Assignment 6

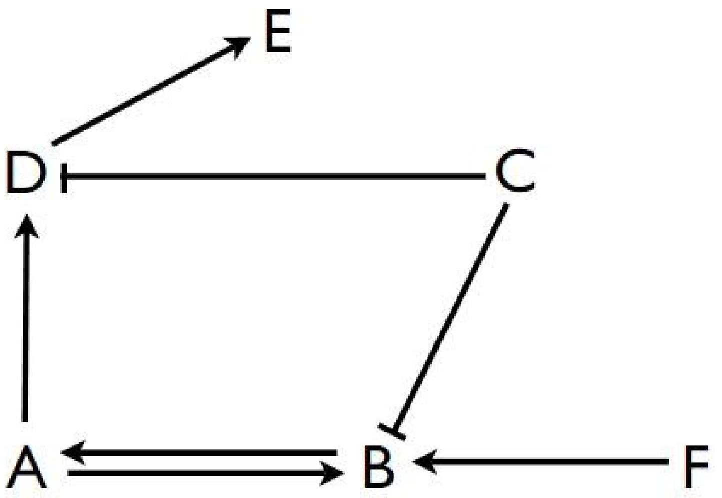
for lecture "Bioinformatics III" WS 08/09

Return by email to p.walter@bioinformatik.uni-saarland.de until **Jan. 11**. This assignment will be discussed in the tutorial on Jan. 12, 2009, room15, building E1 3

ZENTRUM FÜR BIOINFORMATIK

1. Boolean Network (100 points)

Consider the network shown on the right, which describes the mutual regulation of the hypothetical genes A to F. A line with an arrowhead denotes activation, while a flat end denotes inhibition, i.e., if A is high, D is activated, whereas high levels of F inhibit the expression of B and D.
To investigate the behaviour of this network, perform the following steps:



(a) Set up the Boolean functions in the form of condition tables as explained in the lecture (see V11). This gives you six tables, one for each of the genes A to F. Assume that an inhibition is always stronger than any number of activations.

(b) Implement the Boolean network in a dynamic simulation, where you have a variable for each of the genes, which can be 1 or 0, denoting high and low levels of this gene, respectively. Their states in the subsequent step are then determined from the current states according to the condition tables from (a).

Hint: first determine all new states, before you update the states.

To enumerate the initial states, convert the binary levels of the genes into an integer, where A determines the least significant bit and F the most significant one. An initial state, where, e.g., A, C, and D are on high levels, while B, E, and F are low, would translate into 1 + 4 + 8 = 13 (A=1, B=2, C=4, etc). Keep track of the states that the system has already visited and stop the propagation, once a state is visited a second time (Why?).

Which sequences do you get, when you start from state 13, 47, 0, or 37?

Hint: For comparison, you should get the following sequences of states: 4 – 6 – 7 – 15 – 31 – 63 – 53 – 36 – 4 and 8 – 16 – 32 – 0.

(c) To determine the attractors (= periodic orbits) and the corresponding basins of attraction, go through all possible initial states and save at which state the Boolean network closes its orbit, i.e., which state is visited twice. Construct the lists of initial states that converge to a given state. To determine the periodic orbits, you have to combine these lists. List these orbits (attractors) and their respective basins of attraction (all states that end in the orbit). Give the relative coverage of the state space by the basins of attraction.

Hint: an orbit, where the state does not change anymore, has a period of one, while an *orbit with two alternating states has a period of two, etc… The above network will give you one orbit of period one, two orbits of period two, and one orbit of period eight.*

(d) Interpret the orbits from (c): describe the state(s) for the short orbits and qualitatively explain the processes of the long attractor. What is determining its period? Is there a special gen? If yes, identify it and explain its effect.

Hint: what is the difference between the two shorter orbits of period two?

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