A Driver-Centric Vehicle Pricing Framework Based on IoT Telemetry, Behavioral Profiling and Machine Learning for Sustainable Mobility

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Abstract— **The increasing availability of connected vehicle technologies is enabling new mobility services based on the analysis of actual vehicle usage. Traditional pricing models are generally based on static vehicle characteristics and rarely consider the impact of driving behavior on energy consumption, safety, maintenance costs, and sustainability. This paper presents a framework for the development of a driver-centric pricing model using telemetry data acquired from onboard vehicle sensors and transmitted through Internet of Things (IoT) infrastructures. The proposed approach combines supervised data acquisition campaigns, centralized data storage, driver profiling, and machine learning techniques to classify users according to aggressiveness, energy efficiency, and safety criteria. The resulting behavioral models are intended to support future dynamic pricing mechanisms capable of adapting to real driving patterns. By incorporating objective behavioral indicators into mobility services, the proposed framework aims to promote safer, more efficient, and more sustainable transportation systems.**

Keywords—Sustainable mobility, driver profiling, IoT, connected vehicles, telematics, machine learning, dynamic pricing, driving behavior analysis.

I. Introduction

The transportation sector is undergoing a profound transformation driven by the growing demand for sustainability, digitalization and intelligent mobility services. Public institutions recognize connected transportation systems as fundamental enablers of efficient and environmentally responsible mobility. At the same time, road safety and energy efficiency remain among the most significant challenges facing modern transportation systems [6], [7].

While vehicle electrification contributes significantly to reducing emissions, the manner in which vehicles are operated continues to have a direct impact on energy consumption, component degradation, maintenance requirements, and accident risk. Drivers operating identical vehicles under similar environmental conditions may generate substantially different operational costs due to differences in driving style.

Current vehicle pricing models generally rely on static parameters such as vehicle category, travelled distance or operating time. These approaches provide limited insight into the actual impact generated by vehicle operation and fail to account for behavioral differences among users.

Recent advances in connected vehicle technologies offer an opportunity to address this limitation. Modern vehicles incorporate numerous sensors capable of continuously monitoring indicators related to vehicle dynamics. These data can be transmitted to cloud-based platforms for large-scale analysis and behavioral characterization.

Previous research has demonstrated the potential of vehicle telemetry, big-data analytics, and machine learning for extracting actionable knowledge from mobility systems. Connected vehicle data have been successfully used to analyze mobility patterns, support safety-related applications, and characterize driving behavior, while telematics-based insurance and usage-based pricing models have highlighted the economic value of behavioral information in transportation services [1]–[5].

This paper presents a preliminary framework for the development of a behavior-oriented vehicle pricing model in which the driver, rather than the vehicle itself, becomes the primary element of analysis.

II. IoT-Based Acquisition Methodology

The proposed framework relies on the continuous collection of telemetry information generated during vehicle operation.

Data are obtained from sensors already available in modern vehicles, including accelerometers, gyroscopes, speed sensors, throttle position sensors and braking-related measurements. These variables provide an objective description of driving behavior and vehicle dynamics.

The acquired measurements can be transmitted periodically at predefined time intervals or event-driven when one or more monitored variables exceed predefined thresholds. Transmission is performed through IoT communication devices connected to a centralized cloud platform.

Telemetry records are stored in a centralized database designed to support long-term storage, historical analysis, and machine learning experimentation. The database acts as the core repository of operational knowledge and provides the foundation for future behavioral analytics and pricing services.

III. Driver Profiling Methodology

A fundamental requirement of the proposed framework is the creation of reliable behavioral models capable of representing different driving styles.

To achieve this objective, supervised training campaigns are conducted with pilot users operating vehicles under monitored conditions. The acquired telemetry data are analyzed to identify the variables that provide the highest discriminatory capability for driver characterization. Based on this analysis, each driver is described through three complementary dimensions:

A. *Aggressiveness*

Aggressiveness is associated with abrupt acceleration events, harsh braking maneuvers, excessive speed variability, and aggressive cornering behavior. These patterns generally increase operational costs, vehicle wear, and accident risk.

B. *Energy Efficiency*

Energy efficiency evaluates the driver's ability to minimize energy consumption through smooth acceleration, anticipatory behavior and efficient speed management. This dimension becomes particularly relevant in electric mobility systems, where driving style directly affects vehicle autonomy.

C. *Safety*

Safety reflects the stability and predictability of vehicle operation. Drivers exhibiting smooth control actions and reduced variability in vehicle dynamics tend to present lower operational risk and safer driving patterns.

The combination of these three dimensions generates a multidimensional representation capable of characterizing vehicle usage more accurately than conventional user segmentation approaches.

IV. Machine Learning Framework

Machine learning constitutes the core analytical component of the proposed framework. The objective is to automatically identify driver profiles from telemetry data and transform raw measurements into actionable behavioral information.

Following data acquisition, telemetry records undergo preprocessing activities including cleansing, normalization, feature extraction, and statistical analysis. Variables such as average acceleration, braking intensity, throttle utilization, speed variability, and cornering dynamics are transformed into behavioral indicators suitable for model development.

The supervised datasets generated during the pilot journeys are then used to train classification models capable of associating telemetry-derived features with predefined behavioral categories. Algorithms such as Random Forests, Support Vector Machines, Gradient Boosting methods, and Artificial Neural Networks may be evaluated according to classification accuracy, computational efficiency, and interpretability.

Previous studies have shown that machine learning techniques are capable of accurately distinguishing between different driving behaviors using vehicle telemetry data, supporting the feasibility of the proposed approach [3]. Moreover, recent studies relating behavioral indicators to insurance pricing demonstrate the practical value of driver classification systems in economic applications [4], [5].

V. Behavior-Based Dynamic Pricing

The ultimate objective of the proposed framework is the development of pricing mechanisms based on actual vehicle usage rather than solely on static vehicle characteristics.

By continuously evaluating behavioral indicators related to aggressiveness, efficiency, and safety, it becomes possible to associate economic conditions with measurable driving patterns. Such an approach may be applied to usage-based insurance products, vehicle leasing programs, fleet management systems and mobility-as-a-service platforms.

Drivers demonstrating efficient and safe behaviors may benefit from more favorable pricing conditions, while users exhibiting higher levels of operational risk or inefficient vehicle usage may be associated with different pricing structures. Existing telematics-based insurance initiatives provide evidence that behavioral data can be effectively incorporated into risk assessment models and pricing schemes [4], [5].

Beyond economic considerations, the proposed methodology aims to encourage behavioral changes that contribute to sustainability objectives through reduced energy consumption, safer driving practices, and more efficient utilization of transportation resources.

VI. Conclusions

This paper has presented a preliminary framework for the development of a driver-centric vehicle pricing model based on IoT telemetry, centralized data storage, behavioral segmentation and machine learning techniques.

The proposed architecture enables the continuous acquisition of vehicle data, the characterization of drivers according to aggressiveness, energy efficiency, and safety criteria, and the development of predictive models capable of supporting future dynamic pricing systems.

The work builds upon previous research in connected mobility, telemetry analytics and machine learning while extending these concepts toward economically adaptive mobility services. Future research will focus on large-scale data acquisition campaigns, advanced feature engineering, model optimization, and the deployment of real-time behavioral classification systems.

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