Introduction to Focus Areas in Bioinformatics – WS19/20

Prof. Dr. Tim Conrad

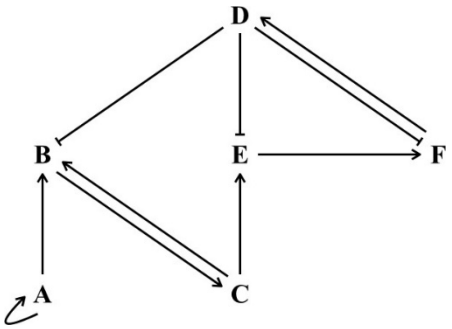
10 Project 10

- Deadline: 12.01.2020, 23:59
- All files need to be available through your GIT repository, in the directory “Project 10”.
- You can work in teams up to 3 people. Please state in the report the group member names.
- If your code is in python, I must be able to run your code within a Google Colab notebook. If your code is not in Python or R, you must provide a manual how to compile and run it on a Linux machine.

We will use the “The CoLoMoTo Interactive Notebook” by Naldi et al. (https://colomoto.github.io/colomoto-docker/) to model and simulate complex biological systems.

10.1 Modeling and Simulation of a simple boolean network

(1a) Implement and simulate the following 6 gene network (as a boolean network):



* A line with an arrowhead means activation while a flat stands for an inhibition, e.g. **A** activates **B** and **D** inhibits **B**.

* Enumerate the initial states in the following way: convert the binary levels of the genes into an integer where **A** is the least and **F** the most significant bit. A state where **A=1, B=0, C=1, D=1, E=0 and F=0** would translate into 1+4+8 = 13.

* Use a synchronous update schema.

(1b) Determine the attractors and the corresponding basins of attraction.

(1c) Interpret the results.

10.2 Modeling and Simulation the quorum sensing of Vibrio fischeri

Implement, simulate and analyze the quorum sensing of Vibrio fischeri. Use the information given in the lecture slides or other resources you might find.

10.3 Deliverables

Your need to upload all source codes and a report to your GIT repository.

- The report should be about 600-1200 words in length (this is roughly 1-2 pages, depending on your layout).
- The report must be delivered in PDF format using the BMC template (including the abstract as defined in project 5).
- The following sections must be present (you can add more if needed):
    - Toy Model
        - Implementation and Simulation

          (1) Describe briefly how the model was implemented and
          (2) the simulation was performed.
          (3) Visualize the implementation using GINsim.
          (4) Perform simulations starting from states `1`, `4`, `21` and `33`. List the individual sequences that you get.
        - Attractors & Fixpoints

          (1) Analyse, how many attractors exist. List the found periodic orbits with their respective lengths and basins of attraction.
          (2) Give the relative coverages of the state space by the basins of attraction. Important: Make sure to consider all possible initial states.
          (3) Compute and list up to three the fixpoints of the network and
          (4) visualize one using GINsim.
        - Interpretation

          (1) Briefly describe / characterize the attractors in terms of the active genes. Which are the special genes and what are their respective effects on the behavior of the network?
          (2) Explain what is determining the period of the orbits.
          (3) Compare the two shorter orbits which each other. Which gene is responsible for the difference?

    - Quorum Sensing Model
        - Background and Description of the model

          Describe briefly the biological background of the model.
        - Implementation and Simulation

          (1) Describe briefly how the model was implemented and
          (2) the simulation was performed.
          (3) Visualize the implementation using GINsim.
        - Attractors & Fixpoints

          (1) Analyse, how many attractors exist. List the found periodic orbits with their respective lengths and basins of attraction.
          (2) Give the relative coverages of the state space by the basins of attraction. Important: Make sure to consider all possible initial states.
          (3) Compute and list up to three the fixpoints of the network and
          (4) visualize one using GINsim.
        - Interpretation

          (1) Briefly describe / characterize the attractors in terms of the active genes. Which are the special genes and what are their respective effects on the behavior of the network?
          (2) Explain what is determining the period of the orbits.