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A STUDY IN OPTIMISING AND FORECASTING EMPLOYEE PERFORMANCE USING SELECTED MACHINE LEARNING MODELS

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Abstract

The purpose of this article is to investigate the impact that machine learning has had on the conventional human resource environment, particularly with regard to employee reviews. Machine learning provides a wide range of data analysis skills, which is something that businesses are actively looking for in order to create more effective methods for evaluating their employees. Because of these algorithms, productivity measures, project achievements, and qualitative input are much improved which results in the creation of performance images that is both complete and objective. The researcher investigates the benefits and drawbacks of implementing this digital giant into human resources. For the purpose of improving performance assessments in contemporary businesses, it is essential to strike the ideal balance between human expertise and technological advancements. The age-old practice of subjective evaluations is becoming increasingly out of date in the ever-changing world of the modern workplace, where results are of the utmost importance. In this study, we investigate the impact that machine learning has had on performance evaluations in human resource management (HRM), focusing on its capacity to deliver assessments that are both objective and nuanced. This study investigates the complexities and potential dangers of machine learning in human resource management (HRM), with the primary objective of achieving performance evaluations that are accurate and equitable. The purpose of this research endeavour is to investigate the sophistication of this method while also locating any possible mistakes. For businesses that want to maximise the potential of their employees by incorporating both technological and human expertise into performance evaluations, this paper provides a detailed roadmap that can help them achieve their goals. The performance of a company's employees is a significant factor in determining the company's potential for commercial success and expansion. On the other hand, the evaluation of the staff's' performance up to this point has been insufficient and downright disappointing. In order to ensure that an employee's performance is evaluated and predicted in a fair manner, this study investigates several external aspects that are related with their lives, including those that are physical and environmental, social, and economical. My research focuses on building an objective algorithmic way for artificial intelligence to forecast future employee performance. This method takes into consideration a variety of environmental parameters, including physical, social, and economic characteristics.

Keywords: Employee performance, Machine learning.

INTRODUCTION

In the ever-evolving modern workplace, where firms strive for excellence by managing a varied global workforce and adjusting to changing dynamics in order to achieve success, human resource management plays a critical role in the management of human resources. As a research scholar, it is necessary to devise a comprehensive technique in order to adequately evaluate the performance of employees within the constantly shifting

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landscape of artificial intelligence and machine learning. As the use of data-driven decision-making becomes more widespread, human resource managers are being encouraged to fully embrace the vast array of opportunities that are made available by sophisticated analytical tools. Specifically, this research investigates the convergence of human resource management (HRM), artificial intelligence (AI), and machine learning (ML), where the harmonious interaction of these three fields creates a multitude of insights that have the potential to revolutionise employee performance assessments (Alshurideh, 2023).

This study investigates the application of sophisticated algorithms, consisting of linear regression and other cutting-edge methods, for the purpose of analysing a wide variety of data. The purpose of this objective is to provide a more accurate, objective, and all-encompassing knowledge of the contributions made by individuals. Evaluation of performance is a difficult process that falls under the purview of Human Resource Management (HRM).

Assessment of current performance, identification of high and low performers, and provision of feedback to staff members are all included in this process. There are a lot of businesses that do not do systematic employee performance reviews, which is a really bad situation. The process of evaluation becomes extremely unpredictable, and it loses its effectiveness as a result.

A systematic strategy must to be adhered to in order to properly conduct consistent evaluations of staff members at the planning level (Ahmed, 2013). Those personnel who are able to demonstrate the requisite attributes of knowledge, abilities, attitudes, and dedication are highly valued by the organisation (Arasi, 2019).

Any information that is generated within an organisation has the potential to significantly stimulate innovation within its human resources. Evaluation of staff performance in an appropriate manner is essential for businesses to achieve their objectives and guarantee the highest possible level of employee satisfaction.

In light of the fact that the development of staff is a vital factor in deciding the profitability of a company, a great number of executives are continually looking for ways to considerably improve performance. It is essential for businesses that want to improve their overall performance to have a thorough understanding of the performance state of each and every individual working for the organisation.

