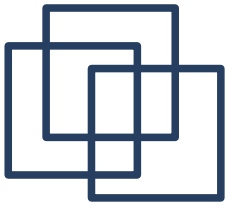
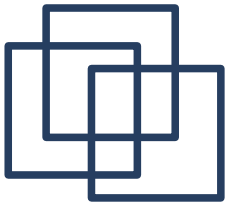


The Idiotypic Network with Binary Patterns Matching

Krzysztof Trojanowski
ICS PAS

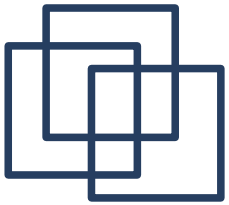
Marcin Sasin
WIT

Warsaw, Poland



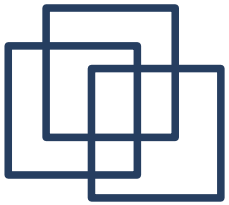
Outline of the presentation

1. Introduction
2. Rules of interaction in the net
3. Evaluation of a new concentration level
4. Affinity measures and transformation T operator
5. Applied measures for evaluation of the results
6. Results of simulations
7. Conclusions



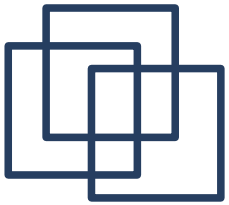
Introduction

- The model represents a network which consists of a set of antibodies (objects in a binary shape space) and rules of relationship between them,
- every object consists of a paratope and an epitope,
- every object represents a set of antibodies with the same patterns of the paratope and the epitope,
- the quantity of a set represented by an object is defined by the concentration attribute.



Introduction

- The proposed specification allows also to introduce antigens into the system,
- different types of antigens are represented by objects equipped with epitope,
- the objects representing antigens interact with the objects representing antibodies in the same manner like the antibodies interact with each other.

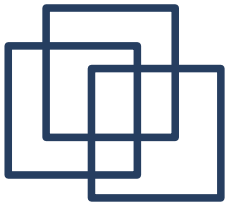


Rules of interaction

- The rules steering the levels of concentrations are based on affinity between paratopes and epitopes of different types,
- when the value of the affinity between any two objects is above the specified level the objects' concentration is modified,
- the rules depend on the number of other types that a type interact with and they do not depend on the concentration of those types,
- there are five rules of stimulation and suppression defined.

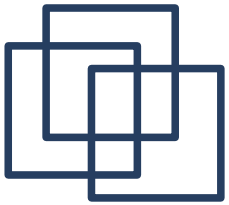
Five rules of interaction

1. For the objects representing type of antibodies there exist two kinds of relation: to recognize anybody (stimulation) and to be recognized by anybody (suppression).
2. If the given type of antibodies neither recognizes nor is recognized by any other type of antibodies it will be suppressed.



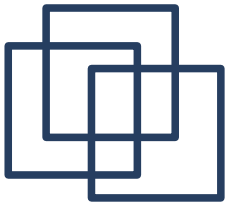
Five rules of interaction

3. If the object representing type of antibodies recognizes any object representing type of antigens the object representing types of antibodies will be activated and the object representing type of antigens will be suppressed.
4. If the object representing type of antibodies neither is recognized by any other type of antibodies in the system nor recognize any type of antigens the object will be suppressed.



Five rules of interaction

5. The real-world antigens try to proliferate continuously in the infected organism so for each of types of antigens a concentration growth is evaluated in every iteration. The concentration growth is proportional to current level of concentration.



A new concentration level

- To evaluate new values of concentrations of types of antibodies and types of antigens the total number of other types of antibodies and antigens they interact with is evaluated.
- The change depends on the number of stimulative and suppressive interactions.
- The concentration change is controlled by two parameters (weights): activation factor and suppression factor.

Affinity measures

1. Russel and Rao,
2. Jaccard and Needham,
3. Kulzinski,
4. Sokal and Michener,
5. Rogers and Tanimoto,
6. Yule.
7. Hamming distance
8. R-contiguous bits matching rule

..*without* and *with* transformation T operator.

Transformation T operator

For every two patterns $A, B \in \{0,1\}^N$:

$$\forall_{i \in \{0,1,\ldots,N\}} A[i] = 0 \Rightarrow ((A[i] = 1) \wedge (B[i] = 1 - B[i]))$$

After transformation one of the strings is always turned into a sequence of digits "1", while the other includes information about differences between the input strings.

