Project Report: Time Series Forecasting for Petroleum Production

Introduction

Time series forecasting is a crucial aspect of many industries, including the petroleum sector. Accurately predicting future production rates can help in optimising operations, planning maintenance, and making informed business decisions. In this project, we have explored various time series forecasting models to predict petroleum production, including Prophet, Artificial Neural Network (ANN), Recurrent Neural Network (RNN), and Long Short-Term Memory (LSTM). This report provides an overview of each model, their performance metrics, and a comparison to determine the most effective model for petroleum production forecasting.

Time Series Forecasting

Time series forecasting involves predicting future values based on previously observed values. It is widely used in many applications such as weather forecasting, stock market analysis, and demand planning. In the petroleum industry, forecasting production rates can help in resource allocation, investment planning, and operational efficiency.

Models Used

1. Prophet

Prophet is an open-source forecasting tool developed by Facebook. It is designed to handle time series data with daily observations that may have missing values and large outliers. Prophet is flexible in modelling seasonality, holidays, and trend changes, making it suitable for business time series forecasting.

2. Artificial Neural Network (ANN)

ANNs are computing systems inspired by biological neural networks. They consist of interconnected nodes (neurons) that process data in layers. ANNs are capable of capturing complex patterns in data and are widely used for regression and classification tasks.

Model Architecture:

- Input Layer
- Dense Layer with 50 units and ReLU activation
- Dense Layer with 6 units and ReLU activation
- Dense Layer with 1 unit and linear activation

3. Recurrent Neural Network (RNN)

RNNs are a type of neural network designed for sequential data. They have connections that form directed cycles, allowing them to maintain a memory of previous inputs. This makes them suitable for time series forecasting.

Model Architecture:

- Input Layer
- SimpleRNN Layer with 50 units and ReLU activation
- Dense Layer with 25 units and ReLU activation
- Dense Layer with 1 unit and linear activation

4. Long Short-Term Memory (LSTM)

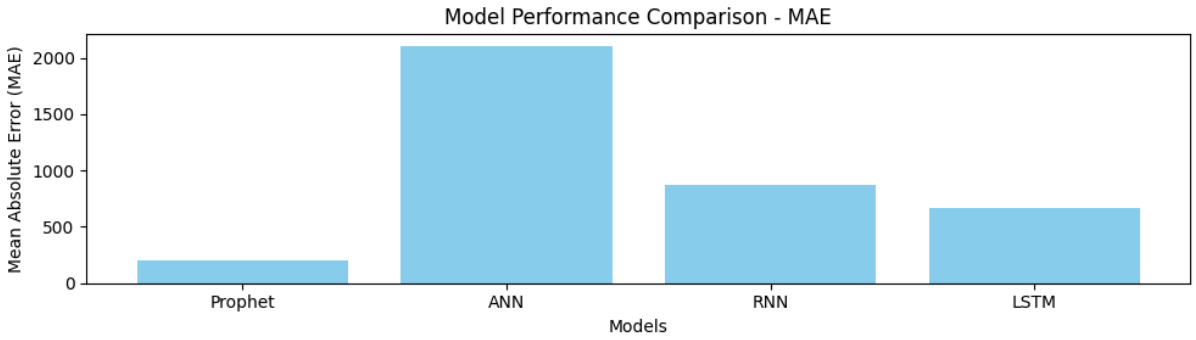
LSTM is a special kind of RNN capable of learning long-term dependencies. It introduces memory cells that can maintain information for long periods, making it effective for time series forecasting.

