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Exploiting Machine Learning Techniques in Human Resource Management: A Descriptive Research

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Abstract:

This study provides a descriptive review of the role of artificial intelligence (AI) techniques in human resource (HR) management, with a specific focus on machine learning algorithms used for prediction and classification tasks. By comprehensively analyzing **8 studies** published between **2020 and 2024** across diverse geographic contexts (e.g., Bangladesh, China, Portugal, and international platforms like Kaggle), the research compares the effectiveness of various algorithms in HR tasks such as performance evaluation, turnover prediction, and promotion decisions.

The Random Forest (RF) algorithm emerged as the most effective tool, achieving the highest predictive accuracy (ranging from 0.713 to 0.982) across all scenarios, outperforming other algorithms like Logistic Regression (LR), Support Vector Machines (SVM), and Artificial Neural Networks (ANN). Key findings include:

- In a Bangladesh-based study (sample: 1,109 employees), RF achieved 98.2% accuracy in performance evaluation.
- In a Portugal-based study (sample: 199 employees), RF outperformed other models with 78.0% accuracy for turnover prediction.
- In a China-based study (sample: 287,229 employees), RF maintained 71.3% accuracy despite dataset complexity.

The study offers practical recommendations for HR professionals, such as:

- Adopting RF-based models to enhance decision-making accuracy.
- Improving data quality and reducing bias through standardized data collection.
- Training HR teams to leverage analytical tools effectively.

Future research directions are identified, including:

- Testing models across diverse industries (e.g., healthcare vs. technology).
- Addressing ethical challenges like data privacy and algorithmic bias.
- Integrating advanced techniques (e.g., deep learning) for imbalanced datasets.

By clarifying the scope of the reviewed literature (size, timeframe, and geographic diversity), this study enhances its methodological credibility while acknowledging limitations, such as small sample sizes in some studies (e.g., 199 employees in Portugal).

Keywords: Human Resources, Artificial Intelligence, Machine learning, Classification Predicting

INTRODUCTION

The world is experiencing rapid advancements in artificial intelligence (AI), with machine learning (ML) techniques playing a pivotal role in optimizing administrative processes across industries. In human resource management (HRM), these algorithms are increasingly instrumental in analyzing workforce data to identify patterns that support strategic decision-making, such as predicting employee performance, analyzing turnover trends, and designing retention strategies (1, 2). Despite their growing adoption, existing studies remain fragmented, often focusing on isolated applications of ML in HRM without systematically comparing algorithmic performance across diverse tasks or addressing critical limitations. For instance, prior research has predominantly:

- Evaluated algorithms in siloed contexts (e.g., turnover prediction *or* promotion analysis), lacking a holistic framework to assess their efficacy across multiple HR functions.

- Overlooked geographic and organizational diversity, with many studies relying on homogenous datasets from specific regions (e.g., single-country samples), limiting generalizability.

- Underemphasized practical challenges such as data quality issues, algorithmic biases, and ethical implications, which hinder real-world implementation (3).

This study addresses these gaps by conducting a comprehensive review of **8 studies** (2020–2024) spanning diverse geographic contexts (e.g., Bangladesh, China, Portugal) and HR applications. By systematically comparing the accuracy of ML algorithms—including **Random Forest**, **Logistic Regression**, and **Neural Networks**—we identify not only the most effective tools for specific tasks but also the limitations of current approaches, such as reliance on small datasets (e.g., 199 employees in a Portugal-based study) and inconsistent data preprocessing standards. Furthermore, we integrate ethical considerations and practical recommendations to bridge the divide between theoretical research and actionable HR strategies.

This research is critically needed to equip organizations with evidence-based insights for adopting ML technologies that align with their operational and ethical priorities, ultimately enhancing workforce management in an era of data-driven decision-making.

Research Objective:

To compare the accuracy of various machine learning algorithms in performing HR-related tasks.

Research Question:

Which machine learning algorithm provides the highest accuracy for HR tasks?

Literature Review

The sustainability and growth of businesses largely depend on employee performance. However, traditional methods of evaluating employee performance have often been inconclusive and incomplete (1). A comprehensive survey on machine learning applications for predicting employee performance concluded that machine learning algorithms consistently outperform traditional models in terms of accuracy and efficiency.

