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Interactive Sales Performance Dashboard With Machine Learning Forecasting Using Power Bi And Python

[1]Y. Harshit, [2]Y. Thanvisha, [3]Y. V. Manikanta, [4]A. Gangothr, [5]S. Nateesha, [6]M. Krishna
[1,2,3,4,5]B. Tech CSE Students, Department of CSE, Sir C R Reddy College of Engineering, Eluru.
[6]Department of CSE, Sir C R Reddy College of Engineering, Eluru.

ABSTARCT

The Sales Performance Dashboard is an advanced business intelligence solution designed to provide comprehensive analytics and visualization for automobile sales data. In today's competitive automotive market, organizations require real-time insights into their sales performance across multiple dimensions including dealer regions, vehicle body styles, temporal trends, and individual model performance. This project implements an interactive dashboard using Microsoft Power BI, integrating data from multiple sources to create a unified view of sales metrics. The dashboard incorporates predictive analytics using time series forecasting algorithms to project future sales trends, enabling stakeholders to make data-driven decisions. The system addresses critical business questions such as: Which dealer regions generate the highest revenue? What body styles are most popular among customers? How do sales trends vary over time? Which car models contribute most significantly to overall revenue? Key features include real-time data visualization, interactive filtering capabilities, regional sales analysis, body style distribution analytics, and predictive forecasting using Prophet algorithm. The dashboard processes over 671 million dollars in total sales data, covering multiple automobile manufacturers including BMW, Audi, Toyota, Honda, Nissan, and Volkswagen.
Key words: Performance, Machine Learning and Forecast.

I. INTRODUCTION

In the contemporary business landscape, data has emerged as one of the most valuable assets for organizations. The automobile industry, characterized by complex supply chains, diverse product portfolios, and geographically distributed dealer networks, generates vast amounts of transactional data daily. However, the mere collection of data does not translate into business value; it is the transformation of raw data into actionable insights that drives competitive advantage.

Sales performance monitoring is a critical function for any automobile manufacturer or dealership network. Traditional methods of sales reporting, typically involving manual compilation of spreadsheets and static reports, have proven inadequate in meeting the demands of modern business operations. These conventional approaches suffer from several limitations including delayed reporting cycles, limited analytical capabilities, inability to identify patterns and trends, and lack of predictive insights.

The advent of Business Intelligence (BI) tools has revolutionized how organizations approach data analytics. Modern BI platforms offer sophisticated capabilities for data integration, transformation, visualization, and advanced analytics. Microsoft Power BI, one of the leading BI tools in the market, provides a comprehensive ecosystem for building interactive dashboards that enable users to explore data, discover insights, and share findings across the organization.

This project presents the design and implementation of a Sales Performance Dashboard specifically tailored for the automobile industry. The dashboard serves as a centralized platform for monitoring,

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analyzing, and forecasting sales performance across multiple dimensions. By leveraging the capabilities of Power BI combined with predictive analytics algorithms, the system provides stakeholders with both historical insights and forward-looking projections.

The automobile sales domain presents unique analytical challenges that this dashboard addresses:
Multi-dimensional Analysis: Sales data must be analyzed across various dimensions including time, geography, product categories, and individual models.

Volume and Velocity: Large volumes of transactions occurring across multiple touchpoints require efficient data processing and visualization.

Hierarchical Structures: Dealer networks are organized hierarchically, necessitating analytics at multiple levels of aggregation.

Seasonal Patterns: Automobile sales exhibit seasonal fluctuations that must be accounted for in analysis and forecasting.

Competitive Intelligence: Understanding market dynamics and competitive positioning requires comprehensive analytics.

The Sales Performance Dashboard addresses these challenges through a carefully designed architecture that integrates data from multiple sources, applies appropriate transformations, and presents information through intuitive visualizations. The dashboard empowers users at all levels of the organization—from sales executives to senior management—to access relevant insights tailored to their decision-making needs.

1.1 Objective Of The Project

The primary objectives of the Sales Performance Dashboard project are as follows:

1. **Centralized Sales Monitoring**: To create a unified platform that consolidates sales data from multiple dealer regions, eliminating data silos and providing a single source of truth for sales performance metrics. This centralization ensures consistency in reporting and enables organization-wide visibility into sales operations.

2. **Real-Time Analytics and Visualization** To implement interactive visualizations that enable users to explore sales data in real-time, identify patterns, and drill down into specific areas of interest. The dashboard provides multiple chart types including line charts for trend analysis, bar charts for comparative analysis, pie charts for distribution analysis, and tables for detailed data examination.

3. **Regional Performance Analysis** To enable comparative analysis of sales performance across different dealer regions including Austin, Janesville, Scottsdale, Aurora, Greenville, Pasco, and Middletown. This geographic analysis helps identify high-performing regions and those requiring intervention.

