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Career Intelligence and Roadmap Recommendation System

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Abstract- Fresh graduates often face significant challenges in identifying the right career path due to unclear role definitions, rapidly evolving job market demands, and limited access to personalized guidance. This paper proposes a Career Intelligence and Roadmap Recommendation System that leverages data analytics and Natural Language Processing (NLP) to provide intelligent, data-driven career guidance for students and fresh graduates. The system collects real-world job posting data from publicly available job portals to analyze current industry requirements, salary trends, and skill demands. It performs a comprehensive skill gap analysis by comparing user-provided skills with market-required competencies for selected job roles. Based on this analysis, the system generates a structured, step-by-step career roadmap that dynamically updates as users acquire new skills. The platform integrates visual analytics such as demand charts and salary trend graphs to help users understand industry expectations. The proposed system aims to reduce skill mismatches, improve job readiness, and enhance overall employability among students and fresh graduates.

Keywords: Career Recommendation, Skill Gap Analysis, NLP, Data Analytics, Roadmap Generation, Job Market Intelligence, Machine Learning, Web Application.

I. INTRODUCTION

In today's rapidly evolving job market, career decision-making has become increasingly complex. Fresh graduates and students often find themselves overwhelmed by the sheer volume of career options, skill requirements, and market dynamics. Without proper guidance, many graduates end up in roles that do not align with their skills or aspirations, leading to high attrition rates and job dissatisfaction. Traditional career guidance platforms offer generic recommendations that lack personalization and real-time market intelligence. Students may possess relevant skills but remain unaware of how those skills align with current industry demands. Moreover, manually exploring career paths through job portals is time-consuming and often yields incomplete or outdated information. With advancements in data analytics, Natural Language Processing, and machine learning, there exists an unprecedented opportunity to build intelligent systems capable of providing personalized, market-aligned career guidance. Such systems can analyze thousands of job postings in real-time, extract skill patterns, and generate actionable career roadmaps tailored to individual user profiles.

This paper proposes a Career Intelligence and Roadmap Recommendation System that bridges the gap between student skills and industry requirements. The system analyzes job market data to guide students toward suitable career paths, explains why a role is suitable, and specifies the exact steps required to achieve career readiness.

II. PROBLEM STATEMENT

Despite the growing availability of online resources, many students and fresh graduates struggle to navigate their career paths effectively. The core issues observed include:

- Lack of personalized, data-driven career guidance tailored to individual skill sets
- Inability to identify skill gaps between current competencies and market-AIrequired skills
- No structured roadmap to guide students from their current state to their career goal
- Limited access to real-time salary trends and job demand statistics
- • Generic career platforms that provide suggestions without market justification
- Rapid skill obsolescence due to continuous technological advancements

These challenges highlight the urgent need for a comprehensive, intelligent system that automates career analysis and provides personalized, actionable guidance. Without such a system, students risk making uninformed career decisions, leading to skill mismatches and reduced employability.

III. EXISTING SYSTEM

The existing approaches to career guidance in educational institutions are primarily manual or offer limited digital support. Most career counseling relies on periodic sessions with advisors who lack real-time market data. Online job portals such as LinkedIn and Naukri provide job listings but do not offer personalized skill analysis or structured career roadmaps.

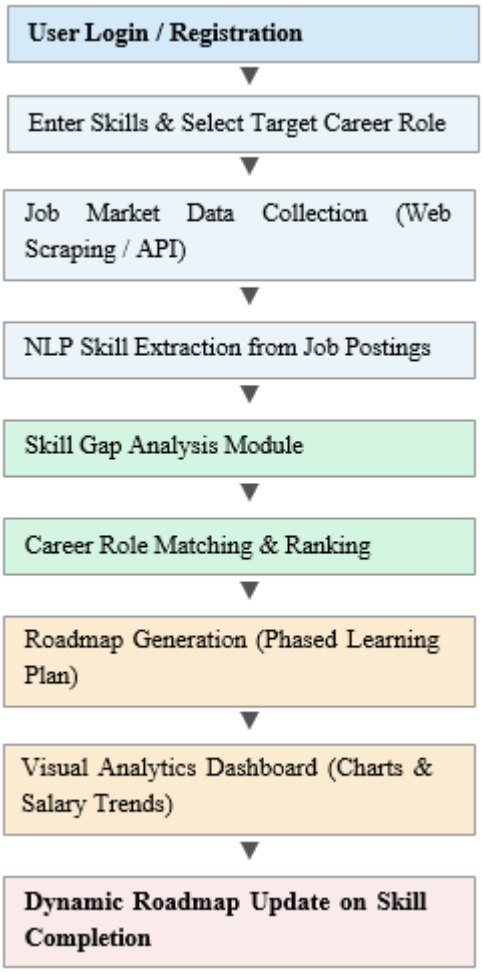
Existing career platforms suffer from several drawbacks:

- Generic recommendations not tailored to individual skills or market conditions
- Static content that does not update dynamically with industry trends
- No mechanism for skill gap identification and prioritized learning suggestions
- Absence of integrated salary trend analysis and job demand forecasting
- No structured, phased learning roadmap to guide career transitions

IV. WORKFLOW

The complete workflow of the proposed Career Intelligence and Roadmap Recommendation System can be summarized in the following sequential steps:

1. User Registration and Profile Creation
2. Skill Input and Assessment by the User
3. Job Market Data Collection from Public Portals
4. NLP-Based Skill Extraction from Job Postings
5. Skill Gap Analysis and Role Matching
6. Career Roadmap Generation with Phased Learning Plan
7. Visual Analytics Display (Salary Trends, Demand Charts)
8. Dynamic Roadmap Update as User Acquires Skills



V. PROPOSED SYSTEM

The proposed Career Intelligence and Roadmap Recommendation System is a web-based platform that connects students and fresh graduates with real-time job market intelligence. The system integrates data analytics, NLP, and machine learning to provide a comprehensive career guidance experience.

Key features of the proposed system include:

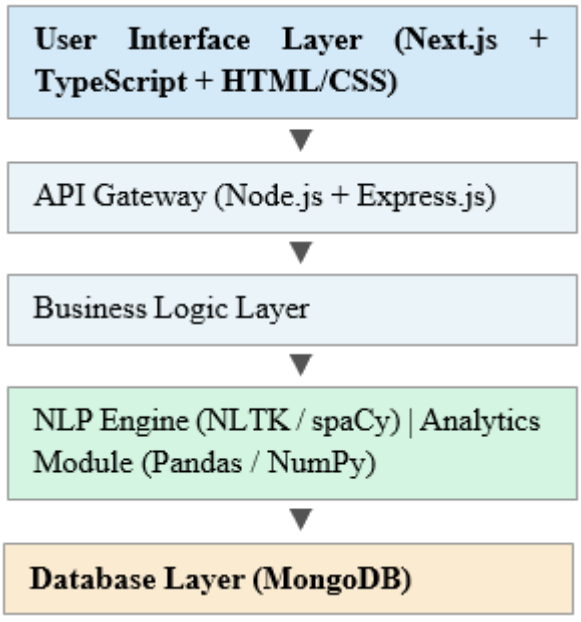
- Real-time job market data collection from publicly available job portals and datasets
- NLP-based skill extraction from thousands of job postings to identify market demand patterns
- Personalized skill gap analysis comparing user skills against role-specific requirements
- Dynamic career roadmap generation organized in phased learning sequences

- Visual analytics including salary trend charts and job demand heatmaps
- Role stability analysis identifying volatile vs. stable job roles using historical data
- Skill urgency ranking to prioritize learning based on market demand and dependency
- Resume mapping feature highlighting improvements needed for a target role

Unlike traditional job portals that only list openings, this system integrates market analysis, skill evaluation, and career planning into a unified platform. The roadmap dynamically updates as users complete skills, ensuring continuous relevance and progress tracking.

VI. SYSTEM ARCHITECTURE

The system follows a client-server architecture with clearly defined frontend, backend, data processing, and analytics layers. The architecture ensures scalability, modularity, and ease of maintenance.



Frontend (Client)

- Built using Next.js with TypeScript for type safety and performance
- Styled using HTML and CSS for responsive, user-friendly interface
- Handles all user interactions including skill input, career selection, and roadmap display.