LITERATURE REVIEW

The performance of an employee is often evaluated based on how well they have performed during a predetermined period of time. The areas of success and failure are identified in order to develop benchmarks that the staff can strive for in order to accomplish the strategic goals of the organisation. There are three different sets of elements that have an effect on employee performance that were included in this study. The physical or environmental, the social or behavioural, and the economical aspects are

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the three major aspects that need to be taken into consideration during this process (Antonio, 2018).

Physical or environmental variables include a variety of features of an employee's place of employment, including the level of cleanliness, the amount of noise, and the ergonomic arrangement of the workspace. These elements have the potential to have an effect on the well-being of the worker, which may result in potential health problems such as headaches, back discomfort, and eye strain (Ldama, 2020). Moreover, the presence of sufficient light and fresh air, in addition to the daily journey to and from the workplace, might also be factors that contribute to the development of this condition. In the role of a research scholar, it is essential to take into consideration the influence that the indoor environment of the workplace has on the attitudes, behaviours, levels of happiness, and levels of productivity of employees. In order for workers to be able to keep their concentration and carry out their responsibilities with accuracy, it is essential to create a working atmosphere that is suitable. According to the findings of the research carried out by Lada, et al. (2023), it has been discovered that the atmosphere of the workplace has a considerable influence on the employment performance of employees. According to the findings of the study, even a minute alteration in the components of the physical environment can result in a significant 36 percent shift in the health of the workforce. The implementation of a single adjustment that is relevant to the wellness of employees can result in a large improvement of 80 percent in employee performance. Positive results are being seen in terms of employee performance and wellness, and the features of the physical environment are exhibiting these positive outcomes. When trying to effectively estimate future employee performance, it is essential to take into consideration the presence of physical environmental elements (Hameed, 2014).

Important social and behavioural factors include, but are not limited to, the following: employee work-life balance, employee welfare, supervisor help, safety, teamwork, security, training facilities, positive connection with coworkers, and development of the employee. The performance of the employees and their level of happiness with their jobs are directly influenced by these factors, which is why they play such an important role (Hafee, 2019). As someone who works in the field of research, it is abundantly clear to me that the successful operation of a business is highly dependent on the contentment and happiness of its workforce. When individuals are able to learn the required skills and capabilities to perform better at work, it ultimately leads to a more successful organisation. This is the reason why this is the case. Additionally, the success of a team can be affected by a variety of elements, including the creation of the team, the distribution of responsibilities, the potential of the members of the team that are being investigated, and the dynamics of their relationships with one another. One should also take into consideration the potential impact that their working environment may have on their performance (Gunaseelan, 2012).

During the course of their investigation, they came to the realisation that a single unit of change in the behavioural environment parameters had a significant influence of 33 percent on the health of workforce members. It is essential for academics working in this

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sector to have a solid understanding of the impact that environmental factors have on the health and performance of employees. The performance of individuals working in the manufacturing industry has been significantly influenced by a number of characteristics that are present in the location of their employment (Fogoroș, 2020). On the other hand, the presence of permanent employment, training facilities, and jobs that were guaranteed suggested a beneficial impact on the performance of workers. A separate evaluation of social components was carried out with the help of the performance grade in order to determine whether or not there were any possible connections between them. When determining an employee's performance grade, various criteria were taken into consideration. These included the employee's length of service with the organisation, their capacity to maintain a healthy work-life balance, the availability of opportunities for training, and the closeness of their place of employment to their residence.

Regarding the conduct category, we have recognised characteristics such as dependability, integrity, and a positive approach towards work procedures. These are all attributes that we have identified. After conducting a research study that was based on surveys, it was found that there is a correlation between employee performance and corporate culture in a number of different software companies in Pakistan. The outcomes of the research suggested that there is a favourable association between performance and the culture of the workplace. Furthermore, a positive association was shown to exist between the performance of workers and the culture of the company themselves (Nilashi, 2023).

There is evidence that suggests that merit pay or performance-based compensation is related with improved performance. This is despite the fact that certain study may not have offered a conclusive conclusion on the impact that this system has on performance.

