## Feedback control for pen-based treatment for people with type II diabetes

In this project, you will develop a controller for people with type II diabetes, which administers 1) basal insulin once daily and 2) meal bolus insulin. Typically, people with type II diabetes administer insulin using pens (instead of pumps), and the basal insulin is administered, e.g., once daily. Consequently, the basal rate cannot be adjusted continuously, and therefore, it is even more important to administer the correct dose.

1. Implement the model of glucose-insulin dynamics in people with type II diabetes developed by Engell et al. (2021). You will use it instead of the MVP model.
2. Create an I-controller that administers basal insulin once daily (e.g., 7:00 in the morning).
3. Develop two versions of the controller assuming the following measurements.
    a. Continuous glucose monitor (CGM).
    b. Blood glucose measurements (BGM), i.e., finger-pricking.
4. Perform closed-loop simulations of the controller under the following meal conditions.
    a. Fasting conditions (no meals).
    b. Regular diet.
    c. High-carb diet (large/many meals).
5. Augment the model with the following sources of uncertainty
    a. Measurement noise – add a zero-mean normally distributed stochastic variable to the measurements.
    b. Process noise – consider the plasma blood glucose concentration dynamics to be uncertain (ask Tobias, Sarah, or John for details).
    c. Time-varying parameter values – consider, e.g., the insulin sensitivity to be a stochastic variable (ask Tobias, Sarah, or John for details).
6. Implement the Euler-Maruyama method (see Section 4 in the paper by Higham (2001)).
7. Perform closed-loop simulations where the physiology of the person changes over time, e.g., introduce a step change in the insulin sensitivity (update the parameters at some point in time).
8. Perform closed-loop simulations of the developed algorithm with 1, 10, and 100 virtual people with type II diabetes.

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Higham, D.J., 2001. An algorithmic introduction to numerical simulation of stochastic differential equations. SIAM Review 43(3), pp. 525-546.