Backend (Server)

- Developed using Node.js with
- Express.js for RESTful API
- management
- Manages business logic, data
- processing pipelines, and API
- integrations
- Provides secure endpoints for user authentication and data retrieval

Database

- MongoDB (NoSQL) for flexible, scalable data storage
- Stores user profiles, job postings, skill mappings, and roadmap data

Data Processing & Analytics

- Pandas and NumPy for data manipulation and statistical analysis
- NLTK / spaCy for Natural Language Processing and skill extraction
- Matplotlib / Power BI for visualization of salary trends and demand charts

VII. MODULE DESCRIPTION

User Profile Module

The user profile module enables students and fresh graduates to register, create detailed profiles, and manage their information within the system.

Features include:

- Secure user registration and authentication
- Profile creationwith academic background and current skill inventory
- Target career role selection and preference management
- Progress tracking across the generated roadmap

Job Market Data Collection Module This module is responsible for gathering real-world job posting data from publicly available sources, ensuring the system operates on current and accurate market information. Features include:

- Automated data collection from public job portals and datasets
- Periodic refresh of job data to maintain currency

- Structured storage of job postings with metadata including role, skills, salary, and location

Skill Gap Analysis Module

The skill gap analysis module forms the analytical core of the system, comparing user-provided skills against market- required competencies for selected career roles. Features include:

- NLP-based extraction of required skills from job descriptions
- Comparison of user skill inventory against role-specific requirements
- Prioritized ranking of missing skills based on urgency and market demand
- Identification of foundational vs. advanced skill dependencies

Roadmap Generation Module

The roadmap generation module creates a structured, phased learning plan based on the identified skill gaps. Unlike static learning paths, the roadmap dynamically updates as users acquire new skills. Features include:

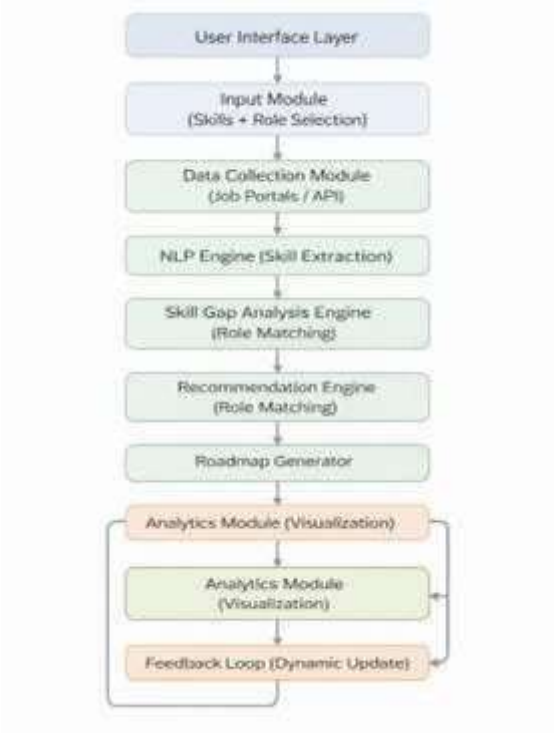
- Phase-wise organization of learning (foundational to advanced)
- Dynamic updates as skills are marked complete by the user
- Integration of recommended learning resources and estimated timelines
- Progress visualization with completion percentages

Visual Analytics Module

The analytics module provides interactive visual representations of job market data to help users understand industry expectations and trends.

Features include:

- Salary trend graphs by role, experience level, and location
- Job demand heatmaps across industries and geographies
- Skill frequency charts showing market demand for specific competencies
- Role stability index visualizing volatile vs. stable career paths



System Workflow Diagram

VIII. IMPLEMENTATION

Frontend Development

The frontend is developed using Next.js with TypeScript, providing a fast, responsive, and type-safe user interface. The component-based architecture enables modular development and easy maintenance. Key implementation aspects:

- Server-side rendering for improve performance and SEO
- Dynamic routing for seamless navigation between modules
- Responsive design supporting desktop and mobile devices
- RESTful API integration for real-time data display

