Control of a CPAP-Device with a Partially Observable Markov Decision Model

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Abstract: Partial Observable Markov Decision Processes (POMDP's) allow finding an optimal control of a hidden Markov model. We develop within this framework a control of a CPAP-device (Continuous Positive Airway Pressure) by which people are treated which suffer from an obstructive sleep apnoea syndrome. By such a device a small additive air pressure is applied to the patient through a mask, different values of the pressure correspond to different actions.

We study the performance of such a control in comparison with other, more traditional control strategies. In commercial devices the applied pressure is held on a constant value, carefully determined in a sleep laboratory. More recently, the pressure is controlled by a classification of the airflow during breathing and then choosing the control variable in dependence on the classification features. Within the POMDP approach we introduce the unobservable state of the airway as the hidden state and regard the features of the airflow during breathing as the observations. We consider models with two and four hidden states, three observation states and three types of actions (values of applied pressure). The parameters of the hidden models are chosen with help of experience from laboratories, where such devices are developed.

The comparison of the different control strategies are done by estimating various key figures for the performance of the control such as the number of apnoea events, mean pressure, or number of action changes. We can show that the control developed within the POMDP approach is significantly superior to the other control strategies, especially in the case of milder forms of obstructive sleep apnoea.

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