CALIFORNIA INSTITUTE OF TECHNOLOGY
BioEngineering

BE 250C

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Problem Set #2

Issued: 13 Jan 11
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1. (Based on Alon 4.6) *Shaping the pulse.* Consider a situation where X in an I1-FFL begins to be produced at time t=0, so that the level of protein X gradually increases. The input signal S_x and S_y are present throughout.

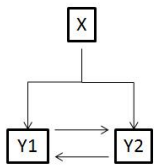
   a) How does the pulse shape generated by the I1-FFL depend on the thresholds K_{xz}, K_{xy}, and K_{yz}, and on β, the production rate of protein X? (i.e. How does increasing or decreasing these parameters change the height or position of the pulse peak, the slope of the rise of the pulse, etc?)

   b) Analyze a set of genes $Z_1, Z_2, ..., Z_n$, all regulated by the same X and Y in I1-FFLs. Design thresholds such that the genes are turned ON in the rising phase of the pulse in a certain temporal order and turned OFF in the declining phase of the pulse with the same order.

   c) Design thresholds such that the turn-OFF order is opposite the turn-ON order. Plot the resulting dynamics.

2. (Based on Alon 5.6) *Bi-fan dynamics.* Consider a bi-fan in which activators X_1 and X_2 regulate genes Z_1 and Z_2. The input signal of X_1, S_X2, appears at time t=0 and vanishes at time t=D. The input signal of X_2, S_X2, appears at time t=D/2 and vanishes at t=2D. Plot the dynamics of the promoter activity of Z_1 and Z_2 given that the input functions of Z_1 and Z_2 are AND and OR logic, respectively.

3. (Based on Alon 6.1) *Memory in the regulated-feedback network motif.* Transcription factor X activates transcription factor Y_1 and Y_2. Y_1 and Y_2 mutually activate each other. The input function at the Y_1 and Y_2 promoters is an OR gate (Y_2 is activated when either X or Y_1 binds the promoter). At time t=0, X begins to be produced from an initial concentration of X=0. Initially $Y_1 = Y_2 = 0$. All production rates are $\beta = 1$ and degradation rates are $\alpha = 1$. All of the activation thresholds are K=0.5. At time t=3, production of X stops.



   a) Plot the dynamics of X, Y_1, Y_2. What happens to Y_1 and Y_2 after X decays away?

   b) Consider the same problem, but now Y_1 and Y_2 repress each other and X activates Y_1 and represses Y_2. At time t=0, X begins to be produced and the initial levels are $X = 0, Y_1 = 0, Y_2 = 1$. At time t=3, X production stops. Plot the dynamics of the system. What happens after X decays away?