Market Segmentation Analysis of Electric Vehicles Market in India

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Link : GitHub

Abstract

This study focuses on segmenting the electric vehicle (EV) market in India using machine learning techniques. Through Exploratory Data Analysis (EDA), Principal Component Analysis (PCA), and KMeans clustering, electric vehicles were grouped based on key features such as range, price, and acceleration. PCA reduced the dataset's complexity while preserving important variance, and KMeans revealed three distinct market segments, providing insights into consumer preferences. The analysis helps identify targeted strategies for manufacturers. Future work could involve acquiring more detailed data and exploring advanced clustering models to refine segmentation further, enhancing the understanding of the EV market in India. measures for their well-being. This application aims to fill this gap by providing a web application that leverages advanced machine learning algorithms to analyze a wide range of user inputs, including symptoms and medical data. The app predicts the likelihood of various diseases, offering users personalized health assessments and actionable insights. The app addresses the critical issue of delayed disease detection by making predictive healthcare accessible to everyone, thus encouraging a more proactive approach to personal well-being.

1. Problem Statement

The rapid growth of the electric vehicle (EV) market in India presents challenges for manufacturers in understanding and targeting diverse consumer preferences. The need for effective market segmentation based on key vehicle attributes like price, range, and performance is crucial for optimizing product offerings. This study aims to use machine learning techniques, including Principal Component Analysis (PCA) and KMeans clustering, to segment the Indian EV market and provide insights that can guide manufacturers in developing targeted strategies to better serve distinct consumer groups.

2. Introduction

- Overview of the Electric Vehicle (EV) Market in India
  - The electric vehicle (EV) market in India is rapidly evolving due to a combination of factors such as rising fuel costs, environmental concerns, and government initiatives promoting green energy. With increasing urbanization and a shift toward sustainable transportation, electric vehicles have become a key focus area for both consumers and manufacturers.
  - However, the EV market is diverse, with varying consumer needs based on factors like price sensitivity, performance, and environmental awareness. Hence, manufacturers must effectively segment the market to offer tailored products that cater to different consumer groups.

- Objective of the Analysis
  - The primary goal of this study is to segment the Indian EV market using data-driven insights derived from machine learning techniques. By applying Exploratory Data Analysis (EDA), Principal Component Analysis (PCA), and KMeans clustering, we aim to identify distinct groups of vehicles that reflect the preferences of different market segments. This segmentation will help manufacturers and stakeholders optimize their product offerings, marketing strategies, and supply chain management.
- Data Used
  - The dataset used for this analysis is ElectricCarData_Clean_Me, which contains information on various electric vehicle models. Key features included in the dataset are:
  - Range_Km: The maximum range of the vehicle on a full charge.
  - PriceEuro: The vehicle's price in Euros.
  - PowerTrain: The type of drivetrain (e.g., electric or hybrid).
  - AccelSec: Time taken by the vehicle to accelerate from 0 to 100 km/h.

3. Exploratory Data Analysis [EDA]

- Initial Insights from the Data
  - EDA was the first step in understanding the underlying structure of the data. By examining descriptive statistics, we gained insights into key features of the electric vehicle market. For example:
  - Range: Most vehicles have a range between 200 and 500 kilometers.
  - Price: The price distribution shows a wide spread, from budget-friendly models to high-end luxury vehicles.
  - Acceleration: The acceleration times vary significantly, reflecting the performance-oriented nature of some EVs compared to more economy-focused models.
- Data Cleaning and Preprocessing
  - Missing values were handled by either dropping rows with incomplete data or filling them using domain knowledge.
  - Numerical features like PriceEuro and Range_Km were standardized to ensure consistent scale during the clustering and PCA process.
- Visualization
  - Using visual tools such as bar plots, scatter plots, and histograms, we explored the relationships between key features. Some key visualizations included:
  - Price vs. Range: Higher-priced vehicles generally offer better range, though some budget-friendly models also provide decent performance.
  - Powertrain vs. Acceleration: Electric powertrains tend to offer better acceleration compared to hybrids.
- Insights from Visualization
  - Vehicles in the high price segment usually provide a balance of both range and acceleration, while budget models often sacrifice performance.
  - There is a visible divide between premium and economy segments, which became the basis for further clustering analysis.