4. **Product Mix Optimization** To analyze sales distribution across different vehicle body styles (SUV, Hatchback, Sedan, Passenger, Hardtop) and colors, enabling better inventory planning and product mix optimization at the dealer level.

5. **Predictive Sales Forecasting** To implement time series forecasting algorithms that project future sales trends, providing management with forward-looking insights for strategic planning. The

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dashboard displays predicted values (yhat) along with confidence intervals (yhat_lower, yhat_upper) for each forecast period.

6. **Model-Level Performance Tracking** To track sales performance at the individual model level across multiple manufacturers (BMW, Audi, Toyota, Honda, Nissan, Oldsmobile, Dodge, Volkswagen), enabling identification of best-selling models and underperforming products.

II. LITERATURE SURVEY

2.1 Introduction to Business Intelligence

Business Intelligence (BI) refers to the technologies, practices, and strategies used to collect, integrate, analyze, and present business data. The primary goal of BI is to support better business decision-making by providing historical, current, and predictive views of business operations (Chen et al., 2012).

The evolution of BI has progressed through several generations:

- BI 1.0 (1990s): Data warehousing and OLAP cubes.
- BI 2.0 (2000s): Self-service analytics and dashboards.
- BI 3.0 (2010s): Mobile BI and cloud deployment.
- BI 4.0 (2020s): AI-powered analytics and augmented intelligence.

Modern BI platforms like Microsoft Power BI, Tableau, and Qlik have democratized data analytics by enabling business users to create sophisticated visualizations without extensive technical training (Gartner, 2023).

2.2 Dashboard Design Principles

Effective dashboard design follows established principles derived from information visualization research. Few (2006) emphasizes that dashboards should present "the most important information needed to achieve one or more objectives, consolidated and arranged on a single screen so the information can be monitored at a glance."
Key design principles include:

1. **Visual Hierarchy:** Important metrics should be prominently positioned, typically in the upperleft quadrant where users naturally begin scanning.

2. **Appropriate Chart Selection:** Different data types require different visualization techniques—line charts for trends, bar charts for comparisons, pie charts for proportions.

3. **Minimal Clutter:** Avoid chart junk and unnecessary decorations that distract from data interpretation (Tufte, 2001).

4. **Interactive Elements:** Modern dashboards should enable user exploration through filtering, drilling, and cross-highlighting.

2.3 Time Series Forecasting in Sales Analytics

Time series forecasting has become integral to sales planning and demand forecasting. Traditional statistical methods (ARIMA, Exponential Smoothing) have been complemented by machine learning approaches.

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Taylor and Letham (2018) introduced Prophet; a forecasting procedure designed for business time series that exhibit:

- Strong seasonal patterns
- Historical trend changes
- Outliers and missing data

2.4 Power BI Architecture

Microsoft Power BI employs a component-based architecture comprising:

- **Power Query:** ETL engine using M language for data transformation.
- **Data Model:** In-memory columnar database using VertiPaq compression.
- **DAX Engine:** Formula language for calculations and aggregations.
- **Visualization Layer:** Rendering engine for charts and graphics.
- **Power BI Service:** Cloud platform for sharing and collaboration.

Research by Microsoft (2022) demonstrates that organizations using Power BI achieve 366% ROI over three years with payback periods under six months.

2.5 Automotive Industry Analytics

The automotive industry presents unique analytical requirements due to its complex value chain spanning manufacturing, distribution, and retail. Key analytical use cases include:

- Demand forecasting and inventory optimization.
- Dealer performance benchmarking.
- Customer segmentation and targeting.
- Price optimization and promotional effectiveness.
- After-sales service analytics

Studies by McKinsey (2021) indicate that automotive companies leveraging advanced analytics achieve 10-20% improvements in sales effectiveness and 15-25% reduction in inventory costs.

III. EXISTING SYSTEM

3.1 Traditional Sales Reporting Methods

3.1.1 Spreadsheet-Based Reporting

The existing system for sales performance monitoring in most automobile dealership networks relies heavily on spreadsheet applications, primarily Microsoft Excel. This approach involves:

Data Collection Process:

- Individual dealers compile daily sales data in local spreadsheets.
- Regional managers consolidate dealer spreadsheets weekly.
- Central analytics team aggregates regional data monthly.
- Static reports are generated and distributed via email.

