Approximation of optimal bolus calculators using surface fitting

In this project, you will develop bolus calculators which approximate the optimal boluses obtained when you assume perfect knowledge of a person's body. That is, you will develop bolus calculators which remove the necessity of having a mathematical model (i.e., the MVP model) with person-specific parameters.

Part 1 – developing the approximation

1. Simulate the meal response (12 h) using the MVP model.
2. Evaluate the objective function, phi.
3. Repeat step 1. and 2. for different insulin boluses and meal carbohydrate contents (0-10 U and 0-150 g CHO).
4. Plot the objective function as a function of both insulin boluses and meal carbohydrate contents (use, e.g., Matlab's surf function).
5. Come up with a proposal for a parametrization of the objective function (ask Sarah, Tobias, or John for a suggestion).
6. Estimate the parameters in the parametrization using Matlab's lsqnonlin (a nonlinear least-squares methods for parameter estimation) as well as the values of the objective function, phi, the insulin boluses, the meal carbohydrate contents.
7. Compare with the original surface; can you find a set of parameters which makes it a good approximation?

Part 2 – testing the approximation

8. For each meal carbohydrate content, compute the optimal bolus (e.g., in increments of 10 g CHO).
9. Divide the meal carbohydrate content with the optimal bolus and take the average over all meals. The result is an estimate of the insulin-to-carb ratio (ICR).
10. Create a simple controller that administers bolus insulin based on the ICR (divide the meal carbohydrate content with ICR).
11. Perform a closed-loop simulation of a month using the simple ICR-based controller.
12. Fit the parametrized curve based on the boluses and their responses using lsqnonlin.
13. Create a controller that administers insulin based on the approximation of the objective function surface.
14. Perform a closed-loop simulation to test the approximate bolus calculator.
15. Test how sensitive the approximation is to the quality of the data
    - What if the person always administers too little insulin?
    - What if the person over- or underestimates their meals?
16. Repeat the parameter estimation and closed-loop simulation for 10 and 100 people.

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