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Analysis of the Impact of Car Design on Sales Rate using CNN

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Abstract

The modern automobile industry is constantly evolving, and consumer preferences are significantly influenced by design aspects. This paper aims to analyze the impact of car design on sales using Convolutional Neural Network (CNN). For the study, images of the top 100 cars with the highest sales in 2022 were collected to extract powerful visual features. The trained CNN model identifies the correlation between specific elements of car design and sales, and constructs a predictive model. Additionally, the model is utilized to collect and analyze price and fuel efficiency data of the top 100 cars. This provides objective numerical data for comparing designs and evaluating the predictive results of the model reliably. The experimental results highlight the importance of design elements and are expected to offer insights into marketing strategies and product development in the automobile industry. Moreover, to verify the model's generalization capability, the predictive performance is evaluated using arbitrary car data, not from the top 100 cars with high sales in 2022. This is crucial for confirming the model's ability to categorize cars and predict sales within those categories.

Keywords

Car Design, Sales Prediction, CNN, Visual Features and Consumer Preferences,

1. Introduction

People consider various factors when buying a car, including price, design, weight, safety, and fuel efficiency. Among these, the impact of design on car purchase decisions is a curious subject, prompting this study Price is no longer the sole crucial factor, as customers now demand more features in their vehicles. Customer preferences have evolved, with factors like image and practicality taking precedence over traditional considerations like environmentalism.
The purpose of this study is to analyze the impact of car design on sales and to predict the ideal car model that people are most likely to buy. This study aims to provide insights into the key features that influence consumer purchasing decisions in the passenger car market.

2. Background

Convolutional Neural Networks (CNNs) are a class of deep learning algorithms specifically designed for processing structured grid data such as images. The architecture of a CNN is inspired by the organization of the animal visual cortex, where individual neurons respond to stimuli only in a restricted region of the visual field, known as the

receptive field. This allows CNNs to effectively capture spatial hierarchies in images through a series of convolutional layers, each designed to detect different features such as edges, textures, and shapes.

A CNN typically consists of several key layers: the convolutional layer, the pooling layer, and the fully connected layer. The convolutional layer applies a set of filters (or kernels) to the input image, performing convolution operations to produce a set of feature maps. Each filter is designed to detect specific features in the image, such as edges or textures. The pooling layer then reduces the spatial dimensions of the feature maps, typically using operations like max pooling or average pooling, which helps to reduce the computational load and makes the detection of features invariant to minor translations and distortions. Finally, the fully connected layer takes the high-level feature maps produced by the convolutional and pooling layers and flattens them into a one-dimensional vector. This vector is then passed through one or more fully connected layers to perform the final classification or regression tasks. The final layer often uses a softmax activation function to output probabilities for each class in a classification problem.

To train a CNN, backpropagation and gradient descent are employed. During training, the CNN adjusts the weights of its filters to minimize the difference between its predictions and the actual labels in the training data. This is done by calculating the gradient of the loss function with respect to each weight and updating the weights in the opposite direction of the gradient. Advanced optimization techniques such as Adam, RMSprop, and momentum are often used to improve the efficiency and effectiveness of this learning process. Through this iterative training process, the CNN learns to recognize increasingly complex patterns and features in the input data, making it a powerful tool for image recognition and other tasks involving structured grid data.

3. Data analysis

For this analysis, we selected the top 100 cars with the highest sales rates in 2022. We created graphs to visualize the relationships between sales volume and price, as well as sales volume and fuel efficiency, using Python to generate scatter plots (Figure 1).