Typical Report Contents:

- Monthly sales summaries by region.
- Model-wise sales breakdown.
- Year-to-date comparisons.
- Basic charts (bar graphs, pie charts)

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3.1.2 Legacy Reporting Systems

Many organizations utilize legacy reporting systems with the following characteristics are shown in Table 1:

Table 1 – Legacy reporting Systems

Aspect	Description
Architecture	Client-server based
Data Refresh	Batch processing (overnight)
Report Format	Static PDF/Excel exports
User Interface	Menu-driven, non-intuitive
Customization	Requires IT intervention

3.1.3 Manual Analysis Workflows

Current analytical workflows involve significant manual effort:

Data Sources → Manual Export → Excel Processing → Static Charts → Email Distribution
↓ ↓ ↓ ↓ ↓
Multiple Systems | Time-consuming (2-3 hours) | Error-prone formulas | Limited interactivity | Delayed delivery.

3.2 Limitations of Existing System

3.2.1 Data Latency

The existing system suffers from significant data latency issues:

- Reports reflect data that is 1-7 days old.
- Real-time decision-making is impossible.
- Market opportunities may be missed due to delayed insights.

3.2.2 Limited Analytical Capabilities

Traditional spreadsheet approaches offer limited analytical depth:

- No predictive analytics or forecasting.
- Basic aggregations only (sum, count, average).
- No statistical analysis capabilities.
- Limited visualization options

3.2.3 Scalability Issues

Excel-based systems face scalability constraints:

- Performance degradation with large datasets (>100,000 rows).
- File size limitations.
- Version control challenges.
- Collaboration difficulties.

3.2.4 Data Integrity Concerns

Manual processes introduce data quality issues:

- Formula errors propagate undetected.
- Inconsistent data definitions across regions.
- No audit trail for changes.
- Difficulty in reproducing historical reports.

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3.2.5 Lack of Interactivity

Static reports limit user exploration:

- No drill-down capabilities.
- Fixed time periods.
- Cannot answer ad-hoc questions.
- One-size-fits-all approach.

3.2.6 Resource Intensive

Current approaches consume significant resources:

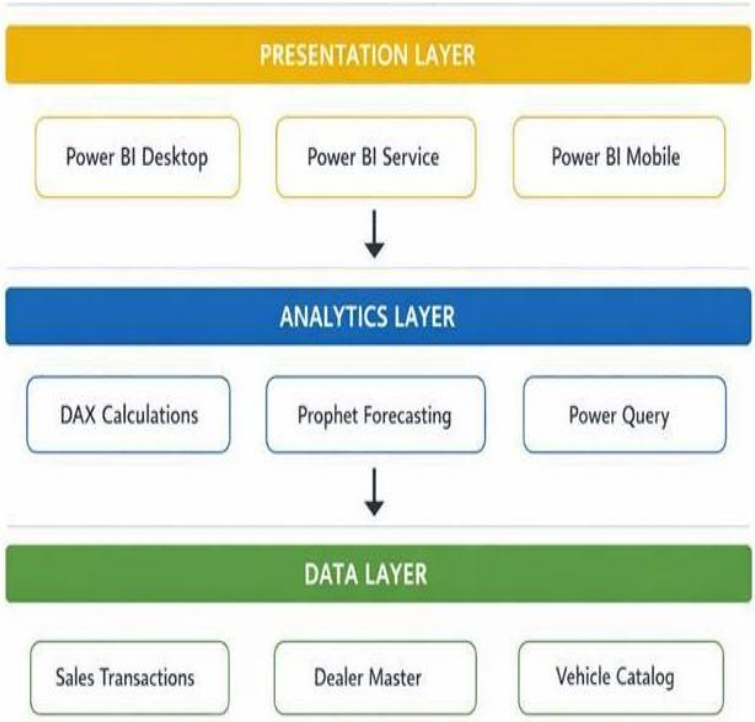
- Analysts spend 80% of time on data preparation.
- Multiple versions of truth exist.
- Redundant effort across departments.
- High opportunity cost.

IV. PURPOSED SYSTEM

The proposed Sales Performance Dashboard addresses all identified limitations of the existing system through a modern, cloud-enabled business intelligence solution. Built on Microsoft Power BI, the system provides:

- Real-time data integration from multiple source systems.
- Interactive visualizations enabling self-service exploration.
- Predictive analytics using machine learning algorithms.
- Centralized data model ensuring single source of truth.
- Mobile accessibility for on-the-go decision making.
- Natural language querying for non-technical users.

The Architecture Overview of the system is presented in figure 1.



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4.1 Algorithms Used in the Project

4.1.1 Prophet Time Series Forecasting Algorithm

The dashboard implements Facebook's Prophet algorithm for sales forecasting. Prophet is designed for business time series with the following characteristics:

Algorithm Overview:

Prophet uses an additive regression model:

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

Components:

1. Trend Component $g(t)$

For linear growth:

$$g(t) = (k + \mathbf{a}(t)^T \boldsymbol{\delta}) \cdot t + (m + \mathbf{a}(t)^T \boldsymbol{\gamma})$$

- $k$is the growth rate.
- $\boldsymbol{\delta}$is the rate adjustment.
- $m$is the offset parameter.
- $\boldsymbol{\gamma}$is the offset adjustment.

