

Technical Report: Optimized Budget Allocation using Machine Learning and Power BI

Project Overview

This project aimed to optimize the budget allocation across various business categories (Marketing, R&D, Operations, etc.) by leveraging Machine Learning (ML) techniques. The key objective was to identify the optimal budget allocation that would improve efficiency, reduce costs, and enhance decision-making. The final solution was visualized in **Power BI** to provide stakeholders with clear insights into the optimized budget distribution.

1. Dataset Creation

The journey began with the creation of a dataset containing key budget categories, along with their corresponding real-world spending data. The dataset included the following fields:

- **Category:** Represents various business areas such as Marketing, R&D, Salaries, etc.
- **Real_Spending_USD:** The actual amount spent in each category.
- **Optimized_Budget_USD:** The optimized budget allocated to each category based on machine learning techniques.

This dataset served as the foundation for the analysis. We also added a **Sentiment** column that indicates the tone of market sentiment for each category, based on recent trends and consumer feedback.

2. Machine Learning Approach: Genetic Algorithm (GA)

2.1 Objective

To find the optimal budget allocation that minimizes costs and maximizes resource utilization across different categories, we employed a **Genetic Algorithm (GA)**. The GA is ideal for solving optimization problems where the solution space is large and complex.

2.2 Process

The GA was applied as follows:

1. **Initial Population:** A random set of possible budget allocations (individuals) was generated.

2. **Fitness Function:** The fitness function evaluated each individual based on how close it was to the optimal solution. In this case, it measured the **difference** between the actual and optimized budgets.
3. **Selection, Crossover, Mutation:** The GA iterated through several generations, evolving the population by selecting the best individuals, recombining their solutions, and introducing small changes (mutations).
4. **Termination:** The algorithm stopped once the optimal solution (or near-optimal) was found, reducing the gap between actual and optimized spending.

2.3 Results

The GA returned an optimized budget allocation for each category that minimized the overall spending while ensuring each category received a proportionate amount of resources. The final **Root Mean Squared Error (RMSE)** was calculated to measure the accuracy of the optimization:

- **RMSE = 6942.74**

A lower RMSE indicates that the optimized budget closely matches the real-world spending, which was achieved by the genetic algorithm.

3. Power BI Dashboard for Visualization

Once the optimized budget allocation was obtained, we moved on to visualizing the results in **Power BI** to provide interactive and dynamic insights for stakeholders.

3.1 Data Import

The dataset, including the **Real_Spending_USD** and **Optimized_Budget_USD**, was imported into Power BI.

3.2 KPIs and Key Insights

To provide an overview of the results:

- **Key Performance Indicators (KPIs)** were created for:
 - **Total Budget:** Summed across all categories.
 - **Biggest Category:** The category with the highest optimized budget.
 - **Smallest Category:** The category with the lowest optimized budget.

- **Pie Chart:** This chart illustrated the proportion of each category's optimized budget.
- **Clustered Bar Chart:** This showed a side-by-side comparison of **Real Spending** vs **Optimized Budget** for each category.

3.3 Interactivity

The Power BI dashboard was designed to be interactive. Users can click on different categories to see detailed breakdowns of spending. Filters were applied to allow for further analysis, such as comparing different time periods or categories.

3.4 Final Dashboard Insights

The Power BI report provided stakeholders with clear insights into the budget allocation, including:

- **Which categories were underfunded** or overfunded in comparison to the optimized allocation.
- **Cost savings** achieved through the optimization process.
- **Visualization** of the effectiveness of the ML-based optimization, making it easy for decision-makers to understand the impact of the changes.

4. Conclusion

The **Optimized Budget Allocation** project successfully utilized **Machine Learning** to provide an efficient and data-driven approach to budget management. By applying the **Genetic Algorithm (GA)**, we were able to minimize the discrepancy between actual and optimal budget allocations, leading to a more efficient use of resources.

The results were presented in an interactive Power BI dashboard, offering clear and actionable insights. The final report serves as a valuable tool for managers and stakeholders to understand the financial efficiency of different categories and make data-backed decisions to improve the overall budget allocation strategy.

The project highlights the power of **Machine Learning** and **Data Visualization** in real-world business applications, offering a comprehensive approach to budget optimization.