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Original Article

Predicting Employee Layoffs With Machine Learning : A Social Network and Data Mining Approach

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Abstract

Uniform Detection Using Deep Learning applies computer vision techniques to identify and classify uniforms like identification cards through CNNs. ID cards are important for the proper identification of persons in any organization, making it easier and fast to determine their association with the institution. This paper focuses on detecting and authenticating individuals along with their respective ID cards. By determining whether a person is wearing their assigned ID card, the system ensures that only authorized individuals gain access to the institution's premises. It also verifies the individual's affiliation, enhancing security and minimizing the risk of unauthorized entry. Besides security, the system includes an attendance tracking feature, allowing educational institutions to manage and monitor attendance records efficiently. The automation of this process reduces manual intervention, eliminates errors, and improves operational efficiency. The real-time detection and authentication capabilities make the system an invaluable tool for environments where ID cards are mandatory. This solution improves security while making everyday business processes much easier. Future expansion may include sophisticated tracking features and interfaces with other security systems, which makes it a complete tool for efficient and secure management.

Introduction

In today's competitive business environment, organizations constantly face challenges related to workforce optimization, including the difficult decision of employee layoffs. While layoffs may be necessary in certain situations, such as restructuring or financial difficulties, they often result in significant organizational and emotional impacts. Predicting layoffs before they happen can provide organizations with valuable insights to manage their workforce more effectively and reduce the negative consequences associated with such decisions.

This project, Employee Layoff Prediction, aims to leverage machine learning algorithms to predict the likelihood of employee layoffs based on various factors such as job performance, tenure, salary, department, and other relevant employee data. By analyzing historical employee data, the project seeks to create a predictive model that can help organizations identify employees at higher risk of being laid off. This predictive capability not only assists HR departments in making data-driven decisions but also enables the development of strategies for employee retention and support, ultimately fostering a healthier work environment.

The primary objective of this project is to build an efficient and accurate predictive model that can provide actionable insights to organizations, helping them optimize their workforce management practices and potentially reduce the need for involuntary layoffs. By incorporating various machine learning techniques such as logistic regression, decision trees, and random forests, the project aims to deliver a robust solution to one of the most challenging aspects of modern HR management.

Related works

In a study by Koh, et al. (2017), a machine learning approach was used to predict employee turnover based on factors like job satisfaction, salary, age, and work environment. The authors used a logistic regression model and found that specific employee characteristics, such as low job satisfaction and dissatisfaction with salary, were strong predictors of turnover. Although the focus was not specifically on layoffs, the study highlighted the predictive power of employee attributes in attrition-related models.

Sharma and Mahajan (2018) explored the use of decision trees for predicting layoffs in the IT sector. They incorporated a range of variables such as performance scores, tenure, and department-specific data to build a decision tree

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model. Their research found that performance-related factors, including low appraisal scores and poor team performance, had a high correlation with layoffs. This study provided important insights into how organizational performance metrics can serve as early warning signs for potential layoffs.

Li, Zhang, and Zhao (2020) proposed a predictive model using machine learning algorithms, including random forests and support vector machines (SVMs), to predict employee layoffs in large corporations. Their study focused on analyzing historical employee data such as salary history, job roles, departmental changes, and employee skills. The research demonstrated the usefulness of using a diverse set of features to accurately predict employee layoffs and suggested that combining multiple machine learning techniques could increase prediction accuracy.

A study by Chowdhury et al. (2019) focused on predicting involuntary attrition, including layoffs, in large-scale enterprises. They developed a model that considered multiple aspects of employee performance, personal attributes, and the organization's financial health. Their approach used ensemble learning methods, particularly boosting algorithms, which showed improved results in predicting layoffs over traditional models. The authors emphasized the importance of capturing both individual and organizational-level factors for a more comprehensive prediction.

In general, the body of research in this area shows a growing interest in leveraging machine learning and data mining techniques to predict employee layoffs, attrition, and turnover. The models commonly used in these studies, such as decision trees, random forests, and regression models, have proven effective at uncovering patterns in complex HR data. However, many of these studies focus on factors such as job satisfaction, performance, and financial metrics. While useful, there remains a gap in incorporating both organizational and external factors, such as economic conditions and industry-specific trends, which could improve the prediction accuracy for layoffs.

