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SYMPOSIUM

Artificial Pancreas: Model Predictive Control Design from Clinical Experience

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Abstract

Background:

The objective of this research is to develop a new artificial pancreas that takes into account the experience accumulated during more than 5000 h of closed-loop control in several clinical research centers. The main objective is to reduce the mean glucose value without exacerbating hypo phenomena. Controller design and *in silico* testing were performed on a new virtual population of the University of Virginia/Padova simulator.

Methods:

A new sensor model was developed based on the Comparison of Two Artificial Pancreas Systems for Closed-Loop Blood Glucose Control versus Open-Loop Control in Patients with Type 1 Diabetes trial AP@home data. The Kalman filter incorporated in the controller has been tuned using plasma and pump insulin as well as plasma and continuous glucose monitoring measures collected in clinical research centers. New constraints describing clinical knowledge not incorporated in the simulator but very critical in real patients (e.g., pump shutoff) have been introduced. The proposed model predictive control (MPC) is characterized by a low computational burden and memory requirements, and it is ready for an embedded implementation.

Results:

The new MPC was tested with an intensive simulation study on the University of Virginia/Padova simulator equipped with a new virtual population. It was also used in some preliminary outpatient pilot trials. The obtained results are very promising in terms of mean glucose and number of patients in the critical zone of the control variability grid analysis.

Conclusions:

The proposed MPC improves on the performance of a previous controller already tested in several experiments in the AP@home and JDRF projects. This algorithm complemented with a safety supervision module is a significant step toward deploying artificial pancreases into outpatient environments for extended periods of time.

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Abbreviations: (AP) artificial pancreas, (BG) blood glucose, (CAT) Comparison of Two Artificial Pancreas Systems for Closed-Loop Blood Glucose Control versus Open-Loop Control in Patients with Type 1 Diabetes, (CGM) continuous glucose monitoring, (CVGA) control variability grid analysis, (LMPC) linear model predictive control, (MPC) model predictive control, (SC) subcutaneous, (SSM) safety supervision module

Keywords: artificial pancreas, closed-loop control, glucose regulations, meal compensation, model predictive control

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