Master Research Proposal Nr:

Topic: Feasibility and Accuracy of Over-Ear PPG Measurements using an Aviation Headset

Durchführbarkeit und Validierung von Over-Ear PPG Messungen mit einem Aviation Headset

During operations such as take-off or landing and particularly in case of an emergency, a disruption of a pilot's concentration can cause major accidents [1, 2]. Fatigue, mental workload and stress contribute to human errors that should be reduced as much as possible in aviation [3]. Simple and objective monitoring of a pilot's condition may be helpful. This may help noticing the early onset of fatigue or signs of excessive stress.
One suited approach to detect fatigue and stress in this context is a physiological signal-based method. Changes in subjects' physiological responses can be determined by measuring certain biosignals such as photoplethysmography (PPG) or electrocardiography (ECG) [4,5]. These parameters change as a response to events related to the appearance of stress as well as fatigue [2,4–6]. PPG measurement is a more comfortable technique than ECG since the setup of the measurement system is easier. After recording and processing PPG data, it is possible to calculate parameters such as the heart rate and heart rate variability. As a sign of drowsiness the heart rate declines while it rises in case of cumulative stress [2]. For this reason, the obtained PPG data enable the assessment of a pilot's mental state.
There is existing research about using a PPG sensor to monitor a pilot's condition. In previous works, PPG data were collected by using an in-ear PPG sensor, attaching an earclip, or fixing the sensor onto the forehead or a finger [1,2,7,8]. However, in this study, over-ear PPG measurements within the ear cushion of a pilot headset shall be conducted. Headsets are already established and worn by pilot inflight. Furthermore, in most studies data were collected during simulated flights instead of real ones [2].
To summarize, the aim of this research is to (i) assess the feasibility of collecting PPG data from a sensor mounted into the ear cushion of an aviation headset and to (ii) compare PPG signals recorded during the flight with those collected on the ground to validate the accuracy of heart rate measurements.
In the light of that objective, this work consists of the following parts:

- Literature research regarding studies that dealt with monitoring a pilot's conditions or wearable systems to collect PPG data
- Development, optimization and testing of a wearable system that incorporates a PPG sensor in the ear cushion of an aviation headset
- Conducting a study composed of two test phases:
    1) First phase performed on the ground: At least 10 participants shall undertake multitasking tests while testing the PPG measurement setup
    2) Second phase performed during the flight: PPG data are collected in the real airborne environment
- Processing, analysis, evaluation and comparison of the PPG data collected during both test phases

The thesis must contain a detailed description of all developed and used algorithms as well as a profound result evaluation and discussion. The implemented code has to be documented and provided. An extended research on literature, existing patents and related work in the corresponding areas has to be performed.

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