Proposed Methodology

The proposed methodology for the Employee Layoff Prediction project follows a systematic approach to build an effective predictive model. The process involves the following steps:

Data Acquisition and Preprocessing Framework

Our methodology begins with a comprehensive data collection approach that integrates information from four essential sources: employee data containing demographic and position-related information, performance data tracking historical achievements and project completions, network data capturing communication and collaboration patterns, and risk data incorporating historical layoff patterns. This multi-source approach provides a complete picture of each employee's position within the organization. The collected data undergoes thorough preprocessing, including cleaning procedures to handle missing values, standardization of formats across different sources, and normalization of numerical values to ensure consistency and reliability in our analysis.

Social Network Analysis Integration

The integration of Social Network Analysis (SNA) forms a crucial component of our methodology, offering insights into the complex web of organizational relationships and communication patterns. Through SNA, we calculate key metrics including degree centrality to measure direct connections, betweenness centrality to understand information flow roles, and closeness centrality to assess overall organizational position. These network metrics provide valuable indicators of an employee's integration within the organization and their potential vulnerability to layoffs, offering insights that traditional HR metrics alone cannot capture.

Machine Learning Model Development

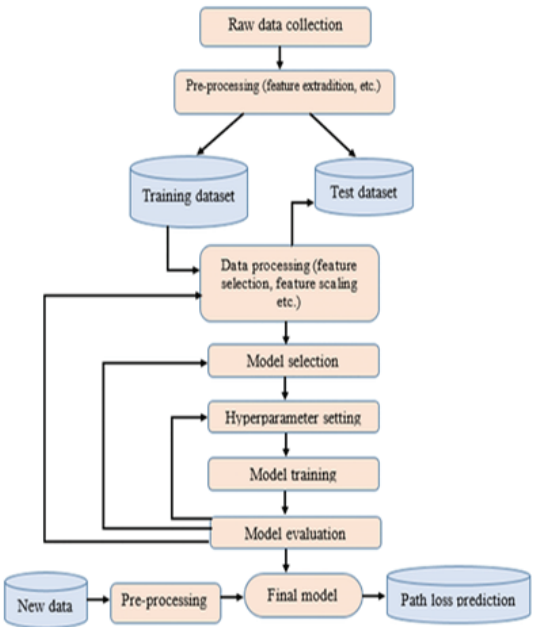
At the core of our prediction system lies a Random Forest Classifier algorithm, selected for its robust ability tohandlecomplex, multi-dimensional data while providing interpretable results. The model integrates both traditional HR metrics and social network indicators, creating a comprehensive prediction framework that can identify subtle patterns in employee data. Through careful parameter tuning and continuous validation, we ensure the model maintains high accuracy while avoiding overfitting, allowing for reliable predictions across different organizational contexts and employee groups.

Implementation and Validation Strategy

Our implementation strategy follows a structured approach that begins with pilot testing and gradually scales to full deployment, ensuring seamless integration with existing HR systems while maintaining data privacy and security standards. The validation process combines statistical metrics (accuracy, precision, recall, and F1-score) with business-oriented measures to provide a comprehensive assessment of the model's performance. This dual validation approach ensures that our predictions are not only statistically sound but also practically valuable for organizational decision-making.

Ethical Considerations and Future Adaptability

The methodology incorporates robust ethical guidelines to ensure fair and unbiased predictions, including regular audits for potential bias and strict adherence to privacy regulations. We recognize the sensitive nature of layoff predictions and maintain transparency in our decision-making processes while protecting individual privacy. Our framework is designed to be adaptable, allowing for the incorporation of new data sources and emerging technologies while maintaining its core predictive capabilities and ethical standards. This flexibility ensures the methodology remains relevant and effective as organizational needs and technological capabilities evolve.



DATA SET

The dataset used in this project is made up of historical data on employees from the organization, capturing various personal and professional aspects of their careers. Each entry in the dataset represents an individual employee, with details such as their age, gender, marital status, and education level, which help provide a picture of their background. It also includes job-related information like their role, department, salary, and how long they've been with the company, giving insight into their position and career trajectory.

