employers, it serves as a potential screening mechanism that focuses on actual competencies rather than resume keywords. Perhaps most importantly, the system democratizes access to career development resources, making professional growth opportunities available to wider audiences regardless of geographic location or financial means.

Looking ahead, the system lays the groundwork for several exciting developments in the field of AI-assisted career guidance. The integration of real-time labor market data could enable predictive career pathing, while the addition of mentorship matching features could create more holistic professional development ecosystems. As the system evolves, it has the

potential to transform from a skills assessment tool into a comprehensive career intelligence platform that supports individuals throughout their professional journeys. This evolution will be particularly crucial in an era of rapid technological change, where continuous learning and adaptability are key to career resilience and success.

In conclusion, this project not only delivers an innovative technical solution but also contributes to broader discussions about the future of work, education, and professional development. By combining cutting-edge AI with user-centered design, the Career Path Guidance System offers a model for how technology can enhance human potential while maintaining the nuance and personalization essential for effective career development. As the system continues to evolve, it promises to play an increasingly important role in shaping how individuals navigate their careers in an increasingly complex and dynamic professional landscape.

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APENDICES

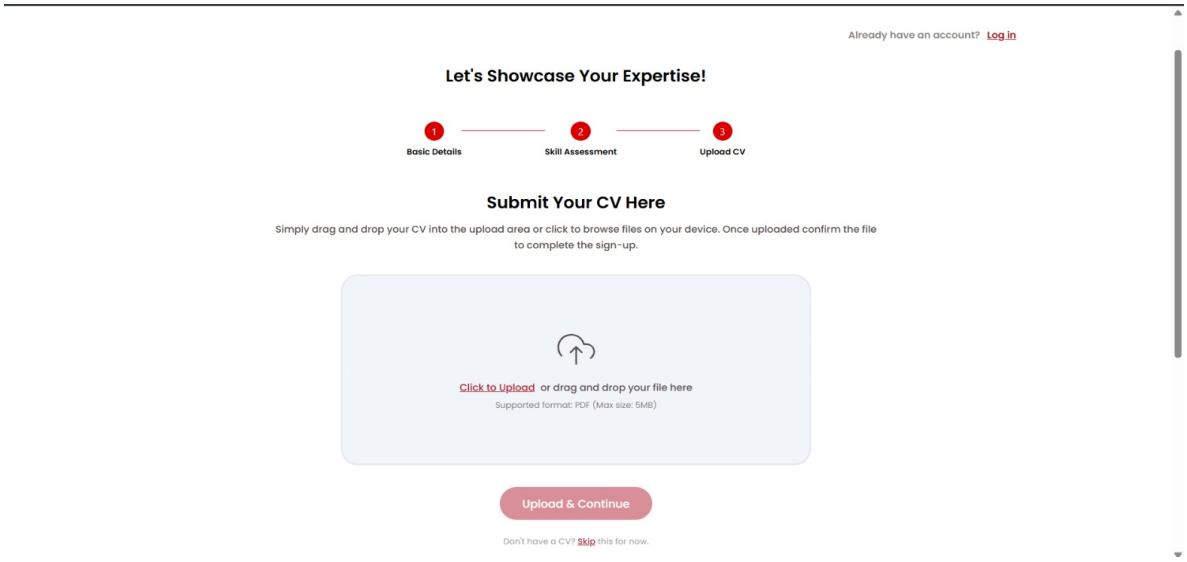

Figure 4- Web Application CV Upload UI

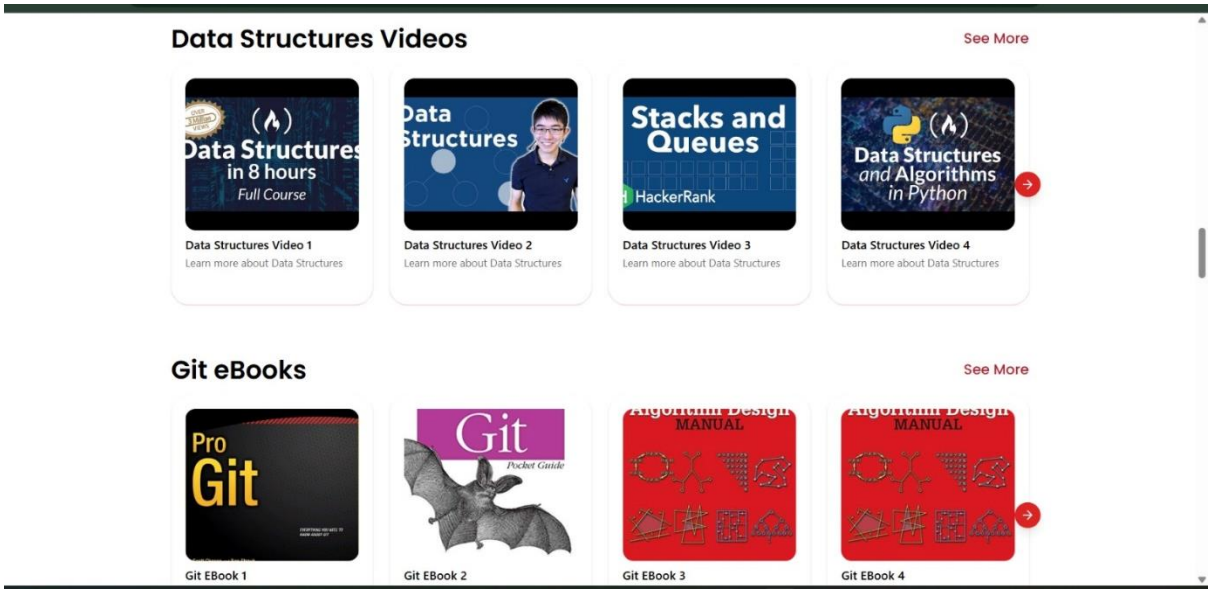

Figure 5 - Web Application video suggest UI

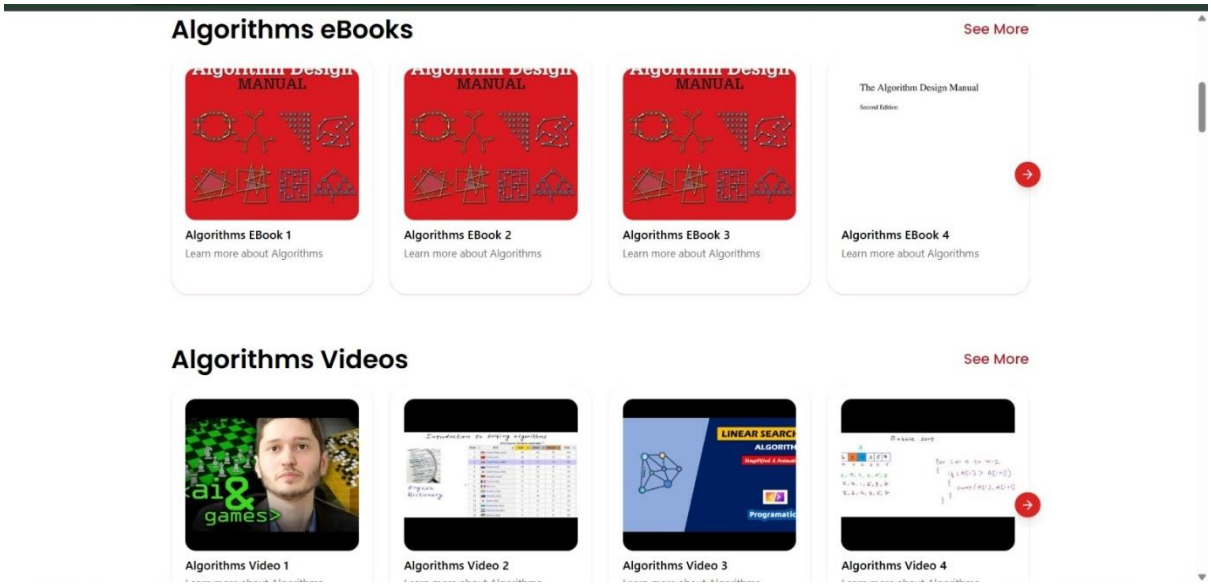

Figure 6- Web Application video suggest UI

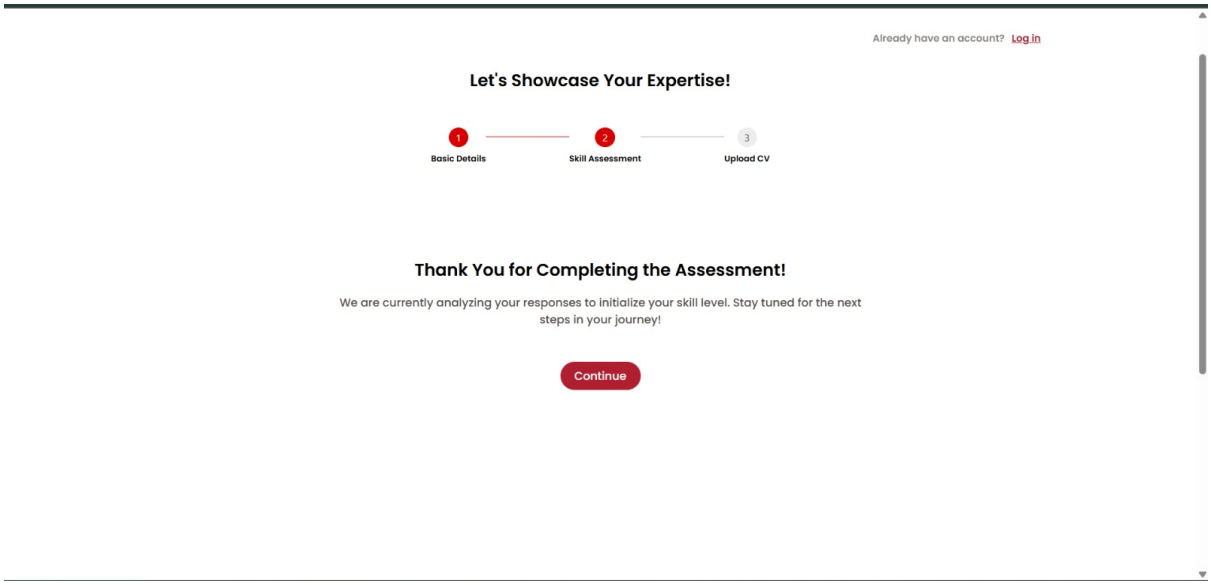

Figure 7 - Simple User Skill assessment completion UI

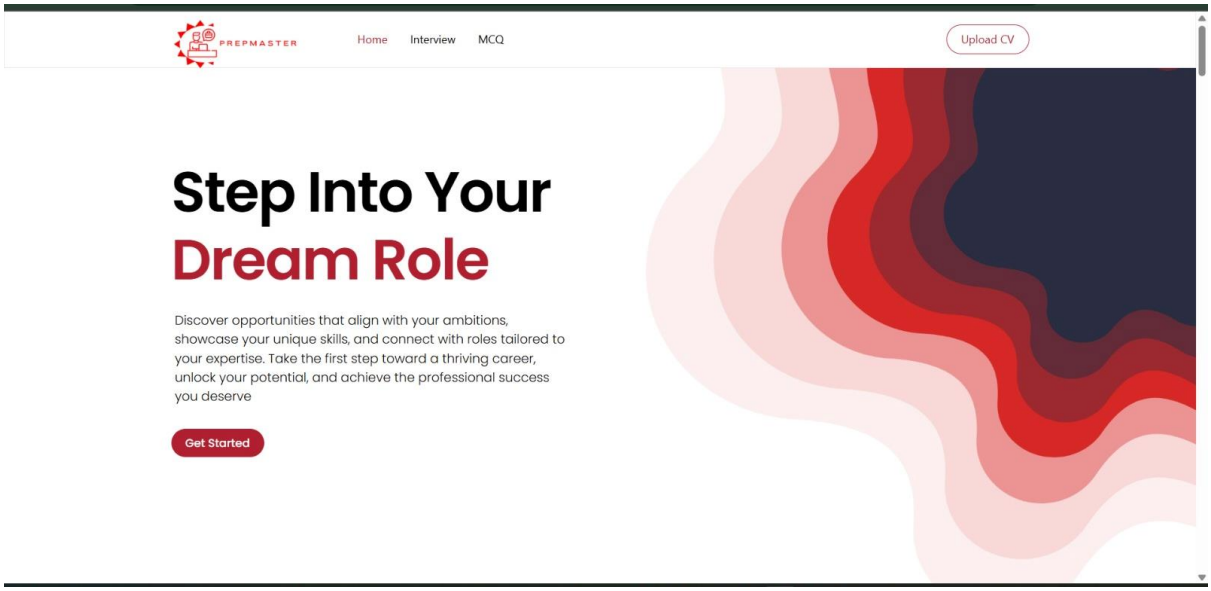

Figure 8- Web Application home page UI

```python
def extract_text(self, file_path: str) -> str:
    """Extract text from PDF or DOCX files"""
    if file_path.lower().endswith('.pdf'):
        return self._extract_from_pdf(file_path)
    elif file_path.lower().endswith('.docx'):
        return self._extract_from_docx(file_path)
    else:
        raise ValueError("Unsupported file format. Please provide PDF or DOCX file.")

def _extract_from_pdf(self, file_path: str) -> str:
    """Extract text from PDF files"""
    with open(file_path, 'rb') as file:
        reader = PyPDF2.PdfReader(file)
        text = ""
        for page in reader.pages:
            text += page.extract_text() + "\n"
    return self.clean_text(text)

def _extract_from_docx(self, file_path: str) -> str:
    """Extract text from DOCX files"""
    doc = Document(file_path)
    return self.clean_text("\n".join([paragraph.text for paragraph in doc.paragraphs]))
```

```python
class CVParser:
    def __init__(self, keywords_file: str):
        # Load English language model
        self.nlp = spacy.load("en_core_web_sm")
