PhD in Bioengineering

Final Defense

POLITECNICO MILANO 1863

PHD BIOENGINEERING – THESIS FINAL DEFENSE

PHD Student
PIERLUIGI REALI
Advisor
Prof.sa Anna Maria Bianchi

THESIS:

Towards the development of physiological models for emotion and stress assessment

Date: 17.03.2021
h. 15:00
Online Microsoft Teams

SCHEDULE OF THE DAY	
15:00 - 15:15	Committee Meeting
15:15 - 16:15	PhD Student PIERLUIGI REALI Thesis presentation - Discussion
16:15 - 16:30	Committee meeting
16:30	Award Ceremony

COMMITTEE MEMBERS		
Prof. Hugo Placido da Silva	Prof. Fabio Babiloni	Prof. Linda Pattini
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SAVE THE DATE

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Final Defense

PhD student: REALI PIERLUIGI – XXXII Cycle

Thesis title: Towards the development of physiological models for emotion and stress assessment

Advisor: Prof. Anna Maria Bianchi
Tutor: Prof. Elena De Momi

Abstract:

In the last decades, there has been a growing interest in the literature concerning the assessment of stress and emotions, especially using physiological signals. Indeed, stress and emotion recognition systems have promising applications in several fields, such as health, human-machine interaction, and marketing. In particular, there is strong evidence of the consequences that high levels of chronic stress or negative emotions may have on people's lives, such as burnout and increased cardiovascular risk. Since these consequences might severely affect life quality, monitoring of the personal stress and emotional state is advocated as essential to prevent or mitigate their effects, as well as to reduce abrupt performance drops in critical work environments (e.g., hospitals). In this context, specific physiological signals, such as electroencephalography (EEG), electrocardiography (ECG), and photoplethysmography (PPG), are envisaged as a mean for the objective assessment of individuals' stress level and emotional state; also, ECG and PPG are appropriate candidates for their unobtrusive monitoring, since they can rely on smaller devices to be acquired.
However, emotion and stress evaluation through physiological signals requires the definition of robust models that could relate the physiological response observed in a specific moment to the emotions or the stress level experienced at that moment. Moreover, their monitoring in daily life requires the adoption of wearable devices able to provide enough accurate measures of the physiological signals of interest. The present Ph.D. dissertation aims to evaluate the physiological response to different emotions and stress levels, select the most sensitive features to stress and emotional variations, and develop physiological models for emotion recognition. In Chapter 2, we compare three different algorithms for quantifying the respiratory sinus arrhythmia (RSA), a well-known marker of vagal activity, from heart rate variability (HRV) and respiratory signal to select the most sensitive to stress variations. This comparison was conducted in a population of healthy preschoolers undergoing a validated experimental stressful procedure, which allowed us to evaluate the performance of the different methods in a more natural context. In Chapter 3, we apply linear mixed-effects regression models (LMM) to select the most valuable EEG features for the prediction of valence and arousal responses from a set of emotional pictures. For this experiment, 90 pictures selected from the International Affective Picture System (IAPS) database, grouped in nine different blocks of valence and arousal, were presented to a sample of healthy adults. In Chapter 4, we explore HRV patterns during the elicitation of the so-called flow state (a highly functional condition linked to increased motivation, effort, and perseverance) to select time-, frequency-domain, and non-linear 8 HRV features predictive of this particular emotional experience. The flow state was elicited through arithmetical tasks of optimal difficulties, and the related HRV features were compared with those derived during the administration of tasks of suboptimal difficulties (i.e., too easy or too hard). Finally, in Chapter 5, we offer an assessment of currently available wearable devices (an ECG-shirt and a PPG-wristband) that could be employed, in the near future, for stress and emotion monitoring. Specifically, we compare several HRV features extracted from these devices with those calculated through the HRV derived from a standard ECG. Besides, since many wearable devices rely on low-sampling rate PPG for the measurement of heart rate, we investigate the efficacy of different PPG interpolation techniques on the accuracy of the derived HRV features at different sampling rates.

Our results provide useful indications about the sensitivity of different RSA measures to stress variations and show that methods that take into account both HRV and respiratory signals provide significant improvements to stress detection. Our feature selection procedure based on LMM proved accurate for choosing EEG indices that show higher explanatory power of valence and arousal scores. We offer some suggestions to improve the generalizability of these models and increase their applicability in emotion recognition applications. Our exploratory analysis of the flow state reveals some HRV features, especially among non-linear ones, that could be more promising to detect this particular emotional experience. Finally, we highlight some current limitations regarding the use of PPG-wristbands for HRV-based stress monitoring and provide indications to improve the accuracy of the inter-beat intervals (IBIs) extracted from low-sampling rate PPG signals.