

AUTOMATED IDENTIFICATION OF DRIVER INATTENTION STATE USING TEXTILE ELECTROCARDIOGRAMS AND BISPECTRUM BASED CLASSIFICATION

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ABSTRACT

Psychosocial stress while driving leads to driver inattention, which is a major contributing factor in many traffic accidents. Fast and accurate detection of a driver's mental state is critical to mitigating health risks and preventing road crashes. Identifying driver inattention states using wearables is still challenging for advanced driver monitoring systems. In this study, we propose the application of Higher-Order Bispectrum (HoB) features for the automated classification of driver inattention states using Textile Electrocardiograms (tECG) signals. For this, electrocardiogram (ECG) data was collected from 15 subjects using textile electrodes at 256Hz while driving normally scenario and driving when engaging in a phone call. HOS bispectrum features were extracted from the ECG data and fed to classifier namely support vector machine(SVM), Random forest(RF) and 1D Convolution neural network fusing Leave-One-Subject-Out cross-validation. Results shows that the proposed is able to identify the driver inattention state with RF and bispectrum features yielding a weighted F1-Score of 70.08 % and an average accuracy of 75.55 % and segments 30 second segment has performed better compared to other segments.Thus the proposed approach could be useful in development of fast and accurate real-world driver monitoring systems.

Keywords: Driver Inattention, ECG Signals, Bispectrum features, Textile Electrodes, Machine Learning.

INTRODUCTION

Psychosocial stress has become a constant part of daily life, stemming from financial pressures, work demands, and more [1]. While driving, Psychosocial stress result in inattention to the driving task, leading drivers to engage in unrelated activities such as phone calls, conversations with passengers, or listening to music—actions that can impair vehicle control and elevate accident risks. With the advancement of driver assistance and autonomous driving systems, real-time monitoring of a driver's Psychosocial Psychosocial stress is essential[2]. This enables systems to provide timely warnings, make automatic adjustments, and for improved driving.

ECG is a reliable indicator for assessing a driver's cognitive status, with signals analyzed in both time and frequency domains. In the time domain [3], key measures include heart rate variability (HRV) features such as the mean RR interval, standard deviation of RR intervals, mean heart rate, and standard deviation of heart rate. Similarly, in the frequency domain [4], HRV features such as low-frequency (LF) power, high-frequency (HF) power, and the LF/HF ratio are commonly used. As cognitive workload increases, LF and the LF/HF ratio tend to rise, while HF power decreases. However, very few studies have explored higher-order, nonlinear features in ECG signals for identifying and classifying driver inattention caused by cognitive distractions [4].

Recent advancements in the Internet of Medical Things (IoMT) have shown promising results in collecting physical and physiological data using noninvasive and wearable hardware in a nonclinical environment [5][6]. Among various physiological and physical methods for mental stress detection, heart rate variability (HRV) is considered one of the most dominant and reliable measurements [7]. In physiological terms, mental stress influences the autonomic nervous system (ANS), which consists of two primary branches: the sympathetic and parasympathetic nervous systems. Under stress, the balance between these branches shifts, inhibiting parasympathetic activity while enhancing sympathetic responses [8].