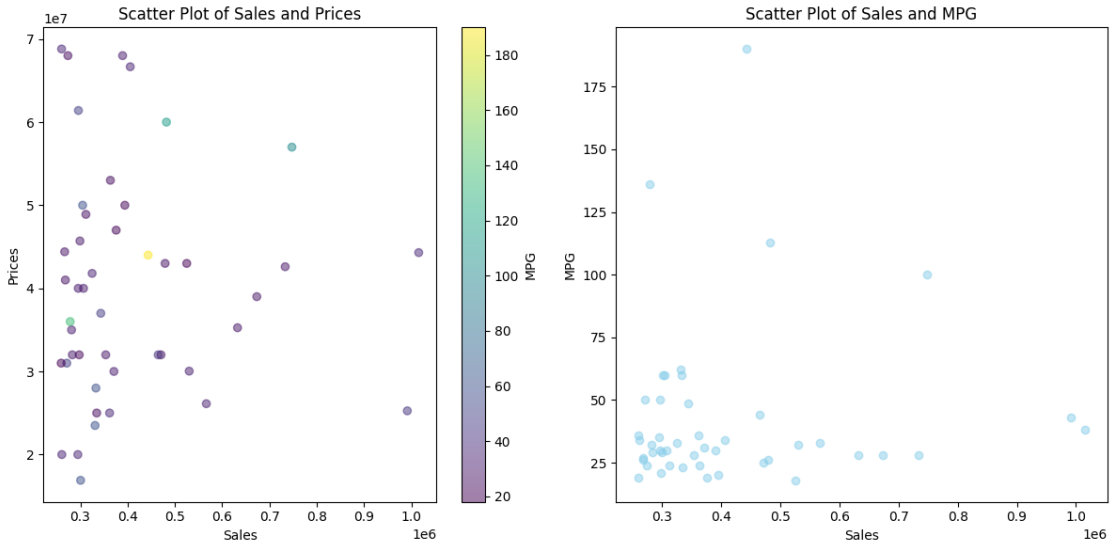

Figure 1. The left graph shows the relationship between sales volume and price.
The right graph shows the relationship between sales volume and fuel efficiency.

To facilitate comparison, and a scatter plot with a linear regression line was used for the sales volume vs. fuel efficiency graph (Figure 2).

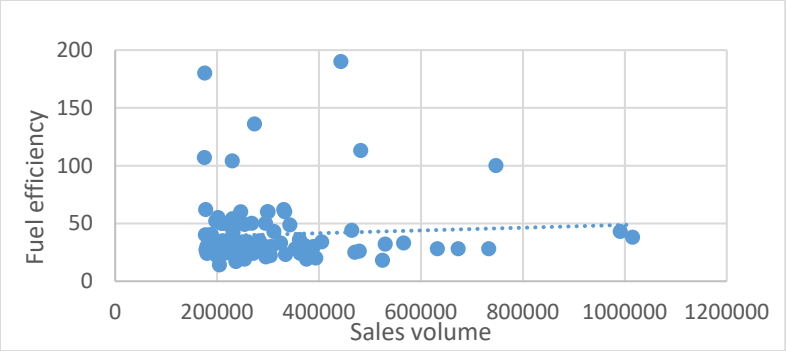

Figure 2. Scatter plot showing the relationship between sales volume and fuel efficiency.

4. Results

The results of our study on the impact of car design on sales provide valuable insights into the predictive capabilities of our model. While the model accurately predicted the sales volume for certain vehicles, such as the Jeep Grand Cherokee which had a sales volume of 264,444 units, it overestimated the sales volume for others, like the Honda Pilot which had a sales volume of 143,062 units.

This finding aligns with recent research which has demonstrated the efficacy of data-driven models in predicting new product demand in the automobile industry. The ability to accurately forecast sales is crucial for car manufacturers and dealerships, as it allows them to better align production, inventory, and marketing strategies to meet customer demand.

However, it is important to consider the limitations and challenges associated with using predictive models for car sales. As highlighted in the literature, the quality and accuracy of the training data is critical to the performance of these models. Additionally, there are potential ethical implications to consider, such as the risk of discriminatory practices if demographic data is used to inform the predictions.

Ultimately, the results of our study underscore the need for a nuanced and multifaceted approach to predicting car sales that takes into account not only design features, but also broader market trends, customer preferences, and ethical considerations (Figure 3 and Figure 4).

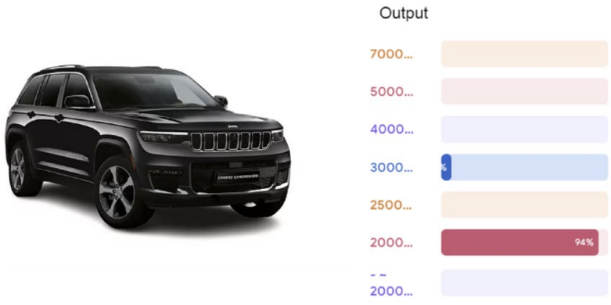

Figure 3. The model accurately predicted the sales volume of the Jeep Grand Cherokee, which had a sales volume of 264,444 units.

