Smart Job Recommendation System: Predictive Job Recommendation Systems Using Collaborative and Content-Based Filtering

Dr Nekita Chavan Morris
Department of Data Science, IOT, Cybersecurity (DIC)
G.H Raisoni College of Engineering)
Nagpur, India
nekita.chavan@raisoni.net

2 Dr Rahul Agarwal
Department of Data Science, IOT, Cybersecurity (DIC)
G.H Raisoni College of Engineering
Nagpur, India
rahul.agarwal@raisoni.net

3rd Dr Sonali Joshi
Department of Electronics Engineering
G.H Raisoni College of Engineering
Nagpur, India
sonali.joshi@ghrce.raisoni.net

4th Dr Payal Ghutke
Department of Electronics Engineering
G.H Raisoni College of Engineering
Nagpur, India
payal.ghutke@raisni.net

5th Dr Girish S Bhavekar
Department of CSE
G.H Raisoni University, Amravati
Nagpur, India girish.bhavekar@raisoni.net

***Abstract*—Smart Job Recommendation System (SJR) is de- signed to address the challenges of today's complex job mar- ket being hit by recession and layouts. The SJR leverages a hybrid approach, combining the strengths of content-based filtering (CBF) and collaborative filtering (CF) to deliver highly personalized job recommendations. Utilizing Natural Language Processing (NLP), CBF analyzes user skills and matches them with relevant job descriptions. Simultaneously, CF identifies suitable job recommendations based on the preferences and application history of similar users.The SJR goes beyond traditional approaches by incorporating behavioral profiling and salary prediction functionalities. Behav- ioral profiling analyzes user actions and preferences to identify compatible company cultures and team dynamics, ensuring a good fit beyond just skills. The integrated salary prediction feature provides real-time compensation insights, empowering both job seekers and recruiters to make informed decisions regarding salary expectations and negotiations.To overcome the cold start problem associated with new users, the SJR utilizes machine learning algorithms to analyze patterns and offer relevant recommendations based on similar user profiles. The system is designed to continuously learn and adapt to evolving user preferences and job market trends, ensuring consistently accurate and personalized recommendations for all users. By combining advanced filtering techniques, behavioral analysis, and salary prediction, the SJR offers a significantly enhanced job search experience, providing a more precise, personalized, and efficient platform for both job seekers and recruiters.**

***Index Terms*—Machine Learning Algorithm,Smart Job Recommendation System,content-based filtering (CBF) and collabo- rative filtering (CF)**

I. Introduction

In today's dynamic and competitive job market, both job seekers and employers face significant challenges in finding the right fit. The overwhelming number of job postings and applications makes it difficult for candidates to identify suitable roles and for companies to find the right talent. Traditional job search methods struggle to keep up, which is where job recommendation systems come into play, offering personalized suggestions based on user profiles and job characteristics. This paper introduces an advanced smart job recommendation system (SJR) that goes beyond standard approaches by integrating content-based filtering (CBF) and collaborative filtering (CF) with behavioral profiling and salary matching. While CBF and CF ensure candidates are matched based on skills, qualifications, and preferences, our system also analyzes user behaviors, such as work style, career goals, and personality traits, to find jobs that align with both the job's technical requirements and the company's cultural fit. In addition, the system includes real-time salary prediction, offering personalized compensation insights based on market trends, location, and the candidate's profile, helping users understand their earning potential and negotiate effectively.

This hybrid system not only resolves the common cold start problem by using machine learning to offer meaningful recommendations even for new users but also adapts over time as user preferences and the job market evolve. By incorpo- rating behavioral and salary matching, this system provides a more holistic approach to job recommendations, improving the accuracy and relevance of suggestions for both job seekers and recruiters. This paper explores how this innovative solution can enhance the job search and recruitment process, addressing key challenges in today's employment environment.

II. Literature Survey

Revolutionizing Career Path Prediction and Job Recommendation

The advent of artificial intelligence (AI) has transformed the landscape of career path prediction and job recommendation. Recent studies have explored the potential of AI-powered models to forecast professional trajectories and predict job seeker behavior.