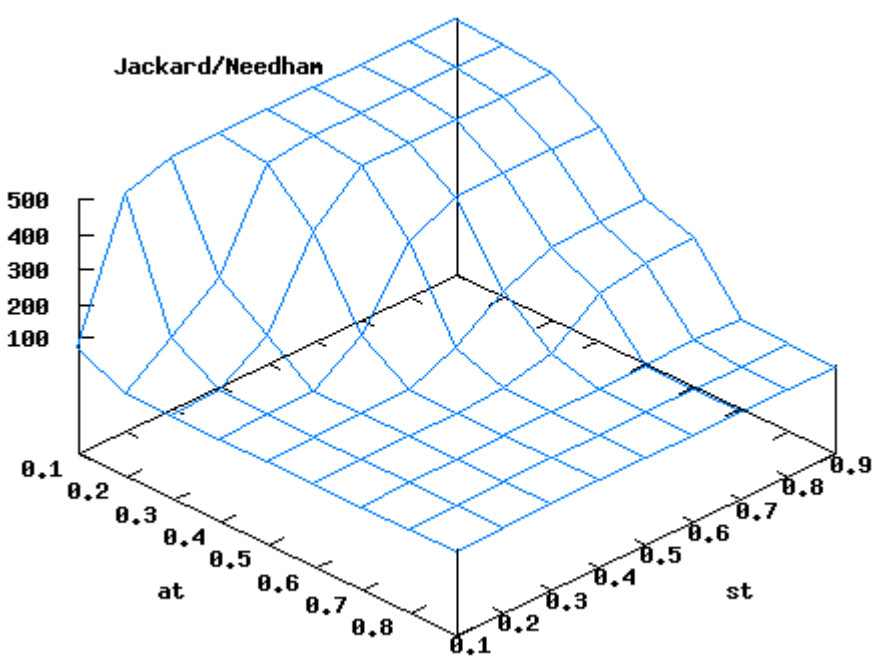
The operator reduces the search space, e.g. for a set of 65536 pairs of 8-bit binary strings we obtain 256 different transformed pairs.

Applied measures

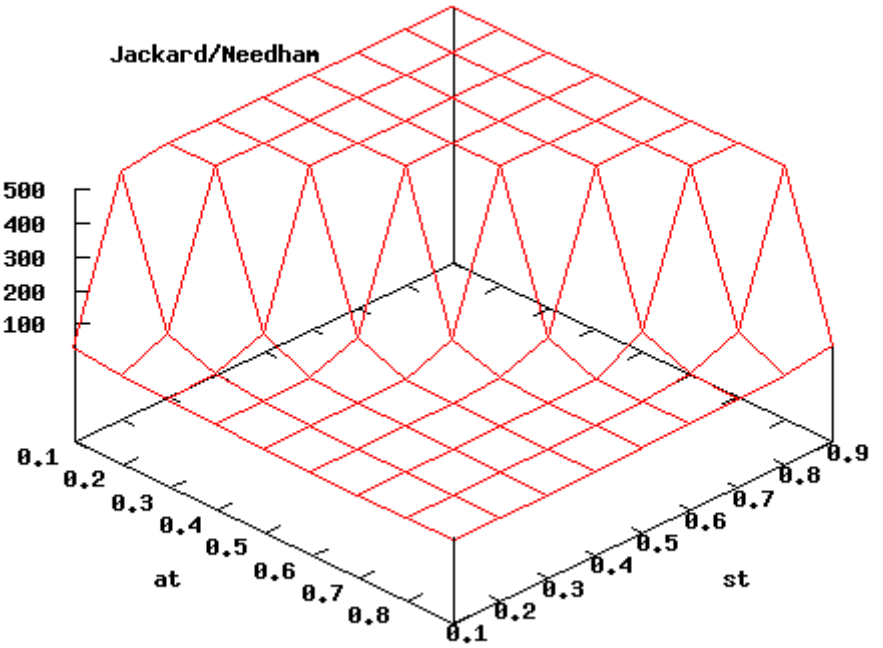
- life spans of the objects:
  the change of concentration is expressed by the life span since the objects with high concentration live longer while the ones with decreasing concentration quickly reach the minimum value and are eliminated.
- number of types of antibodies in the process:
  it necessary to note, that in contrast to other network models the size of repertoire of types of antibodies was fixed. Therefore new types were recruited only if some other disappeared and made room in the repertoire.

