Master's Thesis Summary
Machine Learning for Respiratory Phase Detection

For the verification of ventilators and anesthesia devices, external measuring tools for flow and pressure measurements are necessary. In the scope of a master's thesis, Dräger developed its own measuring device called Flowmonitor. To ease the evaluation of the recorded measurement data, an automatic determination of respiratory parameters is desirable. Especially with regard to endurance tests within the scope of reliability testing, human resources could be saved. All relevant respiratory parameters can be derived from the determination of inspiration and expiration phases. In this work, it was investigated if a machine learning-based approach is beneficial over a conventional threshold-based algorithm for respiratory phase detection. On this account, breathing cycles originating from Dräger products with different drives and varied ventilation settings were recorded with the Flowmonitor to generate a data set that covers a variety of breathing patterns including norm test settings as well as atypical adjustments. A U-Net was trained on these data. The performance of the respiratory phase detection was investigated with regard to completeness and exactness and compared to the performance of a threshold-based algorithm. Error cases of the algorithm were uncovered and countermeasures were implemented in an optimized variant. The optimized algorithm showed the highest accuracy with 99.66% and a median deviation of one sample for the localization of inspiratory and expiratory starting points. However, the U-Net learned the characteristics of inspiration and expiration phases which manifested in a stable phase detection and the lowest failure rate of all investigated approaches meeting the requirements in 96.6% of the cases. Especially for spontaneous breathing, it showed the lowest susceptibility to errors. In addition, it was the only approach that was able to handle flows in the smallest adjustable range. It can therefore be concluded that the U-Net has the largest scope of application. Nonetheless, since the U-Net does not provide a continuous output for each breathing cycle but an output in blocks with a fixed number of samples and a delay, it is not the best solution for monitoring during measurement, but a suitable option as an offline tool for the retrospective analysis of recorded measurements.

Author: Saskia Beier
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