ARC '18

مؤتمر مؤسسة قطر
السنوي للبحوث

QATAR FOUNDATION
ANNUAL RESEARCH CONFERENCE

البحث والتطوير: التركيز على
الأولويات، وإحداث الأثر

R&D: FOCUSING ON PRIORITIES,
DELIVERING IMPACT

20-19 مـــارس
19-20 MARCH

مـؤسـسـة قـطـر
Qatar Foundation
لإطـلاق قـدرات الإنـسـان.
Unlocking human potential.

Computing & Information Technology - Poster Display

http://doi.org/10.5339/qfarc.2018.ICTPD1132

Driver Drowsiness Detection Study using Heart Rate Variability analysis in Virtual Reality Environment

Muhammad E. H. Chowdhury*, Samir Hussein El Beheri, Mohammed Nabil Albardawil, Ahmed Khaled Mohamed Nageb Moustafa, Osama Halabi, Mustafa Serkan Kiranyaz

Lecturer, Electrical Engineering, Qatar University
* mchowdhury@qu.edu.qa

Introduction Mobility and road safety is one of the grand challenges that Qatar is facing during the last decade. There are many ways to enhance the road safety. One way is to characterize the factors contributing to the road fatalities. According to Transport Accident Commission, about 20% of fatal road accidents are caused by driver fatigue [1]. As reported by Monthly Qatar Statistics in [2], the total number of deaths for the first 8 months of the current year is 116. Thus, around 23 of the casualties are caused by driver fatigue. According to the U.S. Department of Transportation's NHTSA, in 2016 the number of fatalities involving drowsy driver is 803, which is 2.1% of total fatalities in the same year in US [3]. Therefore, it is essential to design and implement an embedded system in vehicles that can analyze, detect, and recognize the driver's state. The main aim of this project is to detect and recognize different drowsiness states using electrocardiogram (ECG) based Heart Rate Variability (HRV) analysis through heartbeats data acquisition while he/she is driving the car in different timings of the day. Then an alarm is produced before the driver's situation reaches the dangerous case that might lead him/her to involve in an accident. Background A driver›s drowsiness state can be detected through different methods. One of the most accurate methods is to get the HRV information acquired from Electrocardiogram (ECG) signal helps to identify different states like awake, dizziness, drowsiness and sleep behind the steering. HRV describes the involuntary nervous function, which is in fact the R-to-R interval (RRI) variations of an acquired ECG signal [4]. By identifying the RRI as well as the distance between the RR peaks, we can decide if the

دار جامعة حمد بن خليفة للنشر
HAMAD BIN KHALIFA UNIVERSITY PRESS

Cite this article as: Chowdhury M et al. (2018). Driver Drowsiness Detection Study using Heart Rate Variability analysis in Virtual Reality Environment. Qatar Foundation Annual Research Conference Proceedings 2018: ICTPD1132 http://doi.org/10.5339/qfarc.2018.ICTPD1132.

driver is in drowsy state or not, by analyzing HRV time and frequency domain features. Low Frequency (LF) band (0.04–0.15 Hz) describes the sympathetic and parasympathetic activities of the heart activity whereas; High Frequency (HF) band (0.15–0.4 Hz) describes only the parasympathetic activities of the heart activity [4]. The LF/HF ratio reflects the differences between awake and drowsy states while the ratio was decreasing gradually from the awake state to drowsy state [5-6].Method A portable wireless BioRadio (Fig.2 A) (Great Lakes NeuroTechnologies, Inc.) Electrocardiogram (ECG) system was used with three Ag/AgCl electrodes attached to a participant's chest. The points of attachment are (i) two electrodes under the right and left collarbone, and (ii) one electrode under the lowest left rib bone of the participant. ECG signal was band passed through a filter (0.05-100 Hz) digitized at a sampling frequency of 500 Hz with 12-bit resolution to be displayed on the device GUI software BioCapture. Data were stored from BioCapture software on the hard disk of an Intel Core i7 Personal Computer for off line analysis. The simulation of highway driving was created in virtual reality 3D cave environment (Fig. 2B) (in VR lab, Research Building, Qatar University). Simulation scenario was a two-way highway with two lanes in each direction, low density of traffic, late afternoon and/night environment, path with no sharp curves and rural environment with far apart trees. ECG data were recorded from three subjects while the subjects were driving monotonously a car in VR environment during active and drowsy states. A camera from the front was used to detect the drowsiness stages, and to segment the ECG data based on drowsiness. ECG data of each subject was exported using the Bio-Capture software and segmented using CSV splitter to analyze the data by Kubois software. ECG signal was recorded from each subject for one hour approximately until the subject becomes drowsy. The one-hour sample data was splitted into six segments, each with 10 minutes duration. This was done to make the analysis of each sample easier and to be able to specify and identify exactly the time when the subject was awake and/or drowsy. Result and Discussion Figure 3 shows the sample ECG trace from subject one and selected RR intervals were calculated using Kubios HRV software and the RR series was produced by interpolation. This RR time series was used to calculate heart rate (HR) and HRV using the same software. The RR time series was used to calculate the power spectral density (PSD) by applying the Fast Fourier Transform (FFT) method to identify the LF and HF frequency component of the HRV. Figure 4 shows the PSD averaged over trials for sample participants in case of active and drowsy states. As it can be seen from Figure 4, there is a significant difference in the LF/HF ratios, as it decreased drastically from 4.164 (Fig. 4A) when subject was awake to 1.355 (Fig. 4B) when subject was drowsy. In addition, HF and LF alone can be taken as indicators for drowsiness. The HF increased from 163 ms2 when subject was awake to 980 ms2 when subject was drowsy. Moreover, the LF value also increased from 679 to 1328 ms2. The summary of the LF/HF for different participants are shown in Table 1. Table 1 clearly shows that LF/HF is higher for all the subjects during their active states and the ratio is decreasing, as the subject was getting drowsy. This result is in line with the findings of other researchers.Conclusion It can be summarized from the findings from this experiment that the HRV based drowsiness detection technique can be implemented in single board computer to provide a portable solution to be deployed in the car. Depending on the sleep stages detected through HRV analysis, the driver can be alerted through either piezoelectric sensor or audible alerting message, which will help to reduce significant road accidents.