SmartFuel: Fuel Consumption Prediction Model Using Machine Learning

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ABSTRACT

*Fuel consumption is a critical factor in transportation efficiency, environmental impact, and cost management. Traditional methods for estimating fuel usage rely heavily on manual observations or fixed parameters, which are often inaccurate and lack adaptability. This project presents **SmartFuel**, a machine learning-based fuel consumption prediction system designed to deliver accurate, real-time insights using historical and operational vehicle data.*

SmartFuel utilizes regression algorithms to model fuel consumption based on variables such as engine size, vehicle weight, fuel type, and driving patterns. The system is trained on a real-world dataset and implemented using Python, Flask (for the backend), and HTML/CSS for the web interface. The application provides users with a simple interface to input vehicle parameters and receive precise fuel consumption predictions, enabling better planning, cost reduction, and environmental responsibility.

This project demonstrates the power of predictive analytics in transportation and offers a scalable solution for vehicle efficiency monitoring. With potential applications in fleet management, logistics, and sustainable driving, SmartFuel represents a step toward smarter, data-driven fuel usage decisions.

I INTRODUCTION

Aims to develop a robust fuel consumption prediction model using Random Forest, focusing on its simplicity, interpretability, and efficiency. Random Forest is chosen for its ability to model binary outcomes effectively, making it suitable for predicting vehicle fuel consumption. Random Forest transforms input features into probabilities using a sigmoid function, enabling straightforward interpretation of predictions. The system emphasizes optimizing fuel efficiency and economic benefits by accurately estimating fuel consumption. By leveraging Random Forest strengths in providing probabilistic outputs, the proposed system aims to deliver reliable predictions that can assist manufacturers in making informed decisions to improve vehicle performance and reduce operational costs.

II SCOPE

The scope of SmartFuel includes:

- Predict average fuel consumption using machine learning models.
- Support various fuel types (diesel, petrol, ethanol, natural gas).
- Accept input features like engine size, vehicle class, and fuel type.
- Provide a user-friendly web interface for input and results.
- Display results in an interpretable format for

decision-making.

- Enable scalable and lightweight deployment using Flask.

III LITERATURE SURVEY

Title: Monitoring co2 emissions from hdv in europe-an experimental proof of concept of the proposed methodolgical approach.

Author: G. Fontaras, R. Luz, K. Anagnostopoulus,

Year: 2014 Title: Fuel Consumption Prediction of fleet vehicle using Machine Learning: " A Comparative study".

Author: S. Wickramanayake and H. D. Bandara, Year: 2016

Description: Ability to model and predict the fuel consumption is vital in enhancing fuel economy of vehicles and preventing fraudulent activities in fleet management. Fuel consumption of a vehicle depends on several internal factors such as distance, load, vehicle characteristics, and driver behavior, as well as external factors such as road conditions, traffic, and weather. However, not all these factors may be measured or available for the fuel consumption analysis. We consider a case where only a subset of the aforementioned factors is available as a multi-variate time series from a long distance, public bus. Hence, the challenge is to model and/or predict the fuel consumption only with the available data, while still indirectly capturing as much as

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Title: "Modeling heavy/mediumduty fuel consumption based on drive cycle properties,".

Author: L. Wang, A. Duran,J. Gonder, and K. Kelly. Year: 2015

Description: This paper presents multiple methods for predicting heavy/medium-duty vehicle fuel consumption based on driving cycle information. A polynomial model, a black box artificial neural net model, a polynomial neural network model, and a multivariate adaptive regression splines (MARS) model were developed and verified using data collected from chassis testing performed on a parcel delivery diesel truck operating over the Heavy HeavyDuty Diesel Truck (HHDDT), City Suburban Heavy Vehicle Cycle (CSHVC), New York Composite Cycle (NYCC), and hydraulic hybrid vehicle (HHV) drive cycles. Each model was trained using one of four drive cycles as a training cycle and the other three as testing cycles. By comparing the training and testing results, a represent ative training cycle was chosen and used to further tune each method. HHDDT as the training cycle gave the best predictive results, because HHDDT contains a variety of drive characteristics, such as high speed, acceleration, idling, and deceleration. Among the four model approaches, MARS gave the best predictive performance, with an average percent error of −1.84% over the four chassis dynamometer drive cycles. To further evaluate the accuracy of the predictive models, the approaches were applied to real-world data. MARS outperformed the other three approaches, providing an average percent error of −2.2% over four real-world road segments. The MARS model performance was then compared to powertrain modeling results over HHDDT, CSHVC, NYCC, and HHV drive cycles using NREL's Future Automotive Systems Technology Simulator (FASTSim). The results indicated that the MARS method achieved comparable predictive performance with FASTSim.

