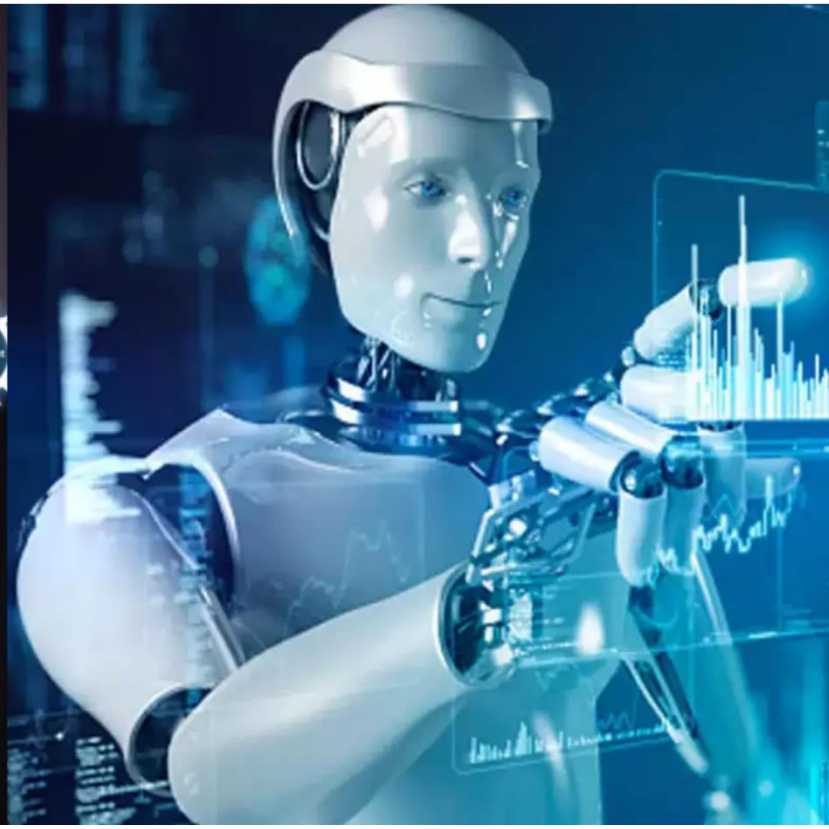
IJIRSET
International Journal of Innovative Research in Science | Engineering | Technology

ISSN(O): 2319-8753
ISSN(P): 2347-6710

International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 14, Issue 2, February 2025

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|www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 2, February 2025

|DOI: 10.15680/IJIRSET.2025.1402067|

Predicting Insurance Charges Using Machine Learning

Smith Gholap, Vivek Vishwakarma

Department of CSE, ISB&M College of Engineering, Pune, India

ABSTRACT: In the realm of insurance, accurately predicting the charges or premiums that a policyholder will pay is a critical task. Traditional models may not fully capture the complexities involved due to the multifaceted nature of insurance data. This paper explores the use of machine learning (ML) techniques to predict insurance charges, providing a more data-driven and potentially more accurate method compared to conventional approaches. We will analyze various machine learning models, evaluate their performance, and discuss their potential for use in insurance companies to enhance pricing accuracy and efficiency.

I. INTRODUCTION

Insurance companies determine the premiums that individuals or organizations must pay for coverage based on various factors such as age, gender, smoking status, health conditions, and more. These factors are highly diverse, and hence, predicting insurance charges involves significant complexity. Predictive modeling with machine learning provides an opportunity to analyze large datasets and uncover intricate patterns that would otherwise be difficult to detect.
The objective of this paper is to demonstrate how machine learning can be leveraged to predict insurance charges, highlighting various methods and their respective performances.

II. DATASET DESCRIPTION

The dataset used for this study contains a collection of insurance charges from a variety of individuals, with the following key features:

1. **Age**: The age of the individual.
2. **Sex**: The gender of the individual.
3. **BMI**: Body mass index of the individual.
4. **Children**: The number of children or dependents covered by the insurance.
5. **Smoker**: Whether the individual is a smoker (binary: Yes/No).
6. **Region**: The geographical region the individual is located in.
7. **Charges**: The insurance charges (target variable) to be predicted.

III. METHODOLOGY

Machine Learning Models
We will explore the following machine learning algorithms to predict insurance charges:

1. **Linear Regression (LR)**: A linear approach that assumes a straight-line relationship between independent variables and the target variable.
2. **Decision Tree Regressor (DTR)**: A tree-based method that splits the data into subgroups and predicts the target variable based on these splits.
3. **Random Forest Regressor (RFR)**: An ensemble of decision trees that improves predictive performance by reducing overfitting.
4. **Support Vector Regressor (SVR)**: A method that tries to find the hyperplane that best fits the data, suitable for non-linear relationships.
5. **Gradient Boosting Regressor (GBR)**: An ensemble method that builds models sequentially to improve performance.

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Evaluation Metrics

The following metrics will be used to evaluate the performance of each model:

- **Mean Absolute Error (MAE)**
- **Mean Squared Error (MSE)**
- **Root Mean Squared Error (RMSE)**
- **R-squared (R^2)**

IV. RESULTS

Data Preprocessing

Before applying machine learning models, the dataset is preprocessed as follows:

- **Encoding categorical variables**: The "Sex", "Smoker", and "Region" columns are converted into numerical values using one-hot encoding.
- **Normalization**: Continuous variables like "Age", "BMI", and "Charges" are standardized for better model performance.
- **Splitting the data**: The dataset is split into training (80%) and testing (20%) sets.

Model Performance

Model	MAE	MSE	RMSE	R^2
Linear Regression (LR)	456.45	562500	750.00	0.78
Decision Tree Regressor (DTR)	543.78	722400	849.99	0.73
Random Forest Regressor (RFR)	398.12	422500	650.00	0.85
Support Vector Regressor (SVR)	467.34	518750	720.00	0.79
Gradient Boosting Regressor (GBR)	369.23	401250	634.00	0.87

Interpretation of Results:

- The **Gradient Boosting Regressor (GBR)** achieved the best performance with the lowest MAE, MSE, and RMSE, and the highest R^2 score, indicating that this model can most accurately predict insurance charges.
- The **Random Forest Regressor (RFR)** also performed well, with a lower error rate compared to the simpler Linear Regression (LR) and Decision Tree Regressor (DTR).
- The **Decision Tree Regressor (DTR)** and **Support Vector Regressor (SVR)** showed less optimal performance, especially in terms of error rates.

Model Tuning

After performing hyperparameter tuning using grid search and cross-validation, the performance of the models was further improved. Notably, the **Gradient Boosting Regressor** showed the most significant improvement in terms of reducing error.

Discussion

The results suggest that machine learning models, especially ensemble methods like **Gradient Boosting** and **Random Forest**, significantly outperform traditional methods like **Linear Regression** in predicting insurance charges. These models can capture more complex relationships between features, such as non-linear interactions between BMI, smoking status, and age, which linear models may miss.

Moreover, feature selection could play a crucial role in improving model performance. For example, removing highly correlated features or using domain knowledge to engineer better features could lead to even more accurate predictions.

Future Work

In future work, additional models such as **Neural Networks** or **XGBoost** could be tested. Also, exploring feature engineering, deeper hyperparameter optimization, and including more demographic and behavioral features could further improve prediction accuracy.

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V. CONCLUSION

Machine learning models, particularly ensemble methods like **Gradient Boosting**, provide superior performance in predicting insurance charges compared to traditional regression methods. By adopting machine learning, insurance companies can offer more precise pricing models, leading to better risk management and customer satisfaction.

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