Topic: Decoding the Hidden Language of Stress: Analyzing Speech Patterns as a Tool for Stress Detection

Nowadays, stress has become one of our daily struggles and is posing a threat to our health and well-being. The health issues stress can cause range from high blood pressure and elevated heart rates to weakened immune system and depression [1], therefore it is in our best interest to detect and minimize stress responses in our daily environment. Stress biomarkers (e.g. cortisol and adrenaline) aren't harmful to us as long as they switch on and off in a balanced way. The acute stress reaction is important for responding to threatening situations. The problem is that they are unhealthy when released continuously over time [1], which is also referred to as chronic stress [2]. In an attempt to avoid this problem, one has to start by assessing the stress reaction and release of biomarkers. Ways to measure said biomarkers include examining saliva [3], blood, urine and sweat samples [4], which can only be collected invasively and at specific sampling times. Less invasive and continuously measured approaches to detect stress are via ECG or EMG signals [5], which lack precision, and interfere with natural human behavior. Recent advances enable contactless approaches, such as analyzing video recordings by using deep learning algorithms to recognize stress symptoms in facial expressions and movements, such as increased blink rate, pupil dilation, and differences in mouth activity (e.g. smiling or frowning) [6]. In addition, the video recordings can be used to examine the audio signals for voice and speech changes related to stress [7]. This method has several advantages including convenience and access to a mass audience at a low cost, which enables researching stress with larger study populations. Furthermore, no invasive procedures (blood samples) or impractical devices (ECG cables) need to be used and as a result, the stress reactions can be collected continuously and in a more natural environment [6]. In summary, biomarkers extracted from video and audio footage can complement traditional stress biomarkers, to give better insight into the acute stress reaction, with the long-term potential to replace these methods.

The goal of this bachelor's thesis is therefore to use digital biomarkers, mainly speech changes, extracted from audio data to learn more about the stress response. The data will be collected in a study within the EmpkinS collaborative research center. So far 110 participants performed the Trier Social Stress Test (TSST) [8] and the control condition, the friendly-TSST [9], on two consecutive days in a randomized order. The focus of this thesis is to analyze the speech patterns of the participants, including phrasing, fluency, articulation, and sentence length, to identify changes related to psychosocial stress. To achieve this, an existing model (e.g. Whisper) will be used to extract transcripts from the audio recordings. With these transcripts, multiple features will be computed, like the number of sentences, lexical richness, and sentiment. The computed features will then be statistically compared between the conditions. To acquire the full bandwidth of parameters associated with a psychological stress reaction, gender differences will be taken into account.

The proposed work consists of the following parts:

- Literature and patent research of relevant work resulting in a comprehensive list of research on digital biomarkers during acute psychosocial stress
- Usage of an existing LLM-based model for acquiring transcripts from audio recordings
- Implementation of a feature extraction pipeline for analyzing speech patterns
- Collection of video data of at least 20 healthy participants in the context of a laboratory stress test
- Statistical comparison of linguistic features between the stress/no stress condition and gender differences

- Optionally: Training and evaluation of a machine learning pipeline to differentiate between stress and non-stress conditions

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. Extended research on literature, existing patents, and related work in the corresponding areas has to be performed.

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Start—End: 01.04.2024-31.08.2024

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