Lucerne University of
Applied Sciences and Arts

HOCHSCHULE

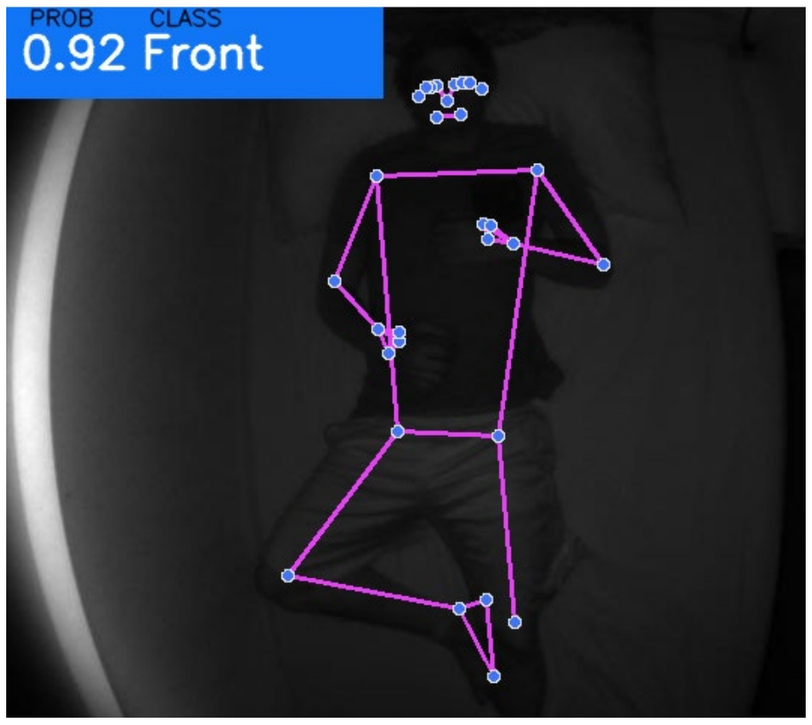
MASTER OF SCIENCE

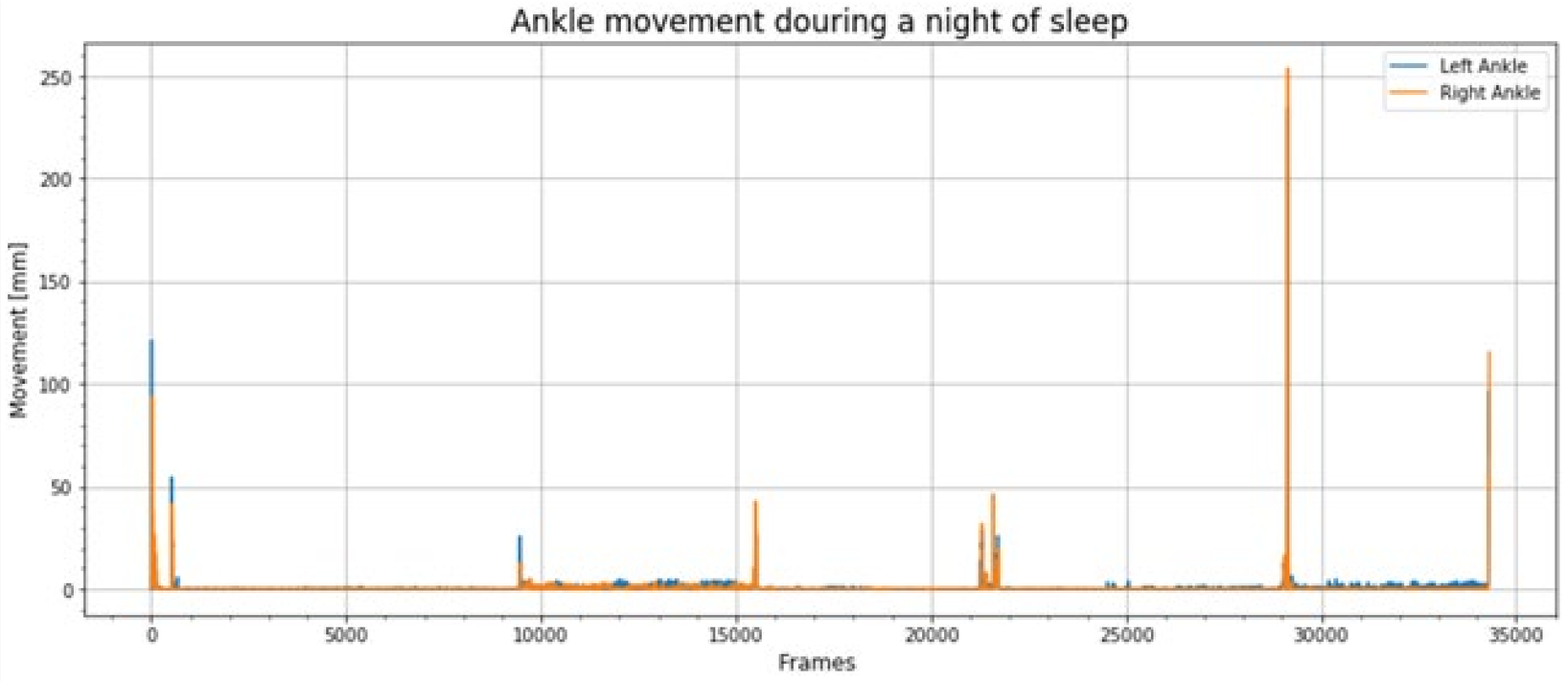
Technik & Architektur

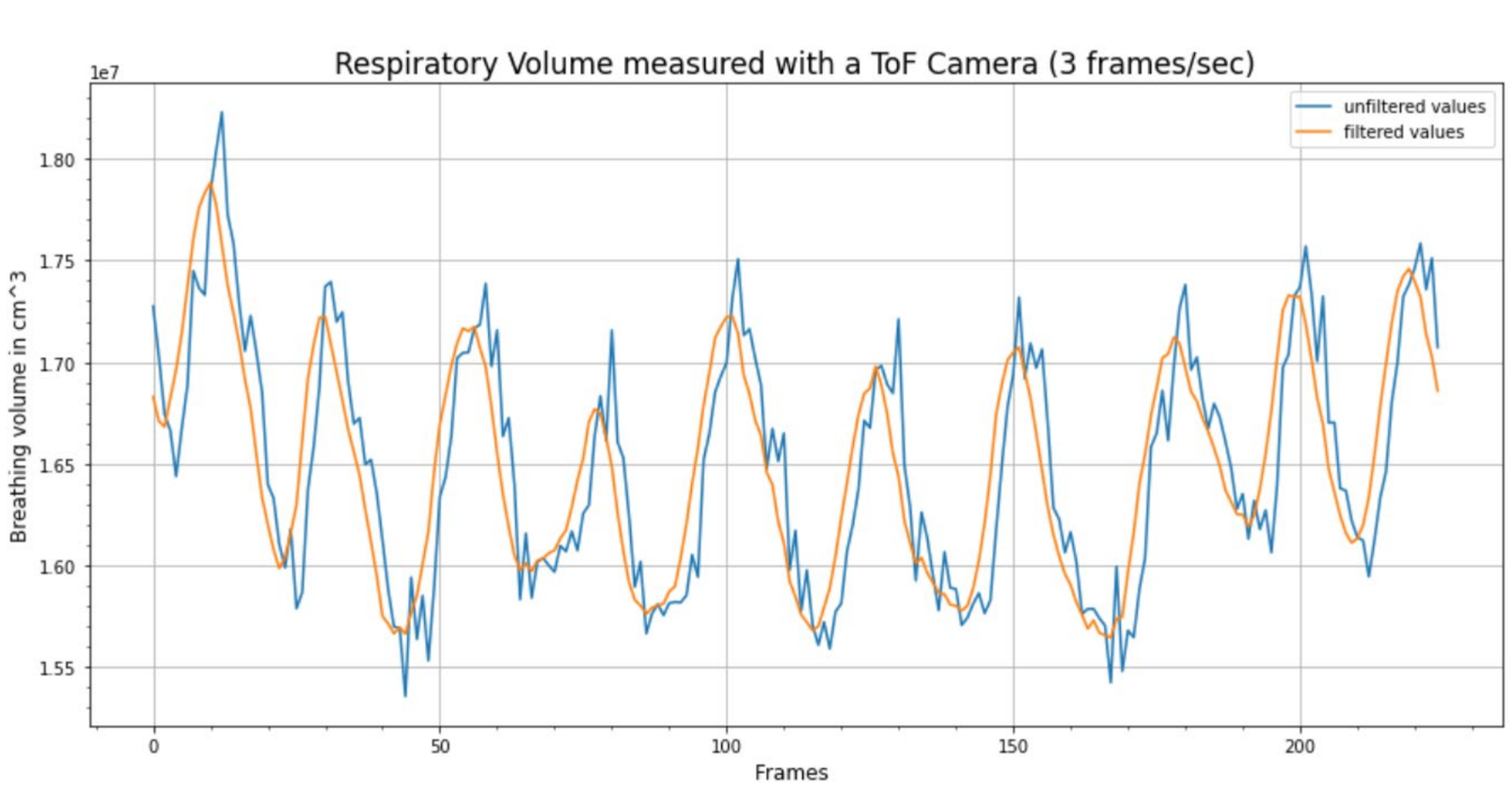
FH Zentralschweiz

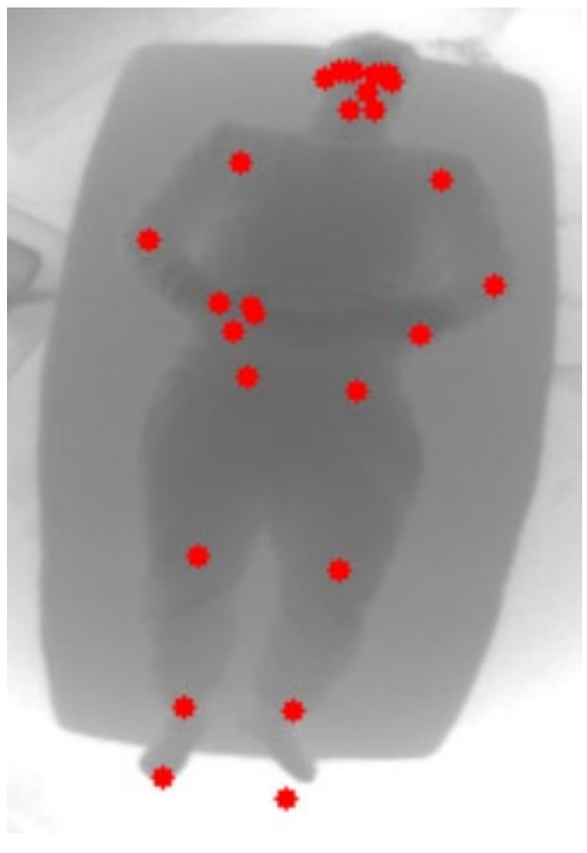
Master-Thesis Engineering, Fachgebiet Electrical Engineering

Sleep Monitoring using 3D ToF









Introduction

Sleep allows the body to recover, tissue regeneration, the immune system to be strengthened, mental health to be regulated, memory to be revitalised and prevent many other diseases. Many times, sleeping is not enough to get rested; it is estimated that between 30% and 48% of adults suffer from sleep disorders, increasing with the age.

At present, sleep analysis is carried out in sleep laboratories and is an expensive procedure with many sources of disturbance and error due to the use of sensors in direct contact with the patient's skin.