MATERIALS AND METHODS

A questionnaire was used to obtain the information that we needed for our investigation. When analysing the performance of employees, a number of aspects will be taken into consideration. These factors include gender, academic background, job involvement, age, overtime, and environmental conditions. For the purpose of this investigation, a mix of qualitative and quantitative approaches was utilised, with the qualitative data being converted into quantitative data.

In my capacity as a research scholar, the study focused on a number of independent variables, including components of the environment or the physical environment, the qualifications and experience of employees, the level of happiness that employees have with their jobs, as well as social and economic factors.

In this particular study, the performance rating served as the dependent variable. Taking into consideration the circumstances, a number of classification methods, including K Nearest Neighbours (K-NN), Logistic Regression and Random Forest have been utilised in order to forecast the performance of the employees.

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Training and testing evaluation

70% of the data were used to train these machine learning models and the rest 30% were used to test the accuracy level of those models. The accuracy level shows how much the actual performance rating of those 30% data match with the performance rating that is predicted or categorized by the machine learning models based on those 80% data.

The more the accuracy the more the model is suited for solving the problem or making prediction. Training the machine learning models and evaluating them were discussed in the results section.

ANALYSIS AND INTERPRETATION

Demographic analysis

Table 1: Frequency analysis

Age	**Frequency**	**in %**
31 - 40 years	53	38.97
41 - 50 years	15	11.03
Less than 30 years	37	27.21
Above 50 years	31	22.79
Location	**Frequency**	**in %**
Metro city	91	66.91
Non metro city	45	33.09
Dependents	**Frequency**	**in %**
More than 2	53	38.97
Less than 2	83	61.03
Position	**Frequency**	**in %**
Middle level management	50	36.76
Lower level management	72	52.94
Top level management	14	
Work experience	**Frequency**	**in %**
8 - 12 years	27	19.85
4 - 8 years	33	24.26
Less than 4 years	35	25.74
Above 16 years	32	23.53
12 - 16 years	9	6.62
Rating	**Frequency**	**in %**
Average	105	77.21
High	16	11.76
Low	15	11.03
Total	**136**	**100.00**

The age distribution of the sample population shows that the majority of individuals fall within the 31-40 years age bracket, accounting for 38.97% with a frequency of 53. The second largest group comprises those less than 30 years, representing 27.21% with 37 individuals. Those above 50 years form 22.79% of the population, with a frequency of 31. The smallest age group is 41-50 years, comprising 11.03% of the population with 15 individuals.

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This distribution indicates a relatively younger workforce, with a significant portion in their early to mid-career stages. The distribution of individuals by location indicates a predominance of metro city residents. Metro city inhabitants constitute 66.91% of the population with a frequency of 91. In contrast, non-metro city residents make up 33.09% with a frequency of 45. This suggests that a significant majority of the sample population is urban-based, possibly reflecting the concentration of employment opportunities and amenities in metro areas.

In terms of dependents, individuals with fewer than two dependents form the majority, representing 61.03% of the population with a frequency of 83. Those with more than two dependents account for 38.97% with a frequency of 53. This distribution could indicate a trend towards smaller family sizes or a younger demographic that has not yet reached a stage of having more dependents.

The position distribution reveals that lower-level management comprises the largest segment, with 52.94% of the population and a frequency of 72. Middle-level management follows with 36.76% and a frequency of 50. Top-level management is the smallest group, representing 10.29% with a frequency of 14. This distribution suggests a workforce structure with a larger base of operational and middle management roles supporting a smaller executive tier.

Analyzing work experience, the largest group has less than 4 years of experience, constituting 25.74% of the population with a frequency of 35. This is closely followed by those with 4-8 years of experience at 24.26% (33 individuals).

Those with above 16 years and 8-12 years of experience account for 23.53% (32 individuals) and 19.85% (27 individuals), respectively. The smallest group has 12-16 years of experience, comprising 6.62% with a frequency of 9. This distribution indicates a balanced mix of experience levels, with a slight skew towards early-career individuals.

