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Publication date: 2011

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):

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Closed-Loop and Semi Closed-Loop Strategies for Control of Blood Glucose in People with Type 1 Diabetes

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Abstract

Comparison between 4 insulin administration strategies
- Nonlinear model predictive control (NMPC) without meal announcement.
- NMPC with meal announcement in advance.
- NMPC with meal announcement at mealtime.
- Feedforward-feedback controller.

Feedforward-feedback controller
- A time-varying reference signal based on meal announcement reduces the risk of hypoglycemia
- Feedback from a glucose sensor
- Differentiate between basal insulin and boluses
  - Basal insulin compensates for small mismatches
  - Boluses are given at mealtimes

Numerical simulations of the feedforward-feedback controller

Scenarios
- A decrease by 50\% in insulin sensitivity while fasting
- A 75g CHO meal with sensor noise
  - right meal announcement
  - meal size underestimated by 50\%
  - meal size overestimated by 50\%

Simulations

Numerical simulations of NMPC

Scenario
- Meal sizes and times
  - Breakfast 62g CHO at 6AM
  - Lunch 55g CHO at 12PM
  - Dinner 50g CHO at 6PM

Simulations
- Insulin administration strategies
  - Meals are not announced.
  - Meals are announced in advance.
  - Meals are announced at mealtimes only.

Conclusion
- NMPC simulations give an upper-bound on the maximal achievable performance for different meal announcement strategies.
- Utilization of the bolus-like nature of the optimal insulin profile to design a feedforward-feedback controller based on linear MPC.
- Demonstration of the robustness of the feedforward-feedback controller wrt. changes in insulin sensitivity and mismatches in meal announcement in the case where an accurate enough model of the patient is available.