Results – mean life spans

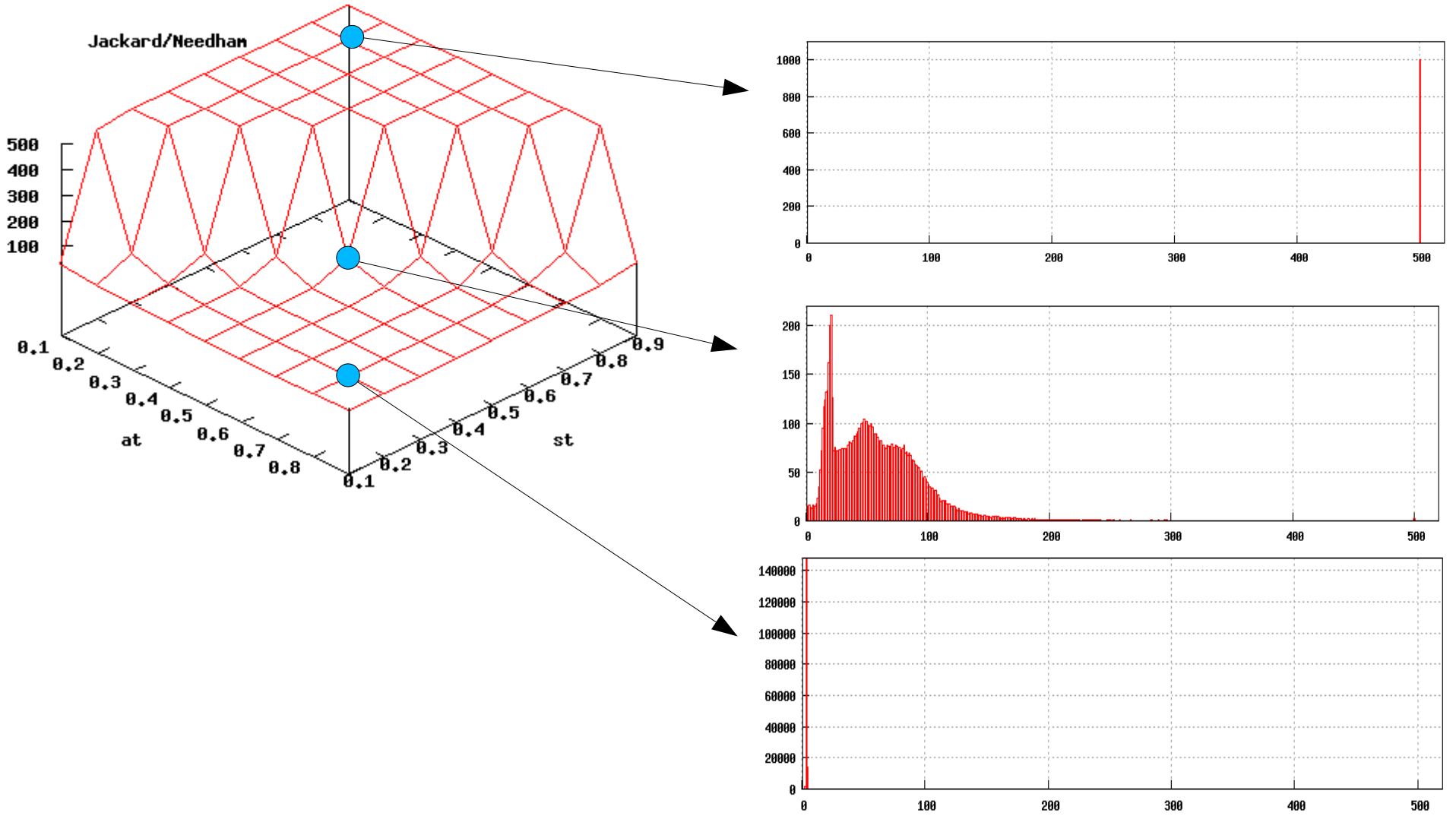
J&N without T



J&N with T (*called* T1)