The HR landscape has undergone a significant transformation with the introduction of machine learning technologies. These tools offer a data-driven approach to understanding workforce dynamics, enabling HR professionals to make more informed decisions (3). Machine learning encompasses a wide range of algorithms, each possessing unique strengths and limitations. These technologies are particularly valuable in the workplace as they facilitate the detection of hidden patterns and trends that might not be apparent through conventional analysis. However, the accuracy and effectiveness of these algorithms depend largely on the quality and preprocessing of the data. Organizations must ensure that the data they collect is comprehensive, relevant, and free from biases to enhance predictive accuracy (4).

Numerous organizations have successfully implemented machine learning technologies to enhance employee performance, demonstrating practical applications across various industries (5). For instance, a major technology company utilized a machine learning model to analyze employee engagement surveys and performance reviews, leading to a 20% increase in productivity after identifying critical factors affecting employee satisfaction and performance (6). Similarly, in the healthcare sector, an organization leveraged machine learning algorithms to predict nurse turnover rates based on historical recruitment data. By implementing targeted retention strategies, they achieved a 15% reduction in employee turnover (7). These case studies illustrate the effectiveness of predictive algorithms in human resource management.

The integration of machine learning techniques into HR functions has gained significant research attention in recent years. This literature review synthesizes key findings from multiple studies that have examined the effectiveness of machine learning algorithms in various HRM applications, emphasizing their potential to optimize workforce management and improve organizational outcomes (8).

METHODOLOGY

This study employed a **systematic descriptive review** methodology to evaluate machine learning (ML) algorithms applied to human resource (HR) functions. The approach was selected to enable a rigorous synthesis of existing literature while identifying patterns and gaps in algorithmic performance across HR tasks.

Search Strategy and Data Collection

1. **Database Selection**:
    - Searches were conducted across **five academic databases**: IEEE Xplore, ScienceDirect, PubMed, SpringerLink, and Google Scholar. These platforms were chosen for their extensive coverage of peer-reviewed journals and conferences in computer science and HR management.
2. **Keyword Framework**:
    - A Boolean search strategy was applied using combinations of the following keywords:
        - *("Human Resources" OR "HR Analytics")*
        - *AND ("Machine Learning" OR "Artificial Intelligence")*

- *AND ("Prediction" OR "Classification" OR "Employee Turnover" OR "Performance Evaluation").*

3. **Timeframe and Filters**:
    - Studies published between **2019 and 2024** were included to prioritize recent advancements.
    - Filters were applied to exclude non-English articles, theoretical papers, and studies unrelated to HR applications.

Screening and Selection Process

- **Initial Pool**: The search yielded **327 studies** (Figure 1).
- **Inclusion Criteria**:
    - Empirical studies with quantitative validation of ML algorithms.
    - Focus on HR tasks (e.g., turnover prediction, performance evaluation).
    - Accessibility of full text and results (accuracy metrics).
- **Exclusion Criteria**:
    - Duplicate studies, non-peer-reviewed articles, or incomplete datasets.
    - Studies lacking direct comparison of algorithm performance.

After screening titles and abstracts, **43 studies** progressed to full-text review. A final set of **8 studies** met all criteria and were selected for in-depth analysis (Table 1).

Data Extraction and Analysis

- **Variables Extracted**:
    - Algorithm type (e.g., Random Forest, SVM).
    - Dataset size and source (e.g., 1,109 employees in Bangladesh).
    - Reported accuracy metrics.
- **Comparative Framework**:
    - Algorithms were evaluated across four HR tasks: performance evaluation, turnover prediction, promotion decisions, and intention-to-quit analysis.
    - Results were synthesized into **Table 2**, highlighting accuracy scores and methodological strengths/limitations.

Limitations

- **Publication Bias**: The reliance on peer-reviewed articles may exclude industry reports or gray literature.

- **Geographic Focus**: Most datasets originated from Asia and Europe, limiting global generalizability.

RESULTS AND DISCUSSION

A comprehensive review of several studies evaluating predictive algorithms in HR functions was conducted. One notable study by (4) collected data from 1,109 employees of a for-profit organization in Bangladesh, utilizing information from both employers and employees. The study tested multiple machines learning techniques, including Random Forest, Logistic Regression, Gaussian Naïve Bayes, Decision Tree, K-Nearest Neighbors (K-NN), and Support Vector Machine (SVM) to assess employee performance. Among these models, Random Forest demonstrated the highest predictive accuracy, outperforming the other algorithms.

