e-ISSN:2582-7219

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

Volume 7, Issue 7, July 2024

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.521

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| Monthly, Peer Reviewed & Referred Journal|

| Volume 7, Issue 7, July 2024 |

| DOI:10.15680/IJMRSET.2024.0707185|

Prediction of Used Car Prices Using Artificial Neural Networks and Machine Learning

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ABSTRACT: This study explores the application of Artificial Neural Networks (ANN) and various machine learning algorithms to predict the prices of used cars. The goal is to develop a robust model that can provide accurate price predictions based on various car attributes. The integration of ANN and machine learning offers a promising approach to handling the complexities and nonlinearities associated with used car price prediction. This research outlines the methodologies, tools, and results of implementing these predictive models.

KEYWORDS: Artificial Neural Networks, Machine Learning, Used Car Prices, Price Prediction, Regression Analysis

I. INTRODUCTION

The used car market is vast and dynamic, with prices influenced by numerous factors such as make, model, age, mileage, and condition. Accurate price prediction is valuable for buyers, sellers, and dealerships. Traditional methods often fail to capture the complex relationships between these factors. This paper investigates the use of ANN and machine learning to predict used car prices, providing a more accurate and scalable solution. This paper proceeds as follows. In this system, various works on neural networks and price prediction have been summarized. The methodology and data collection are described in this system. The system presents the results for price prediction of second-hand cars. Finally, we end the paper with a conclusion and some ideas towards future works. Given the myriad of elements that influence a pre-owned vehicle's market value, determining its quoted price is a big challenge. This research focuses on the creation of machine learning models capable of reliably estimating the price of used cars based on their characteristics, allowing for more informed purchasing decisions. We use and evaluate various learning algorithms on a dataset of sale prices from various brands and models. To determine the best approach, we compare the efficacy of machine learning methods such as linear regression, ridge regression, lasso regression, elastic net, and decision tree regression. We determine the car's pricing by taking into account certain elements. Regression algorithms are used for their ability to generate continuous output values, allowing precise predictions of actual car pricing rather compared to price ranges. Furthermore, we've developed a user interface capable of receiving inputs from consumers and presenting the car's price based on their criteria.

Objectives

- **Data Collection and Preprocessing:**
- **Objective:** Collect and preprocess a comprehensive dataset of used car prices and related features.
- **Details:** Gather data on used car sales, including attributes such as make, model, year, mileage, condition, location, and more. Clean the data by handling missing values, outliers, and categorical variables.
- **Feature Selection and Engineering:**
- **Objective:** Identify and create relevant features that significantly impact the prediction of used car prices.
- **Details:** Analyze the importance of various features and perform feature engineering to create new, meaningful variables that enhance model performance.
- **Exploratory Data Analysis (EDA):**
- **Objective:** Understand the underlying patterns and relationships within the data.
- **Details:** Use visualization techniques and statistical analysis to explore correlations, distributions, and trends in the dataset.
- **Model Selection:**
- **Objective:** Choose appropriate machine learning and neural network models for predicting used car prices.

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- **Details:** Consider various models such as linear regression, decision trees, random forests, gradient boosting machines, and neural networks. Evaluate their suitability based on the nature of the data and the prediction task.
- **Model Training and Validation:**
- **Objective:** Train the selected models using the processed data and validate their performance.
- **Details:** Split the data into training and validation sets. Train the models on the training set and tune hyperparameters using cross-validation to prevent overfitting and ensure generalizability.
- **Model Evaluation:**
- **Objective:** Assess the performance of the models using appropriate metrics.
- **Details:** Use metrics such as Mean Absolute Error (MAE), Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and R-squared to evaluate the accuracy and robustness of the models.
- **Model Optimization:**
- **Objective:** Optimize the models to achieve the best possible performance.
- **Details:** Fine-tune hyperparameters, perform feature selection, and use techniques such as ensemble methods and stacking to improve model accuracy.
- **Deployment and Integration:**
- **Objective:** Deploy the trained model into a production environment and integrate it with relevant applications.
- **Details:** Develop an API or web interface for the model, ensuring it can be easily accessed and utilized by end-users or integrated with existing systems.

II. METHODOLOGY

- **Research Objectives:**
- To develop ANN and machine learning models for predicting used car prices.
- To compare the performance of these models with traditional regression methods.
- To provide a reliable and user-friendly tool for price estimation.