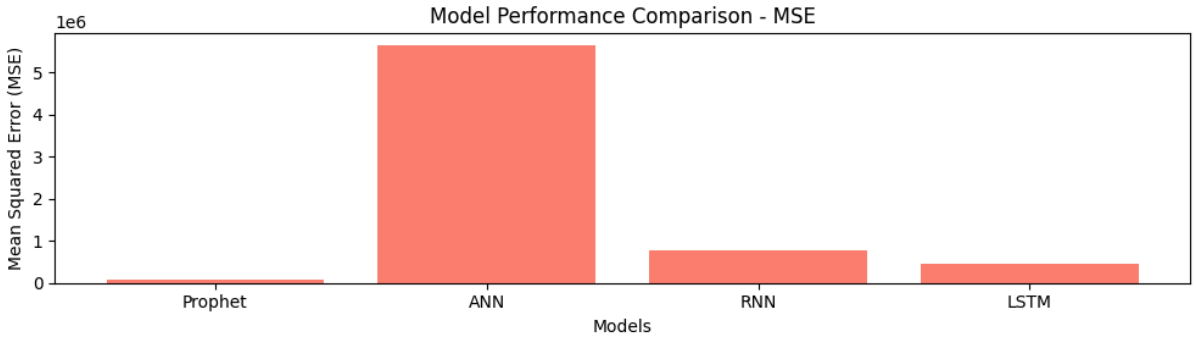
Model Architecture:

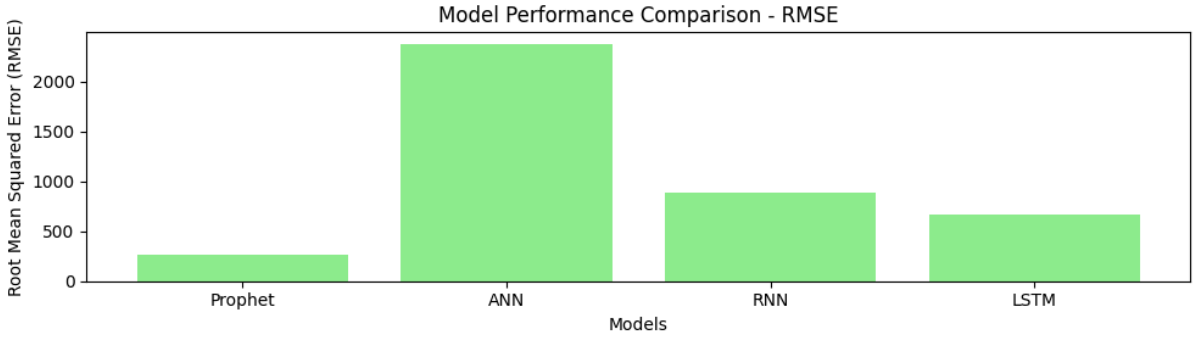
- Input Layer
- LSTM Layer with 50 units and ReLU activation
- Dense Layer with 25 units and ReLU activation
- Dense Layer with 1 unit and linear activation

Model Performance Comparison

The performance of each model is summarised below:







From the performance metrics, it is evident that the Prophet model outperforms the other models in terms of MAE, MSE, and RMSE. Prophet's ability to handle missing values, large outliers, and its flexibility in modelling seasonality and trend changes make it the most suitable for petroleum production forecasting in this case.

Future Implications for the Petroleum Industry

Accurate forecasting models like Prophet can significantly benefit the petroleum industry by providing reliable predictions of production rates. This can help in:

- **Operational Planning:** Optimising resource allocation and scheduling maintenance activities.
- **Financial Planning:** Making informed investment decisions based on expected production rates.
- **Risk Management:** Identifying potential production shortfalls or surpluses and taking proactive measures.
- **Strategic Decision Making:** Enhancing overall decision-making processes by providing data-driven insights.

Conclusion

In this project, we explored various time series forecasting models for petroleum production, including Prophet, ANN, RNN, and LSTM. The Prophet model demonstrated the best performance, highlighting its effectiveness in capturing the complexities of time series data. Implementing such models in the petroleum industry can lead to improved operational efficiency, better financial planning, and more informed strategic decisions. Future work could involve exploring hybrid models and incorporating additional features to further enhance forecasting accuracy.