
Mathematics for Systems Biology and Bioinformatics

Lecture Prof. Dr. Thomas Filk

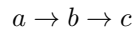
Tutorials Dr. Tim Maiwald, Christian Tönsing

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



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.

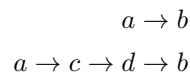
b) $A^k = \underbrace{A \cdot A \cdot \dots \cdot A}_{k \text{ times}}$ presents every link in the graph over k edges. Calculate A^2 .

Homework 7: Adjacency Matrix II (4 Points)

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

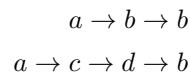
$$B = \begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 1 \end{pmatrix}$$

b) For the system



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

c) For the system



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 .

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

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 $r = l$?

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