Fig. 1. Screenshot of User Dashboard

Fig. 2. Screenshot of Admin Dashboard

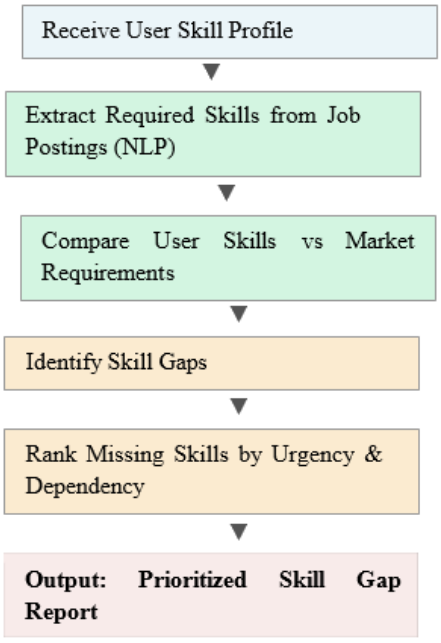
Backend Development

The backend is developed using Node.js with Express.js, providing a high-performance server capable of handling multiple concurrent API requests efficiently. Key implementation aspects:

- RESTful API endpoints for all system functionalities
- JWT-based authentication for secure session management
- Middleware for request validation and error handling
- Integration with NLP and data processing pipelines

Data Processing Implementation

The data processing pipeline leverages Python-based libraries for efficient handling of large volumes of job posting data.



- Pandas for data cleaning, transformation, and analysis
- NumPy for numerical computations and statistical operations
- NLTK / spaCy for tokenization, named entity recognition, and skill extraction
- Matplotlib for generating charts and visual representations

Fig. 3. Screenshot of Skill Gap Analysis Results

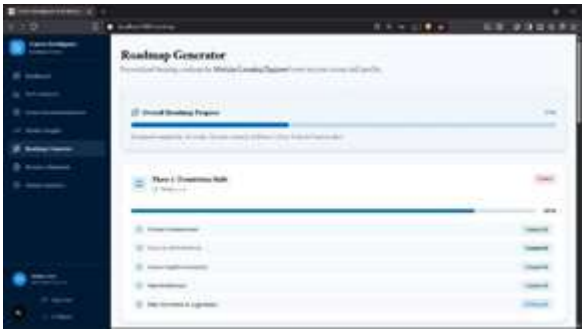


Fig. 4. Screenshot of Generated Career Roadmap

Database Design

The system uses MongoDB, a NoSQL document database, chosen for its flexibility in handling varied and evolving data schemas common in job market datasets. Primary collections include:

- Users: Profile information, skills, and progress data
- JobPostings: Collected job advertisements with metadata
- SkillMappings: Extracted skill-to-role mappings
- Roadmaps: Generated career roadmaps per user
- Analytics: Aggregated market data for visualization

IX. SYSTEM TESTING

System testing was a critical phase in validating the reliability, accuracy, and performance of the Career

Intelligence and Roadmap Recommendation System. Multiple testing methodologies were employed to ensure correctness across all modules.

Unit Testing

Unit testing was performed on individual modules to verify their isolated functionality. Each component — user authentication, job data collection, NLP processing, skill gap analysis, and roadmap generation — was tested independently.

- Authentication modules tested with valid and invalid credentials
- NLP skill extraction validated against labeled job description datasets
- Skillgap analysis verified with predefined user skill and job skill sets
- API endpoints tested using Postman for correct responses and error handling

Integration Testing

Integration testing verified the seamless interaction between all modules, ensuring smooth data flow from user input through NLP processing to roadmap generation.

- Frontend-to-backend communication validated for all API endpoints
- Database operations verified for correctness after each user action
- NLP pipeline outputs validated for accuracy in skill extraction

User Acceptance Testing (UAT) UAT was conducted with a group of students and fresh graduates who interacted with the system under real-world scenarios.

Feedback was collected and used to improve usability and output accuracy.

- Career roadmap relevance rated by users across different skill profiles
- Skill gap analysis accuracy validated against manually curated benchmarks
- Visual analytics readability and usefulness assessed by user groups

Performance Testing

Performance testing evaluated system response under varying load conditions.

- API response times measured under single and concurrent user loads
- Data processing pipeline benchmarked for job data ingestion speed
- NLP processing throughput validated for large job posting datasets

Security Testing

Security testing ensured data protection and unauthorized access prevention.