Figure 4. The model overestimated the sales volume for the Honda Pilot, which had a sales volume of 143,062 units.

6. Conclusion

This study analyzed the car sales data from 2022 using various data visualization and machine learning techniques. By visualizing the relationships between sales volume, price, and fuel efficiency, we identified key trends and insights. The use of CNNs allowed us to examine the impact of car design on sales performance, providing valuable predictions despite some limitations.

Our findings indicate that while price and fuel efficiency are significant factors influencing sales, the visual appeal of a car also plays a crucial role. The machine learning model demonstrated the potential for accurate sales predictions based on car design, although further refinement is needed to improve accuracy.

Overall, this research underscores the importance of integrating data visualization and advanced analytics in understanding market dynamics and making informed business decisions. Future work should focus on enhancing model accuracy and exploring additional features that impact car sales.

Reference

Aradhya, A. M., Ashfahani, A., Angelina, F., Pratama, M., de Mello, R. F., and Sundaram, S., Autonomous CNN (AutoCNN): A data-driven approach to network architecture determination. *Information Sciences*, 607, 638-653, 2022.

Arya, R., Khanduja, M., Rani, P. S., Pundhir, P., Tiwari, M., and Shelke, C. J., Empirical Analysis of Deep Learning for Big Data and Its Applications using CNN. *In 2022 2nd International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE)*. pp. 01-05, 2022.

Bisong, E., Optimization for Machine Learning: Gradient Descent. In: Building Machine Learning and Deep Learning *Models on Google Cloud Platform. Apress, Berkeley*, CA., 2019.

Chauhan, R., Ghanshala, K. K., and Joshi, R. C., Convolutional neural network (CNN) for image detection and recognition. *In 2018 first international conference on secure cyber computing and communication (ICSCCC)* (pp. 278-282). IEEE, 2018.

Duan, J., Chang, M., Chen, X., Wang, W., Zuo, H., Bai, Y., and Chen, B., A combined short-term wind speed forecasting model based on CNN–RNN and linear regression optimization considering error. *Renewable Energy,* 200, 788-808, 2022.

Eaves, Y. D., A synthesis technique for grounded theory data analysis. *Journal of advanced nursing*, 35(5), 654-663, 2001.

Erickson, M., MacDonald, E. F., and Long, M., Modeling Consideration Gives Strategic Design Insight for Addressing Diesel and Brand Perception. *In International Design Engineering Technical Conferences and Computers and Information in Engineering Conference*, Vol.50107, p.V02AT03A019. American Society of Mechanical Engineers, 2016.

Hafner, R. J., Walker, I., and Verplanken, B., Image, not environmentalism: A qualitative exploration of factors influencing vehicle purchasing decisions. *Transportation Research Part A: Policy and Practice,* 97, 89-105, 2017.

He, K., Zhang, X., Ren, S., and Sun, J., Deep residual learning for image recognition. *In Proceedings of the IEEE conference on computer vision and pattern recognition*, pp. 770-778, 2016.

Kaur, M., and Sandhu, H. S., Factors Influencing Buying Behaviour-A Study Of Passenger Car Market. *Paradigm,* 8(2), 26-30, 2004.

Kayalibay, B., Jensen, G., and van der Smagt, P. CNN-based segmentation of medical imaging data. *arXiv preprint arXiv*:1701.03056, 2017.

Messelodi, S., Modena, C. M., Zanin, M., De Natale, F. G., Granelli, F., Betterle, E., and Guarise, A., Intelligent extended floating car data collection. *Expert systems with applications*, 36(3), 4213-4227, 2009.

Rahman, M., Prodhan, R., Shishir, Y., and Ripon, S., Analyzing and evaluating boosting-based CNN algorithms for image classification. *In 2021 International Conference on Intelligent Technologies (CONIT),* pp. 1-6, 2021.

Song, J., Gao, S., Zhu, Y., & Ma, C., A survey of remote sensing image classification based on CNNs. *Big earth data*, 3(3), 232-254, 2019.

Taha, Z., Alli, H., and Abdul Rashid, S. H., Users' requirements and preferences in the success of a new product: a case study of automotive design. *Applied Mechanics and Materials*, 215, 484-488, 2012.

Biographies

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