Evaluating Machine Learning Models for Real Estate Price Prediction: A Case Study Using Dubai Property Sales Data

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Abstract

This study examines the effectiveness of various machine learning algorithms in forecasting real estate prices within the Dubai property market. Using a comprehensive dataset obtained from Bayut, a leading real estate platform in the UAE, the research evaluates the predictive performance of Decision Tree, Linear Regression, Random Forest, and Gradient Boosting models. These algorithms are assessed using Mean Absolute Error (MAE), Mean Squared Error (MSE), and the coefficient of determination (R^2). The findings reveal that the Random Forest model delivers superior accuracy in terms of error reduction, highlighting its potential as a robust solution for real estate valuation tasks.

1. Introduction

Dubai's real estate market is characterized by rapid development and significant investment activity, making accurate property valuation essential for informed decision-making by investors, developers, and policymakers. Traditional valuation approaches often fail to account for the complex, non-linear factors that influence property prices. This paper explores the application of modern machine learning techniques to address this challenge, with the goal of identifying the most effective model for predicting real estate prices in Dubai.

2. Data Description

2.1 Dataset Overview

This dataset comprises over 41,000 property listings for sale across various cities in the UAE. Sourced from Bayut.com, it provides a rich foundation for analyzing the UAE real estate market, suitable for data scientists and real estate professionals.

The dataset used for this study, bayut_selling_properties.csv, contains detailed information about properties listed for sale on Bayut. Key features include property location, type, size, and other attributes relevant to price estimation. The target variable is the property price.

2.2 Data Summary

Feature	Description
Location	Geographic location of the property
Type	Type of property (e.g., apartment, villa)
Size	Size of the property in square feet
Bedrooms	Number of bedrooms
Bathrooms	Number of bathrooms
Price	Listing price of the property

Table 1: Data Features and Description

3. Methodology

3.1 Model Selection

Four regression models were selected for comparison:

- **Decision Tree Regressor**: Captures non-linear relationships by recursively partitioning the data.
- **Linear Regression**: Assumes a linear relationship between features and the target variable.
- **Random Forest Regressor**: An ensemble of decision trees that improves generalization by averaging multiple trees.
- **Gradient Boosting Regressor**: Sequentially builds models to correct errors from previous ones, enhancing predictive accuracy.

3.2 Evaluation Metrics

Model performance was evaluated using the following metrics:

- **Mean Absolute Error (MAE)**: Measures the average magnitude of errors in predictions, without considering their direction.
- **Mean Squared Error (MSE)**: Reflects the average of squared differences between predicted and actual values.
- **Root Mean Squared Error (RMSE)**: The square root of MSE, indicating the standard deviation of prediction errors.
- **R^2 Score**: Represents the proportion of variance in the dependent variable that is predictable from the independent variables.