- JWT-based authentication tested for token validity and expiry handling
- Role-based access control verified for all restricted API endpoints
- Input validation and sanitization tested against common injection attacks

X. SECURITY MECHANISMS

The system implements multiple layers of security to protect user data and ensure safe system operation. JWT-based authentication is used to verify user identity and manage session control securely. All user passwords are hashed before storage using industry-standard algorithms, preventing unauthorized access even in the event of data breaches. Role-based access control restricts system functionalities based on user roles. All API endpoints are secured with authentication middleware, and data transmitted between the frontend and backend is protected via HTTPS protocols.

XI. SYSTEM FEATURES

The proposed system offers a comprehensive set of features designed to address the full spectrum of career guidance needs:

- Personalized career role recommendations based on individual skill profiles
- Real-time skill gap analysis with prioritized, urgency-ranked missing skills
- Dynamic, phase-wise career roadmap updated as skills are acquired
- Market-validated salary trend analysis by role, experience, and location
- Job demand visualization identifying high-growth and stable career paths

- Role volatility analysis to minimize career risk in selection
- Resume improvement mapping aligned to target career requirements
- User-friendly visual analytics dashboard for comprehensive market insights

Fig. 5. Screenshot of Visual Analytics Dashboard

XII. RESULTS AND DISCUSSION

The Career Intelligence and Roadmap Recommendation System was evaluated across multiple real-world test scenarios including user profile creation, skill gap analysis, roadmap generation, and visual analytics display. The results demonstrate that the system effectively addresses the core challenges of career guidance for students and fresh graduates.

The NLP-based skill extraction module demonstrated high accuracy in identifying relevant skills from job postings, enabling precise skill gap computation. The roadmap generation module produced structured, phased learning plans that users found actionable and achievable. The visual analytics dashboard provided clear insights into salary expectations and job market demand, helping users make informed career decisions.

User feedback collected during UAT indicated high satisfaction with the personalization quality and roadmap relevance. The system's ability to dynamically update roadmaps as users progressed through learning phases was highlighted as a particularly valuable feature distinguishing it from existing static platforms.

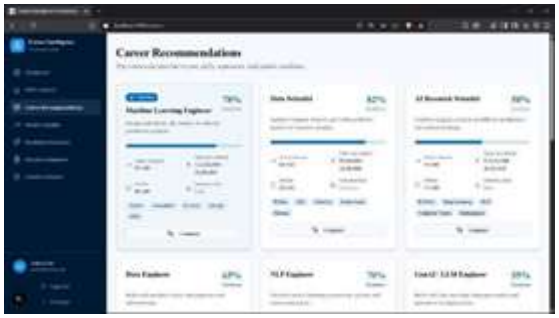


Fig. 6. Screenshot of Career Role Matching Results

Fig. 7. Screenshot of Roadmap Completion Progress

XIII. LITERATURE SURVEY

A comprehensive review of related work in career recommendation, skill extraction, and job market analysis was conducted to establish the research foundation of the proposed system.

XIV. FEATURE ENHANCEMENTS

While the current system provides a robust foundation for career guidance, several enhancements are planned to further improve its capabilities and reach:

- Integration of LinkedIn and GitHub profile analysis for automated skill assessment
- AI-powered mock interview simulation with personalized feedback
- Email and SMS notification system for roadmap reminders and market alerts
- Mobile application development for wider accessibility
- Advanced predictive analytics using machine learning for career demand forecasting
- Community features enabling peer learning and mentor connections

- Integration with online learning platforms (Coursera, Udemy) for direct skill acquisitions

XV. CONCLUSION

The proposed Career Intelligence and Roadmap Recommendation System presents an intelligent, data-driven solution to one of the most pressing challenges faced by students and fresh graduates — identifying and preparing for suitable career paths in a rapidly evolving job market. By combining real-time job market analysis, NLP-based skill extraction, personalized gap assessment, and dynamic roadmap generation, the system provides actionable and market-validated career guidance.

The system successfully integrates job market intelligence, skill evaluation, and career planning into a unified platform, addressing the limitations of existing generic career guidance tools. Its ability to dynamically update roadmaps, rank skills by urgency, analyze role stability, and map resume improvements makes it a comprehensive and practical solution for modern career preparation.

Experimental evaluation and user feedback confirm the system's effectiveness in improving career decision-making quality and reducing skill mismatches. Future enhancements will further extend the system's capabilities through AI-powered interview preparation, mobile accessibility, and deeper learning platform integrations.

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