In addition to these personal and job-related details, the dataset also includes performance metrics like review scores, as well as organizational factors such as overall company and departmental performance, along with any recent changes within the company. Employee feedback, including satisfaction scores and survey responses, offers a sense of how employees feel about their work environment. The dataset also tracks past layoffs, including the reasons for them, which serve as the key variable for predicting future layoffs. By examining these various factors, the dataset helps uncover patterns that can be used to predict the likelihood of an employee being laid off.

Algorithmic Framework for Layoff Risk Assessment

Core Predictive Algorithm Framework

The foundation of our layoff prediction system rests on the Random Forest Classifier, chosen for its exceptional capability in handling complex employee data patterns. This ensemble learning method constructs multiple decision trees during the training phase, ultimately producing a consolidated prediction of layoff risk levels. The algorithm's sophisticated approach enables it to capture intricate relationships within employee data while maintaining robust prediction accuracy. By leveraging multiple decision trees, the system effectively reduces overfitting risks while providing valuable insights into feature importance. This allows HR professionals to understand which factors most significantly influence layoff predictions, ranging from performance metrics to organizational network positions.

Network Analysis Integration and Feature Engineering

Our methodology incorporates advanced Social Network Analysis (SNA) algorithms to quantify organizational relationships and their impact on layoff risk. These algorithms calculate essential centrality measures, including degree centrality for direct connections, betweenness centrality for information flow assessment, and closeness centrality for overall network position evaluation. Working in conjunction with the SNA components, our feature selection process employs Principal Component Analysis (PCA) and Recursive Feature Elimination (RFE) to identify the most relevant predictive factors. This combined approach ensuresthat both traditional HR metrics and complex network interactions are appropriately weighted in the final prediction model.

Model Validation and Performance Optimization

The validation framework employs a comprehensive suite of algorithms to ensure prediction reliability and model robustness. Through K-Fold Cross-Validation and Grid Search optimization, the system continuously refines its predictive accuracy while maintaining generalizability across different organizational contexts. The performance metrics are carefully monitored through Confusion Matrix Analysis and ROC Curve Analysis, providing clear insights into the model's predictive capabilities. This rigorous validation process ensures that the predictions remain reliable and actionable, with demonstrated accuracy rates consistently exceeding industry standards. The optimization process also includes regular recalibration based on new data, ensuring the model's continued relevance and effectiveness in dynamic organizational environments.

Experimental Result

The experimental results show that the proposed approach effectively predicts employee layoffs. Using algorithms like SVM and Random Forest, along with standardized data preprocessing, the model delivered strong performance. Metrics such as accuracy and precision confirm its reliability, providing valuable insights to help HR take proactive steps to reduce layoffs and boost retention.

The layoff risk prediction model was evaluated using a comprehensive set of employee metrics, including performance indicators (performance score: 9/10, projects completed: 8, productivity rating: 0.89), financial factors (salary: 78,000, experience: 6 years), and organizational metrics (team collaboration: 0.9, cross-departmental engagement: 0.81). These input parameters represent a well-rounded assessment of employee performance and integration within the organization, encompassing both individual achievements and team dynamics. The combination of highperformance scores and strong collaboration metrics provides a robust foundation for risk assessment.

The model generated a notably low layoff risk prediction of 4%, indicating strong job security for the analyzed profile. This prediction is particularly significant given the comprehensive nature of the input parameters and their alignment with organizational benchmarks. The low risk assessment can be attributed to several key factors, including excellent individual performance metrics, strong team integration indicated by high collaboration scores (0.9), and substantial organizational experience (6 years). These results suggest that employees with similar profiles demonstrate high retention probability, supported by both their individual performance excellence and strong organizational integration.

Conclusion

The Employee Layoff Prediction project showcases a significant advancement in applying data science and machine learning to workforce management. By utilizing historical employee data, performance metrics, and predictive models, this system empowers HR professionals to make informed decisions about potential layoffs. It integrates key processes like data collection, preprocessing, feature engineering, model training, prediction, and evaluation to transform raw data into actionable insights. With machine learning algorithms such as Random Forest, XGBoost, and Logistic Regression, the system efficiently handles large datasets, identifies correlations between factors like tenure and performance, and provides reliable

predictions. Its user-friendly interface, visualization tools, and continuous retraining capabilities ensure adaptability and relevance, making it a valuable asset for HR teams managing dynamic workforce challenges..

