Exercise sheet 6
Systems Biology class 2014

April 28, 2014

Print and return to during classes, tutorials or office hours to Miri Adler until May 11th 2014.

1 Simulating an incoherent type 1 feed-forward loop (I1FFL) on the computer

1. In the file `SolveIFFL1.m` on the course website, you will find a MATLAB script that simulates the dynamics of the following model for the I1FFL:

$$\frac{dY}{dt} = \beta_y X - \alpha_y Y \tag{1}$$

$$\frac{dZ}{dt} = \beta_z \frac{X}{Y} - \alpha_z Z \tag{2}$$

In the script, the parameters are initially set as following: $\beta_y = \beta_z = \alpha_y = \alpha_z = 1$. Running the function `SolveIFFL1` of the `SolveIFFL1.m` script produces a plot of Y and Z as a function of time. To run the function, start Matlab, go to the directory where you saved `SolveIFFL1.m`, type '`SolveIFFL1`' and press ENTER.

Assume that the signal X changes from X_0 to X_1 at $t = 0$ in a step manner. Also assume that Y and Z are at steady state at $t = 0$.

Plot Z as function of time with $X_0 = 1$, $X_1 = 2$.

2. Plot Z as function of time with $X_0 = 5$, $X_1 = 10$. Does the figure for $Z(t)$ overlap with $Z(t)$ from the previous case? why?

3. Plot Z as function of time with $X_0 = 1$, $X_1 = 5$. Is $Z(t)$ the same as in the previous case? If not, why and how did the maximal value of $Z(t)$ change (is it bigger/smaller than in the previous case)?

2 Simulating a degradation based incoherent type 1 feed-forward loop (I1FFL) on the computer

1. Consider the set of differential equations:

$$\frac{dY}{dt} = \beta_y X - \alpha_y Y \tag{3}$$

$$\frac{dZ}{dt} = \beta_z X - \alpha_z Y Z \tag{4}$$

Consider also that the siganl X changes from X_0 to X_1 at $t = 0$ in a step manner and that Y and Z are at steady state at $t = 0$.

Show that Z has exact adaptation. What is the steady state level of Z?

2. Use the file `SolveIFFL2.m` from the course website to simulate this model (Eq. 3,4).

Plot $Z(t)$ for $X_0 = 1$, $X_1 = 2$ and for $X_0 = 5$, $X_1 = 10$. Do the plots overlap? What does this mean for the FCD potential of this circuit?

3. Extra: Change the values of α_y and α_z in the script. Can you find values for which FCD approximately holds? What parameter should be large/small for this approximation to take place?

3 FCD in human sensory systems

Design an experiment that can test for FCD in the vision system. The results of your experiment should show that in the human vision system the perception of a signal doesn't depend on absolute levels but only on fold changes. Describe the experiment in details and what you will measure (200 words or less).