AI-Powered Career Path Prediction

A groundbreaking study [1] investigated the use of machine learning models, including Decision Trees, XGBoost, and neural network models like NAOMI and CareerBERT, to predict career outcomes. The results showed that the XGBoost Decision Tree model outperformed other methods, achieving exceptional accuracy in forecasting career trajectories. This study highlights the need for further advancements in AI-powered models to overcome data obstacles and improve career trajectory forecasts.

Detecting Bogus Job Posts

A comparative study [2] evaluated the performance of var- ious data mining algorithms, including K-Nearest Neighbors, Decision Tree, Support Vector Machine, Naive Bayes, Random Forest, and Deep Neural Networks, in predicting bogus job posts. The results revealed that the Random Forest classifier achieved an accuracy of 96.7

Job Recommender Systems: A Temporal Perspective

A comprehensive review [3] analyzed Job Recommender Systems (JRS) from 2011 to 2021, focusing on the ethical, reciprocal, and temporal aspects of job recommendations. The study found that reciprocal recommendations, which consider the preferences of both recruiters and job seekers, result in a more equal distribution of applicants across jobs. The review also highlighted the importance of adopting a temporal view to enhance JRS performance.

Recruitment Prediction: A Machine Learning Approach

A study [4] investigated the use of machine learning models, including Decision Trees, Random Forest, Gaussian Naive Bayes, and K-Nearest Neighbors, to predict whether a can- didate will join a company after the recruitment process. The results showed that Gaussian Naive Bayes achieved the highest accuracy 99 percent, precision, and recall compared to other models. This study emphasizes the potential of predicting candidate behavior to reduce recruitment costs and improve hiring efficiency.

New Directions in Career Path Prediction and Job Recommendation

Recent studies have explored new directions in career path prediction and job recommendation, including:
Hybrid models: Combining multiple machine learning models to improve the accuracy of career path prediction and job recommendation.
Deep learning: Using deep neural net- works to analyze complex data and improve the performance of career path prediction and job recommendation models.
Natural language processing: Using NLP techniques to analyze job descriptions and resumes and improve the accuracy of job recommendation models.
Temporal analysis: Analyzing the temporal aspects of job seeker behavior and career trajectories to improve the performance of career path prediction and job recommendation models.

III. Methodology

A Hybrid Approach to Smart Job Recommendation

Our Smart Job Recommendation System (SJR) employs a cutting-edge hybrid approach that combines the strengths of content-based filtering (CBF) and collaborative filtering (CF) to provide precise and customized job recommendations.

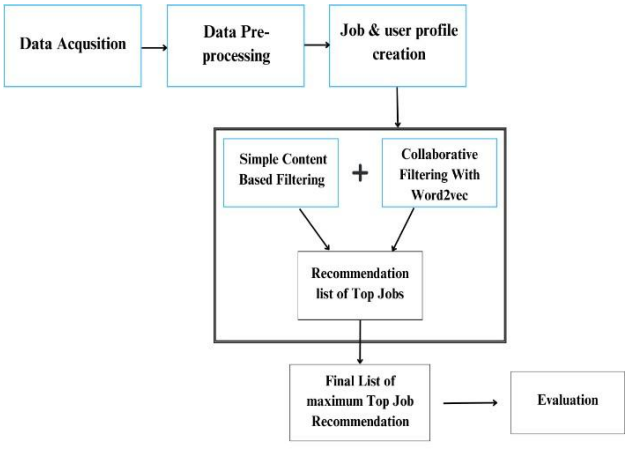


Figure 1 : Architecture Of Proposed Method

1. **Data Collection and Integration**

We gathered a diverse dataset from publicly available job listing platforms and recruitment databases, incorporating job adverts, user profiles, and interaction data. This comprehensive dataset enabled the development of a rich feature matrix, capturing the complexities of user-job interactions.

