Optimizing Medical Inventory Management : A Data-Driven Approach with Advanced Machine Learning Techniques

Details of the Solution

Problem Statement

- Inefficient management of medical inventory within healthcare facilities.

- This inefficiency results in a range of challenges, including stockouts, overstocking, and the inability to meet patient demands for essential medications due to the lack of accurate forecasting of drug demands affecting patient care due to missed and delayed doses

- Suboptimal inventory management practices lead to increase in bounce rate, increased costs and resource wastage.

- Over stocking leads to increase in holding cost affecting cashflow and wastage and financial loss due increased in percentage of expired medicines

Objectives of the Solution

The proposed solution involves the development and implementation of a comprehensive drug demand forecasting system that leverages cutting-edge machine learning models trained on historical medication sales data to accurately predict drug demand patterns.

The solution is driven by the objectives as:

- Optimize The Stock Availability.

- Minimize Bounce rate.

- Enhance Customer Satisfaction.

- Reduction of Inventory Cost Waste.

Solution Overview

Data Collection: Gather historical medication sales data, including drug categories, volumes, and sales dates

Data Preprocessing: Clean and prepare the data, handle missing values, and perform feature engineering.

Data Mining: Use advanced machine learning algorithms (RNN, BI RNN, LSTM, BiLSTM, GRU, BiGRU, Ensemble model) to analyze and identify patterns in the data.

Model Deployment: Integrate the predictive models with the medical inventory management system for real-time forecasting and optimization.
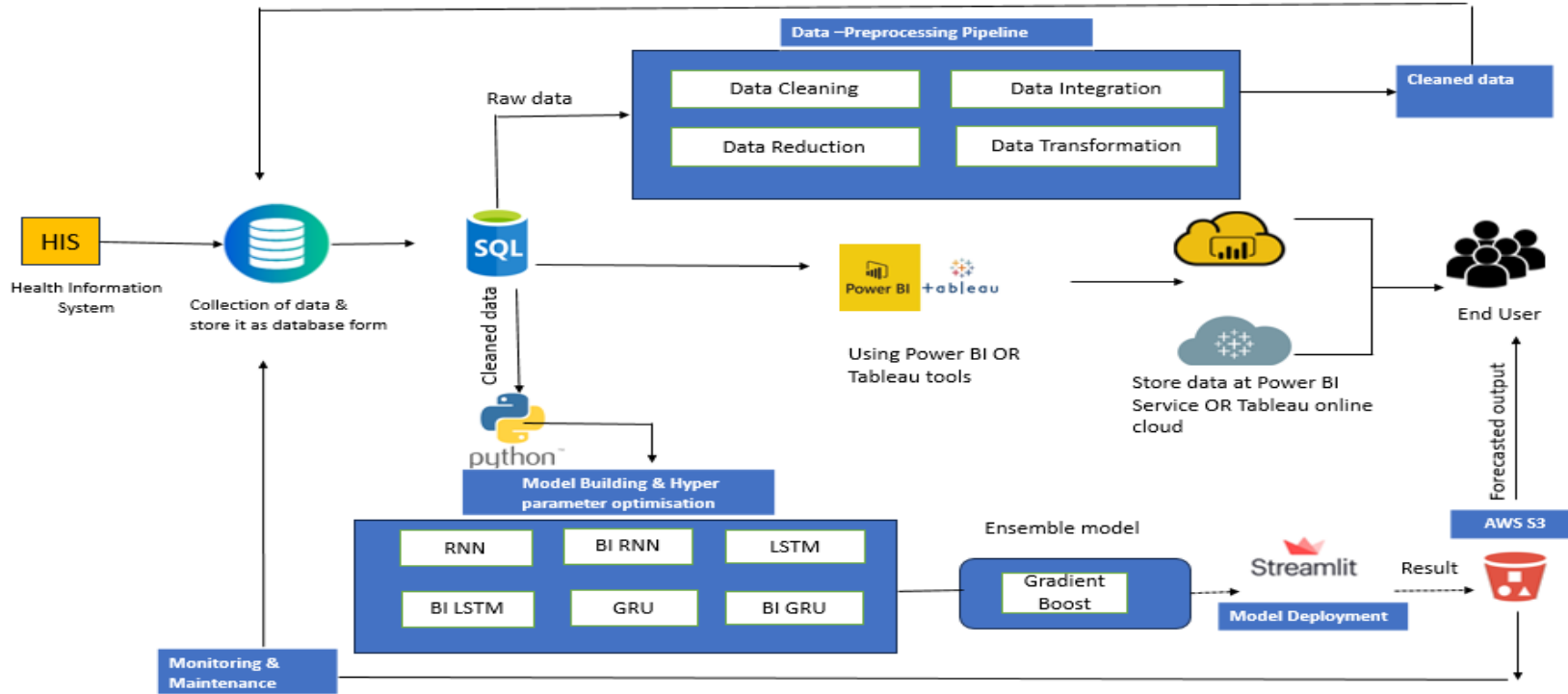
Architecture Diagram representing a Drug Demand for Optimal Medical Inventory Management incorporating forecasting Models

MAPE	Meropenem		Noradrenaline		Pantoprazole		Paracetamol	
	Train	Test	Train	Test	Train	Test	Train	Test
RNN	41.7	21.8	50.5	56.3	9.52	10.7	53.6	75.8
BI-RNN	43	69	43	118.8	21.6	7.9	33.3	6.4
LSTM	44.7	81.8	30.7	48.4	21	9.69	30.3	6.7
BI-LSTM	35.7	76.8	32.2	76.1	22.8	14.6	22.1	13.9
GRU	64.7	78.8	50.5	56.3	65.7	82.7	53.6	75.8
BI-GRU	36.7	67.8	32	67.2	20.7	10.9	22.3	11.7
Gradient Boost	5.1	1.98	2.82	4.91	0.78	2.78	1.34	2.5

MAPE Values Of Each Model

Outcome Analysis

- The top 10 medicines constitute 49.61% of the total cost. The top 60 medicines constitute 80% of the total cost.
  The top 10 medicines constitute 35.46% of the total Quantity. The top 64 medicines constitute 80% of the total Quantity.
  The top 10 medicines constitute 55.47% of the profit.
- The top 35 medicines constitute 80 % of the profit.
- Gradient Boost model outperformed others, achieving MAPE values as low as 1.98% for training and 5.1% for testing, compared to other models with values ranging from 21.8% to 81.8%.

Conclusion

- With a MAPE score of below 5%, our model for forecasting drug demand and optimising medical inventory management demonstrates exceptional reliability

Scalability and Usefulness To Other Hospitals

Scalability of the Solution

➢ **Flexibility Across Specialties:**
  - Suitable for a wide range of medical specialties.
  - Adaptable to varying medication demands in different departments.

➢ **Multi-Facility Implementation:**
  - Enables seamless coordination across multiple healthcare facilities.
  - Centralized control and monitoring for regional healthcare networks.

➢ **Global Applicability:**
  - Scalable to international healthcare contexts.
  - Supports cross-border collaborations and pharmaceutical supply chain optimization

Usefulness to Other Hospitals

➢ **Resource Sharing:**
  - Facilitates collaboration among hospitals.
  - Sharing of demand insights and supply chain data for mutual benefit.

➢ **Benchmarking and Best Practices:**
  - Enables hospitals to benchmark against each other.
  - Promotes the adoption of best practices in inventory management.

➢ **Support for Healthcare Networks:**
  - Ideal for healthcare networks and alliances.
  - Enhances supply chain efficiency for multiple affiliated hospitals.