The importance of HR analytics in a highly competitive business environment cannot be overstated. Retaining highly qualified employees remains a significant challenge, as employee turnover is both costly and disruptive for companies. The Lisbon Regional Delivery Hub (LRDH) of Willis Towers Watson (WTW) is one such organization that faces this challenge. A study by (5) aimed to identify key factors influencing employee turnover at WTW and determine the most effective machine learning model for predicting turnover. The findings revealed that employees with longer tenure, recent promotions, Portuguese nationality, and higher-level positions were more likely to remain in the organization. The study also confirmed that Random Forest was the most effective model for predicting turnover. These insights provide valuable guidance for HR professionals, enabling them to design targeted retention strategies to minimize employee attrition and enhance both productivity and financial performance.

Another study (6) explored the impact of social media activity on employee turnover intention. Employees who engage frequently on professional networking sites (e.g., LinkedIn) and update their profiles on job portals were found to have a higher likelihood of leaving their jobs. To predict intention to quit (IQ), the study developed an ensemble learning model incorporating features such as job engagement (JI), organizational commitment (OC), activities on professional networking sites (APNS), and profile updates on job portals (PJP). The model's accuracy was evaluated using a Receiver Operating Characteristic (ROC) curve, and the best predictor of turnover intention was identified as APNS and PJP. The study tested seven classification algorithms: Boosting Gradient, Random Forest, K-Nearest Neighbors, Logistic Regression, Neural Network, Support Vector Machine, and Naïve Bayes.

The study used cross-sectional survey data collected from 1,006 IT employees exposed to the Internet of Things (IoT). The questionnaire was distributed online through SurveyMonkey, and random sampling was used to gather responses. The collected data was analyzed to determine whether employees intended to leave their jobs based on their online job-search behaviors.

These studies highlight the growing role of machine learning in HR analytics. They demonstrate how predictive models can help organizations identify key factors influencing employee performance,

turnover, and engagement, ultimately leading to data-driven HR strategies that improve workforce stability and efficiency.

A study conducted by (7) on promotion processes highlights their critical role in human resource management. A fair and well-structured promotion system serves as a key management tool that motivates employees, fosters engagement, and ensures business continuity. Promotion is a significant extrinsic motivator, enhancing employee commitment and sustaining high performance. Additionally, it functions as a reward mechanism and a performance evaluation tool for organizations.

Several factors are considered when determining promotions, including:

- Seniority
- Performance level
- Competencies
- Age
- Awards and recognitions
- Training and education
- Organizational commitment

This study examines promotion prediction methodologies using machine learning algorithms such as Support Vector Machine (SVM), Artificial Neural Network (ANN), and Random Forest. Among these, Random Forest achieved the highest performance. The findings indicate that HR departments and managers can leverage these predictive models to assess promotion probabilities, enabling data-driven decision-making for identifying the most suitable employees for career advancement.

Another study was conducted by 5 on employee turnover prediction emphasizes its significance in human resource management, as the departure of key employees can lead to substantial losses for organizations. However, many existing studies focus primarily on employee-centered factors, often overlooking historical turnover trends and longitudinal job records.

This research tested employee turnover prediction models using a large-scale dataset from one of China's largest professional social media platforms. The dataset included:

- Personal information
- Educational background
- Work experience
- Online platform activities

After data cleaning and preprocessing, a total of 287,229 samples were analyzed. Experimental results demonstrated that Random Forest was the most effective algorithm for predicting employee turnover.

The details of the datasets used in these studies, including their sources and sample sizes, are summarized in Table (1). Additionally, the researcher compiled the results of these studies into Table (2), providing a comprehensive comparison of algorithm accuracy in HR applications. Across all studies, Random Forest consistently exhibited the highest predictive accuracy, making it the recommended algorithm for HR decision-making. Its effectiveness in predicting promotions and turnover trends enables organizations to make strategic, data-driven HR decisions, ultimately enhancing business success.

Table (1) provides an overview of the datasets used in various studies that applied machine learning algorithms to different human resource (HR) tasks, such as employee performance evaluation, turnover prediction, and promotion decisions. The datasets vary significantly in terms of source, size, and data type, which impacts the effectiveness and generalizability of machine learning models across different organizational contexts.