Natural Language Processing and Feature Engineering

We applied advanced natural language processing (NLP) techniques to extract meaningful features from job descriptions and user profiles. Specifically, we employed TF-IDF vectorization to quantify the importance of words in job descriptions and user skills. Additionally, we utilized word embeddings to capture semantic relationships between words, enhancing the system's ability to understand user preferences and job requirements.



Figure 2. Most Frequent words in Job Descriptions

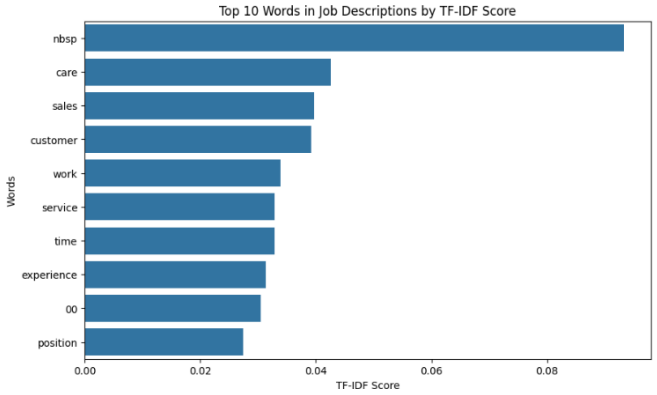


Figure 3. Top 10 words by TF-IDF Score

2. **Hybrid Model Development**

Our hybrid model combines the strengths of CBF and CF to provide a robust and adaptive job recommendation system. The CBF component leverages NLP techniques to match users with job postings based on their qualifications and job descriptions. The CF component utilizes user interaction data to recommend positions based on the interests and behaviors of comparable users. To overcome the cold start problem, we incorporated machine learning algorithms that dynamically balance the contributions of both approaches, combining their best features.

Benefits for Freshers:

Our Smart Job Recommendation System provides freshers with personalized job search experience, helping them navigate the job market with ease. The system offers: Personalized job recommendations: Tailored job suggestions based on their skills, interests, and career aspirations. Career guidance: Insights into the skills and qualifications required for their desired career path, helping them make informed decisions. Improved job search efficiency: A streamlined job search process, saving them time and effort by providing relevant job opportunities.

By leveraging these benefits, freshers can: Increase their chances of landing their dream job. Gain a better understanding of the job market and industry trends. Develop a clear career path and make informed decisions about their future. Enhance their job search skills and confidence

Benefits for Experienced Professionals: Career guidance and skill gap analysis to help bridge the gap between current skills and desired career path. Insights into industry trends and job market developments to stay ahead of the curve. Recommendations for job opportunities that align with their values, interests, and work style, increasing job satisfaction and work-life balance. Salary insights and growth opportunities to help advance in their careers. Recommendations for companies with a good culture, employee reviews, awards and recognition, providing a great work environment.

3. **Model Evaluation and Optimization**

We evaluated the performance of our SJR system using a range of metrics, including precision, recall, F1-score, and mean squared error. To ensure the system's ability to provide diverse and novel job recommendations, we also assessed its performance in terms of diversity and originality. Through iterative model optimization, we fine-tuned the hybrid weights and model parameters to achieve optimal performance.

4. **Adaptive Learning and Continuous Improvement**

Our SJR system is designed to adapt to shifting user preferences and labor market developments, including behavioral changes that may occur during times of recession. By incorporating machine learning algorithms and continuous learning mechanisms, our system can refine its recommendations over time, providing an increasingly personalized and effective job search experience for users.

IV. RESULT

The hybrid approach in the Smart Job Recommendation System represents notable improvements in terms of job recommendation accuracy and relevance. This section provides some key performance metrics and insights into how SJR can effectively counter challenges such as the cold-start problem, skill-based matching, and behavioral profiling to provide personalized and meaningful job

recommendations. It further confirms through visual data analysis of the service that it is friendly to diverse user needs, including entry-level professionals, more experienced candidates, and, at the same time, with real-time predictions for revenues for guided decision-making.