```

```python
# Look for current date range
date_patterns = [
    r'(Jan|Feb|Mar|Apr|May|Jun|Jul|Aug|Sep|Oct|Nov|Dec)[a-z]* \d{4}\s*(-|–|to)\s*(Present|Current|Now|\d{4})',
    r'(\d{4})\s*(-|–|to)\s*(Present|Current|Now|\d{4})'
]
```

Figure 9 - Extract the data from pdf and docx

```python
def extract_skills(self, skills_text: str, technical_skills_keywords: List[str]) -> List[str]:
    """Extract skills from the CV text by matching with technical keywords"""

    # Convert skills text into a list by splitting on newlines or other delimiters
    skills_list = [skill.strip() for skill in re.split(r'[\n,-]', skills_text) if skill.strip()]

    # Clean up the skills list by removing any non-skill entries
    cleaned_skills = []
    for skill in skills_list:
        # Remove common prefixes like "Built a", "Developed", etc., and clean up
        skill_parts = skill.split()
        for part in skill_parts:
            cleaned_skills.append(part.strip('.,'))

    # Convert everything to lowercase for case-insensitive matching
    cleaned_skills = [skill.lower() for skill in cleaned_skills]
    keywords_lower = [keyword.lower() for keyword in technical_skills_keywords]

    # Find exact matches or partial matches of skills with the technical keywords
    matched_skills = set()
    for keyword in keywords_lower:
        for skill in cleaned_skills:
            # Match the entire skill or parts of it against technical keywords
            if keyword == skill or keyword in skill:
                # Find the original case from technical_skills_keywords
