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Literature Survey on Drowsiness Detection using ECG Sensors

Mrunal K. Pathak [1], *Tanmayee S. Mali* [2]

[1]*Assistant Professor, Department of Information Technology, AISSMS's Institute of Information Technology, Pune-411001, INDIA*
[2]*TE. BE (Information Technology), AISSMS's Institute of Information Technology, Pune-411001, INDIA*

A B S T R A C T

Fatigue and drowsiness account for a significant proportion of traffic accidents. Drowsiness detection can prevent accidents caused by drivers who fell asleep while driving. In recent years, driver drowsiness detection based on biological signals such as an electrocardiogram has been studied. Heart rate variability (HRV) can be used to capture changes in driver drowsiness, fatigue and stress. As the QRS complex is the most prominent feature of the electrocardiogram (ECG) signal, its detection is important for ECG signal analysis. HRV is derived from the ECG RR interval. This paper focus on study of drowsiness detection using electrocardiographic features. In this paper we proposed drowsiness monitoring system based on a combination of convolutional and recurrent neural networks.

Keywords: ECG monitoring system, Drowsiness detection, Neural Network

Introduction

The drowsiness state can be defined as an intermediate state between awake and sleep. Detecting this state is a real and open challenge since high vehicle accident rates are due to drowsiness. This state particularly involves lack of concentration, partial eye closure and relaxation. Various methods have been investigated to detect drowsiness, including monitoring physiological measurements based on wearable sensors and face and eye recognition using the Computer Vision algorithm. Since there is a strong correlation between sleep rhythm and brain and heart activity, drowsiness can be detected accurately from physiological signals. One of these physiological signals is the electrocardiogram (ECG). An electrocardiogram represents the electrical activity of the heart and can be sensed by electrodes placed on the surface of the body.

1.1 Motivation

Annually, over 1.2 million people die on the world's road, and between 20 and 50 million suffer nonfatal injuries. Therefore, drowsiness detection are important especially in case of drivers to prevent traffic accident and reduce the injury. The development of an effective driver monitoring and warning system will prove helpful in reducing the road accidents caused due to driver drowsiness.

1.2 Aims and Objective of work

- Develop a driver monitoring system to measure and analyze the driver's ECG signal
- Measure and analyze the driver's electrocardiogram for various driving situations
- Analyzes the driver's behavior.

2. Literature Survey

2.1 ECG Monitoring Value Chain

The ECG monitoring value chain includes many common processes such as data acquisition, preprocessing, feature extraction, processing, analysis and visualization. A study and analysis of the ECG monitoring system value chain to understand the value and contribution of each process within the system, the best practices that each process can adopt, and the ultimate goal of the system as a whole to deliver better quality disease was helpful. Diagnostics make resource utilization more efficient in terms of energy and cost. Most of the existing studies agree with the above main his ECG monitoring method. However, depending on the nature of the surveillance application, some studies have defined additional discrete or overlapping processes such as data cleaning, encryption and compression, which could be integrated or integrated as part of the main existing process. It can be merged or separated as a supporting process.

One of the most important processes is data acquisition, which uses various sensors to measure and record cardiac activity. The large amount of data generated by the EKG acquisition process requires preprocessing to prepare the data for the next stage, feature extraction and processing. Preprocessing accuracy has an indirect impact on subsequent stages in the value chain. Such preprocessing activities include cleaning his ECG data without loss of key components or functionality. For this reason, most research papers devote a great deal of effort to the pretreatment stage. Prior to the processing and analysis phases, large amounts of ECG signals require a feature extraction process to reduce processing overhead and save resources. Feature extraction is a very important phase because it has a large impact on the subsequent lifecycle phases.

