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Short-Term Diabetes Blood Glucose Prediction Based On Blood Glucose Measurements

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Problem

Given current glucose value, amount and timing of insulin injections and food intake is it possible to predict future blood glucose levels with a prediction error of ± 20 mg/dL? In the current study an attempt is made to empirically model the glucose-insulin dynamic interplay and to provide model-based short-term predictors suitable for the purpose.

Data

Three days CGMS measurements were collected by one outpatient in CSII therapy with Medtronic MiniMed together with information on food intake and insulin doses (Fig. 1).

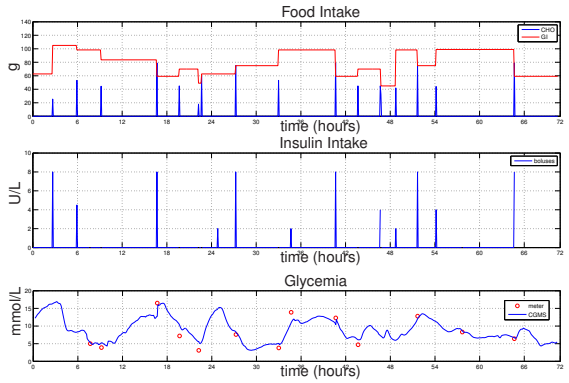

Figure 1: Patient data. Carbohydrate intake and short-acting insulin as noted in the diary, blood glucose level measured by personal meter and CGM system

Methods

Using the diary and nutrition tables the amount of carbohydrates and the glycemic index of each meal were estimated. A meal model describing the rate of appearance of the glucose in the blood stream following a meal based upon (Dalla Man et al. 2006) and an insulin model representing the insulin kinetics from subcutaneous depots to blood based upon (Wilinska et al. 2005) were applied to raw data in order to obtain the corresponding fluxes to be used in the estimation. Subspace identification was used to identify linear models of the glucose dynamics and Kalman filtering was used for prediction. Prediction performance was evaluated using Clarke Point Error Grid Analysis.

Modeling

The data were divided into three segments, each corresponding approximately to one day. Various models for each of the first two days were derived by means of subspace-based identification techniques and tested on calibration data. The model that outperformed all the others in simulation accuracy was then used to build short-term glucose predictors of glucose evolution on Day 3.

Results

Figure 2 shows the predictors performances on a 30 minutes look-ahead horizon. The predicted curves mostly fell within the confidence interval of ± 20 mg/dL of real measurements. According to Clarke point-Error-Grid-Analysis (Fig. 3) the percentages of points falling within regions A and B were 81.50% and 18.50% respectively for Day 1-based prediction, 90.40% and 9.60% respectively for Day 2-based prediction.

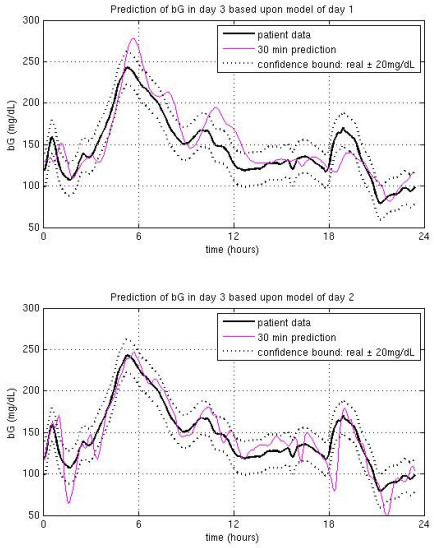

Figure 2: Predictor evaluation

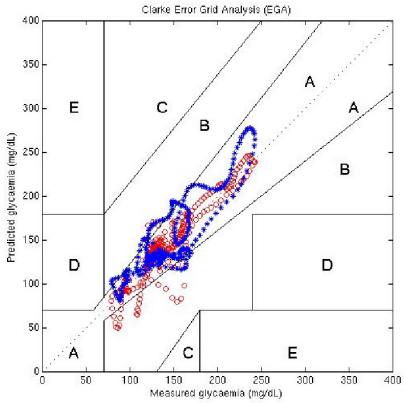

Figure 3: Clarke pEGA. Day 2-based prediction (blue) Day 1-based prediction (red) vs real measurements, respectively

Conclusions

Blood glucose development look-ahead up to 30 minutes was considered satisfactory on the basis of Clarke pEGA (100% of the points in regions A+B) and could provide early warnings of hypoglycemia. Neverthless, a population study is needed to clarify whether the proposed procedure can be used to approach the problem or not.

Acknowledgements

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