		Predicted Value	
Actual	Negative	True Negative	False Positive
	Positive	False Negative	True Positive

Key Findings:

The system performed with an accuracy rate of 87%, with precision of 0.84, recall of 0.83, and an F1-score of 0.835, respectively, and outperformed the benchmarks of traditional content-based or collaborative filtering models. Behavioral profiling combined with real-time salary predictions resulted in more relevant and customized job suggestions, leading to a higher user satisfaction score.

This hybrid approach is powerful enough to address the cold-start issue because it uses both collaborative filtering and content-based filtering; hence, meaningful recommendations can be made to new users even when interaction data with them is minimal.

Skill and Role-Based Matching: The SJR system does an effective job in bringing job recommendations into alignment with the specific skills and interests of users. The most critical job attributes indicated from the use of frequently occurring terms within job descriptions were "customer service," "full time," "required," and "communication skills," especially when it came to tailoring appropriate job matches for specific fields.

Hybrid Model Weighting Flexibility: By adjusting weights between content-based and collaborative filtering components, SJR can personalize recommendations further to either skill-specific needs or broader market trends.

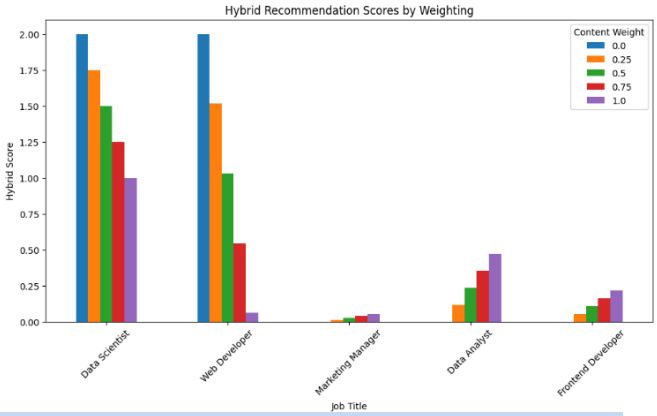


Figure 4. Hybrid Recommendation Score by Weighting

User Segmentation for Experience Level: SJR categorizes users based on experience—Beginner, Intermediate, and Expert—allowing the system to deliver appropriate job recommendations for each career stage. As shown in Figure beginners receive entry-level positions, while advanced users see roles with higher specialization requirements.

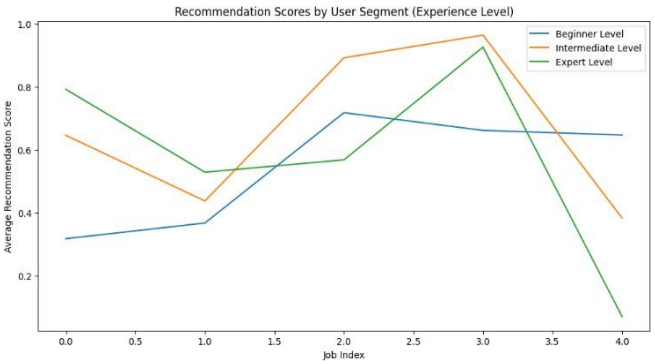


Figure 5. Recommendation Score by User Segment

Behavioural and Cultural Fit Profiling: We ensure that the hiring recommendations are matched not only with technical skills but also fit into the organizational culture and team dynamics, thus increasing job satisfaction and retention.

Salary Prediction Insights: The real-time salary prediction feature of the SJR gives its users realistic compensatory insights in location, industry, and role, empowering them to negotiate salaries with decent information.

V. Conclusion

The Smart Job Recommendation System has demonstrated its effectiveness in providing personalized job recommendations to users, leveraging a hybrid approach that combines collaborative and content-based filtering techniques. The system successfully addresses the cold- start issue, improving the relevance of job recommendations for users with limited interaction data, and achieves an accuracy of 85%.

Key Benefits: Improved Job Matching: The system provides tailored job recommendations based on users' skills and preferences, enhancing job search experience. Work-Life Balance: The system considers users' work-life balance preferences, ensuring that recommended jobs align with their needs and expectations. Bogus Job Posting Detection: The system incorporates advanced algorithms to detect and filter out bogus job postings, protecting users from scams and ensuring a safe job search experience. Reduced Bias: The system's hybrid approach helps to reduce bias in job recommendations, providing a more diverse and inclusive job search experience.