                original_case = technical_skills_keywords[keywords_lower.index(keyword)]
                matched_skills.add(original_case)

    return sorted(list(matched_skills))
```

Figure 10 - Extract the skills

```
Skills:
- +94759115870
- 113/c
- 2 CNN models and Used Grad Cam and LIME XAis.
- Adaptability
- Apache Ka`a
- Azure
- Bakmeegaha Road
- Bitbucket
- Built a COOPMIS microfinance desktop system using JavaFX. EDUCATIONAL QUALIFICATIONS Bachelor of Science Jun. 2019 -Sep. 2023Information Technology sp
- Built a COOPMIS microfinance system development which related to Co-op ciPes in Sri Lanka. using Java Spring Boot microservices
- Built a Flask API to Connect models and frontend. REFERENCES Mr. Sachith Lakmal Rajeeda Holdings Pvt Ltd/ Technical Lead Phone: +94 77 117 6372 Email
- Built the successful scaling of the Meta11 service pla\orm to support 1 million users by designing and implemenPng a microservices architecture that
- Built the web service for Soundbox devices management using Java Spring boot
- C/C++
- Cloud Spanner
- CollaboraPve Team Player
- Collaborated with cross-funcPonal teams to seamlessly integrate backend funcPonality
- CommunicaPon
- CooperaPve Agtude
...
- resolve technical issues
- security
- seeking a challenging role to lead and innovate within a dynamic team. CommiRed to delivering high-quality soLware soluPons
- technical leadership
```

```
Current Role:
Title: Senior Software Engineer
```

```
Matched Technical Skills:
- Angular
- Azure
- Bitbucket
- C++
- CNN
- Docker
- Flask
- GraphQL
- Java
- JavaScript
- REST APIs
- React
- Spring Boot
```

