MOTIVATION

Artificial pancreas (AP)
- Continuous glucose monitoring (CGM)
- Fully automated insulin infusion
- No user input
- Increased safety and reliability requirements
- Need for automatic fault detection

Insulin infusion faults
- Insulin infusion sets are the ‘Achilles heel’ of continuous insulin infusion [1]
- With in-line detection, occlusions may remain silent (for hours) [2]
- Alternative detection based on CGM, e.g. [3]
- Time delays and slow dynamics of insulin infusion and glucose sensing with the subcutaneous (SC) approach may compromise the detection based on CGM.

Variable insulin sensitivity
- Changing over time [4]
- Inter- and intrainsubject variability
- Affects the glucose levels by variable insulin needs.

Aim: Distinguish insulin infusion faults from other disturbances in an artificial pancreas

RESULTS

Sensitivity to parameter changes over time
- Example of time course of a 3-meal-scenario for one subject
- Sensitivities of intravenous (IV) and SC CGM glucose

Sensitivity to parameter changes
- Mean local sensitivity after a meal of 25 g carbohydrates
- Normalized sensitivity coefficients

Comparison of perturbations with glucose-increasing effect

Insulin infusion fault
- Parameter $R_i$, rate of insulin appearance in plasma [5]
- Time course of $R_i$ with subject’s insulin needs
- Example of sudden stop:

Meal disturbance
- Parameter $R_d$, rate of glucose appearance in plasma [5]
- Time course of $R_d$ from meal simulation
- Example of step from 0 to 2 mg/kg/min:

Decreased insulin sensitivity
- Parameter $k_{p3}$, insulin action on liver [5]
- Nominal parameter value of each subject
- Example of sudden change to 50% of nominal value:

INTERPRETATION:
- Especially low sensitivity to insulin infusion faults.
- SC CGM has lower sensitivity than blood measurements.
- Significant differences between subjects.

REFERENCES

[6] Hindmarsh AC and Serban R User Documentation for CVODES v2.9.0 (SUNDIALS v2.7.0), 2016.