Regarding ratings, the majority of individuals fall into the average rating category, constituting 77.21% of the population with a frequency of 105. The high rating category includes 11.76% of the population with a frequency of 16, while the low rating category comprises 11.03% with a frequency of 15. This distribution suggests that most individuals are performing at an average level, with a smaller proportion of high and low performers.

The total sample population comprises 136 individuals, with diverse distributions across age, location, dependents, position, work experience, and ratings. The largest segments are urban residents, lower-level management, those with fewer than two dependents, and individuals with average performance ratings.

This comprehensive demographic and performance analysis provides insights into the workforce composition and potential areas for targeted interventions.

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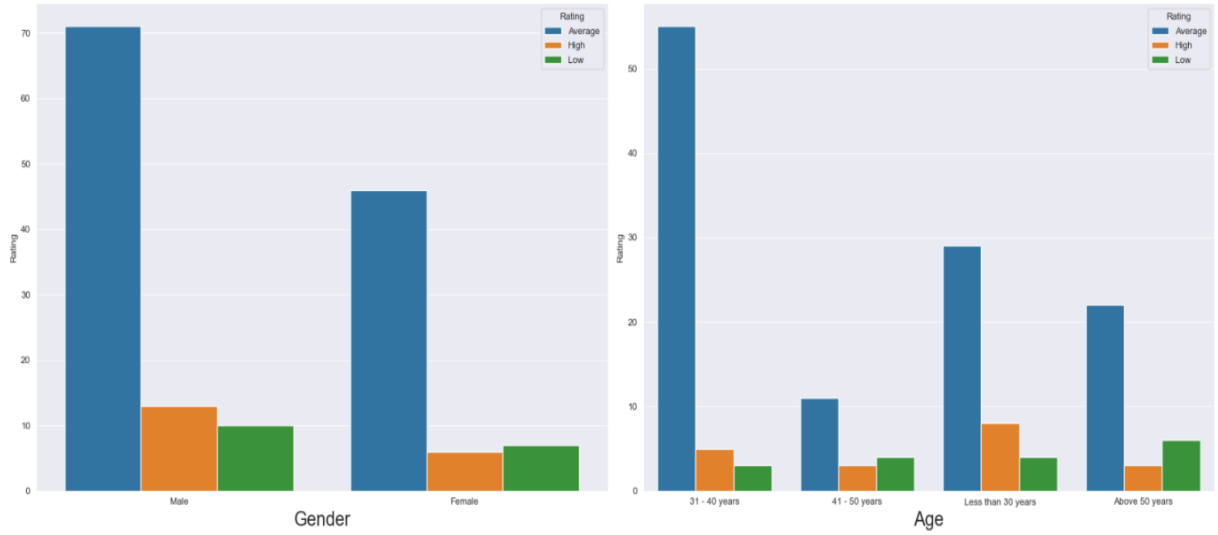
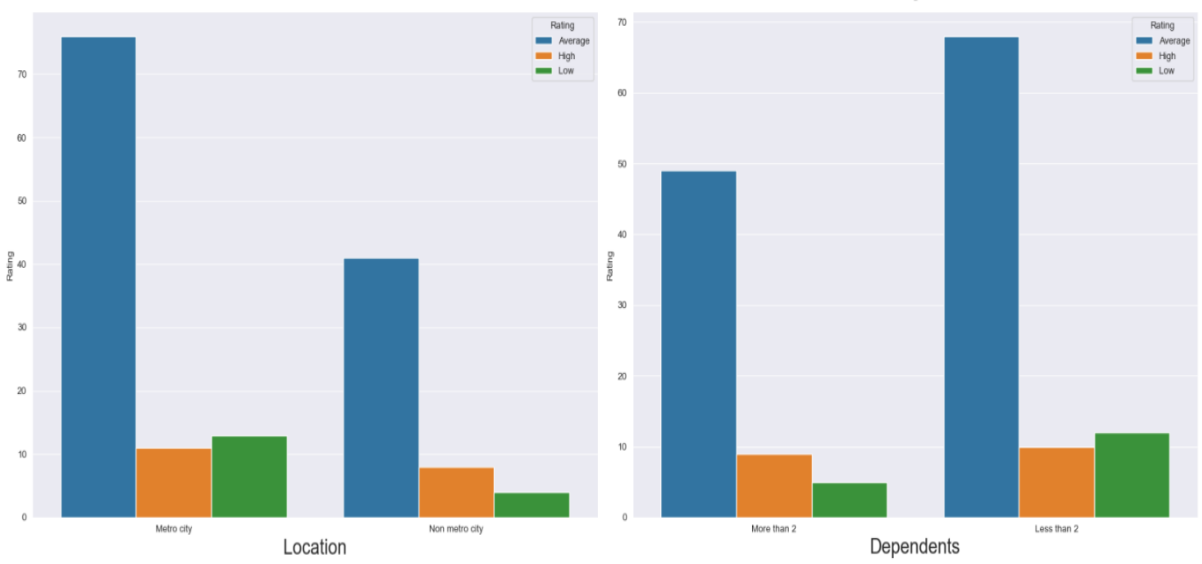
Exploratory data analysis