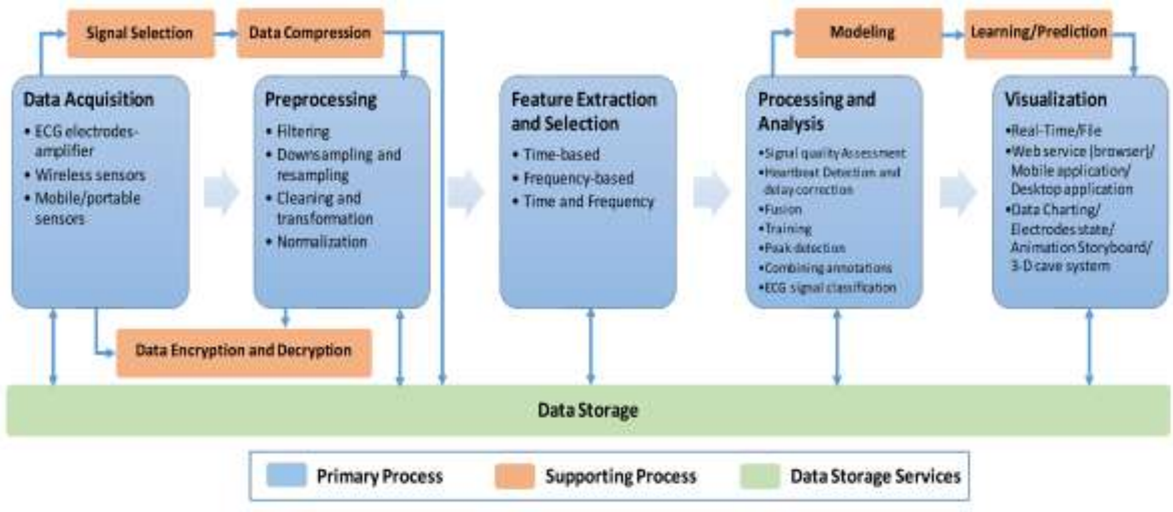

Figure 2.1 ECG Monitoring Lifecycle

3. Methodology

3.1. QRS identification

Since the QRS complex is the most prominent feature of the electrocardiogram (ECG) signal, its detection is important for ECG signal analysis. A typical ECG-based heartbeat consists of three main waves: the P wave, the QRS complex, and the T wave. The QRS complex is the most prominent feature and can be used to obtain additional useful clinical information from ECG signals such as: B. RR interval, QT interval, PR interval, etc. Therefore, QRS detection is important for ECG-based health assessment. The QRS width is useful in determining the origin of each QRS complex (e.g. sinus, atrial, junctional or ventricular).

A QRS complex can be examined by looking closely at their characteristics, especially their location, configuration, and deflection.

- Q wave - first negative deviation from baseline after P wave
- R wave - first positive deviation after Q wave
- S wave - first negative deviation below baseline after R wave

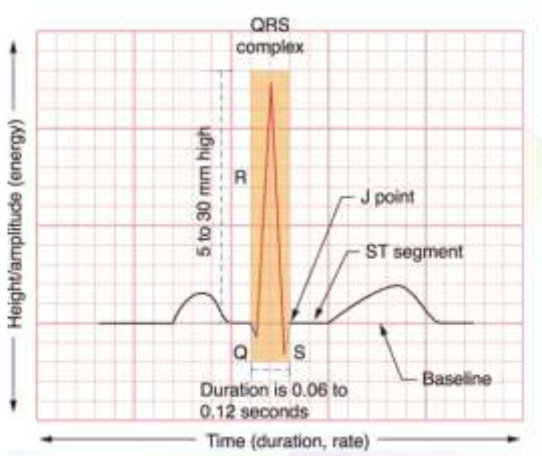

Figure 3.1 QRS Complex

- The starting point is where the first complex wave begins to deviate from the baseline.
- The endpoint is where the last complex wave begins to level off (flatten) above or below the baseline.

