Meal Detection for Type 1 Diabetes Using Moving Horizon Estimation

In this paper, we develop a method for detection of unannounced meals for blood glucose regulation in diabetes. A smoothing formulation using moving horizon estimation (MHE) estimates the unknown rate (g/min) of carbohydrate (CHO) ingestion. The inputs to the meal detection algorithm are the CGM measurements and insulin infusion rate. The MHE uses second-order linear input-output models for insulin to subcutaneous (sc) glucose dynamics and for the carbohydrate (CHO) to sc glucose dynamics. We test the algorithm on 9 in silico type 1 diabetes patients and a total of 45 meals during 13.5 days of simulation. The model in the patient simulator is a nonlinear model of glucose regulation. Results indicate that the detection delay is 33 min, and the algorithm has two false negatives (96 % sensitivity) and one false positive. The mean elevation in sc glucose concentration due to meals is 10.6 mg/dL at the detection time.