Title: "Assessing the regeneration potential for a refuse truck over a real-world duty cycle,"

Author: A. Ivanco, R. Johri, and Z. Filipi.

Year: 2012

Description: The majority of a refuse truck collection cycle consists of frequent Stop and Go events while moving from one household to another. The nature of this driving mission creates the opportunity to reduce fuel consumption by capturing and re-using the kinetic energy normally wasted during braking. This paper includes the evaluation of the brake energy available for regeneration from the conventional drivetrain; the description of the impact of the vehicle variable mass and auxiliary loads; a model validation over a real-world duty cycle; and the potential for an increase in fuel efficiency through hybridization of the drivetrain. The Hydraulic Hybrid (HH) technology is selected since it has a large power density. Special attention is paid to two main issues related to refuse truck modeling: i) the fact that each time the trash bin is picked up, the vehicle mass increases in a discrete manner; ii) the load from the additional auxiliary Power Take-Off unit used to lift and compact the refuse. The model of the complex vehicle system is validated with data from real-world refuse collection duty cycles in Texas.

IV PROBLEM STATEMENT

Fuel consumption plays a vital role in determining the operational efficiency and environmental impact of vehicles. In most cases, users—whether individual vehicle owners or fleet managers—lack access to tools that accurately predict fuel usage based on a combination of vehicle-specific parameters and driving conditions. This leads to inefficient fuel planning, increased operational costs, and higher carbon emissions. Moreover, the absence of predictive systems makes it difficult to estimate how modifications in vehicle specifications, such as engine size or fuel type, affect overall consumption.

Traditional methods used to estimate fuel usage are either too generalized or require the use of hardware sensors and onboard diagnostics, which may not be feasible for small-scale users. These systems often fail to adapt dynamically to user input and do not leverage the power of modern data-driven techniques. As a result, they provide limited support for decision-making or environmental awareness.

Furthermore, there is a lack of easily accessible, intelligent, and user-friendly platforms that utilize machine learning to predict fuel consumption based on historical datasets. Existing applications often ignore the potential of artificial intelligence in improving prediction accuracy and optimizing resource utilization. Therefore, there is a pressing need for a system that can bridge this gap by offering accurate, real-time fuel consumption prediction using machine learning models, combined with an intuitive interface for ease of use.

V PROPOSED SYSTEM

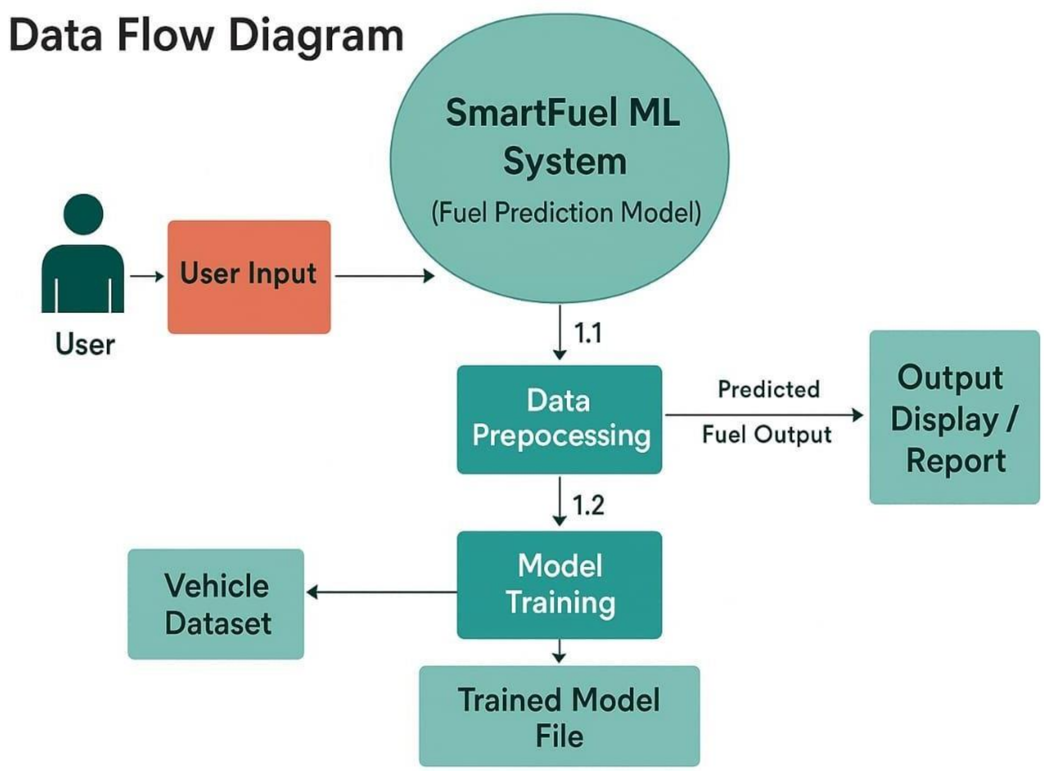
SmartFuel is a predictive application that uses machine learning to estimate the average fuel consumption of vehicles. It allows users to input parameters such as:

- Fuel Type (Petrol, Diesel, Ethanol, Natural Gas)
- Engine Size
- Vehicle Class
- Transmission Type
- Cylinders

The backend model — developed using Python and scikit-learn — processes these inputs and returns a predicted fuel consumption value (litres per 100km or mpg). The user interface is built using HTML and CSS, while Flask handles the interaction between frontend and backend.

The system supports CO2 emission prediction as well, using a separate ML model trained on similar features. Results are displayed instantly after submission.

VI ARCHITECTURE



IMPLEMENTATION

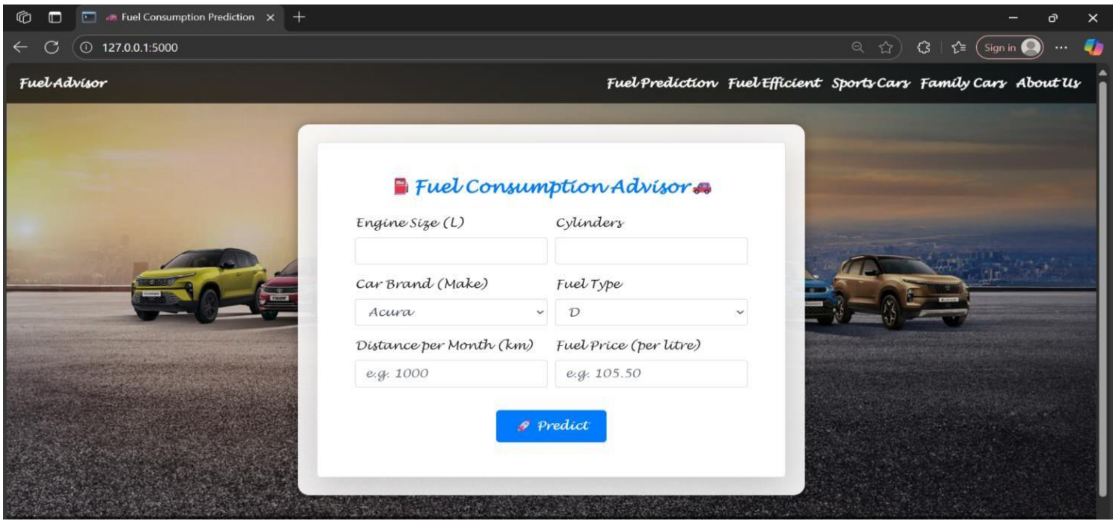
Admin

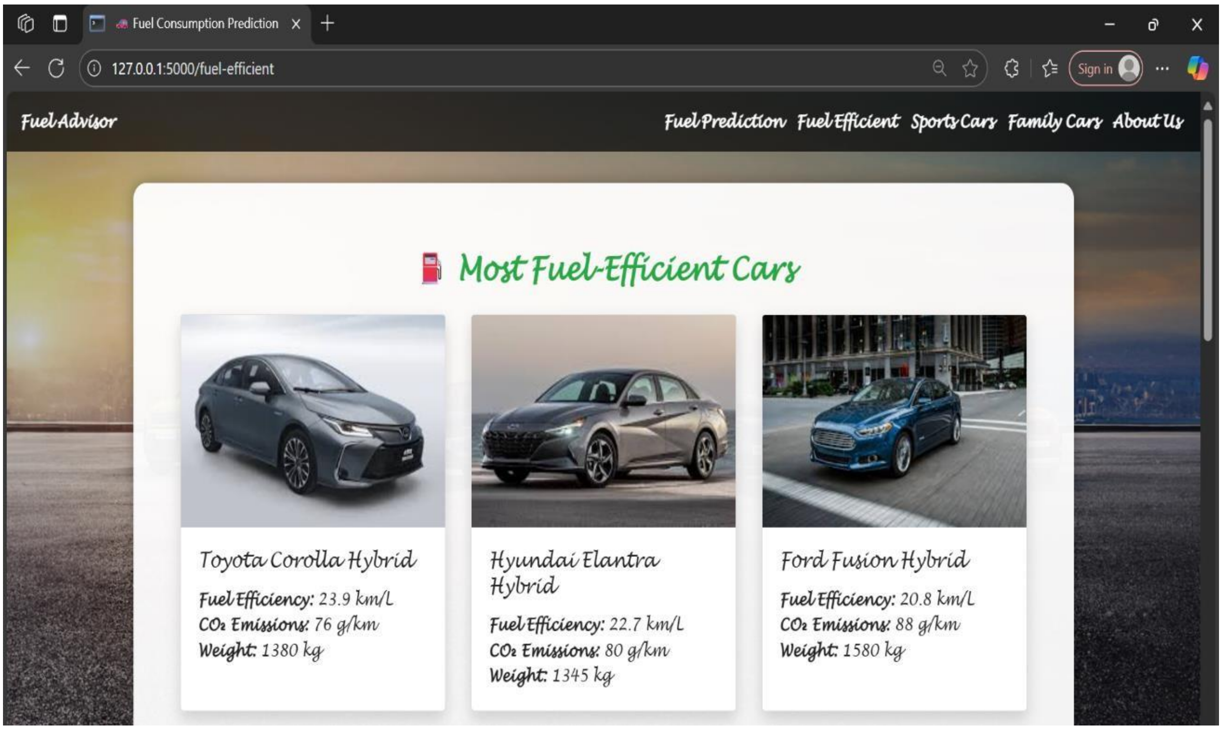
- Login
- User Authentication
- Manage User Accounts
- View System Logs
- Logout

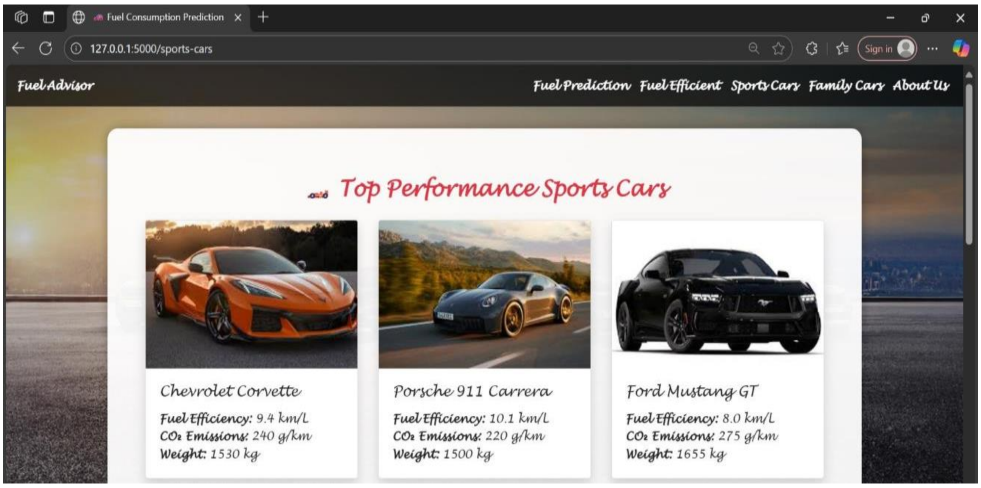
User

- Registration
- Login
- View & Upload OBD Data.
- View Fuel Consumption Predictions
- Logout

