

# Hypoglycemia Early Alarm Systems Based on Recursive Autoregressive Partial Least Squares Models

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## Abstract

### Background:

Hypoglycemia caused by intensive insulin therapy is a major challenge for artificial pancreas systems. Early detection and prevention of potential hypoglycemia are essential for the acceptance of fully automated artificial pancreas systems. Many of the proposed alarm systems are based on interpretation of recent values or trends in glucose values. In the present study, subject-specific linear models are introduced to capture glucose variations and predict future blood glucose concentrations. These models can be used in early alarm systems of potential hypoglycemia.

### Method:

A recursive autoregressive partial least squares (RARPLS) algorithm is used to model the continuous glucose monitoring sensor data and predict future glucose concentrations for use in hypoglycemia alarm systems. The partial least squares models constructed are updated recursively at each sampling step with a moving window. An early hypoglycemia alarm algorithm using these models is proposed and evaluated.

### Results:

Glucose prediction models based on real-time filtered data has a root mean squared error of 7.79 and a sum of squares of glucose prediction error of 7.35% for six-step-ahead (30 min) glucose predictions. The early alarm systems based on RARPLS shows good performance. A sensitivity of 86% and a false alarm rate of 0.42 false positive/day are obtained for the early alarm system based on six-step-ahead predicted glucose values with an average early detection time of 25.25 min.

### Conclusions:

The RARPLS models developed provide satisfactory glucose prediction with relatively smaller error than other proposed algorithms and are good candidates to forecast and warn about potential hypoglycemia unless preventive action is taken far in advance.

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**Abbreviations:** (CGMS) continuous glucose monitoring sensor, (FPE) final prediction error, (PH) prediction horizon, (PLS) partial least squares, (RARPLS) recursive autoregressive partial least squares, (RMSE) root mean square error, (SSGPE) sum of squares of glucose prediction error, (T1DM) type 1 diabetes mellitus

**Keywords:** hypoglycemia alarms, partial least squares regression, recursive algorithm, type 1 diabetes mellitus

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