

Dugga 1, TBMT19, 2014-01-31

Each question gives 3 points. 7 points are required to pass. You have approx. 45 min.

1) Consider the following model, in reaction form



$$(x_1(0), x_2(0)) = (2, 3); k_1 = 1, \hat{y} = k_y \cdot x_2, k_y = 1, V_{\max} = 2, K_m = 1$$

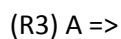
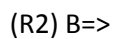
- What are the states?
- What are the parameters?
- What can be measured?

ANSWER:

a) x_1, x_2 b) $k_1, V_{\max}, K_m, k_y, x_1(0), x_2(0)$ c) x_2 times a scaling parameter

(note that the sloppy version of formulating was used here, i.e. $x_1 = \#x_1$)

2) Consider the following set of reactions:



- What are the corresponding differential equations? Assume mass action kinetics for R1 and R2, and Michaelis-Menten kinetics for R3. Don't forget to specify the initial conditions. Specify some values for any parameters you might introduce.
- Expand the model to say that you can measure something that is proportional to the rate of the second reaction, R2.

ANSWER:

$$a) \quad x_1 = [A], \quad x_2 = [B], \quad v_1 = k_1 \cdot x_1, \quad v_2 = k_2 \cdot x_2, \quad v_3 = V_{\max} \cdot x_1 / (K_m + x_1)$$

$$d/dt(x_1) = -v_1 - v_3$$

$$d/dt(x_2) = v_1 - v_2$$

$$V_{\max} = K_m = 3, \quad k_1 = k_2 = 8.76, \quad x_1(0) = 1, \quad x_2(0) = 88$$

b) Add the following equation: $\hat{y} = v_2 \cdot k_y$ where $k_y = 8$

3) Cost functions

- a) What is the input and output of a cost function?
- b) What are the residuals, and how do they relate to the cost function?
- c) What is the difference between a local and a global optimization algorithm?

ANSWER:

a) Input: parameters, Output: cost, i.e. a measure of the agreement with data

b) The residuals are the differences between measured data (y) and corresponding simulated data for a specific parameters ($\hat{y}(p)$). In the cost function, all the residuals are squared, normalized with the variance of the measurement noise, and finally summed together.

c) A local optimization algorithm stops at local minima, but a global optimization algorithm finds, or at least attempts to find, the global minimum.