VIII RESULTS






Fuel Consumption Prediction
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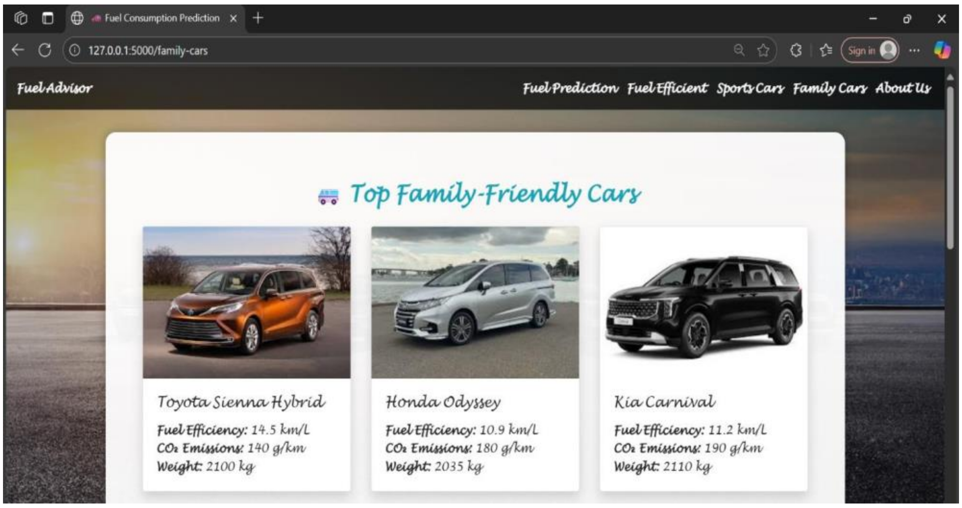
Fuel Advisor
Fuel Prediction
Fuel Efficient
Sports Cars
Family Cars
About Us
Top Performance Sports Cars
Chevrolet Corvette
Fuel Efficiency: 9.4 km/L
CO₂ Emissions: 240 g/km
Weight: 1530 kg
Porsche 911 Carrera
Fuel Efficiency: 10.1 km/L
CO₂ Emissions: 220 g/km
Weight: 1500 kg
Ford Mustang GT
Fuel Efficiency: 8.0 km/L
CO₂ Emissions: 275 g/km
Weight: 1655 kg


Fuel Consumption Prediction
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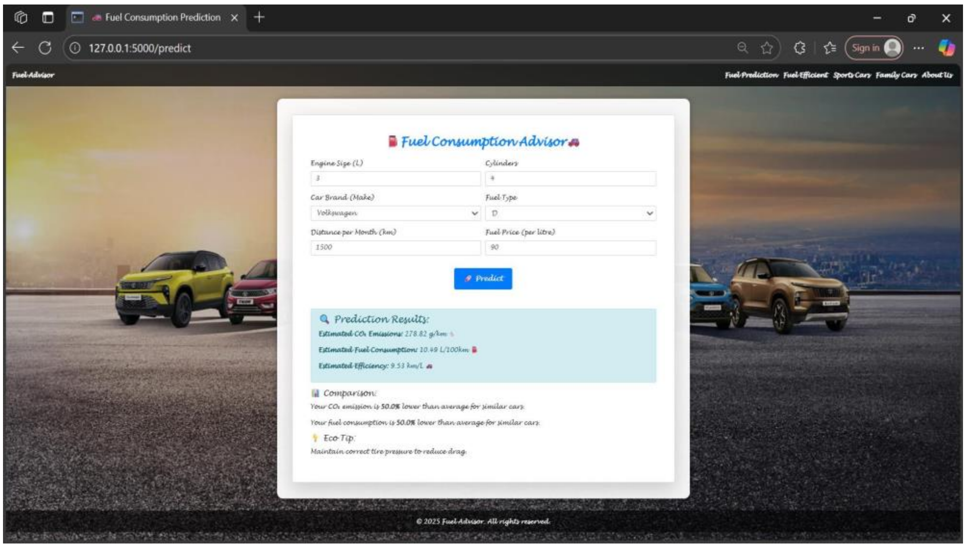
Fuel Advisor
Fuel Prediction
Fuel Efficient
Sports Cars
Family Cars
About Us
Top Family-Friendly Cars
Toyota Sienna Hybrid
Fuel Efficiency: 14.5 km/L
CO₂ Emissions: 140 g/km
Weight: 2100 kg
Honda Odyssey
Fuel Efficiency: 10.9 km/L
CO₂ Emissions: 180 g/km
Weight: 2035 kg
Kia Carnival
Fuel Efficiency: 11.2 km/L
CO₂ Emissions: 190 g/km
Weight: 2110 kg