Comparison of demographic variables with the last year ratings



Males have a significantly higher high rating than females. Among age groups, 31-40 years have the highest ratings, followed by those less than 30 years. Low ratings are minimal across both gender and age groups



Employees in metro cities have higher ratings compared to those in non-metro cities. Employees with fewer than 2 dependents have higher ratings compared to those with more than 2 dependents. Low ratings are relatively minimal across both location and dependents categories.

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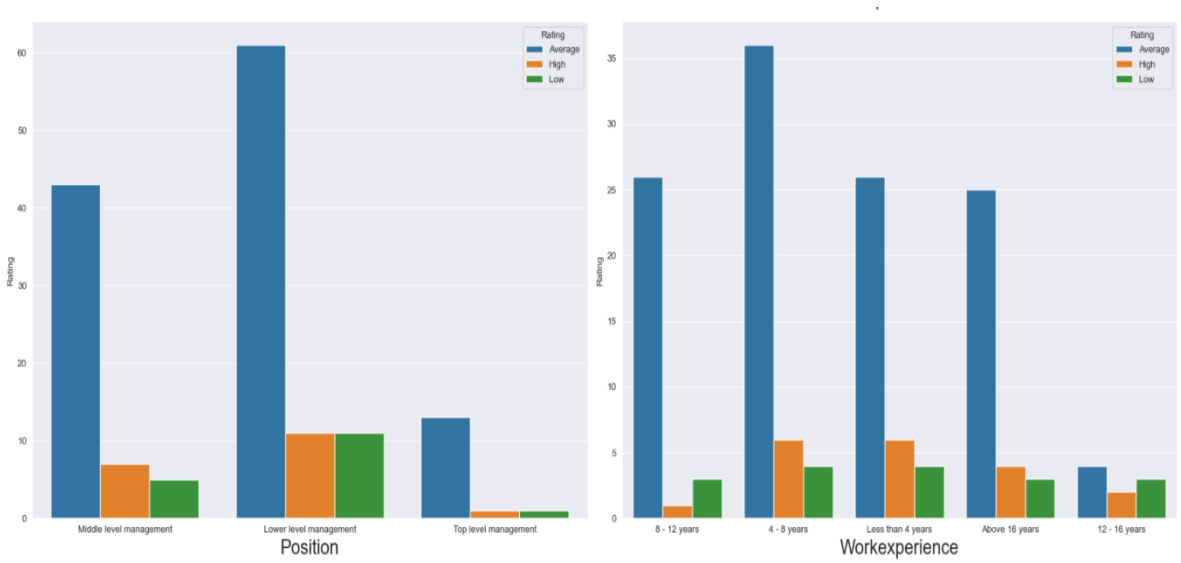

Lower-level management has the highest ratings compared to middle and top-level management. Among work experience groups, employees with 4-8 years of experience have the highest ratings, followed by those with 8-12 years. Low ratings are relatively minimal across both position and work experience categories

