Fleet-Level Optimization of Tire Allocation based on a Verified Tire State Prediction Framework

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Abstract:

Tires represent a significant cost for fleets, typically ranking just behind fuel and driver wages in operating expenses. Tire retreading is a sustainable, cost-effective solution that extends tire life, reduces costs, minimizes waste, and supports the circular economy. However, the implementation of the retreading process has not been fully leveraged to realize its potential benefits for both the environment and businesses. This is largely due to conservative practices adopted by fleets to minimize downtime risks, in the absence of a comprehensive technological framework to guide the tire maintenance operations.

Truck tire casings are designed to withstand multiple retreads, allowing them to serve over long distances and extended periods, unless they are disqualified from retreading due to severe carcass damage, such as punctures, sidewall cuts, or impact breaks. Tires are mounted in various wheel positions on vehicles across a fleet and operate under a range of conditions, loads and durations throughout their life. Remaining Casing Potential (RCP) is an intuitive metric employed to assess a tire's condition at a specific point in its lifespan and determine whether it has enough structural capacity left for subsequent retreads.

Previously, the authors introduced a technological approach for monitoring tread wear and casing condition in real-time, along with methodologies for communicating a tire's status to fleet operators. A machine learning model for time-series forecasting, called the Temporal Fusion Transformer (TFT), was then implemented to predict the RCP with preliminary results presented. The optimization of tire allocation across an entire fleet of trucks, aimed at maximizing the total lifespan of a set of tires, was proposed as a potential direction for future work.

In this paper, the authors first provide an update on the latest RCP predictions obtained from the machine learning model, retrained on extended telematics data, and compare these predictions with the anticipated RCP rankings to demonstrate the performance of the developed framework. Next, the paper presents the development of a linear-constrained dynamic programming algorithm to address fleet-level optimization, minimizing the number of tires used within a prescribed mileage while making informed retreading decisions based on the tire's casing health.