Master Research Proposal Nr: xxxx

Topic: Machine Learning-based Sleep Staging from Contactless Vital Sign Radars

According to estimations by the World Health Organization (WHO), more than 8.5 million people have been diagnosed with Parkinson's disease, making it the second most prevalent neurodegenerative disorder worldwide. With a doubling in diagnosed patients in the last 25 years, Parkinson's disease (PD) further shows the most rapidly growing spread among all neurodegenerative conditions [1].
While the primary motor symptoms of PD, tremors, bradykinesia, and stiffness, are well known to the general population, the disease is also characterized by non-motor symptoms such as cognitive deterioration and sleep disturbances [2], including symptoms like rapid-eye-movement sleep behavior disorder, restless legs syndrome, and sleep-disordered breathing. These symptoms often occur prodromal to the diagnosis of PD [3]. Reliable sleep monitoring is thus crucial for not only the diagnosis but also the prevention and treatment of the disease [4].
The gold standard approach for sleep analysis is polysomnography (PSG), which is typically performed in a sleep laboratory. Thereby, different physiological signals such as brain activity, muscle and eye movement, cardiovascular signals, and respiratory information are recorded during sleep [5]. The high precision of PSG allows accurate diagnosis of sleep disorders [6]. However, this method is both obtrusive, as it interferes with typical sleep behavior during night, as well as cost- and resource-intensive. A promising unobtrusive alternative to the gold standard of sleep analysis might be given by contactless measurement via radar sensing systems. Even though sleep staging without electroencephalography (EEG) remains difficult [7], the possibility of sleep analysis via radar technology presents various advantages over PSG, such as less cost- and resource intensiveness, a more normal sleep behavior during the monitoring, and the possibility of longitudinal studies due to its unobtrusiveness [8]. However, existing research on sleep staging using vital parameters extracted only from radar technology is still insufficient, even though it has shown promising results in previous works [9].

The goal of this master's thesis is therefore to implement different machine and deep learning algorithms to perform sleep staging from radar signals according to the AASM (American Academy of Sleep Medicine) Guidelines [10]. For this, various features from heart sounds and respiratory information are used. These vital signs are extracted from a 61 GHz radar system that is attached to the bed frame [11]. The results will then be compared to simultaneously recorded PSG data. Furthermore, this work might be expanded to include simple features describing macroscopic movements to explore whether sleep staging via radar can be further enhanced.

The proposed work consists of the following parts:

- Literature and patent research of relevant work resulting in a comprehensive list of research on sleep staging using vital parameters extracted from radar data.
- Data collection during an in-lab study recording data from 61 GHz radar sensors and concurrently measured PSG with at least 15 participants.
- Specifically, feature extraction of heartbeat data and respiratory waves from radar data should be performed.
- Implement algorithms to synchronize signals from radar and PSG.
- Implementation of a deep learning algorithm (CNN) to perform classification of the sleep phases. Furthermore, the different existing networks from previous theses (TCN, LSTM, Random Forest, AdaBoost, MLP, SVM, XGBoost) should be adjusted and applied with the features extracted within the thesis.
- Evaluation of the implemented algorithms regarding their sleep staging performance.

Master Research Proposal Nr: xxxx

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 must be performed.

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