

Title: Analyzing Customer Engagement with Promotional Offers Using Machine Learning: A Case Study of Starbucks Rewards Data

Abstract

This paper presents an analysis of customer engagement with promotional offers using the Starbucks Rewards mobile app dataset. The dataset includes transaction, demographic, and offer data that reflect user interactions with various promotional offers. The primary objective of this study is to predict customer responses to different types of offers—Buy-One-Get-One (BOGO), discounts, and informational messages—by integrating and analyzing data from multiple sources. This study employs various data preprocessing techniques, feature engineering, and machine learning models to derive insights and build predictive models that assess customer behavior based on demographic attributes and offer characteristics.

Introduction

Promotional offers are a critical tool for businesses to drive customer engagement and increase sales. The effectiveness of these offers often varies based on customer demographics and preferences. The Starbucks Rewards dataset provides a unique opportunity to explore customer behavior in response to different types of promotional offers. The dataset contains information about offers received, viewed, and completed by customers, along with demographic data such as age, gender, income, and membership tenure. By analyzing these data, we aim to identify patterns in customer responses to different types of offers and build predictive models that can help in personalizing future marketing strategies.

Data Overview

The dataset comprises three main components:

1. **Portfolio Data:** Contains information about the offers, including the offer type (BOGO, discount, informational), the channels through which the offer was sent (email, mobile, social, web), and the offer's validity period.
2. **Profile Data:** Includes demographic information about the customers, such as age, gender, income, and the date they became a member of the Starbucks Rewards program.
3. **Transcript Data:** Tracks customer interactions with the offers, including the events of offer received, offer viewed, and offer completed, along with transaction details.

Data Preprocessing

Data preprocessing is a crucial step in preparing the dataset for analysis and modeling. Several preprocessing techniques were applied:

- **Data Cleaning:** Missing values were handled, and erroneous data, such as unrealistic ages (e.g., over 115 years), were identified and addressed.
- **Feature Engineering:** The channels column in the portfolio data was expanded into multiple binary columns to indicate whether each channel was used for a given offer. Similarly, the event column in the transcript data was transformed using one-hot encoding to create binary indicators for different events.
- **Merging Datasets:** The three datasets were merged based on common identifiers, such as customer ID and offer ID, to create a comprehensive dataset that captures the interactions between customers and

offers.

Exploratory Data Analysis (EDA)

Exploratory data analysis was conducted to uncover patterns and trends in the dataset:

- **Demographic Insights:** The age distribution revealed that most users are middle-aged, with a notable outlier group having ages greater than 115. The income distribution showed that the typical user falls within the middle-income group, with an average income around \$64,337.
- **Offer Engagement:** Analysis of the offer-received, offer-viewed, and offer-completed events highlighted the popularity of different offer types. BOGO offers had the highest viewership and completion rates, indicating strong customer interest in these promotions.

Modeling Approach

Two neural network models were built to predict customer responses to promotional offers. The models were evaluated based on their accuracy and loss values.

1. Model 1: Baseline Neural Network

- This model consisted of three dense layers with 6 neurons each and ReLU activation functions, followed by an output layer with softmax activation for multi-class classification.
- The model achieved an accuracy of approximately 45.23%, suggesting moderate predictive capability but also indicating room for improvement.

2. Model 2: Enhanced Neural Network

- A more complex neural network was designed with four hidden layers, starting with 32 neurons and gradually reducing to 6 neurons in the final hidden layer. The output layer used softmax activation.
- Despite the increased complexity, the model's accuracy remained similar to the baseline model, highlighting the need for further refinement in feature selection or model architecture.

Discussion

The models' performance indicates that customer responses to offers are influenced by a combination of factors, including demographics and offer characteristics. However, the relatively modest accuracy suggests that more sophisticated modeling techniques, such as hyperparameter tuning or ensemble methods, may be necessary to capture the nuances of customer behavior. Additionally, the use of more advanced feature engineering techniques, such as interaction terms or non-linear transformations, could improve the models' predictive power.

Conclusion

This study provides insights into customer engagement with promotional offers on the Starbucks Rewards mobile app. The findings suggest that demographic factors, such as age and income, play a significant role in determining customer responses to different types of offers. While the initial models show promise, further refinement is needed to enhance their predictive accuracy. Future work could explore more advanced machine learning techniques and alternative model architectures to better capture the complexities of customer behavior in response to promotional offers.

Future Work

Future research could focus on:

- **Hyperparameter Tuning:** Experimenting with different neural network architectures and optimization algorithms to improve model performance.
- **Advanced Feature Engineering:** Incorporating interaction terms, polynomial features, or domain-specific knowledge to create more informative features.
- **Alternative Modeling Approaches:** Exploring other machine learning models, such as gradient boosting or random forests, which may offer better performance on this dataset.

This analysis demonstrates the potential of data-driven approaches in personalizing marketing strategies and optimizing customer engagement through targeted offers.