4. KMeans Clustering

- Choice of Algorithm
  - KMeans clustering was chosen for market segmentation because it is an efficient, unsupervised learning algorithm that finds natural groupings in the data based on the distance between points in feature space. The PCA-reduced dataset provided an ideal platform for clustering since it minimized redundancy in the data.
- Clustering Process
  - Using the Elbow Method, we determined that three clusters provided the optimal segmentation for this dataset. These clusters were generated using key vehicle attributes like Range_Km, AccelSec, and PriceEuro.
- Visualization of Clusters
  - The clusters were visualized in the PCA space, showing clear separation between distinct groups of vehicles:
  - Cluster 1: High-end electric vehicles with a long range and fast acceleration.
  - Cluster 2: Mid-range EVs offering a balance of price, range, and performance.
  - Cluster 3: Budget-friendly vehicles with lower range and performance but affordable prices.
- Cluster Interpretation
  - Cluster 1: Represents luxury EVs, often priced above INR 4,000,000 with top-tier range and acceleration.
  - Cluster 2: Consists of vehicles aimed at the middle market, balancing affordability with decent range.
  - Cluster 3: Includes economy EVs, catering to budget-conscious consumers.
- Insights Gained from Clustering
  - The segmentation shows clear market differentiation between luxury, mid-tier, and budget electric vehicles.
  - Manufacturers can target Cluster 1 for high-income consumers, Cluster 2 for the urban middle class, and Cluster 3 for price-sensitive buyers.

5. Final Conclusions and Insights

- Key Takeaways from the Analysis: The study revealed that the Indian EV market can be segmented effectively based on price, range, and acceleration. These segments are critical for manufacturers looking to target specific customer groups. PCA helped simplify the data, and KMeans clustering revealed three clear segments, providing valuable insights for product development and marketing strategies.
- Segmentation Strategy : EV manufacturers can leverage this segmentation to optimize their product lines and marketing campaigns. For instance:
- Luxury segment (Cluster 1): Focus on high-end features like superior range and fast acceleration.
- Mid-tier segment (Cluster 2): Offer vehicles with a balance of performance and price.
- Budget segment (Cluster 3): Emphasize affordability and practicality.

6. Future Improvements for the Market Segmentation Project

- Data Collection : With additional time and budget, more granular data could be collected to improve the segmentation:
  - Battery Life: Information on battery durability and lifecycle.
  - Charging Infrastructure Availability: Data on the presence of charging stations in different regions.
  - Customer Preferences: Survey data capturing consumer opinions and preferences.
- Additional ML Models
  - Gaussian Mixture Models (GMM): To allow for probabilistic (soft) clustering, providing more nuanced segmentation.
  - DBSCAN: To identify clusters with non-linear shapes, useful for finding outlier vehicles like ultra-luxury EVs.

7. Market Size of EV Market in India

- Estimated Market Size
  - As of 2024, the Indian EV market is expected to grow significantly, with estimates suggesting that the number of electric vehicles will surpass 4 million units by 2030. The market is driven by government incentives, rising fuel costs, and growing environmental awareness.
- Global Context
  - Compared to global leaders like China and the U.S., the Indian market is still emerging. However, with an expected annual growth rate of 36%, India is poised to become one of the largest EV markets globally in the next decade.

8. Top 4 Variables/Features for Optimal Market Segmentation

- Price: A crucial differentiator across luxury, mid-range, and budget segments.
- Range (Km): Determines vehicle usability and appeal to consumers.
- Acceleration (Sec): Particularly important for performance-driven buyers.
- PowerTrain Type: Differentiates between fully electric and hybrid models.

9. Conclusion

The analysis highlights the importance of market segmentation in the Indian EV market. By leveraging machine learning techniques like PCA and KMeans clustering, manufacturers can identify distinct consumer groups and tailor their products accordingly. Future improvements could involve more detailed datasets and the use of advanced models to enhance segmentation.