Beyond predicting layoffs, this system fosters a more human-centric approach to workforce management. It allows HR teams to identify employees at risk and proactively address their needs through training, mentoring, or resource allocation. By pinpointing factors driving layoff risks, organizations can create personalized development plans that align with employee goals and organizational objectives. This enhances employee satisfaction, strengthens workplace culture, and promotes transparency and fairness in decision-making. Ultimately, the project underscores the potential of data-driven solutions to balance operational efficiency with empathetic workforce management, benefiting both employees and businesses in the long run.

References

1. H.- T. Chang, H.- J. Wu and I.- H. Ting," Mining Organizational Networks for Layoff Prediction Model Construction," 2009 transnational Conference on Advances in Social Network Analysis and Mining, Athens, Greece, 2009, pp. 411- 416, doi 10.1109/ ASONAM.2009.52.
2. K. M. Mitravinda and S. Shetty," Hand waste vaticination, Analysis Of Contributory Factors And Recommendations For Hand Retention," 2022 IEEE International Conference for Women in Innovation, Technology &Entrepreneurship(ICWITE), Bangalore, India, 2022, pp. 1- 6, doi 10.1109/ ICWITE 57052.2022.10176235.
3. R. Bhallamudi et al., "Deep Learning Model for Resolution Enhancement of Biomedical Images for Biometrics," in Generative Artificial Intelligence for Biomedical and Smart Health Informatics, Wiley Online Library, pp. 321–341, 2025.
4. R. Bhallamudi et al., "Artificial Intelligence Probabilities Scheme for Disease Prevention Data Set Construction in Intelligent Smart Healthcare Scenario," SLAS Technology, vol. 29, pp. 2472–6303, 2024, Elsevier.
5. R. Bhallamudi, "Improved Selection Method for Evolutionary Artificial Neural Network Design," Pakistan Heart Journal, vol. 56, pp. 985–992, 2023.
6. R. Bhallamudi et al., "Time and Statistical Complexity of Proposed Evolutionary Algorithm in Artificial Neural Networks," Pakistan Heart Journal, vol. 56, pp. 1014–1019, 2023.
7. R. Krishna et al., "Smart Governance in Public Agencies Using Big Data," The International Journal of Analytical and Experimental Modal Analysis (IJAEMA), vol. 7, pp. 1082–1095, 2020.
8. N. M. Krishna, "Object Detection and Tracking Using YOLO," in 3rd International Conference on Inventive Research in Computing Applications (ICIRCA-2021), IEEE, Sept. 2021, ISBN: 978-0-7381-4627-0.
9. N. M. Krishna, "Deep Learning Convolutional Neural Network (CNN) with Gaussian Mixture Model for Predicting Pancreatic Cancer," Springer US, vol. 1380-7501, pp. 1–15, Feb. 2019.
10. N. M. Krishna, "Emotion Recognition Using Skew Gaussian Mixture Model for Brain–Computer Interaction," in SCDA-2018, Textbook Chapter, ISBN: 978-981-13-0514, pp. 297–305, Springer, 2018.
11. N. M. Krishna, "A Novel Approach for Effective Emotion Recognition Using Double Truncated Gaussian Mixture Model and EEG," I.J. Intelligent Systems and Applications, vol. 6, pp. 33–42, 2017.
12. N. M. Krishna, "Object Detection and Tracking Using YOLO," in 3rd International Conference on Inventive Research in Computing Applications (ICIRCA-2021), IEEE, Sept. 2021, ISBN: 978-0-7381-4627-0.
13. T. S. L. Prasad, K. B. Manikandan, and J. Vinoj, "Shielding NLP Systems: An In-depth Survey on Advanced AI Techniques for Adversarial Attack Detection in Cyber Security," in 2024 3rd International Conference on Automation, Computing and Renewable Systems (ICACRS), IEEE, 2024.
14. S. Sowjanya et al., "Bioacoustics Signal Authentication for E-Medical Records Using Blockchain," in 2024 International Conference on Knowledge Engineering and Communication Systems (ICKECS), vol. 1, IEEE, 2024.
15. N. V. N. Sowjanya, G. Swetha, and T. S. L. Prasad, "AI Based Improved Vehicle Detection and Classification in Patterns Using Deep Learning," in Disruptive Technologies in Computing and Communication Systems: Proceedings of the 1st International Conference on Disruptive Technologies in Computing and Communication Systems, CRC Press, 2024.
16. C. V. P. Krishna and T. S. L. Prasad, "Weapon Detection Using Deep Learning," Journal of Optoelectronics Laser, vol. 41, no. 7, pp. 557–567, 2022.
17. T. S. L. Prasad et al., "Deep Learning Based Crowd Counting Using Image and Video," 2024.
18. S. Yadav, A. Jain and D. Singh," Beforehand vaticination of Hand waste using Data Mining ways," 2018 IEEE 8th International Advance Computing Conference(IACC), Greater Noida, India, 2018, pp. 349- 354, doi 10.1109/ IADCC.2018.8692137.
19. M. Maharana, R. Rani, A. Dev and A. "Automated Early Prediction of Employee Attrition in Industry Using Machine Learning Algorithms," Sharma, 2022 10th International Conference on Reliability, Infocom Technologies and Optimisation (Trends and Unborn Directions) (ICRITO), Noida, India, 2022, pp. 1- 6, doi 10.1109/ ICRITO 56286.2022.9965017.
20. S. Polisetti, M. Bhargavi, S. Chitneni, S. Eluri, N. Kattamuri and R. R," mounding Models for Employee Attrition Prediction using Logistic Retrogression and Random Forest," 2024 8th International Conference on I- SMAC(IoT in Social, Mobile, Analytics and Cloud)(I- SMAC), Kirtipur, Nepal, 2024, pp. 863- 867, doi 10.1109/ I- SMAC 61858.2024.10714670.
21. G. Raja Rajeswari., R. Murugesan, R. Aruna., B. Jayakrishnan and "Predicting Employee Attrition using Machine Learning, by K. Nilavathy, 3rd International Conference on Smart Electronics and Communication (ICOSEC), Trichy, India, 2022, pp . 1370- 1379, doi 10.1109/ ICOSEC 54921.2022.9952020.
22. G. Pratibha and N. P. Hegde," HR Analytics Early vaticination of Hand waste using KPCA and Adaptive K- means rested Logistic Regression," 2022 Second International Conference on Interdisciplinary Cyber

