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ORIGINAL ARTICLES

Evaluating the Efficacy of Closed-Loop Glucose Regulation via Control-Variability Grid Analysis

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Abstract

Background:

Advancements in subcutaneous continuous glucose monitoring and subcutaneous insulin delivery are stimulating the development of a minimally invasive artificial pancreas that facilitates optimal glycemic regulation in diabetes. The key component of such a system is the blood glucose controller for which different design strategies have been investigated in the literature. In order to evaluate and compare the efficacy of the various algorithms, several performance indices have been proposed.

Methods:

A new tool—control-variability grid analysis (CVGA)—for measuring the quality of closed-loop glucose control on a group of subjects is introduced. It is a method for visualization of the extreme glucose excursions caused by a control algorithm in a group of subjects, with each subject presented by one data point for any given observation period. A numeric assessment of the overall level of glucose regulation in the population is given by the summary outcome of the CVGA.

Results:

It has been shown that CVGA has multiple uses: comparison of different patients over a given time period, of the same patient over different time periods, of different control laws, and of different tuning of the same controller on the same population.

Conclusions:

Control-variability grid analysis provides a summary of the quality of glycemic regulation for a population of subjects and is complementary to measures such as area under the curve or low/high blood glucose indices, which characterize a single glucose trajectory for a single subject.

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Abbreviations: (BG) blood glucose, (CGM) continuous glucose monitoring, (CVGA) control-variability grid analysis, (MPC) model predictive control, (PID) proportional–integral–derivative

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