Bioinformatics III
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Exercise Sheet 6
Due: December 04, 2015 13:15

Submit your solutions on paper, hand-written or printed at the *beginning* of the lecture or in building E21, Room 3.03. Alternatively you may send an email with a single PDF attachment. If possible, please include source code listings. Additionally hand in all source code via mail to duy.nguyen@bioinformatik.uni-saarland.de.

Boolean Networks and Graph Connectivity

Exercise 5.1: Boolean Network (60 points)
Consider the following network, which describes the mutual regulation of the hypothetical genes **A** to **F**. A line with an arrowhead denotes an activation while a flat end denotes an inhibition, i.e., if **A** is high, **B** is activated, whereas high levels of **D** inhibit the expression of **B**.

To investigate the behavior of this network use a dynamic simulation as introduced in lecture 10 with a synchronous update scheme. Assume that an activation has a weight of 1, while an inhibition is always 3 times stronger than an activation. Set all threshold to 0.
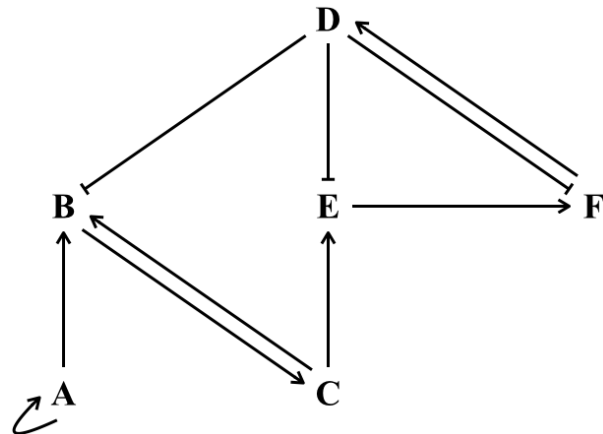
(a) **Weighted Interactions (10)**

Set up the propagation matrix that relates the states of the genes **A** to **F** in the next iteration to the current state.

(b) **Implementation (20)**

Write a program to simulate the Boolean network.

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 initital state where, e.g., only **A**, **C**, and **D** are on high levels would translate into $1 + 4 + 8 = 13$.

(1) When does it make sense to stop the propagation and why?

(2) Which sequences do you get when you start from states 1, 4, 21, and 33?

(c) **Periodic Orbits (20)**

To determine the attractors and the corresponding basins of attraction, go through all possible initial states and save at which state the Boolean network closes its orbit.

(1) List these orbits with their respective lengths and basins of attraction.

(2) Give the relative coverages of the state space by the basins of attraction.

(d) **Interpretation (10)**

(1) Give the attractors in terms of active genes and characterize them with a few words.

(2) Which are the special genes and what are their respective effects on the behavior of the network? For this, explain what is determining the period of the orbits. Further, compare the two shorter orbits which each other. Which gene is responsible for the difference?

Exercise 5.2: Graph Connectivity (40 points)

(a) Consider the graph G_1 showns below.
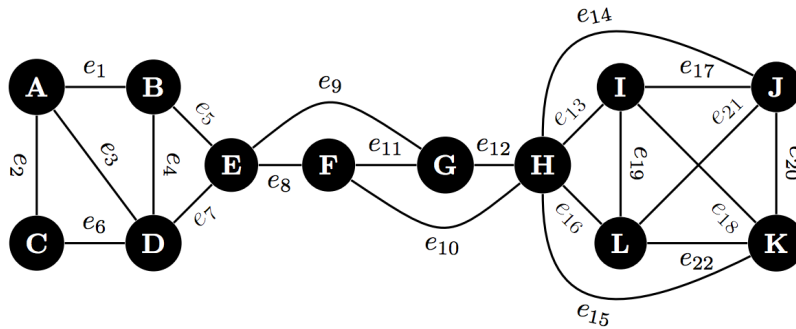
(1) **Edge Cut (10)**

Consider all edge cuts of $G_1 = (V_1, E_1)$. Is there any cut edge? Are there any minimal edge cuts consisting of precisely two edges?

(2) **Partition Cut (10)**

Give the partition cut of G_1 for the partitions $X = \{A, B, C, D, E, F\}$ and $Y = \{G, H, I, J, K, L\}$.

(b) **Connected Graph (10)**

Draw the graph $G_2 = (V, E)$ which satisfy each of the following conditions simultaneously:

(1) G_2 is connected

(2) $|V| = 5$

(3) $\forall v, w \in V$ there is a cycle containing v and w

(4) $\forall v \in V, e \in E$ there is a cycle containing v and e

(5) $\forall e, f \in E$ there is a cycle containing e and f

(6) $\forall v, w \in V, e \in E$ there is a path from v to w containing e

(7) $\forall u, v, w \in V$ there is a path from u to v containing w

(8) $\forall u, v, w \in V$ there is a path from u to v not containing w

(c) **Edge Connectivity (10)**

Give the edge connectivity of G_2.