Modular Model of the Cardiorespiratory System under Mechanical Ventilation

(Masterarbeit)

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Motivation

Mechanical ventilators are usually tested through animal experiments on large mammals. Due to difference in biological species and individual human differences, such tests cannot avoid uncertainty. In addition, these animal experiments are costly and laborious and to be reduced for ethical reasons. To minimize the uncertainties and ease biomedical research, a test rig of the cardiorespiratory system controlled by computer model of the patient could be an alternative solution.

State of the Art

There have been lots of cardiorespiratory models developed for different uses. These models typically divide the cardiorespiratory system into several compartments with lumped parameters, which can be expressed by ordinary differential equations. As research on mechanical lung simulators has been focused on representing lung mechanics so far, no dedicated model describing gas-exchange and detailed cardiorespiratory interaction for this application exists, yet. At i11, a respiratory model specialized for neonates and an additional cardiorespiratory model specialized for ARDS patients under mechanical ventilation have been implemented through MATLAB Simulink. Both models have been designed for simulation during research and development, but not for controlling a physical test rig for ventilators. Thus, they do not consider computation time restrictions. Further, they are implemented by explicit causal mathematical modeling, which leads to complex graphical representations.

Goals

In this thesis, an implicit acausal cardiorespiratory model as basis for the model-based control of the ventilator test rig will be worked out through MATLAB Simscape. The model will be divided into three submodules representing lung mechanics, gas-exchange, and cardiovascular dynamics. For each submodule representations of different complexity will be implemented to be freely combinable allowing adaption of the needed model accuracy depending on the represented patient pathology while aiming at computational efficiency.

Planned Approach

The planned approach can be divided into three stages. In the first stage, literature about cardiorespiratory patient models will be reviewed to specify the parameters that indicate different patient types and inputs and outputs of the model. In the second stage, the cardiorespiratory system model will be implemented through MATLAB Simscape in a modular form going from simple to more complex versions of the modules to simulate different kinds of patient. Finally, the effect of combining modules of different complexity on the computation time will be evaluated and the simulation results will be compared to reference values from the clinical literature.

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Informatik 11
Embedded Software

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Kommentiert [VP1]: the essential idea, that the model is planned to be used for model-based control of a physical test rig for testing the model is missing (you only say a computer model is used for this purpose). Mentioning this idea is important, because it is a very specific application, that needs a custom model.

Kommentiert [VP2]: Some general words on the state of the art should be written in the beginning. How much has this area been researched before and with which application focus? Are there many or few models available? For which applications were these models developed?

Kommentiert [VP3]: Here you should state how you are going to solve the task a bit more specific. What are the different parts and concrrete steps of your project? How will you start, what is needed to solve the task?