Drowsiness Detection by Combining Eye Closure and Non-contact Heart Rate Variability using RGBD Camera

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Vinod Pathangay
Wipro Limited


Ankita Kalra
Wipro Limited


Anandaraj Thangappan
Wipro Limited

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Ankita Kalra, Rahul Jain, Yadhunandan U. S., Vinod Pathangay and Anandaraj Thangappan

Abstract — **In this paper, we describe ongoing experiments on drowsiness detection using an RGBD camera[1] based on two types of features: (1) eye closure and (2) heart-rate variability (HRV) as derived from the heart rate estimated using a non-contact method.[2] The eye closure percentage is determined using computer vision technique based on active shape model. The HRV is used to extract a physiological sleepiness metric. This combination has the advantage that it reduces false alarms raised by systems that solely rely on eye closure based measures. For preliminary experiments, it is observed that there is a significant correlation between the two metrics. The proposed method has the advantage that only a single RGBD camera is required for drowsiness detection.**

I. Introduction

Drowsiness reduces the cognitive abilities of drivers and other workers involved in jobs requiring constant alertness. Falling asleep in such situations can be fatal or lead to losses. Hence it is important to detect drowsiness and provide warnings. Prior solutions detect visual features based on eye closure detection, or use contact based sensors based on ECG, EEG and pressure of hands holding the steering wheel. However they can be prone to false alarms due to their dependency on single modality. Also contact based sensing for ECG or EEG is not well adopted due to usability constraints. In this paper, we present preliminary work on detecting driver drowsiness using a single RGBD camera without using any other sensor. The correlation between eye closure percentage and HRV based physiological sleepiness metric is studied.

II. Prior Work

Eye closure detection using computer vision techniques has been widely researched. A survey of driver drowsiness methods using different modalities are presented in [1], [2]. In [4], a range of eyelid parameters (blink duration, eyelid closure speed, and opening speed, etc.) are used to train a support vector machine (SVM). Measurement of sleepiness using HRV (ratios of low-frequency (LF) and high-frequency (HF) of the Welch power spectrum of the heart rate sequence) as proposed in [3]. Although the idea of combining different modalities are mentioned in prior work, it requires multiple sensors. The novelty of this paper is in the use of a single RGBD camera which provides non-invasive and non-contact drowsiness measurement.

III. Proposed Method and Results

The two measures used are obtained as follows: (1) **Eye closure detection**: An active shape model was trained and used to localize key landmark points in the eye region in every frame. The percentage of eye closure is computed using the distance between the landmark points on eyebrows and eyelashes normalized w.r.t. eye height. Averaging window is applied to get smooth variation of eye closure percentage over time which takes care of eye blinks (Fig. 1). (2) **Sleepiness metric**: Welch power spectral density (WPSD) of the heart rate is first obtained. Low (0.04 - 0.15 Hz) to high (0.15 – 0.4 Hz) frequency ratio is calculated. It is observed that this ratio lies between zero and 0.1. This ratio is normalized with respect to 0.06 (baseline when person is fully awake) and shown as a percentage. Fig. 1 shows the correlation between both the measures.

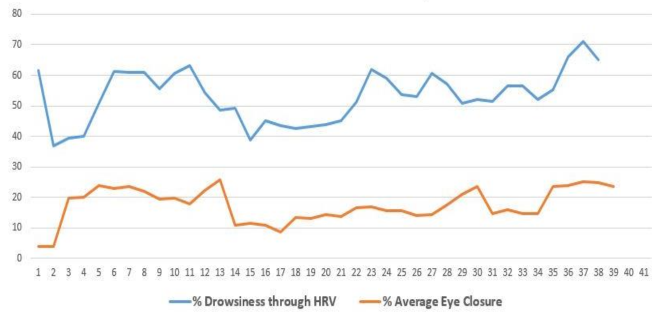

Figure 1. Correlation between eye closure (bottom red curve) and HRV based sleepiness metric (top blue curve) observed for one subject. X-axis: each unit is 30 sec. Y-axis: Percentage of the measure with offset introduced to visualize without overlap.

IV. Conclusion and Future Work

Visual and physiological measures can be extracted from the RGBD video. These show a promising correlation that can be combined to provide improved accuracy for drowsiness detection. Future work involves testing on a larger scale and in realistic conditions.

References

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Authors are with Wipro Technologies, CTO Office, Electronics City, Bangalore-560100, Karnataka, India. *Phone: +91-99800-44033; *E-mail: *vinod.pathangay@wipro.com.

[1] We used Intel Real Sense F200 3D camera that provide depth along with RGB colour frames.

[2] The heart rate estimation algorithm was provided by the Intel Real Sense camera API.