Fuel Consumption Prediction
127.0.0.1:5000/predict
Fuel Consumption Advisor
Engine Size (L)
3
Cylinders
4
Car Brand (Make)
Volkswagen
Fuel Type
D
Distance per Month (km)
1500
Fuel Price (per litre)
90
Predict
Prediction Results:
Estimated CO₂ Emissions: 278.82 g/km
Estimated Fuel Consumption: 10.49 L/100km
Estimated Efficiency: 9.53 km/L
Comparison:
Your CO₂ emission is 50.0% lower than average for similar cars.
Your fuel consumption is 50.0% lower than average for similar cars.
Eco Tip:
Maintain correct tire pressure to reduce drag.
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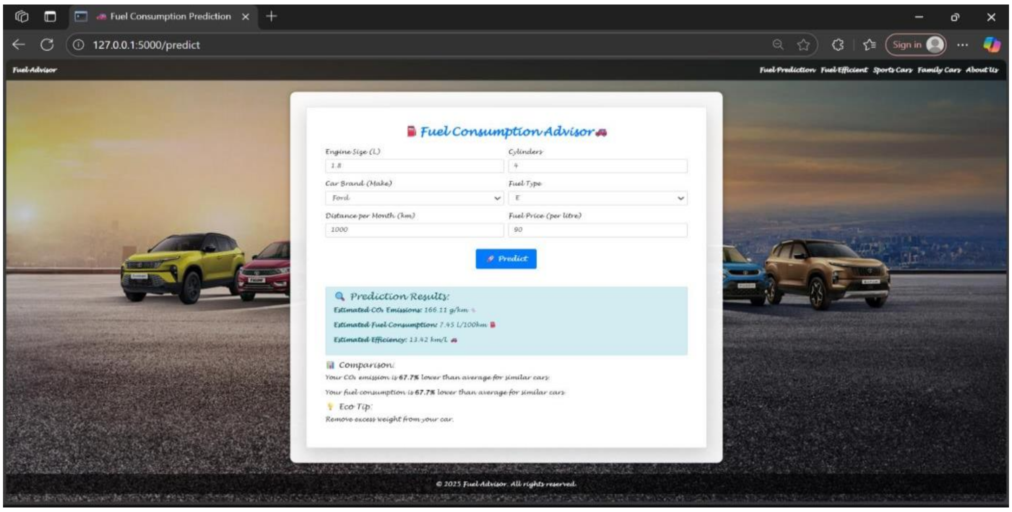

CONCLUSION

This project, introduces a machine learning model designed to predict fuel consumption for heavy vehicles using seven key predictors derived from vehicle speed and road grade data. Among these predictors, the change in kinetic and potential energy are newly introduced to better capture the vehicle's dynamic behavior. All inputs can be obtained through telematics devices commonly found in connected vehicles, and computations can be performed onboard. The model aggregates predictor data over fixed distance windows instead of time intervals, which aligns with the target fuel consumption metric and improves prediction accuracy. The model achieved high accuracy, with an RMSE of less than 0.015 l/100km and a coefficient of determination (CD) of 0.91 for 1 km window sizes. Comparisons across 1, 2, and 5 km windows showed the 1 km window performed best, particularly in mixed urban and highway driving conditions. Shorter windows are ideal for applications like construction fleets or city traffic, while longer windows may suffice for long-haul vehicles. The model outperforms previous ML approaches, which required entire trip data for similar results. Future work will focus on adapting the model to account for vehicle characteristics such as varying mass and wear over time.

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