Optimizing Retail with Time-Based Insights and Machine Learning in Online Grocery

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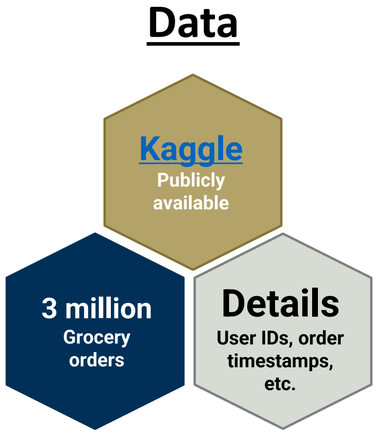
Motivation/Introduction

- Online shopping, especially in groceries, lacks consideration for the timing of customer purchases.
- Enhancing retail experiences with time-based recommendation systems fills a crucial gap, enabling retailers to optimize prices, manage stock, and offer consumers timely recommendations, thus improving overall satisfaction.

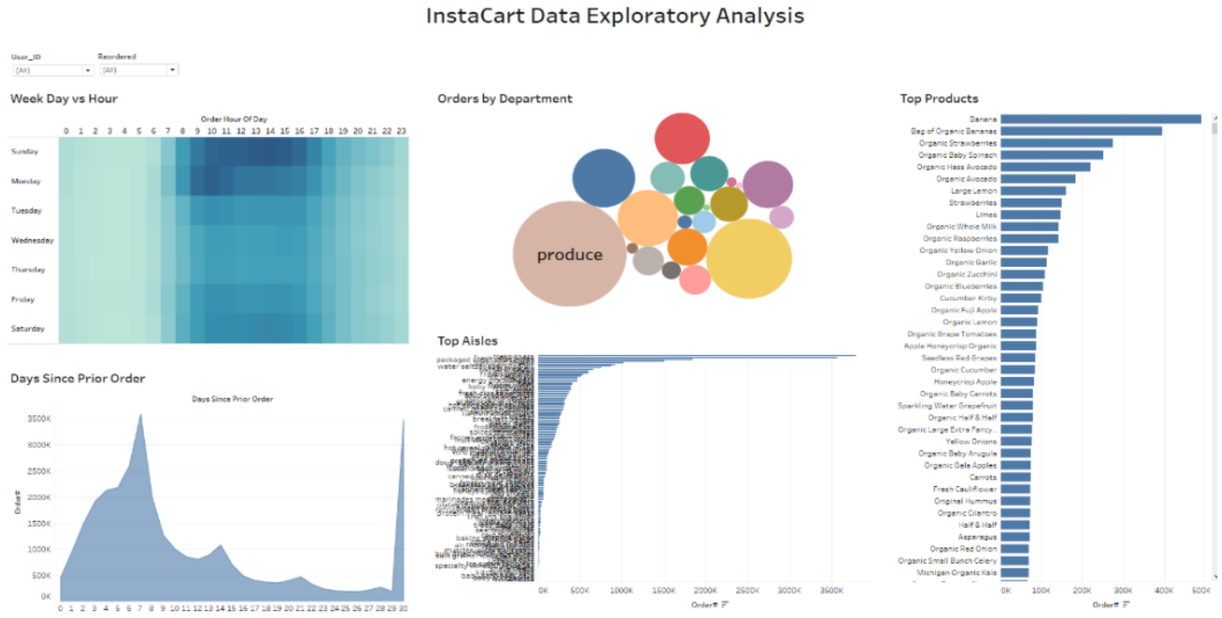
Data



Approaches

- Utilizing machine learning models and an interactive visualization tool (Tableau and Dash).
- Machine learning models analyze historical data to predict customer behavior and optimize shopping times. The visualization tool offers insights into customer clustering, personalized recommendations, and inventory management based on temporal shopping patterns.
- The models leverage historical purchasing patterns to predict future behavior, while the visualization tool provides a comprehensive view, enabling retailers to optimize strategies based on temporal insights.
- Incorporating temporal aspects into recommendation systems and providing an interactive tool that integrates customer profiling, smart cart features, and dynamic inventory management based on time.

Exploratory Data Analysis



Interactive Tool

The welcome page contains the title of our dashboard "Time-Based Smart Product Recommendation" with the Instacart logo positioned on the top right and a decorative picture of grocery goods at the bottom. The blue button "Got to Your Business Account" in the middle will take the store owners to log in to our main interface. The transition seamlessly redirects users to our Tableau dashboard, accessible via a Python Dash application.

The dashboard is organized with various interactive components. At the top, users would find three filers – user_id, department, and product_id, allowing for a customized view of customer shopping behavior. The upper left of the dashboard is a heat map that reveals optimal shopping times by displaying data across a 24-hour x-axis and a 7-day y-axis. The user can hover over to the timeframe, and it will reveal the best day of week, best hour and count of items. Adjacent to the section, in the lower left section, packed bubbles visually show different customer group clusters. Upon filter selection of a user, hover over to the bubble will show the group of the user belongs to, and count of user in that group. The right half of the dashboard detailed out the department, product_id, and product names. The section ensures that any selection made via the filters or any interaction on the dashboard elements dynamically updates the displayed data, providing a real-time insights and analytics tailored to the users' need.

