Non-Contact Tidal Volume Estimation

English

Graduate

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Introduction: The growing world population poses various challenges for humanity, one of which is ensuring and monitoring the health of every individual. To support human resources in medical facilities in the future, this bachelor's thesis examines whether it's possible to measure a crucial vital parameter, a person's respiratory volume, using a depth camera.

Measuring respiratory volume is of central importance for diagnosing and monitoring lung and respiratory diseases, as well as assessing overall respiratory health. In research and medical practice, two main categories of measurement methods can be distinguished: contact methods and non-contact methods. Contact methods generally provide more precise results but require direct physical contact with the patient.

Spirometry represents an established contact method for diagnosing and tracking respiratory volume, but it has certain limitations. For the patient, spirometry can be uncomfortable as it requires active cooperation and specific breathing maneuvers that can be challenging for some individuals. Additionally, the results of spirometry can be influenced by the patient's cooperation and physical condition.

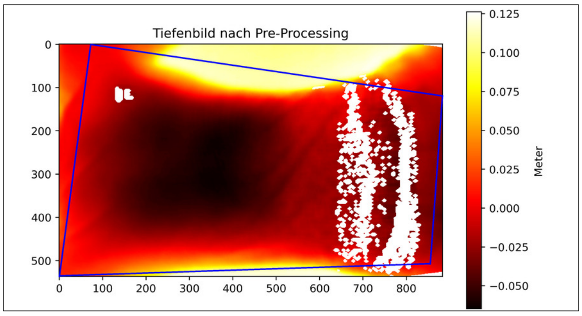
Definition of Task: The primary objective of this thesis is to investigate the feasibility and accuracy of using depth cameras for non-contact measurement of respiratory volume. This objective encompasses both the technical feasibility and the evaluation of accuracy in comparison to the established method, spirometry. Developing such a non-contact respiratory volume measurement method could not only enhance the patient experience but also improve the precision and efficiency of respiratory diagnosis and monitoring. Machine learning models are to be developed and assessed to predict spirometry measurement data using depth data. To achieve this, measurements were conducted with a depth camera involving 15 volunteer participants at the Campus Buchs of the University of Applied Sciences Eastern Switzerland (FH OST). Additional information about the participants, such as age, weight, and chest and abdomen dimensions, was also collected to generalize individual models.

Result: It has been demonstrated that correlations exist between the deformation of the upper body during respiration and the inhaled or exhaled volume. Linear models were developed for each of the 15 test participants, capable of predicting respiratory volume with a mean relative error of 12.9%. The mean absolute error of the linear models stands at 0.15 liters across the entire volume range and 0.11 liters for resting respiration volumes, which varied from 0.3 to 1.3 liters among the participants. Global models, independent of specific individuals, estimate respiratory volume slightly less accurately, with a relative error of 13.72% and an absolute error of 0.16 liters.

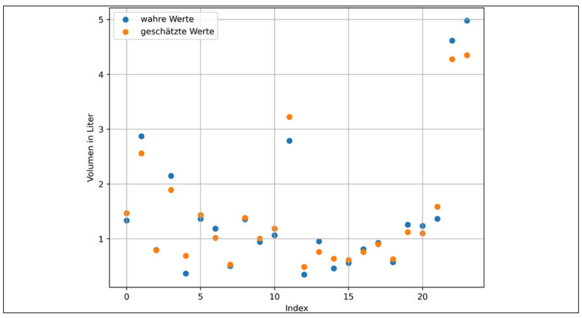
Factors such as the participant's weight or their level of physical activity showed minimal influence on the models, which can be attributed to the limited size of the experimental group.

Measurement setup Buchs
ICE FH OST

Depth image of the torso and torso estimation from a test person after preprocessing
Own presentment



Predicted tidal volumes from a global model versus measured tidal volumes
Own presentment



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