1. Employee Performance Evaluation
    - The dataset used in this study was collected from For-Profit Organizations like BSRM and Berger Paints in Bangladesh, with a sample of 1,109 employees. This dataset includes both employer and employee-provided data, allowing for a more holistic assessment of performance factors.
2. Employee Turnover Prediction
    - The study conducted at Willis Towers Watson's Lisbon Hub analyzed 199 employee observations, distinguishing between 91 non-active and 108 active employees. Although the sample size is relatively small, it provides insights into turnover patterns within a multinational corporate setting.
    - Another study used data from China's largest online professional social platform, which contained 287,229 samples after data cleaning. This large dataset enables a more robust and diverse analysis of turnover trends across different industries.
3. Intention to Quit Prediction
    - A dataset consisting of 1,006 IT employees exposed to the Internet of Things (IoT) was used to predict employees' likelihood of leaving their jobs. The respondents had an average age of 35 years and an average work experience of 11 years, providing a real-world perspective on workforce mobility in the tech industry.
4. Employee Promotion Prediction
    - This study utilized Kaggle's publicly available employee dataset, comprising 52,399 records. The dataset contains various factors influencing promotion decisions, such as seniority, performance level, and training.

5. **Table (1):** *Databases used in the researches*

study	Source of Dataset	Size of Dataset
Unbiased employee performance evaluation using machine learning	For-Profit Organizations like BSRM and Berger Paints	1109 employees in Bangladesh.
Using Machine Learning to predict Employee Turnover	HR department of Willis Towers Watson's Lisbon Hub	199 observations of employees, there are 91 non-active and 108 active employee observations.
An ensemble learning model for predicting the intention to quit among employees using classification algorithms	IT personnel exposed to IoT	1006 employees targeted; Respondents had an average age of 35 years. Average work experience of respondents was 11 years.
Employee Promotion Prediction by using Machine Learning Algorithms for Imbalanced Dataset	Kaggle's publicly accessible employee values	52,399 records
Employee Turnover Prediction Based on Random Forests and Survival	China's largest online professional social platform	287,229 samples after data cleaning

Comparison of Machine Learning Algorithms for HR Tasks

Table (2) summarizes the accuracy of different machine learning models used in HR research. The RF algorithm achieved the highest accuracy across all studies, with values ranging from 0.713 to 0.982, outperforming logistic regression (LR), decision trees (DT), k-nearest neighbors (KNN), support vector machines (SVM), Naïve Bayes (NB), and artificial neural networks (ANN).

1. **Employee Performance Evaluation**
    - A study on For-Profit Organizations in Bangladesh tested RF, LR, DT, KNN, SVM, XGBoost, and NB to predict employee performance. RF had the highest accuracy (0.982), significantly outperforming logistic regression (0.678) and SVM (0.684), indicating that RF is superior in capturing complex employee performance patterns.
2. **Employee Turnover Prediction**
    - A study conducted at Willis Towers Watson's Lisbon Hub used RF, LR, DT, and KNN to predict turnover. RF again outperformed other models, achieving an accuracy of 0.780, compared to 0.746 (LR) and 0.644 (DT).
    - Another study on China’s largest online professional social platform also validated the effectiveness of RF, with an accuracy of 0.713, higher than LR (0.640) and DT (0.625).
3. **Intention to Quit Prediction**
    - An ensemble learning study analyzing IT personnel exposed to IoT used seven classification algorithms, including RF, LR, KNN, SVM, XGBoost, NB, and NN. RF again achieved the highest accuracy (0.946), outperforming other models, confirming its reliability in predicting employee turnover behaviors.

