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ORIGINAL ARTICLE

Predicting Subcutaneous Glucose Concentration Using a Latent-Variable-Based Statistical Method for Type 1 Diabetes Mellitus

Chunhui Zhao, Ph.D.,[1] Eyal Dassau, Ph.D.,[1] Lois Jovanovič, M.D.,[2] Howard C. Zisser, M.D.,[2] Francis J. Doyle III, Ph.D.,[1] and Dale E. Seborg, Ph.D.[1]

Abstract

Background:

Accurate prediction of future glucose concentration for type 1 diabetes mellitus (T1DM) is needed to improve glycemic control and to facilitate proactive management before glucose concentrations reach undesirable concentrations. The availability of frequent glucose measurements, insulin infusion rates, and meal carbohydrate estimates can be used to good advantage to capture important information concerning glucose dynamics.

Methods:

This article evaluates the feasibility of using a latent variable (LV)-based statistical method to model glucose dynamics and to forecast future glucose concentrations for T1DM applications. The prediction models are developed using a proposed LV-based approach and are evaluated for retrospective clinical data from seven individuals with T1DM and for *In silico* simulations using the Food and Drug Administration-accepted University of Virginia/University of Padova metabolic simulator. This article provides comparisons of the prediction accuracy of the LV-based method with that of a standard modeling alternative. The influence of key design parameters on the performance of the LV-based method is also illustrated.

Results:

In general, the LV-based method provided improved prediction accuracy in comparison with conventional autoregressive (AR) models and autoregressive with exogenous input (ARX) models. For larger prediction horizons (≥30 min), the LV-based model with exogenous inputs achieved the best prediction performance based on a paired *t*-test ($\alpha = 0.05$).

Conclusions:

The LV-based method resulted in models whose glucose prediction accuracy was as least as good as the accuracies of standard AR/ARX models and a simple model-free approach. Furthermore, the new approach is less sensitive to changing conditions and the effect of key design parameters.

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Author Affiliations: [1]Department of Chemical Engineering, University of California, Santa Barbara, Santa Barbara, California; and [2]Sansum Diabetes Research Institute, Santa Barbara, California

Abbreviations: (AR) autoregressive, (ARX) autoregressive with exogenous input, (CCA) canonical correlation analysis, (CG) continuous glucose, (CGM) continuous glucose monitoring, (CHO) carbohydrate, (CVP) constant value prediction, (EGA) error-grid analysis, (FDA) Food and Drug Administration, (I:C) insulin-to-carbohydrate ratio, (LV) latent variable, (LVX) latent variable with exogenous input, (MAD) mean absolute deviation, (PLS) partial least squares, (RMSE) root mean-square error, (T1DM) type 1 diabetes mellitus, (UVa/Padova) University of Virginia/University of Padova

Keywords: autoregressive model, autoregressive model with exogenous inputs, continuous glucose monitoring, glucose concentration prediction, latent variable model, latent variable model with exogenous inputs, type 1 diabetes mellitus

Corresponding Author: Dale E. Seborg, Ph.D., Department of Chemical Engineering, University of California, Santa Barbara, Santa Barbara, CA 93106-5080; email address seborg@engineering.ucsb.edu