

ASSESSMENT OF DRIVER STRESS STATE USING MULTIMODAL FUSION OF SIMULTANEOUS CONTACT-FREE PHOTOPLETHYSMOGRAPHY AND FACIAL VIDEOS

Swarubini P J, Nagarajan Ganapathy
Department of Biomedical Engineering, Indian Institute of Technology, Hyderabad, Telangana, India

Corresponding Author: Swarubini P J
Email: bm23resch11010@iith.ac.in
doi:10.34107/UKKK6693.099

ABSTRACT

Driver stress is characterized by complex psychological, physiological, and behavioral responses to various stressors encountered on the road. Traditionally, driver stress has been assessed through physiological, facial, and vehicle motion measurements. Recently, non-contact sensing have been explored for physiological measurement. In this study, attempt has been made to classify the driver stress using imaging photoplethysmography (iPPG) signals, facial keypoints and intermediate fusion based convolutional neural network (CNN). For this, we acquired infrared facial videos from N=20 healthy subjects using driving simulator in a controlled environment. Facial keypoints and iPPG signals are extracted using CNN and Local Invariance group method from the facial videos. iPPG signals are fed into the 1D CNN architecture and facial keypoints are fed into 2D CNN architecture for feature learning. Experiments are performed and the performance metrics is computed. Results show that the proposed approach could classify between the drivers' stress states. The proposed fusion approach achieved an average classification accuracy (ACC), F1- score (F-m), precision (PRE), and recall (REC) of 87.00%, 86.33%, 86.67% and 86.67% respectively. The iPPG signals demonstrated the highest average ACC (90.00%), F-m (90.33%), PRE (90.33%), and REC (90.00%), among the individual models. When facial keypoints are alone taken for analysis, it showed significantly lower performance, with an ACC, F-m, PRE, REC of 67.00%, 66.67%, 68.33% and 66.67% respectively. The proposed methodology demonstrated superior performance, consistently outperforming most existing state-of-the-art methods. Thus, the proposed framework could be extended for driver stress detection in real-time scenarios, offering potential applications in improving road safety.

Keywords: Driver stress, non-contact, 2D CNN, iPPG signals, facial keypoints, multimodal fusion.

INTRODUCTION

Stress is a complex physiological response to changing environmental, internal, psychological, or social conditions. According to Selye, stress can be classified into two categories: pathological stress, commonly termed distress, and health-promoting stress, known as eustress [1]. Driver stress involves the psychological and physiological strain experienced by individuals while driving a vehicle, typically resulting from various factors such as traffic congestion, aggressive driving behaviors etc. This can lead to increasing the risk of accidents and road incidents [2].

Driver stress measurement can be classified into three main categories: physiological measurements, assessments of facial behavior, and evaluations of vehicle motion. Measurements of facial behavior involve analyzing facial expressions and movements to assess emotional states, including stress. Physiological data, in contrast, tends to be unaffected by external contextual factors that are unrelated to stress, such as variations in lighting conditions or alterations in driving techniques. Physiological measurements involve monitoring the body's physical responses to stress with the help of wearable sensors. The utilization of multiple sensors positioned on a driver's body can lead to discomfort and heightened stress levels for the user [3]. Hence, there is a need for a physiological monitoring technique that is robust and convenient, ensuring comfort for the user.