Correlation analysis

Table 2: Correlation analysis

	Physical_factors	Behavioural_factors	Economic_factors	Emp_performance
Physical_factors	1.000	0.892	0.834	0.858
Behavioural_factors	0.892	1.000	0.851	0.864
Economic_factors	0.834	0.851	1.000	0.830
Emp_performance	0.858	0.864	0.830	1.000

The performance of employees is significantly influenced by a variety of physical factors, including their physical health, the conditions of their environment, and the ergonomics of their job. The correlation matrix reveals that there is a strong interaction between physical characteristics and employee performance, with a correlation coefficient of 0.858. Based on this high link, it appears that improving the physical conditions of a workplace, such as optimising the layout of the office, providing appropriate lighting, assuring comfortable seating, and providing access to healthcare facilities, can considerably improve the performance and productivity of employees. Furthermore, the fact that there is a significant connection (0.892) between physical characteristics and behavioural aspects suggests that a suitable physical environment also has an effect on employee behaviour, which may result in workers who are more motivated and involved in their work. The aspects of employees' attitudes, motivations, and general psychological condition that are referred to as behavioural components include there is a substantial association between these factors, as indicated by the correlation value of 0.864, which underlines the vital significance of these aspects in affecting the task performance of employees. With a

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correlation coefficient of 0.892 for physical variables and 0.851 for economic factors, behavioural features suggest that an employee's behaviour is influenced by both their physical work environment and their financial situation. This is the case since the correlation coefficients for both types of components are 0.892. As a result, any tactics that are targeted at improving employee performance must to take into consideration holistic approaches that incorporate behavioural, physical, and financial components. Implementing efforts such as mental health support, employee recognition programmes, and the cultivation of a healthy corporate culture are all examples of behaviours that can be improved via the implementation of these initiatives. The correlation coefficient between employee performance and economic elements, such as compensation, perks, and general financial incentives, is 0.830, which indicates that economic considerations have a significant impact on employee performance. Due to the fact that it illustrates that maintaining high levels of employee performance is dependent on stable economic conditions and incentives, this element is essential despite the fact that it is the least relevant of the three variables. There is a considerable link between economic factors and physical elements (0.834), as well as between economic factors and behavioural features (0.851). This strong correlation highlights the interconnectedness of these drivers. Monetary incentives have the potential to improve an employee's financial security, which in turn has a favourable impact on the employee's emotional and physical well-being, which eventually leads to improved performance. It is necessary for businesses to strike a balance between the many different methods of employee motivation and the financial incentives that are available in order to maximise the performance of their workforce.

Regression analysis

Table 3: Regression

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	0.3539	0.171	2.071	0.04	0.016	0.692
Physical_factors	0.3271	0.089	3.683	0.00	0.151	0.503
Behavioural_factors	0.3241	0.089	3.656	0.00	0.149	0.499
Economic_factors	0.2454	0.076	3.241	0.00	0.096	0.395

Physical traits have a positive and statistically significant impact on employee performance (P = 0.00). Additionally, this impact is beneficial. While it is reasonable to assume that all other parameters will remain unchanged, it is anticipated that the performance of the employees will improve by 0.3271 units for every unit that the score for physical elements becomes higher. This estimate's dependability is further improved by the fact that the confidence interval is relatively narrow. The performance of employees is significantly influenced by the behavioural traits of the employees (P = 0.00). Assuming that all other factors remain unchanged, there is a correlation between a one-unit rise in behavioural factors and a 0.3241 unit increase in employee performance. After conducting an analysis of the significance and confidence interval, it is unequivocally clear that there is a significant and persistent influence. In the same way as the other variables, economic factors exhibit a statistically significant positive association with employee

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performance when the value of P is equal to 0.00. An improvement of 0.2454 units in employee performance can be attributed to an increase of one unit in the economic considerations score, provided that all other parameters remain unchanged.