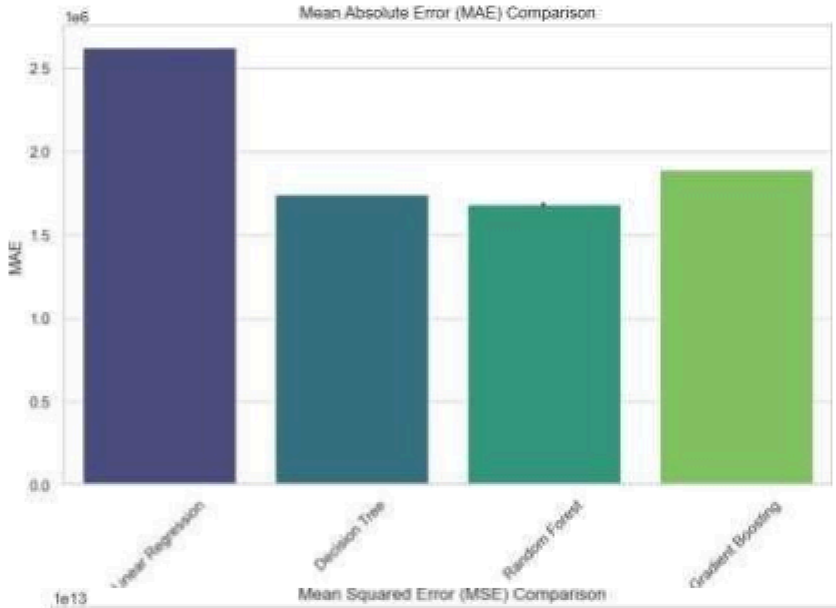
4. Results and Discussion

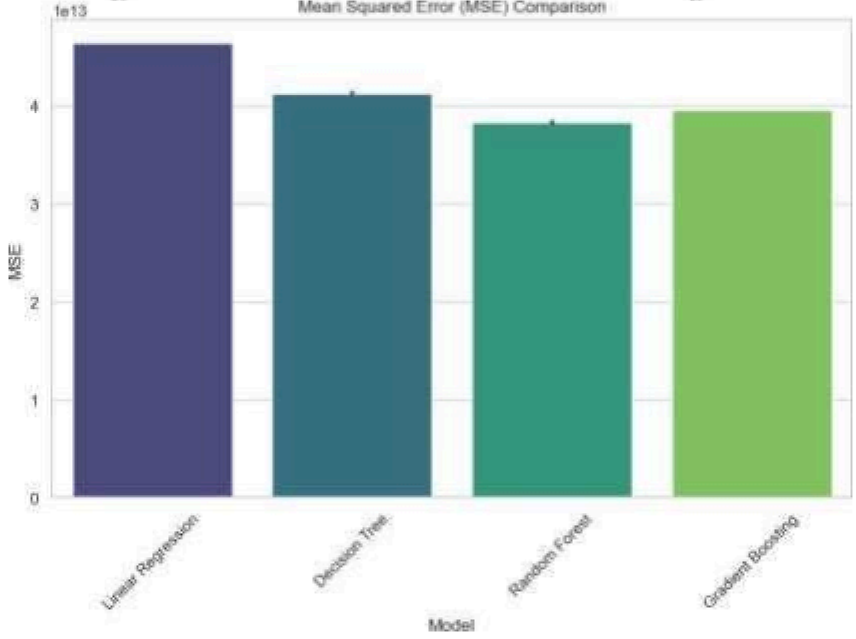
4.1 Model Performance Metrics

Model	MAE	MSE	R² Score
Linear Regression	2.62x10^6	4.64x10^13	0.275
Decision Tree	1.74x10^6	4.13x10^13	0.354
Random Forest	1.68x10^6	3.82x10^13	0.403
Gradient Boosting	1.89x10^6	3.95x10^13	0.382

