Adaptive model predictive control for a dual-hormone artificial pancreas - DTU Orbit

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We report the closed-loop performance of adaptive model predictive control (MPC) algorithms for a dual-hormone artificial pancreas (AP) intended for patients with type 1 diabetes. The dual-hormone AP measures the interstitial glucose concentration using a subcutaneous continuous glucose monitor (CGM) and administers glucagon and rapid-acting insulin subcutaneously. The discrete-time transfer function models used in the insulin and glucagon MPCs comprise a deterministic part and a stochastic part. The deterministic part of the MPC model is individualized using patient-specific information and describes the glucose-insulin and glucose-glucagon dynamics. The stochastic part of the MPC model describes the uncertainties that are not included in the deterministic part of the MPC model. Using closed-loop simulation of the MPCs, we evaluate the performance obtained using the different deterministic and stochastic models for the MPC on three virtual patients. We simulate a scenario including meals and daily variations in the model parameters for two settings. In the first setting, we try five different models for the deterministic part of the MPC model and use a fixed model for the stochastic part of the MPC model. In the second setting, we use a second-order model for the deterministic part of the MPC model and estimate the stochastic part of the MPC model adaptively. The results show that the controller is robust to daily variations in the model parameters. The numerical results also suggest that the deterministic part of the MPC model does not play a major role in the closed-loop performance of MPC. This is ascribed to the availability of feedback and the poor prediction capability of the model, i.e. the large disturbances and model-patient mismatch. Moreover, a second order adaptive model for the stochastic part of the MPC model offers a marginally better performance in closed-loop, in particular if the model-patient mismatch is large.