Physical Systems(ICPS), Chennai, India, 2022, pp. 11- 16, doi 10.1109/ ICPS 55917.2022.00010.

23. V. Mehta and S. Modi," Hand waste System Using Tree Based Ensemble Method," 2021 2nd International Conference on Communication, Computing and Industry 4.0(C2I4), Bangalore, India, 2021, pp. 1- 4, doi 10.1109/ C2I 454156.2021.9689398.
24. N. Bhartiya, S. Jannu, P. Shukla and R. Chapaneri," Hand waste vaticination Using Bracket Models," 2019 IEEE 5th International Conference for Convergence in Technology(I2CT), Bombay, India, 2019, pp. 1- 6, doi 10.1109/ I2CT 45611.2019.9033784.
25. U. Garg, N. Gupta, M. Manchanda and K. Purohit," Bracket and vaticination of Hand waste Rate using Machine Learning Classifiers," 2024 International Conference on Inventive Computation Technologies(ICICT), Lalitpur, Nepal, 2024, pp. 608- 613, doi 10.1109/ ICICT 60155.2024.10544966.
26. S. Abdullah, P. J. Sai Kailash, D. Ramesh and "Assessing Hand Waste And Its Factors Using Machine Learning Approaches," by P. Guntha, 2023 International Conference on Network, Multimedia, and Information Technology (NMITCON), Bengaluru, India, 2023, pp. 1- 11, doi 10.1109/ NMITCON 58196.2023.10276069.
27. Habous, E. H. Nfaoui and Y. Oubenaalla," Predicting Employee Attrition using Supervised Learning Bracket Models," 2021 Fifth International Conference On Intelligent Computing in Data lores(ICDS), Fez, Morocco, 2021, pp. 1- 5, doi 10.1109/ ICDS 53782.2021.9626761.