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SYMPOSIUM

A Closed-Loop Artificial Pancreas Using Model Predictive Control and a Sliding Meal Size Estimator

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Abstract

The objective of this article is to present a comprehensive strategy for a closed-loop artificial pancreas. A meal detection and meal size estimation algorithm is developed for situations in which the subject forgets to provide a meal insulin bolus. A pharmacodynamic model of insulin action is used to provide insulin-on-board constraints to explicitly include the future effect of past and currently delivered insulin boluses. In addition, a supervisory pump shut-off feature is presented to avoid hypoglycemia. All of these components are used in conjunction with a feedback control algorithm using model predictive control (MPC). A model for MPC is developed based on a study of 20 subjects and is tested in a hypothetical clinical trial of 100 adolescent and 100 adult subjects using a Food and Drug Administration-approved diabetic subject simulator. In addition, a performance comparison of previously and newly proposed meal size estimation algorithms using 200 *in silico* subjects is presented. Using the new meal size estimation algorithm, the integrated artificial pancreas system yielded a daily mean glucose of 138 and 132 mg/dl for adolescents and adults, respectively, which is a substantial improvement over the MPC-only case, which yielded 159 and 145 mg/dl.

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Abbreviations: (CHO) carbohydrate, (FDA) Food and Drug Administration, (IOB) insulin on board, (MPC) model predictive control, (MSE) meal size estimation, (PID) proportional-integral-derivative, (TDI) total daily insulin

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