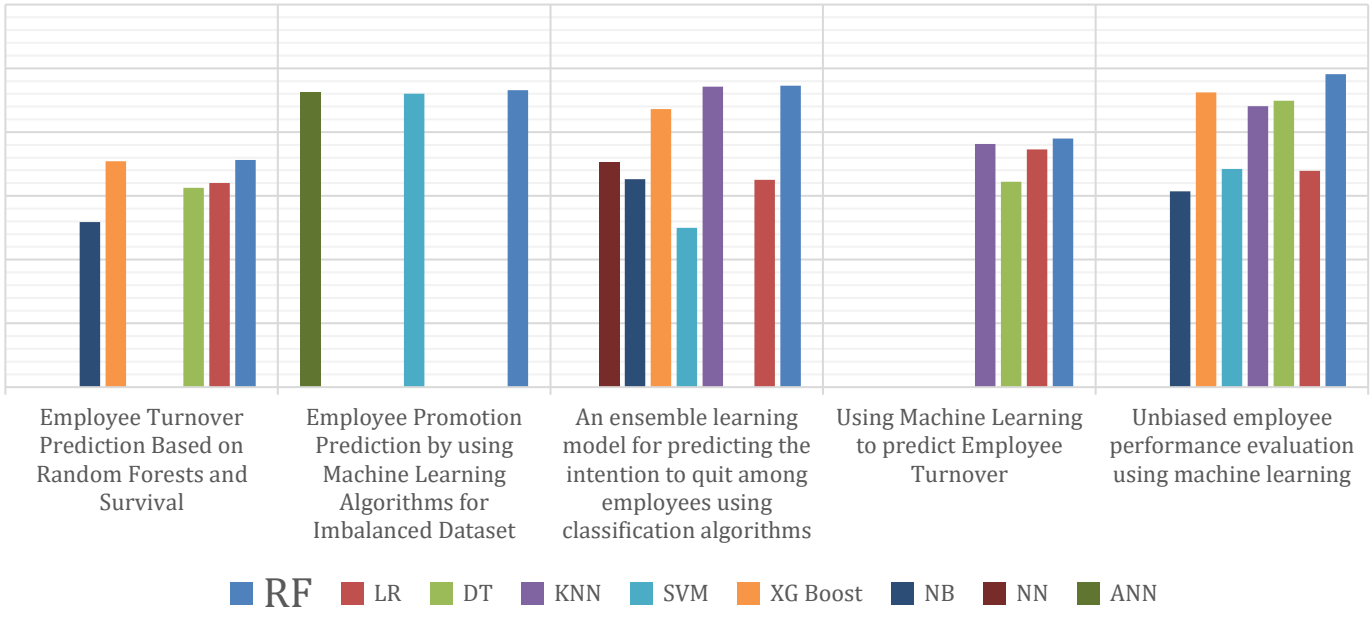
4. Employee Promotion Prediction

- In a study using Kaggle's publicly available employee dataset, RF was found to be the most effective predictor of promotion eligibility (0.931 accuracy), outperforming SVM (0.920) and ANN (0.923).

Table (2): *Accuracy comparison between machine learning algorithms*

Study	**Model**	**RF**	LR	DT	KNN	SVM	XG Boost	NB	NN	ANN
Unbiased employee performance evaluation using machine learning	2024	**0.982**	0.678	0.898	0.881	0.684	0.924	0.614		
Using Machine Learning to predict Employee Turnover	2024	**0.780**	0.746	0.644	0.763					
An ensemble learning model for predicting the intention to quit among employees using classification algorithms	2023	**0.946**	0.650		0.942	0.500	0.872	0.652	0.705	
Employee Promotion Prediction by using Machine Learning Algorithms for Imbalanced Dataset	2022	**0.931**				0.920				0.923
Employee Turnover Prediction Based on Random Forests and Survival	2020	**0.713**	0.640	0.625			0.709	0.518		

Figure (1): *Accuracy comparison between machine learning algorithms*



CONCLUSION

This descriptive review discusses different machine learning algorithms and their uses in human resource management, the efficiency and accuracy of each of these algorithms. The summary of the comparisons showed that the Random Forest algorithm is the most effective and accurate algorithm. The study concludes with recommendations for future research and practical applications in human resources.

RECOMMENDATIONS

- **Adopting machine learning models:** Organizations should consider implementing machine learning models, especially random forest models, to enhance their decision-making efficiency and ensure greater success for the organization.
- **Ongoing training for HR professionals:** Training HR staff to use and work with machine learning models to ensure seamless integration into HR processes.

Suggestions for Future Research:

- **Compare Machine Learning Models Across Different Industries**: Future studies could analyze the effectiveness of various machine learning models in diverse sectors to understand their adaptability.
- **Explore Ethical and Privacy Concerns**: Further research could focus on ethical implications, data privacy, and fairness when using machine learning models in HR functions.

Disclaimer

The article has not been previously presented or published, and is not part of a thesis project.

Conflict of Interest

There are no financial, personal, or professional conflicts of interest to declare.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript**.**

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