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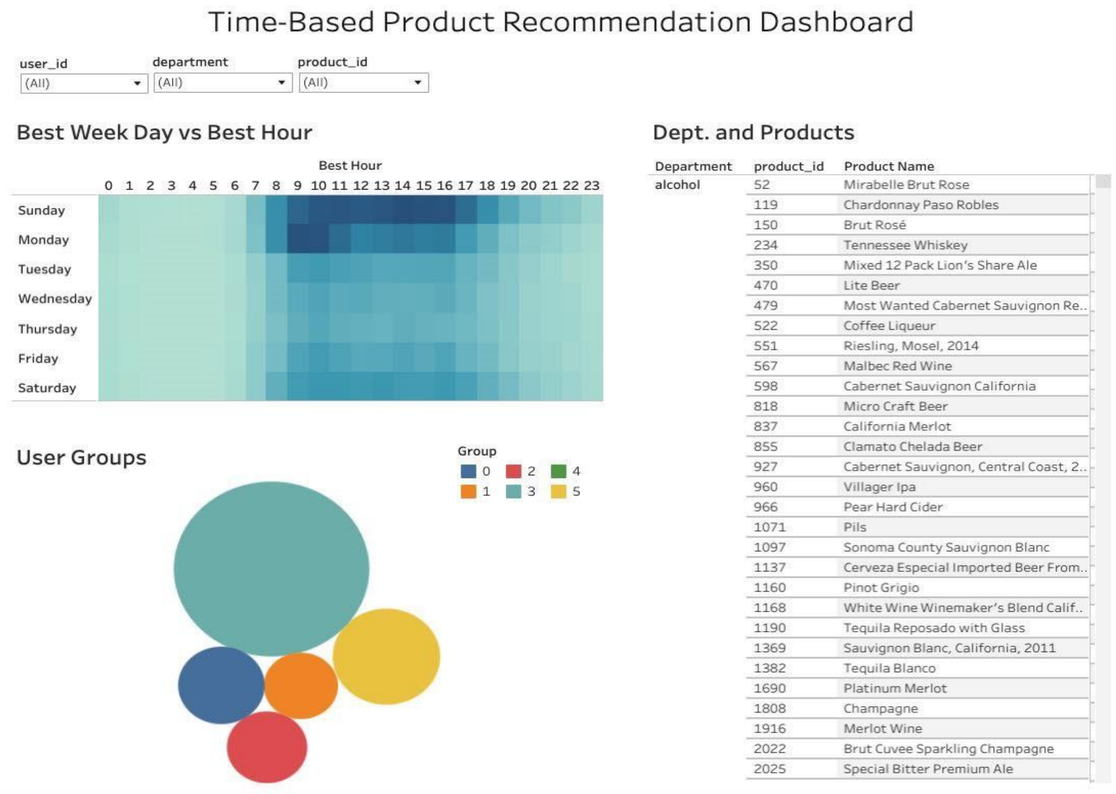

Experiments and results

Prediction Models

We utilized K-means clustering to segment customers effectively, identifying distinctive clusters essential for understanding purchase timing. Among the algorithms employed, AdaBoost emerged as the most effective, particularly for predicting both smart cart content and inventory levels. Its accuracy scores of 70.18% stood out among Decision Tree (63.41%) and Logistic Regression (68.69%).

Interface Evaluation

Our comprehensive evaluation of the "Time-Based Smart Product Recommendation" interface employed various methods, including surveys, interviews, and a detailed case study walkthrough. The survey, conducted with 30 participants, highlighted the interface's effectiveness, especially in inventory management, garnering praise for its clarity and user-friendliness. Interviews with five participants further underscored the interface's adaptability and data visualization capabilities. Additionally, a focused case study, centered around a fictional liquor store owner, showcased the interface's practical application in optimizing product management and enhancing business performance.

Conclusion

The extensive evaluation underscored the interface's efficacy in aiding data-driven retail decisions, particularly in inventory management and strategic decision-making. Positive feedback and suggestions gathered from these evaluations are pivotal in guiding future enhancements, ensuring the interface remains adaptable and valuable across diverse retail contexts.

Conclusions

The integration of temporal insights into recommendation systems is pivotal in advancing the online retail sphere. By catering to the 'when' of customer behavior, retailers can enhance customer satisfaction, streamline inventory management, and bolster their competitive edge in the market.

- Temporal Insight Integration: Our study successfully unearthed intricate temporal patterns in customer purchasing behavior, highlighting peak shopping hours, weekly and monthly shopping cycles, and popular department-wise preferences.
- Machine Learning Recommendations: Through a range of machine learning models, we personalized recommendations for both new and existing customers, optimizing product suggestions based on timing, user segments, and departmental considerations.
- Innovative Visualization Tool: Our prototype showcased a user-friendly interface offering real-time insights into optimal shopping times, customer profiling, and inventory management.

Future Directions

By adding timing insights to retail recommendations, we aim to improve satisfaction and inventory management. Although our project is a step forward, there are areas to explore:

- Real-time updates for better accuracy.
- Continuous tool refinement based on user input.
- Integrating recommendations with broader marketing.

Constraints led us to use fictional data. For future improvement:

- Real-world testing with actual businesses.
- Accessing larger datasets and better processing for more accurate models.
- Refining models with advanced algorithms and long-term studies on changing customer behavior.
- These improvements will enhance our project's relevance and usefulness in the online retail landscape.

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