

Prophet-Based Time Series Model for Automotive Sales Prediction

Ebuka Chinaechetam Nkoro *, Judith Nkechinyere Njoku *, Cosmas Ifeanyi Nwakanma[†],
Jae-Min Lee *, Dong-Seong Kim *

*IT Convergence Engineering, [†] ICT Convergence Research Center, Kumoh National Institute of Technology, Korea.

Abstract—Automotive sales forecasting is integral to the automobile commerce industry, necessitating precise decision-making for sustained profitability among car retailers. This study employs the Prophet time-series model to predict future sales patterns, aiming to maximize sales opportunities. Preliminary results highlight the Prophet model’s features, including automatic seasonality detection, flexible trend modeling, robustness to missing data, and a user-friendly interface. Additionally, the RMSE, MSE, and MAE, derived from the application of the Prophet model on the car sales dataset are 1050.32, 1103170.27, and 887.74 respectively.

Index Terms—Forecasting, Time series analysis, additive model, Machine learning, Sales, Facebook prophet.

I. INTRODUCTION

About \$120.81 billion was generated by the automobile sector in 2020 and is predicted to attain an estimated annual growth rate of approximately 32.5% between 2021 and 2028 [1]. This exponential growth in the automobile industry can be attributed to factors that strongly correlate with sales patterns. Thus, by analyzing sales patterns, automobile business owners can forecast upcoming sales trends and make decision policies that would enable them to maximize profits.

The use of forecasting methods, as summarized by Ensafi et al [2], offers good accuracy and can enable automobile business owners to make the right upsell decisions while maximizing profits and gaining a competitive advantage over other businesses by analyzing and understanding historical financial data. While sales forecasting remains highly explored, it is important to understand the **seasonality and trends** of business sales to maximize profits. However, various autoregression forecast models do not incorporate seasonal forecasting trends [2].

This study employs a seasonal forecast model, Prophet, to analyze the historical data of an automobile retail company to predict future car sales, understand business dynamics in historical sales, and inform upsell business decisions [3].

II. SYSTEM MODEL OF THE PROPOSED APPROACH

A. Dataset Selection, and Preprocessing

This study utilizes a private automobile dataset of a USA-based client, consisting of retail Chevrolet car sales for six months, ranging from May to July 2023. The dataset was collected to interpret historical/future car sales for informed up-selling business decisions. This dataset contains over 7577 data entries and over 200 sales features, with several strings and null values representing personal customer information. Some of the features are Dealer IDs, open date, close date, total cost, total sales, profit, and so on.

B. Prophet Model for Car Sales Optimization

This study employs the Prophet model [4] shown in Fig 1, to evaluate historical car retail sales, clearly understand seasonal sales trends, and predict future Chevrolet car sales. First, the p-value test on the dataset is evaluated for stationarity, (value = -57.7, p-value = 0.0), and next, the Prophet forecasting **model features** (open date and profit $y(t)$). The forecast accuracy metrics employed include the RMSE, MAE, and MSE [2].

The Prophet model [4] was developed by Facebook’s data science team to forecast time series data based on an additive model where nonlinear trends are fit with yearly, weekly, and daily seasonality, including holiday effects. A significant benefit of the Prophet model is its seasonal flexibility compared with other classical models. The Prophet model $y(t)$ in Equation 1 is distinguished by its seasonal component, representing periodic changes in predicting the car profit.

$$y(t) = g(t) + s(t) + h(t) + \epsilon_t \quad (1)$$

where: $y(t)$ is the Observed time-series data, $g(t)$ represents the trend component capturing non-periodic changes, $s(t)$ is the seasonal component representing periodic changes, $h(t)$ is expressed as the holiday effects accounting for special events, and ϵ_t , the error term.



Fig. 1. A summarized system model of the Prophet model, employed for car sales forecasting.

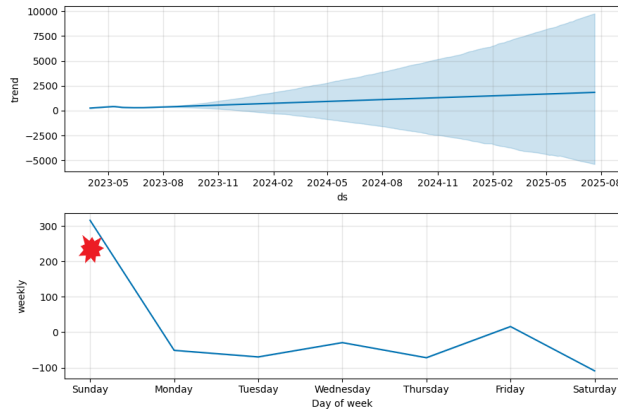


Fig. 2. The Prophet model shows the yearly and weekly (seasonal) forecast of car sales.

III. RESULT AND PERFORMANCE EVALUATION

The results of the Prophet model are presented in Fig. 2 shows the predicted future profit of the retail company (2023-2025). The model remains a favorable choice for seasonal analysis, showing that ‘Sundays’ have the highest sales. Following the weekly seasonal trend analysis in Fig. 2, we advised the company to trigger marketing promotions on Sundays to maximize profit. Table I shows the RMSE, MSE, and MAE of the Prophet model using the provided car sales dataset.

TABLE I
PROPHET MODEL PREDICTIONS

Model	RMSE	MSE	MAE
Prophet	1050.32	1103170.27	887.74

IV. CONCLUSIONS

This study explores the Prophet forecasting model to predict seasonal and future car sales. The future work will employ a comparative analysis of other auto-regression classical forecast models, and explainable deep-learning models, for improved evaluation.

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