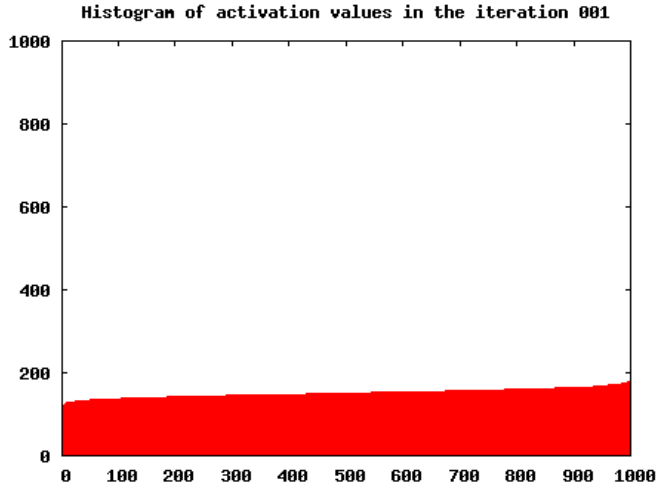


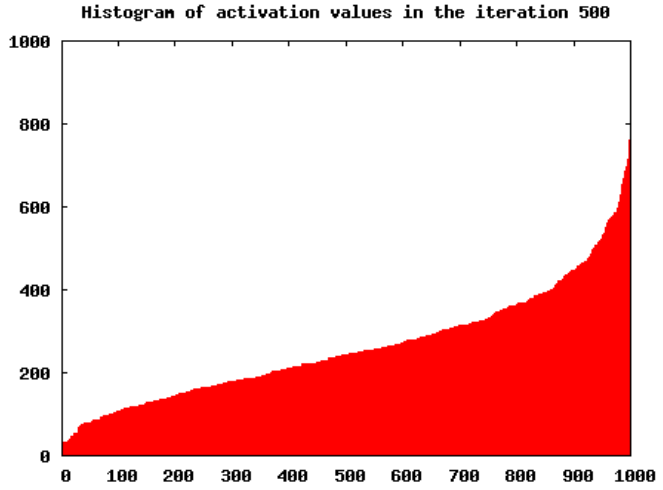
T1 - life span histograms



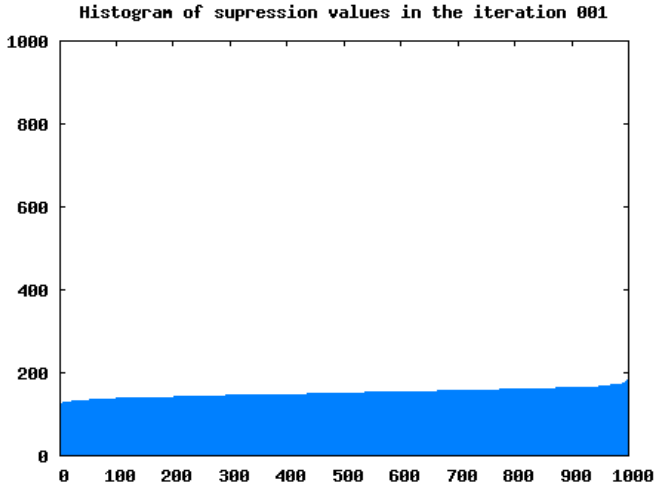
T1: at=0.5, st=0.5

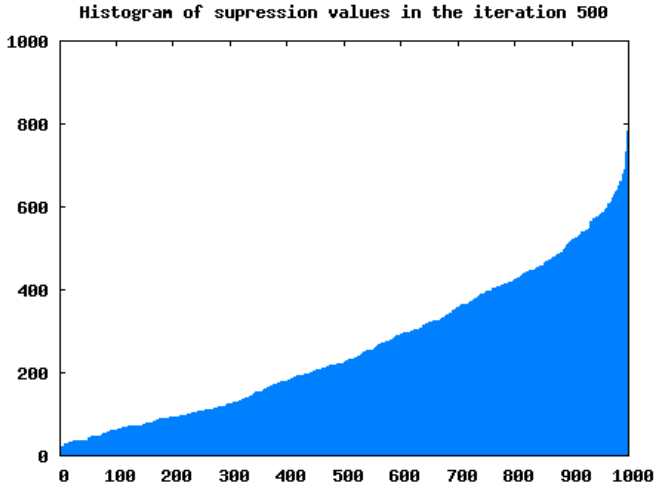