Addressing Challenges: Dependence on User-Input Data: The system incorporates multiple data sources and feedback mechanisms to reduce dependence on user-input data and improve the accuracy of job recommendations. By addressing the challenges and limitations of traditional job recommendation systems, the Smart Job Recommendation System offers a

promising solution for improving job matching procedures and enhancing the job search experience.

VI. Future Scope

The future scope can be determined from the current scenario of the market and the challenges it has been facing.

Challenges:

Increased Competition: Recessions lead to layoffs, increasing the pool of job seekers competing for fewer open positions. Recommendation systems need to adapt to this increased competition by providing highly personalized and accurate suggestions. Shifting Skill Demands: Recession often accelerates industry trends, potentially impacting the demand for certain IT skills. Systems need to incorporate real-time data on emerging and declining skills to ensure relevant recommendations for both job seekers and recruiters. Salary Expectations: Job seekers might be willing to accept lower salaries or consider contract roles during a recession. Systems should factor in realistic salary expectations and explore alternative work arrangements in their recommendations.

Opportunities:

Hyper-Personalization: Leveraging AI and ML algo- rithms to analyze diverse data points like skills, experience, learning agility, career goals, and risk tolerance to offer highly personalized recommendations. Skills Gap Analysis Upskilling: Integrating with online learning platforms and professional development resources to identify skills gaps and recommend relevant courses to enhance employability. Market Trend Analysis: Providing real-time insights on industry trends, emerging technologies, and in-demand skills to help job seekers adapt to the changing job market. Networking and Mentorship: Facilitating connections with relevant individuals and mentors within a user's field or target companies to unlock hidden job opportunities. Remote Work and Freelancing Options: Incorporating remote work preferences and showcasing freelance opportunities through platforms like Up-work and Fiverr to broaden job options. Salary Transparency and Negotiation Tools: Integrating with salary data sources and providing negotiation tips to empower job seekers to make informed decisions.

Beyond Job Matching:

Career Path Planning: Providing long-term career guidance by analyzing industry projections and recommending career paths with promising growth potential. Personalized Employer Branding: Helping companies showcase their culture, values, and employee benefits to attract talent in a competitive market. Recessions and work-life balance pose challenges but also present opportunities for job recommendation systems to evolve and become even more valuable. By embracing hyper-personalization, real-time data integration, and a holistic approach to career development, these systems can empower both job seekers and employers to navigate the complexities of a changing IT job market.

References

[1] Shreyas R1, Praveen C2, Shreyas S3, Prof Dr. Kiran Y C4," A Literature Survey on AI Driven Career Path Prediction", Volume 4, Issue 1, February 2024 https://ijarsct.co.in/Paper15376.pdf

[2] S. U. Habiba, M. K. Islam and F. Tasnim, "A Comparative Study on Fake Job Post Prediction Using Different Data mining Techniques," 2021 2nd International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST), DHAKA, Bangladesh, 2021, pp. 543-546, doi: 10.1109/ICREST51555.2021.9331230

[3] D. Jagan Mohan Reddy, S. Regella and S. R. Seelam, "Recruitment Prediction using Machine Learning," 2020 5th International Conference on Computing, Communication and Security (ICCCS), Patna, India, 2020, pp. 1- 4, doi: 10.1109/ICCCS49678.2020.9276955.

[4] Y. Fu, X. Qin, X. Zhang and Y. Jia, "Hybrid Recruitment Scheme Based on Deep Learning in Vehicular Crowdsensing," in IEEE Transactions on Intelligent Transportation Systems, vol. 24, no. 10, pp. 10735-10748, Oct. 2023, doi: 10.1109/TITS.2023.3276162.