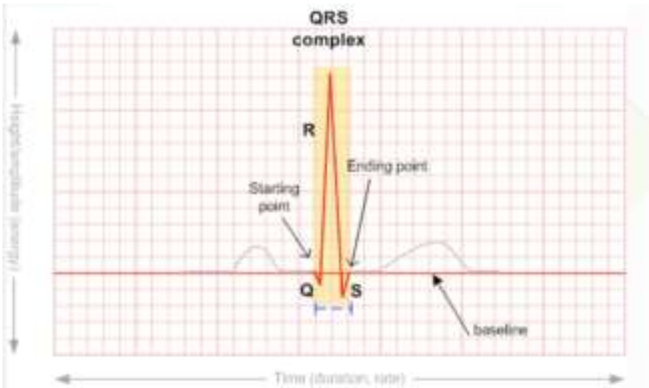

Figure 3.2 QRS Complex measurement

4. Architecture

4.1. ECG Analysis using Deep Learning

The proposed model for joint ECG data analysis relies on two different analyses, both performed using artificial neural networks: frame and temporal analyses.

A. Frame Analysis:

This analysis aims to characterize drowsiness states using data frames passed through a CNN. Each frame is analyzed independently from others. Inspired by classics CNN [20], the used CNN is made up of a succession of 6 layers, each of them involving 1 Convolution, 1 MaxPooling and 1 Batchnormalization layer. Finally, a Dropout and a GlobalAverage-Pooling layers are applied.

B. Temporal Analysis

In addition to frame analysis, drowsiness is said to be a condition that occurs after a progressive decline in attention. As a result, analysis of segments arising from consecutive frames seems appropriate. A recurrent neural network (RNN) is used to characterize the temporal evolution of different frames. A Long Short-Term Memory (LSTM) network is used to capture memory effects between consecutive frames. LSTMs are widely used in the literature, especially because they can overcome the vanishing gradient limitation by adding weights that manage memory.

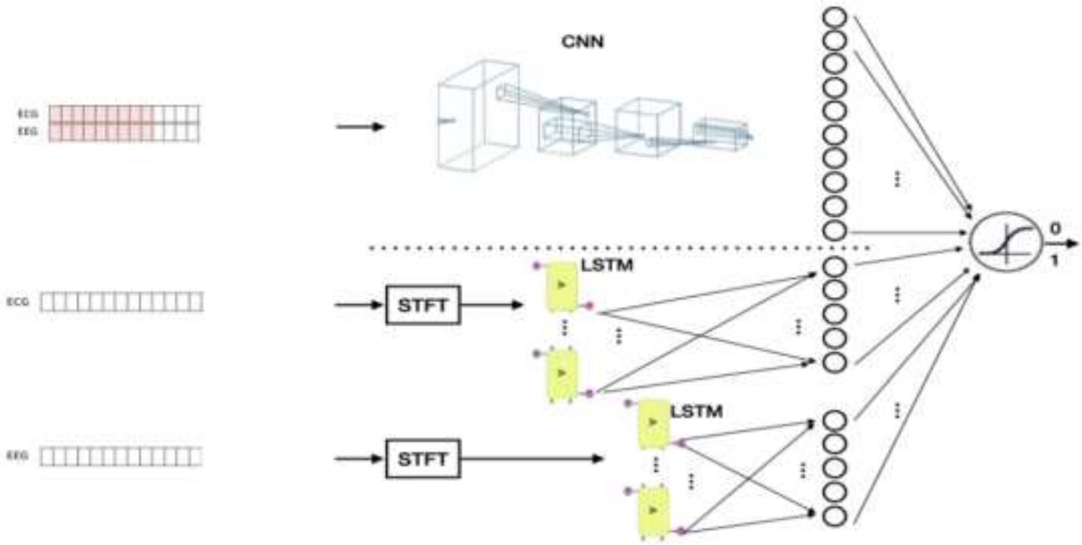

Figure 4.1 Proposed architecture for drowsiness detection

5. Conclusion

This paper studied a new method for drowsiness detection using ECG data. The proposed method is based on a combination of convolutional and recurrent neural networks. A very accurate detection was obtained, especially when the learning step involves frames from the target subjects.

Implementing this architecture in driver monitoring system will make the system more efficient and reliable. Thus, we were able to contribute in achieving road traffic safety.

Future work will focus on investigating the use of fractal features to improve the performance of the proposed model, as well as large scale validation with data collected using connected ECG devices.

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