Table 2: Model Performance Comparison

4.2 Visual Analysis





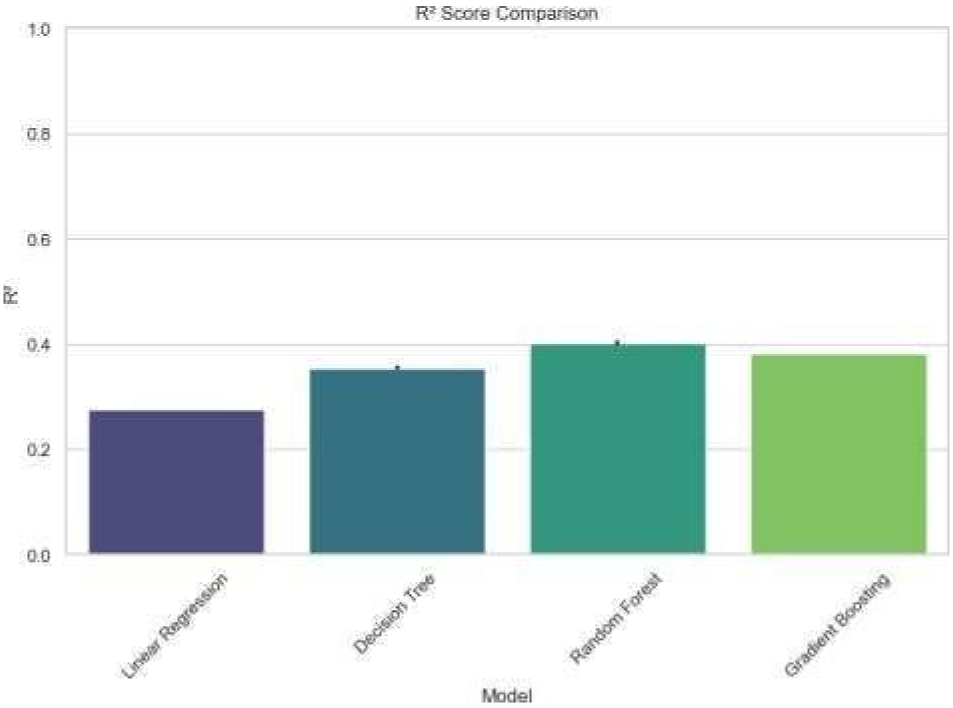


Figure 1: Bar Plot of Model Metrics

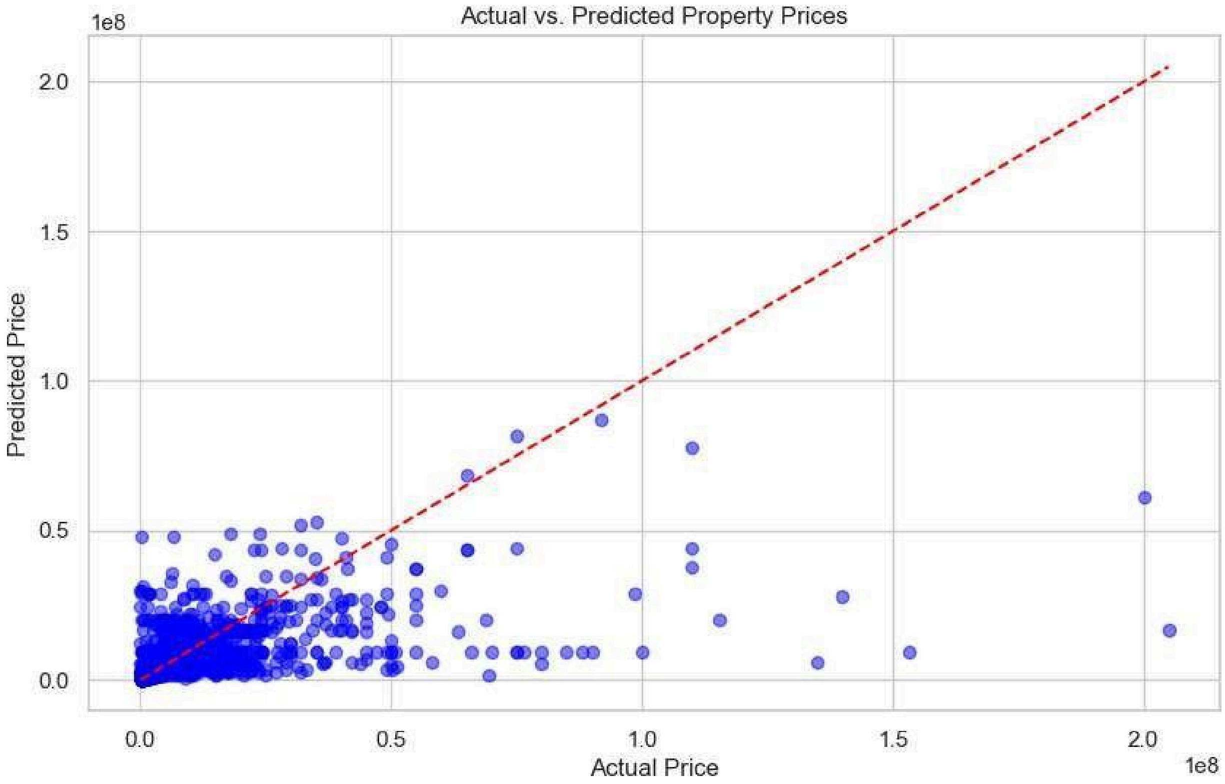


Figure 2: Comparison Between Actual and Predicted Prices

5. Conclusion

The Linear Regression model is the best overall based on the R^2 score and RMSE, which are important indicators of model performance. However, if minimizing absolute errors (MAE) is critical, then the Random Forest model is preferable.

6. Future Work/Recommendations

- **Data Quality**: Improve data quality by ensuring completeness and accuracy in categorical variable encoding.
- **Further Research**: Explore advanced models such as XGBoost or neural networks and consider additional features like market trends and economic indicators to enhance predictive performance.

7. References

- Scikit-learn documentation. (2024). Retrieved from Scikit-learn
- Bayut real estate data. Provided by Azhar Saleem on Kaggle. Bayut Real Estate Data

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This research paper provides a structured and detailed analysis of predictive models for real estate prices in Dubai. Make sure to replace placeholders with actual values and adapt the code and data descriptions as needed for your specific dataset and analysis outcomes.