Based on the findings of the regression analysis, it can be concluded that the three independent variables—namely, physical characteristics, behavioural aspects, and economic considerations—have a significant influence on the ability to forecast workforce performance. Given the positive coefficients, it appears that enhancements in any of these areas have the ability to increase the performance of the employed individuals. The most significant influence is exerted by behavioural and physical factors, as seen by the greater coefficients and t-values associated with these components. Economic considerations have a little diminished but still large influence, despite the fact that they continue to be vital. The fact that all of the significant p-values are only 0.05 demonstrates that every single metric is a reliable indicator of how efficiently employees perform their jobs. The quality and dependability of these approximations are further validated by the confidence intervals. The improvement of physical circumstances, the provision of behavioural support, and the provision of financial incentives should be the primary focuses of managers and organisations in order to improve employee performance.

Machine learning models

Several different methods of machine learning were utilised by the researchers. These methods included Random Forest, K-Nearest Neighbourhood, and Logistic regression. It is possible to determine the accuracy score of each model.

Logistic regression

The hyperparameter C=5 and random_state=0 were the ones that we decided to use, despite the fact that it is normally unnecessary to make any changes to the hyperparameter in Logistic Regression. There is a possibility that the C parameter, which controls the severity of the penalty, can be advantageous because it guarantees consistent outcomes when a random process is utilised. This model achieves an accuracy of 67.8% after being trained on the standard dataset during its training course.

K-nearest neighbors (K-NN)

In this section, the performance of the model that was utilised in this investigation is evaluated based on a variety of performance criteria, including accuracy, recall, precision, and F1-score, among others. Random Forest was the machine learning model that achieved the best accuracy, which was 98.2%, among the numerous models that were analysed. Furthermore, the Gaussian naive Bayes model earned the lowest accuracy score, which was sixty-one point four percent. There were several models that earned accuracy ratings that were lower than 100%, but they still managed to maintain accuracy levels that were higher than 80%.

In order to compare the accuracy scores of three different machine learning models, a bar chart is utilised. These models are K-Nearest Neighbours (KNeighbors), Logistic Regression, and Random Forest. An approach to understanding it is as follows: It is

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estimated that KNeighbors (shown by the blue bar) has an accuracy score of roughly 0.63, which is somewhat higher than 0.6. It is estimated that Logistic Regression (Green Bar) has an accuracy score of roughly 0.68, which is higher than the value that KNeighbors was given. The accuracy score of the Random Forest model, which is represented by the red bar, is roughly 0.67. This number is slightly superior to that of the logistic regression model, but it is not quite as close as it could be. Among the three models, the Logistic Regression model earns the greatest accuracy score, with Random Forest coming in a close second. The K-Nearest Neighbours algorithm has the lowest accuracy score out of the three systems.