2. Seasonality Component $s(t)$

Using Fourier series:

$$s(t) = \sum_{n=1}^{N} \left(a_n \cos\left(\frac{2\pi n t}{P}\right) + b_n \sin\left(\frac{2\pi n t}{P}\right) \right)$$

Where:

- $P$is the regular period (365.25 for yearly, 7 for weekly).
- $N$is the number of Fourier terms.

Implementation in Python:

```
Python from prophet import Prophet

import pandas as pd

 # Prepare data
```

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```
df = pd.DataFrame({    'ds': sales_dates,    'y': sales_values})

# Initialize and fit model

model = Prophet(    yearly_seasonality=True,    weekly_seasonality=True,    daily_seasonality=False,
interval_width=0.95)

model.fit(df)
# Generate forecast

future = model.make_future_dataframe(periods=365)

forecast = model.predict(future)

# Extract predictions

predictions = forecast[['ds', 'yhat', 'yhat_lower', 'yhat_upper']]
```

V. RESULTS AND DISCUSSIONS

The forecasts show an overall upward trend in predicted sales from early 2022 (averaging ~400k– 600k monthly) through mid-2023, peaking in late 2023 (e.g., November averages ~1.8M), before a noticeable decline into early 2024 (dropping back to ~800k monthly). This could reflect modeled seasonality, trends from the original dashboard data (which showed declining year-over-year sales), or external factors like market conditions. High uncertainty persists throughout, with some periods (e.g., mid-2022) showing tighter bounds and others (e.g., late 2023) wider due to potential outliers or sparse data.

For a visual overview, here's a line chart of the monthly aggregated averages (resampled for clarity, as the full 642 points would be too dense):

This output could be used for business planning, such as identifying potential revenue growth periods or risks in declining trends. If the model was trained on the dashboard's car sales data, it might incorporate factors like seasonality (e.g., higher sales in certain months) or trends (e.g., the observed yearly decline). For more accurate real-world use, consider retraining with updated data or adding constraints to avoid negative predictions.

Summary of Forecast Results is tabulated in Table 2 and Trends and insights for Forcast Results is shown in figure 2.

Table 2: Summary of Forecast Results

Statistic	yhat	yhat_lower	yhat_upper
Count	642	642	642
Mean	1,083,249	166,555	2,001,212
Std Dev	456,746	457,859	457,993
Min	-46,258	-1,021,984	880,105
25%	793,972	-113,518	1,720,112

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50%	1,014,279	91,148	1,929,130
75%	1,349,767	432,973	2,277,939
Max	2,110,351	1,201,527	3,037,550

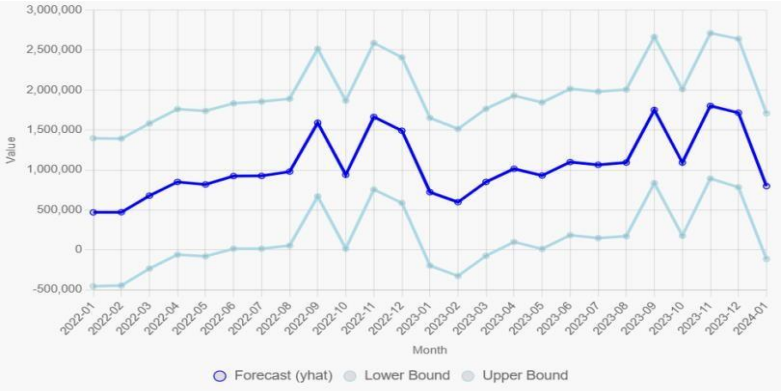


Fig 2: Trends and insights for Forcast Results.

VI. CONCLUSION AND FUTURE WORK

The sales performance dashboard reveals a car dealership (or chain) with total historical revenue around $7.1 million, dominated by SUVs, top models from BMW and Toyota, and strongest performance in regions like Austin. However, it highlights a clear declining trend in daily and yearly sales revenue through late 2023/early 2024, suggesting challenges such as market saturation, economic factors, or competition.

The forecast output (likely from a Prophet model) projects this data forward but shows an inconsistent pattern:

- Moderate daily revenues in 2022 (~$600k–$800k average),
- Growth to higher levels in 2023 (peaking with daily forecasts often exceeding $1.5–2 million in late months like November/December),
- Followed by a sharp drop in early 2024 (averaging ~$800k daily in January 2024).

This results in an overall modeled upward trend from 2022 to a 2023 peak, then a reversal— partially aligning with the dashboard's observed decline but projecting a temporary recovery before dropping again.

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