Problem definition

This master's work is in the context of the development of systems that allow sleep analysis to be carried out in a cost-effective and minimally invasive manner. An embedded device was developed to detect sleep stages by monitoring body movement, breathing and heart rate. This device consists of a fitness watch for detecting the heart rate, a ToF camera for detecting both body movement and breathing frequency and an embedded board for the management of the sensors.

Methodology

In the beginning, the work focused on finding the most suitable algorithm for monitoring respiration with a 3D ToF camera and respectively on finding the most suitable pose estimator for an embedded system.

Afterwards, both the algorithm for detecting the movement of the keypoints of the body and the algorithm for determining the position (supine, prone, etc.) of the subject during the night were developed. For the monitoring of breathing, an algorithm was developed to detect the frequency and volume of breathing.

Finally, Machine and Deep Learning methods were developed to determine the Hypnogram using the heart rate obtained from a Smartwach and all the information obtained with all the algorithms described above.

Results

The algorithms were tested over two nights. The algorithm for the movement of the keypoints was able to record it accurately and obtain important statistical information. The algorithm for determining body position showed very good accuracy (>99%).

The algorithm for the analysis of respiration made it possible to determine the respiratory frequency and volume and was tested with the subject in supine position; it showed results that require further investigation.

The algorithms for the determination of the hypnogram showed a problem of underfitting, however, the best was a ML method with an accuracy of 87.5%.

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