A Project Proposal on "Using Machine Learning Approach by Python to Predict Optimum Engine Parameters"

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Introduction

According to a prediction [1], the worldwide requirement for energy in the transportation sector is anticipated to keep growing at a pace of 1 to 1.5% per year up to 2040. This growth is mostly due to the anticipated increases in living standards, GDP, and population. Therefore, the optimization of engine parameters is critical in the design of efficient and high-performing engines. The traditional trial-and-error approach is time-consuming and expensive. Nowadays, machine learning (ML) techniques have been increasingly used to optimize engine parameters as significant progressions have been achieved in the field of artificial intelligence (AI) in recent years. The aim of this project is to explore different machine learning approach that can predict engine parameters with high accuracy and provide insights for optimizing engine performance and emissions.

Objectives

The main objectives of this project are as follows:

- To analyze a dataset from a Cummins ISX15 four-stroke six-cylinder engine, which incorporates a turbocharger with adjustable geometry, an EGR loop for cooling exhaust gas at high pressure, and a charge air cooler [2].
- To preprocess the dataset by performing data cleaning, missing value imputation, normalization and scaling.
- To determine the key features that mostly affect engine performance and emissions.
- To implement different regression-based machine learning algorithm and analyze and compare their performances.
- To select the best machine learning algorithm that can accurately predict engine's critical performance parameters and emissions based on the identified features.
- To provide insights for optimizing engine performance parameters and engine emissions based on the results of the machine learning model.

Data

The dataset should contain 2000 samples of engine operating parameters such as the Swirl Ratio (SR), Start of Injection (SOI), Nozzle Angle, Total Nozzle Area (TNA), Number of Nozzles (nNoz), Injection Pressure (P_{inj}), Exhaust Gas Recirculation (EGR), Intake Valve Closing Pressure (P_{ivc}) and Intake Valve Closing Pressure Temperature (T_{ivc}) as well as the engine out parameters include soot, NOx, Mean Piston Ring Radial Pressure (MPRR), Peak Cylinder Pressure (PCP), and Indicated Specific Fuel Consumption (ISFC). The dataset will be split into training set and testing set, where the training set will be used to develop the machine learning model, and the testing set will be used to assess its performance.

Methodology

- Data Visualization and Preprocessing: The dataset will be visualized by performing data visualization tools such as Pandas, Matplotlib and Seaborn package. Data preprocessing will be performed by cleaning, missing value imputation, normalization.
- Feature Selection: Feature selection techniques such as correlation analysis, feature importance analysis and principal component analysis (PCA) will be used to identify the most important features that influence engine performance and emissions.
- Model Selection: Several regression-based machine learning algorithms will such as linear regression, lasso regression, ridge regression will be explored. Decision based algorithms such as decision trees, random forests, extremely randomized forest will also be explored along with the regression models. Their performance will be compared using evaluation metrics such as mean squared error (MSE), confusion matrix, f1 score, root mean squared error (RMSE), and tree indexes.
- Hyperparameter Tuning: Hyperparameter optimization methods such as grid search, manual search and random search will be used to improve the performance of the selected machine learning algorithm.
- Model Evaluation: The final machine learning model will be evaluated using the testing set and compared with the baseline model.

Expected Outcomes

Exploring machine learning models that can precisely forecast critical engine performance parameters and emissions based on multiple engine operating factors is the goal of the proposed study. The study's findings can be utilized to improve engine settings for greater fuel economy and lower emissions. The goal is to find out a machine learning model that can accurately forecast engine characteristics and offer guidance for improving emissions and performance.

Conclusion

The proposed study aims to use machine learning techniques to predict engine performance and emissions based on various engine operating parameters. The developed machine learning model can be used to optimize engine parameters for better fuel efficiency and reduced emissions. The results of this study can provide valuable insights for the future development of more efficient and environmentally friendly engines.

References

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2. Zhang, Y., Kumar, P., Traver, M., & Cleary, D. (2016). Conventional and low temperature combustion using naphtha fuels in a multi-cylinder heavy-duty diesel engine. SAE International Journal, 9(2016-01-0764), 1021-1035. doi:10.4271/2016-01-0764