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ORIGINAL ARTICLES

Real-Time Glucose Estimation Algorithm for Continuous Glucose Monitoring Using Autoregressive Models

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Abstract

Background:
Continuous glucose monitors (CGMs) present a problem of lack of accuracy, especially in the lower range, sometimes leading to missed or false hypoglycemia. A new algorithm is presented here aimed at improving the measurement accuracy and hypoglycemia detection. Its core is the estimation of blood glucose (BG) in real time (RT) from CGM intensity readings using autoregressive (AR) models.

Methods:
Eighteen patients with type 1 diabetes were monitored for three days (one at the hospital and two at home) using the CGMS® Gold. For these patients, BG samples were taken every 15 min for 2 h after meals and every half hour otherwise during the first day. The relationship between the current measured by the CGMS Gold and BG was learned by an AR model, allowing its RT estimation. New capillary glucose measurements were used to correct the model BG estimations.

Results:
A total of 563 paired points were obtained from BG and monitor readings to validate the new algorithm. 98.5% of paired points fell in zones A+B of the Clarke error grid analysis with the proposed algorithm. The overall mean and median relative absolute differences (RADs) were 9.6% and 6.7%. Measurements meeting International Organization for Standardization (ISO) criteria were 88.7%. In the hypoglycemic range, the mean and median RADs were 8.1% and 6.0%, and measurements meeting ISO criteria were 86.7%. The sensitivity and specificity with respect to hypoglycemia detection were 91.5% and 95.0%.

Conclusions:
The performance measured with both clinical and numerical accuracy metrics illustrates the improved accuracy of the proposed algorithm compared with values presented in the literature. A significant improvement in hypoglycemia detection was also observed.

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Abbreviations: (AR) autoregressive, (BG) blood glucose, (BJ) Box–Jenkins, (CGM) continuous glucose monitor, (EGA) error grid analysis, (IG) interstitial glucose, (ISO) International Organization for Standardization , (RAD) relative absolute difference, (RT) real time

Keywords: autoregressive model, continuous glucose monitoring, hypoglycemia, type 1 diabetes

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