# Stochastic Seasonal Models for Glucose Prediction in Type 1 Diabetes

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## Background & objective

- A clinically important task in type 1 diabetes management is the prevention of hypo- and hyperglycemia.
- Thus, an important feature of any artificial pancreas (AP) is its ability to predict glucose along a given prediction horizon (PH), either as part of the control algorithm or the patient supervision subsystem.
- In this study we explored the concept of seasonality in time-series models for glucose prediction to improve prediction accuracy and allow longer PHs. This is expected to improve AP performance and safety.

## Materials and Methods

- **Data overview**: CGM glucose data was available for eight hours after a meal, from 12:00 PM until 20:00 PM, with a sampling period of 15 minutes. Data covering 7 post-prandial periods for a same 60g CHO meal was used, both in open-loop (OL) and closed-loop (CL) scenarios.
- **Method**: SARIMA and SARIMAX models were identified following the Box-Jenkins methodology and evaluated with a Leave-one-out Cross-validation procedure (LOOCV).
- **Goodness-of-fit**: Residual analysis (Ljung-Box Q-Test ), Akaike information criterion (AIC) and mean squared error (MSE) were compared.
- **Forecast accuracy**: Evaluated via mean absolute error (MAE), root mean squared error (RMSE), mean absolute percentage error (MAPE) and Theil inequality coefficient (UI).
- **Computational algorithms:** Eviews software, version 9.5, was used.

## Conclusions

- Seasonality improved model accuracy allowing the extension of the PH, although longer time-series might be needed.
- SARIMAX models exhibit relatively higher forecasting accuracy for larger prediction horizons.

## References

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2) M. Eren-Oruklu, A. Cinar, L. Quinn, and D. Smith, "Estimation of future glucose concentrations with subject-specific recursive linear models,",2009.

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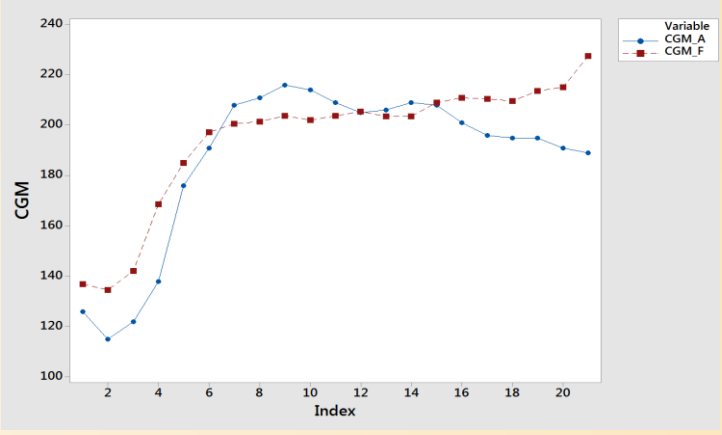
## Results

**1) The average of the forecast accuracy measure for a 5-h prediction horizon in both cases (OL & CL) of study, by using LOOCV technique.**

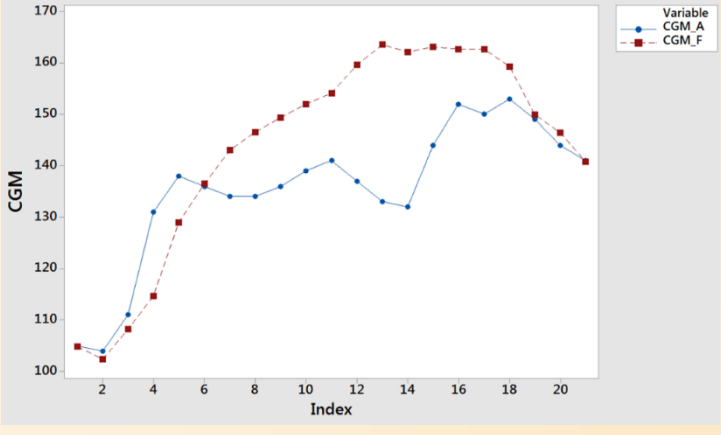
| Forecasting accuracy measures | OL_Case study | CL_case study |
|---|---|---|
| MAE | 27,5997 | 21,1895 |
| RMSE | 33,3558 | 25,2725 |
| MAPE | 27,91% | 14,82% |
| UI | 0,1108 | 0,0867 |

**2) Comparison of observed and predicted glucose for 5 hours in the best OL and CL cases of study, by using SARIMA models.**

➢ **OL case:**




➢ **CL case:**




**3) Comparative study between SARIMA and SARIMAX in the best CL case study & different linear empirical dynamic models, by using MAPE as a statistical measure for comparison.**

| Model \ PH | 30 min | 60 min | 120 min | 180 min | 240 min | 300 min |
|---|---|---|---|---|---|---|
| SARIMA (2,0,1) (1,0,1) | 1.39% | 4.63% | 5.49% | 8.26% | 9.34% | 7.87% |
| SARIMAX.CSII (2,0,1,1) (1,0,1) | 4.20% | 8.42% | 6.91% | 6.53% | 7.07% | 6.36% |
| SARIMAX.Meal (2,0,1)(1,0,1) | 4.75% | 8.10% | 5.74% | 6.47% | 7.01% | 5.86% |
| SARIMAX.CSII,Meal (2,0,1,1)(1,0,1) | 3.76% | 8.34% | 7.20% | 6.58% | 7.02% | 6.33% |
| ARIMA(2,0,1) | 4.31% | 13.86% | 11.12% | 15.22% | 16.76% | 12.25% |
| ARIMAX.CSII (2,0,1,1) | 6.78% | 13.13% | 15.39% | 14.11% | 12.87% | 11.80% |
| ARIMAX.Meal (2,0,1) | 6.05% | 11.44% | 12.78% | 11.63% | 11.13% | 10.97% |
| ARIMAX.CSII.Meal (2,0,1,1) | 5.88% | 12.84% | 15.59% | 14.43% | 13.10% | 11.89% |