Omdugga 2013-02-11

All questions give 3 points. Do 1-3 for Omdugga 1, 3-5 for Omdugga 2, 1-5 for both.

7/9 to pass one, 12/15 to pass both

1. Consider the following little model:

   d/dt(x1) = u – k1*x1 –Vmax*x1/(Km + x1)

   d/dt(x2) = Vmax*x1/(Km + x1) – k3

   k1 = 1, Vmax = 2, Km = 3, k3 = 5, x1(0) = 2, x2(0) = 3, yhat(t,p) = ky*x2, ky = 4

   a) What are the states?, b) What are the parameters? c) What can be measured?

ANSWER:

a) x1, x2 b) k1, Vmax, Km, k3, x1(0), x2(0), ky c) ky*x2, i.e. x2 times a scaling parameter

2. a) What is the input and output of a cost function?
   b) How does Euler's forward method for simulation work?
   c) What are the residuals in question 1, if y(0) = 3 ?

ANSWER:

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

b) Use the current values of the states to calculate the derivative, and then take a step in this direction, to get the updated values of the states. Then calculate new derivatives, etc.

Short versions: "go with the flow" or "be like a leave in the wind"

c) r = y – yhat = 3 – 4*3 = 3-12 = -9 (sign doesn't matter, you can reply yhat-y as well)

3. Consider again the model in question 1
   a) What are the reactions?
   b) What changes if you assume that the reaction with saturation no longer has the saturation?

ANSWER:

a) Say x1 = [A] and x2 = [B]. Then the reactions are => A => Ø and A => B => Ø

You can also write => x1 => Ø and x1 => x2 => Ø, but that is a bit sloppy writing

b) d/dt(x1) = u – k1*x1 –k2*x1

d/dt(x2) = k2*x1 – k3

So, the parameters Vmax and Km are replaced by k2, which needs a value, e.g. k2 = 8.97

4. Optimization and tests
    a) What is the input and output of an optimization algorithm?
    b) What is the null hypothesis of a whiteness test?
    c) What happens if you do not reject a chi-square test?

ANSWER:

a) Input: start guess, cost function, Output: Optimal parameters

b) that the residuals are not correlated

c) nothing, there is no conclusion (but the model is tentatively accepted, and may move to phase 2)

5. Closing the loop
    a) A core prediction is tested experimentally, and the experiment shows that a value outside the predicted interval was obtained. What can we then conclude? How would that be different if the prediction was not known to be a core prediction?
    b) You have two models that are acceptable given the current data. How can you use predictions to design an experiment that *ensures* that a new experiment will be able to distinguish between the models?
    c) Give an example of what makes modelling preferable to ordinary inspection and reasoning around data?

ANSWER:

a) If it is a core prediction, we know that the model can be rejected. Otherwise we know nothing new about the model (except that the specific parameters that were tested are rejected; the model, i.e. the model structure, the actual equations, may still hold, for some other parameters).

b) You find an experimental design in which the models produce different non-overlapping core predictions. Then you know that at most one of the models will be able to describe the result of the experiment.

c) One example is a system with several different time-series; then it is very seldom possible to reason yourself to all the possible mechanisms by which these time-series could have been produced.

Another example is the case of large amounts of data (omics). Then ordinary inspection cannot grasp all the implications of data – more formal methods are needed.