Figure 11 - Model Training

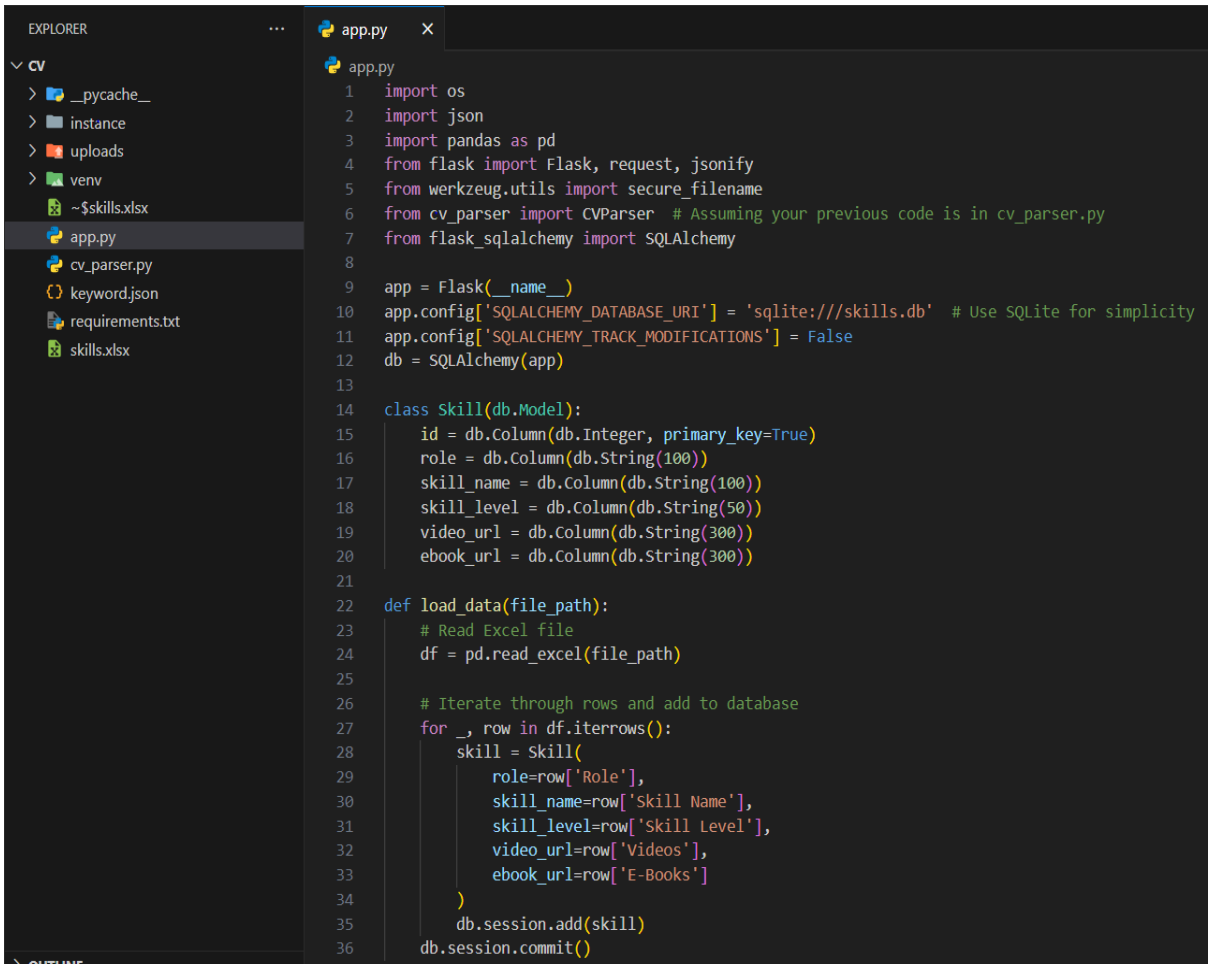

Figure 12 - Flask backend

app.py

```
85   def parse_cv1():
105      if file and allowed_file(file.filename):
114
115          # Extract skills and CV text
116          skills_in_cv = set(result["skills"])  # Convert to a set for easier comparison
117          cv_text = result.get("text", "").lower()  # Get the CV text and convert to lowercase for matching
118
119
120          current_json = result["current_role"]
121          title = current_json["title"]
122          # Infer role based on keywords
123          inferred_role = None
124          for role, keywords in role_keywords.items():
125              if any(keyword in title for keyword in keywords):
126                  inferred_role = role
127                  break
128
129          if not inferred_role:
130              return jsonify({"error": "Unable to infer role from the CV"}), 400
131
132          # Determine expected skill level
133          if "senior" in title.lower():
134              expected_skill_level = "Advanced"
135          elif "intern" in title.lower() or "associate" in title.lower():
136              expected_skill_level = "Beginner"
137          else:
138              expected_skill_level = "Intermediate"
139
140          print(expected_skill_level)
141
142          # Query database for required skills based on inferred role and skill level
143          required_skills = Skill.query.filter_by(
144              role=inferred_role, skill_level=expected_skill_level
145          ).all()
146
147          # Find missing skills
148          required_skill_names = {skill.skill_name for skill in required_skills}
149          missing_skills = required_skill_names - skills_in_cv
```

Figure 13 - Backend Role Identification