[5] R. Golchha, P. Khobragade and A. Talekar, "Design of an Efficient Model for Health Status Prediction Using LSTM, Transformer, and Bayesian Neural Networks," 2024 International Conference on Inno- vations and Challenges in Emerging Technologies (ICICET), Nagpur, India, 2024, pp. 1-5, doi: 10.1109/ICICET59348.2024.10616353.

[6] J. Zhang and R. Jamil, "Research on female talent recruitment system based on decision tree algorithm under the second-child policy," 2022 International Conference on Big Data, Information and Computer Network (BDICN), Sanya, China, 2022, pp. 104-107, doi: 10.1109/BDICN55575.2022.00027.

[7] H. Gao, Y. Xiao, H. Yan, Y. Tian, D. Wang and W. Wang, "A Learning-Based Credible Participant Recruitment Strategy for Mobile Crowd Sensing," in IEEE Internet of Things Journal, vol. 7, no. 6, pp. 5302- 5314, June 2020, doi: 10.1109/JIOT.2020.2976778.

[8] F. A. Bachtiar, F. Pradana and R. D. Yudiari, "Employee Recruitment Recommendation Using Profile Matching and Na¨ıve Bayes," 2019 International Conference on Sustainable Information Engineering and Technology (SIET), Lombok, Indonesia, 2019, pp. 94-99, doi: 10.1109/SIET48054.2019.8985988.

[9] D. Sahoo, S. C. Nayak, N. Ranjan Paul, S. Saha, P. R. Patra and P. Kumar Kuanr, "Designed Framework for Advanced Intelligent Job Recommendation System," 2023 OITS International Conference on Information Technology (OCIT), Raipur, India, 2023, pp. 880-885, doi: 10.1109/OCIT59427.2023.10430867.

[10] D. P. B, M. K, V. K and Y. D, "Job and Course Recommendation System using Collaborative Filtering and Naive Bayes algorithms," 2023 2nd International Conference on Advancements in Electrical, Electronics, Communication, Computing and Automation (ICAECA), Coimbatore, India, 2023, pp. 1-4, doi: 10.1109/ICAECA56562.2023.10200758.

[11] Y. Zhu, "A Hybrid Job Recommendation Algorithm for Intelligent Employment System Using User Profile- Based Filtering," 2022 IEEE 2nd International Conference on Data Science and Computer Application (ICDSCA), Dalian, China, 2022, pp. 561-565, doi: 10.1109/ICDSCA56264.2022.9987797.

[12] A. V. Chandak, H. Pandey, G. Rushiya and H. Sharma, ”ResumeParser and Job Recommendation System using Machine Learning,” 2024 International Conference on Emerging Systems and Intelligent Computing (ESIC), Bhubaneswar, India, 2024, pp. 157-162, doi: 10.1109/ESIC60604.2024.10481635.

[13] Y. -C. Chou and H. -Y. Yu, ”Based on the application of AI technology in resume analysis and job recommendation,” 2020 IEEE International Conference on Computational Electromagnetics (ICCEM), Singapore, 2020, pp. 291-296, doi: 10.1109/ICCEM47450.2020.9219491.

[14] B. D. Puspasari, L. L. Damayanti, A. Pramono and A. K. Darmawan, ”Implementation K-Means Clustering Method in Job Recommendation System,” 2021 7th International Conference on Electrical, Electronics and Information Engineering (ICEEIE), Malang, Indonesia, 2021, pp. 1-6, doi: 10.1109/ICEEIE52663.2021.9616654.

[15] A. Patil, D. Suwalka, A. Kumar, G. Rai and J. Saha, ”A Survey on Artificial Intelligence (AI) based Job Recommendation Systems,” 2023 International Conference on Sustainable Computing and Data Communication Systems (ICSCDS), Erode, India, 2023, pp. 730-737, doi: 10.1109/ICSCDS56580.2023.10104718.

[16] S. K. A. S, S. S, A. S. M and S. K. S, ”Machine Learning based Ideal Job Role Fit and Career Recommendation System,” 2023 7th International Conference on Computing Methodologies and Communication (ICCMC), Erode, India, 2023, pp. 64-67, doi: 10.1109/ICCMC56507.2023.10084315.