Artificial Neural Networks for Predicting Deviations in DAQ Tests of Motorsport Dampers

Antoni Wolski
PUT Motorsport, Poznan University of Technology
Poznań, POLAND
Email: antoni.wolski@student.put.poznan.pl

Aleksandra Świetlicka
Poznan University of Technology
Institute of Automatic Control and Robotics
Poznań, POLAND
Email: aleksandra.swietlicka@put.poznan.pl

***Abstract*—This paper presents an application of a one-dimensional convolutional neural network (1D CNN) to predict the behaviour of motorsport shock absorbers under external forces. Data was acquired using DAQ systems from KITSUMA dampers used on the Formula Student PM10 Malta race car. The model evaluates temporal deviations in damping force compared to a linear reference model, functioning as an early warning system for impending performance drops. The proposed model achieved an AUROC of 0.961, demonstrating its effectiveness for condition monitoring and predictive maintenance in motorsport applications.**

I. Introduction

Shock absorbers play a critical role in motorsport vehicles by controlling suspension dynamics, maintaining tire contact with the road surface, and improving handling and stability. Their performance directly affects ride quality, cornering behavior, braking efficiency, and safety [1]. Accurate characterization of damper behavior is therefore essential for vehicle development and suspension setup optimization.

Data acquisition (DAQ) systems enable the measurement of damper force, displacement, velocity, suspension travel, accelerations, and control signals under laboratory and real-world conditions [2], [3], [4]. Such measurements support force–velocity characterization, model validation, suspension tuning, and damper condition assessment [1], [4], [5]. DAQ systems have been implemented in dedicated damper dynamometers and shock test rigs using both commercial and low-cost acquisition platforms [2], [5], as well as in on-vehicle measurement and telemetry systems for suspension analysis [3], [4].

Beyond conventional damper characterization, DAQ measurements can support condition monitoring by identifying changes in damping behavior associated with component degradation. This creates an opportunity to combine measured damper responses with machine learning methods for early detection of abnormal behavior. In this study, DAQ data from KITSUMA shock absorbers used in the PM10 Malta Formula Student race car are analyzed using a one-dimensional convolutional neural network (1D CNN). The proposed approach predicts future deviations of damping force from a linear reference model, providing an early warning of potentially degraded damper behavior.

II. Methodology

The dataset was obtained from controlled DAQ testing of KITSUMA shock absorbers used in the PM10 Malta Formula Student race car, shown in Fig. 1. The physical shock absorbers used in the tests are presented in Fig. 2. The dampers were subjected to gradually increasing external force, while force, displacement, and time were recorded at 10 Hz during approximately 2-minute tests.

Each window was assigned a binary label based on the future response: label 1 was assigned if the force deviation exceeded the predefined threshold in window $n + H$. Thus, the model uses the current window n to predict an impend-

Fig. 1. The PM10 MALTA Formula Student race car during track operation.

Fig. 2. Physical shock absorbers utilized in the DAQ testing and vehicle setup.