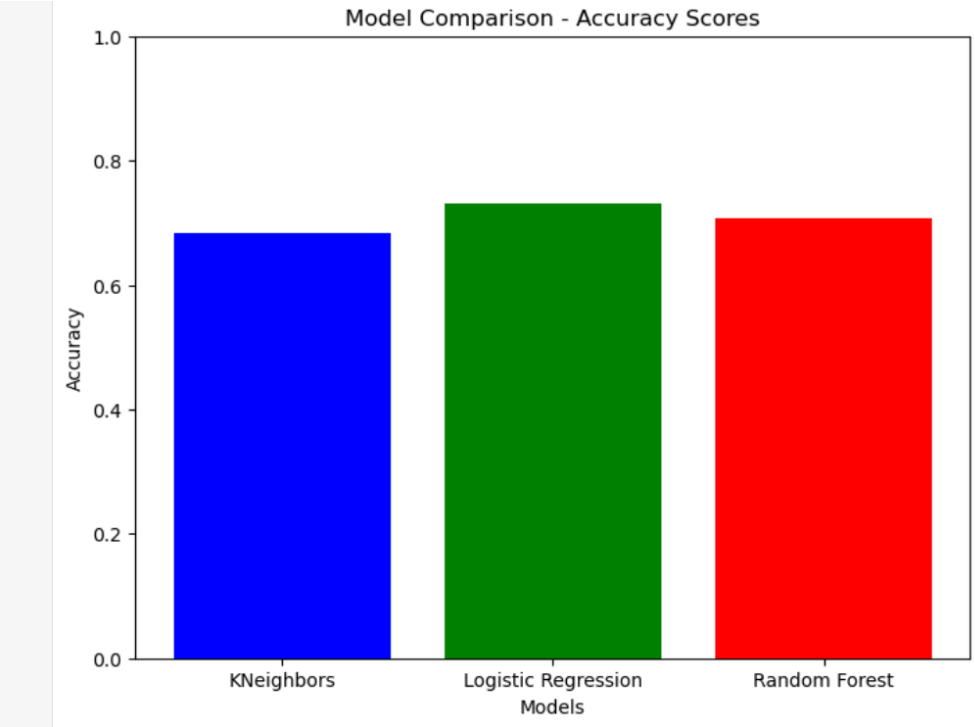

Fig 2: Accuracy % of different ML Models

DISCUSSION

The purpose of this endeavour was to establish a structure that would allow for the objective prediction of future employee performance. A total of seven different machine learning models were utilised. All of the factors that influence job success, whether they be physical, social, or behavioural, as well as financial, were taken into consideration by these models.

Logistic regression, random forest, and k-nearest neighbours (K-NN) were the methods that were utilised in the training of the later models investigated in this study. A satisfactory level of accuracy was obtained by each and every model. A recommended ensemble ranker method as well as the standard machine learning methodology has both been observed to be capable of predicting employee performance through its use.

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According to the findings of the study, the ranker approach earned the highest accuracy score of 96.25%, while the artificial neural network managed to get the lowest score of 87.08%. The Random Forest algorithm achieved the highest accuracy score, which was 68.3%, when it came to predicting employee productivity.

Within the scope of this investigation, the dependent variable consisted of employee performance ratings. On the other side, the independent factors included things like job-related experience, employee credentials and experience, social and environmental elements, economic concerns, and satisfaction in the workplace. Out of all of these factors, the relationships between employee performance evaluations and age, space, work-life balance, family time, tension at work, work experience, training facility, willingness to change, and compensation increment features were the ones that were the most robust. The results of this study demonstrated that it is possible to make objective predictions about employee performance ratings by utilising machine learning.

Critical Implications

This evaluation of employee performance can serve as a guide for decision-makers when they make decisions on employee promotions, career development, training requirements, and other HRM-related matters. Machine learning can be utilised by any firm to estimate future employee performance. All that is required is the inclusion of some of the employee data that demonstrates the essential components that are discussed in this paper.

Using this strategy, businesses have the potential to readily obtain objective evaluations of the performance of their employees through the utilisation of machine learning. The conclusions of this study are based on the assumption that they will be beneficial to any firm since they provide a novel technique to obtaining objective employee performance evaluations that are free of bias.

By having this information, human resources will be able to make more objective decisions on the training requirements, employee career development, and promotion rules. The availability of qualified human resources is vitally necessary for both a corporation and a nation, and these options are completely necessary for both.

Overall outcomes of the research

This study collected data from both the employer and the employee by means of a questionnaire and the employee's record within the business. The purpose of this study was to develop an objective method for predicting the future performance of an employee that would be more accurate. Additionally, the performance of an employee was evaluated with regard to considerations of social, financial, and ecological factors. In today's world, every contemporary business makes use of artificial intelligence in order to enhance the precision and precision of their forecasts and decision-making processes. Consequently, the purpose of this study was to apply machine learning models in order to forecast the future job performance of employees.

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CONCLUSION

To summarise, the performance of the company's personnel is a significant factor in determining the company's potential to continue to develop and thrive, as well as the path it will take in the future. Over the course of this work, numerous external factors (social, economic, and physical) that are pertinent to the life of an employee have been incorporated in order to evaluate and project their performance in a fair manner. The purpose of this project is to develop a system for making ethical decisions that is based on artificial intelligence and has an algorithmic foundation. The framework will take into consideration the various environmental factors that have an impact on worker performance, including those that are physical, social, and economical in nature.

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