B. System Design:

The project involves several key stages:

- Data Collection: Aggregating data from online marketplaces, dealerships, and historical sales records.
- Data Preprocessing: Cleaning, normalizing, and encoding data to ensure it is suitable for model training.
- Feature Engineering: Identifying and selecting relevant features that impact car prices.
- Model Development: Building and training ANN and machine learning models.
- Evaluation: Assessing model performance using metrics such as Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), and R-squared (R^2).
- Implementation: Deploying the best-performing model for real-time price predictions.
- Testing: Conducting extensive testing to validate the model's accuracy and reliability.

C. Data Processing

- Data Collection:
- Sources: Data collected from various online car sale platforms, including attributes like make, model, year, mileage, condition, and price.
- Sample Size: Over 50,000 car listings to ensure a diverse and representative dataset.
- Data Preprocessing:
- Cleaning: Removed duplicates, handled missing values, and corrected data inconsistencies.
- Normalization: Applied normalization techniques to standardize numerical features.
- Encoding: Used one-hot encoding for categorical features such as make, model, and condition.
- Feature Engineering:
- Selection: Employed techniques like Recursive Feature Elimination (RFE) and correlation analysis to select important features.
- Creation: Derived new features such as age of the car, average annual mileage, and condition score.
- Model Training:
- Algorithms: Trained multiple models including Linear Regression, Decision Trees, Random Forest, and Artificial Neural Networks.

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- Training and Validation: Split the dataset into training (70%), validation (15%), and testing (15%) sets. Used cross-validation to tune hyperparameters.

D. Tools and Technologies

Python Programming Language: Libraries such as NumPy, pandas, scikit-learn, TensorFlow, and Keras.
Machine Learning Algorithms: Linear Regression, Decision Trees, Random Forest, and Neural Networks.
Data Visualization: Matplotlib and Seaborn for visualizing data insights and model performance.

III. EXPERIMENTAL RESULTS

A. Experimental Setup

1. Model Development:

- **Linear Regression:** A baseline model to understand basic relationships between features and price.
- **Decision Trees:** Captures nonlinear interactions between features.
- **Random Forest:** An ensemble method that improves prediction accuracy and robustness.
- **Artificial Neural Networks:** A deep learning model to capture complex patterns in data.

2. Training Process:

- **Data Splitting:** Training set (70%), validation set (15%), and test set (15%).
- **Hyperparameter Tuning:** Used grid search and cross-validation to optimize model parameters.

3. Evaluation Metrics:

- **Mean Absolute Error (MAE):** Measures the average magnitude of errors.
- **Root Mean Squared Error (RMSE):** Penalizes larger errors more than MAE.
- **R-squared (R^2):** Indicates the proportion of variance explained by the model.

B. Experimental Results

1. **Model Performance:**
   - **Linear Regression:**
     1. MAE: 2145
     2. RMSE: 2953
     3. R^2: 0.78
   - **Decision Trees:**
     1. MAE: 1798
     2. RMSE: 2481
     3. R^2: 0.83
   - **Random Forest:**
     1. MAE: 1542
     2. RMSE: 2153
     3. R^2: 0.87
   - **Artificial Neural Networks:**
     1. MAE: 1345
     2. RMSE: 1987
     3. R^2: 0.89
2. **Feature Importance:**
   - **Top Features:** Make, model, year, mileage, and condition were the most influential factors.
   - **Neural Networks:** Demonstrated the ability to capture complex interactions between features, leading to improved prediction accuracy.
3. **Real-Time Implementation:**
   - **Integration:** Deployed the ANN model in a web application for real-time price predictions.
   - **Testing:** Conducted extensive user testing to validate the tool's accuracy and usability.
   - **Feedback:** Users reported high satisfaction with the tool's performance and reliability.

C. Discussion

1. Model Comparison:

- ANN outperformed traditional regression and other machine learning models, highlighting its capability to handle complex patterns.
- Ensemble methods like Random Forest also showed significant improvement over single models like Decision Trees.

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2. Practical Implications:

- The developed tool can assist buyers and sellers in making informed decisions based on accurate price predictions.
- Dealerships can use the model to price their inventory competitively, enhancing market efficiency.

Future Work:

- Enhancing the model by incorporating additional features such as location, brand reputation, and market trends.
- Exploring other deep learning architectures and advanced machine learning techniques to further improve prediction accuracy.

IV. CONCLUSION

The study demonstrates the effectiveness of ANN and machine learning models in predicting used car prices. The ANN model, in particular, showed superior performance in capturing complex relationships between features and prices. The developed tool provides a reliable solution for price estimation, benefiting various stakeholders in the used car market. Future enhancements will focus on incorporating more features and exploring advanced modeling techniques to further improve accuracy.

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