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Driver Anomaly Quantification for Intelligent Vehicles: A Contrastive Learning Approach With Representation Clustering

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Abstract:

Driver anomaly quantification is a fundamental capability to support human-centric driving systems of intelligent vehicles. Existing studies usually treat it as a classification task and obtain discrete levels for abnormalities. Meanwhile, the existing data-driven approaches depend on the quality of dataset and provide limited recognition capability for unknown activities. To overcome these challenges, this paper proposes a contrastive learning approach with the aim of building a model that can quantify driver anomalies with a continuous variable. In addition, a novel clustering supervised contrastive loss is proposed to optimize the distribution of the extracted representation vectors to improve the model performance. Compared with the typical contrastive loss, the proposed loss can better cluster normal representations while separating abnormal ones. The abnormality of driver activity can be quantified by calculating the distance to a set of representations of normal activities rather than being produced as the direct output of the model. The experiment results with datasets under different modes demonstrate that the proposed approach is more accurate and robust than existing ones in terms of recognition and quantification of unknown abnormal activities.

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I. Introduction

Intelligent driving has attracted considerable attention, and tremendous progress has been achieved in recent years [1], [2]. Autonomous vehicles have been primarily investigated to replace human drivers in order to enhance driving performance and avoid possible fatalities. However, human drivers will still play an important role in the driving task for a certain period before full driving automation is achieved. Hence, the coexistence and cooperation of humans and vehicles represents an urgent and exciting new focus for the development in-vehicle technology [3], [4]. To enhance user safety and the efficiency of collaboration with intelligent vehicles, a reliable driver monitoring system (DMS) should be further pursued to parse the state of a human driver, which is a fundamental functionality to support advanced driver assistance systems and partially automated vehicles [5]–[8].

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