Mathematics for Systems Biology and Bioinformatics

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Exercise sheet no. 5

Submission until 28. Nov 2012 10:00 am in the tutorials

Exercise 7: Adjacency Matrix I

Consider a graph of a system

$$a \to b \to c$$

with its adjacency matrix

$$A = \begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{pmatrix}$$

where entries a_{ij} represent a directed link from i to j.

a) Given vector $v_0 = (10, 2, 0)$ as a starting value for the species a, b and c, calculate $v_1 = v_0 \cdot A$ and $v_2 = v_1 \cdot A$. Discuss the result.

b) $A^k = \underbrace{A \cdot A \cdot \ldots \cdot A}_{\text{k times}}$ presents every link in the graph over k edges. Calculate A^2.

Homework 7: Adjacency Matrix II (4 Points)

a) Calculate the above exercises and draw the according graph of the system of the adjacency matrix

$$B = \begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 1 \end{pmatrix}$$

b) For the system

$$\begin{aligned} a &\to b \\ a \to c &\to d \to b \end{aligned}$$

find the adjacency Matrix C and prove that the graph contains no path over more than 3 edges.

c) For the system

$$\begin{aligned} a \to b &\to b \\ a \to c &\to d \to b \end{aligned}$$

find the adjacency Matrix C. Consider starting values $v_0 = (7, 0, 0, 0)$ and calculate v_3. Find a simple way to modify the system such that $v_3 = (0, 7, 0, 0)$, using the same starting values v_0. *Hint:* You may exchange $'1'$ in the adjacency matrix by any suitable number.

Homework 8: Analysis of Stability (6 Points)

Given r and l constant parameters over time, starting value $x_0, r, l \in \mathbb{R}^{\neq 0}$

a) Calculate the fix points and find a generally accepted solution for any x_n.

$$x_{n+1} = r\, x_n$$

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b) Calculate the fix points. Discuss cases $x_{n+1} > x_n$ and $x_{n+1} < x_n$ and set in biological perspective.

$$x_{n+1} = r\, x_n - l$$

c) Calculate the fix points. *Hint:* The solution includes a special case.

$$x_{n+1} = r\, x_n - l\, \sin(n)$$

d) Find fix points. How could you change the equation by adding one term to create a fix point for $r = l$?

$$x_{n+1} = r\, x_n \sin(n) - l\, x_n \sin(n)$$