ENHANCING METRO RAIL EFFICIENCY: A PREDICTIVE MAINTENANCE APPROACH LEVERAGING MACHINE LEARNING AND DEEP LEARNING TECHNOLOGIES

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MOTIVATION / INTRODUCTION

- The project encompasses designing and deploying a predictive maintenance system for the air production units of metro rail, using state-of-the-art machine learning, deep learning, and AI technologies. Such a system is active on proactive intervention of sensor-based initiation of equipment malfunction from large sensor data to keep downtimes to a minimum.
- It is structured with an interface that alarms the maintenance staff at the right time, therefore they can act on them and avoid failures. This study shows the key role of AI and ML technologies driving predictive maintenance into the industrial sector with indication over what transformations the practice is likely to bring for maintenance, operational efficiency, and overall sustainability within the industrial setup.

OBJECTIVES

- **Accurate Insights and Failure Prediction:** Employing advanced machine learning and deep learning algorithms to analyze data from Metro Rail's Auxiliary Power Units (APUs) enables accurate identification of potential failures before they occur, ensuring proactive maintenance and minimizing service disruptions.
- **Email Alerts for Maintenance Personnel:** Upon detection of potential issues or anomalies in the APU systems, automated email alerts are generated and sent to maintenance personnel in real-time. This timely notification allows for prompt action to be taken, preventing potential breakdowns and ensuring uninterrupted service.
- **Predictive Maintenance in Transportation:** Implementing a predictive maintenance approach in the transportation sector revolutionizes maintenance practices by shifting from reactive to proactive strategies. By leveraging data-driven insights, transportation systems like Metro Rail can optimize operational efficiency, reduce downtime, and enhance passenger satisfaction.

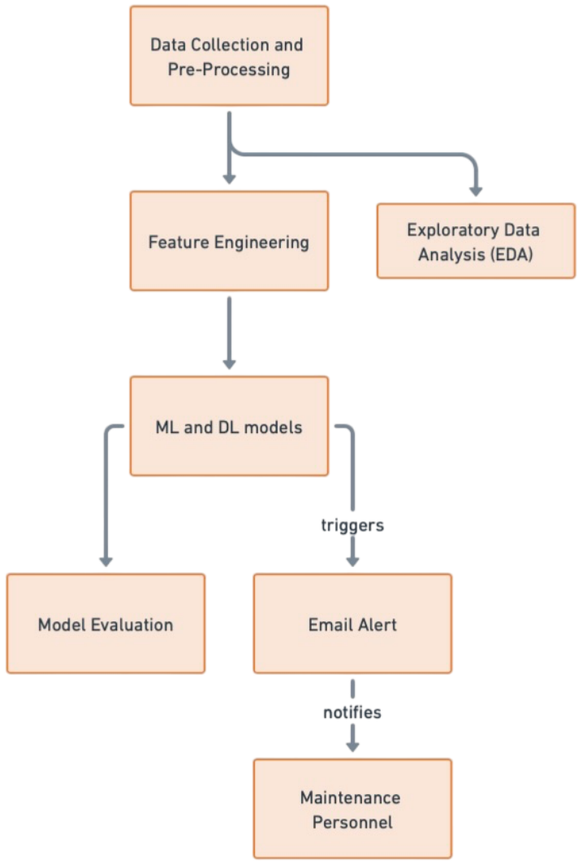
SCOPE OF THE PROJECT

The scope of this project encompasses the comprehensive integration of machine learning and deep learning techniques to forecast potential failures within the Air Production Unit of Metro Rails. It entails an exhaustive process beginning with meticulous data preprocessing, followed by detailed visualization, and thorough model evaluation. The overarching objective is to achieve precision in predicting failures, thereby facilitating timely alerts to maintenance personnel. By deploying ML and DL methodologies, this initiative aims not only to enhance operational efficiency but also to establish a proactive maintenance paradigm, ensuring seamless Metro Rail services and passenger safety. In addition, the project aims to establish a robust framework for continuous monitoring and improvement of maintenance protocols.

METHODOLOGY

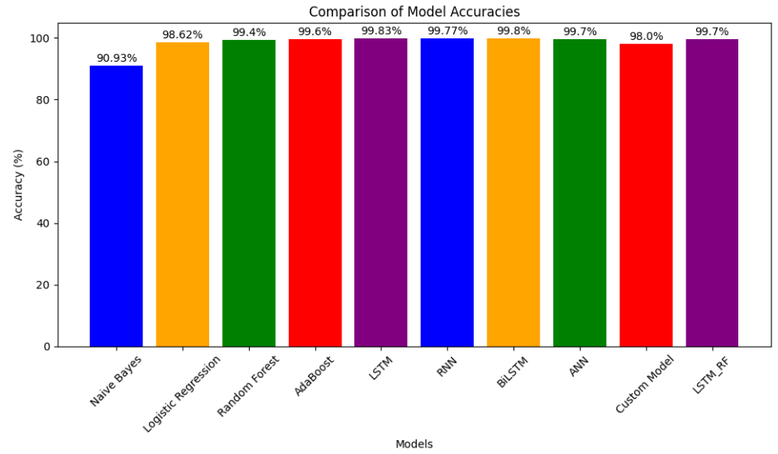
- The proposed system involves data collection, data preprocessing, model development, exploratory data analysis, model evaluation and email alerter. Ten different classifiers were implemented, including Naïve Bayes, Logistic Regression, Random Forest, AdaBoost, ANN, SimpleRNN, LSTM, BiLSTM, a hybrid LSTM-RF and a custom neural network model. An email alert system was developed for new test cases which tells the user if a failure has occurred or not via an email.

PROPOSED SYSTEM



Time intervals when APU was found to be faulty were assessed. These time intervals play a very important role because they give a window into the conditions that led to malfunction incidents and are directly associated with them. The failure periods identified were, therefore, classified as '1', and the other records of data were classified as '0'. Leveraging this structured dataset, our work revolves around the development and assessment of various machine learning and deep learning models. These models are designed to predict potential failures in air production units, thereby enabling preemptive maintenance actions.

RESULTS



CONCLUSION

LSTM and BiLSTM networks demonstrate the best performances in terms of accuracy where both have a precision of above 95% and recall around 96%. The hybrid model had a good accuracy but marked a low precision of 57% which suggests that the model might be having more False Positive instances compared to the DL models.

FUTURE ENHANCEMENTS

- The work can be further extended by adding more real time data with additional attributes
- Explainable AI approaches can be implemented so that the predictions of DL models will be more transparent and understandable to maintenance personnel.
- The usage of GANs to improve the training using data augmentation.

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