Activation values



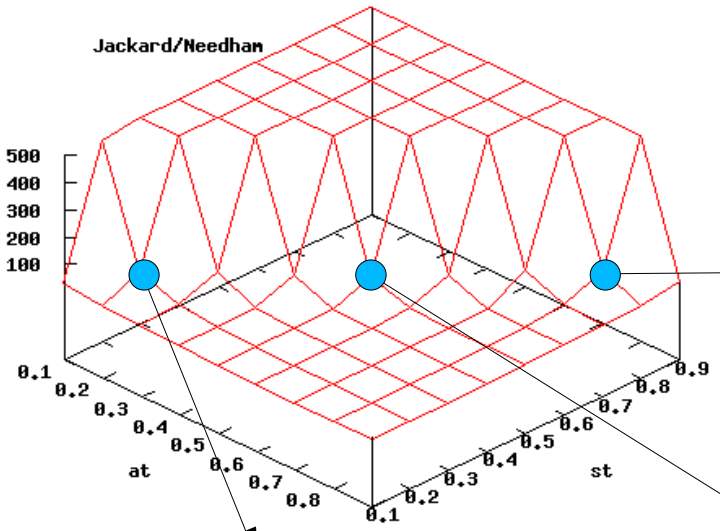


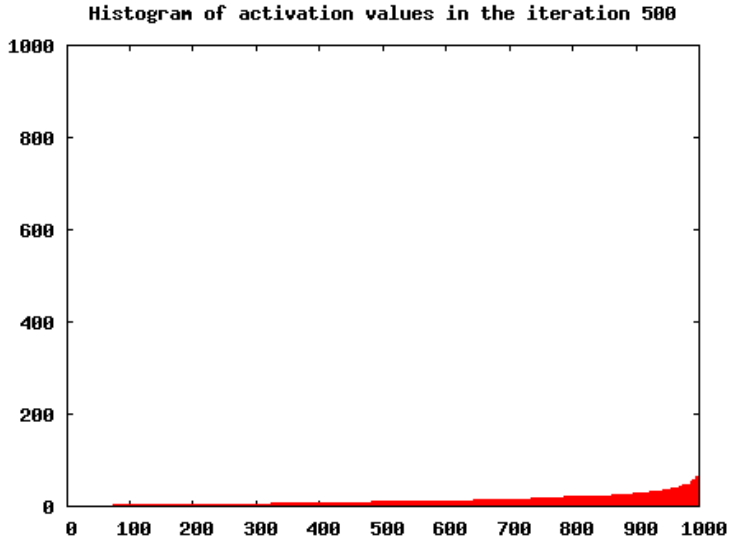
Suppression values

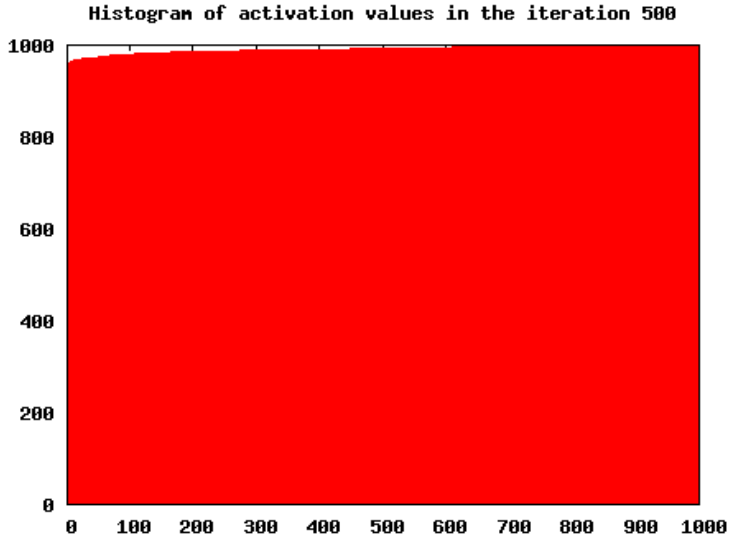


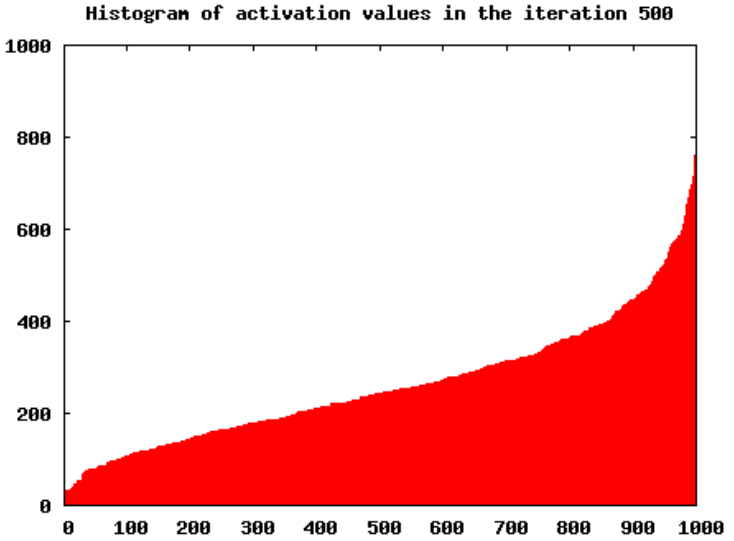


T1 – activation values

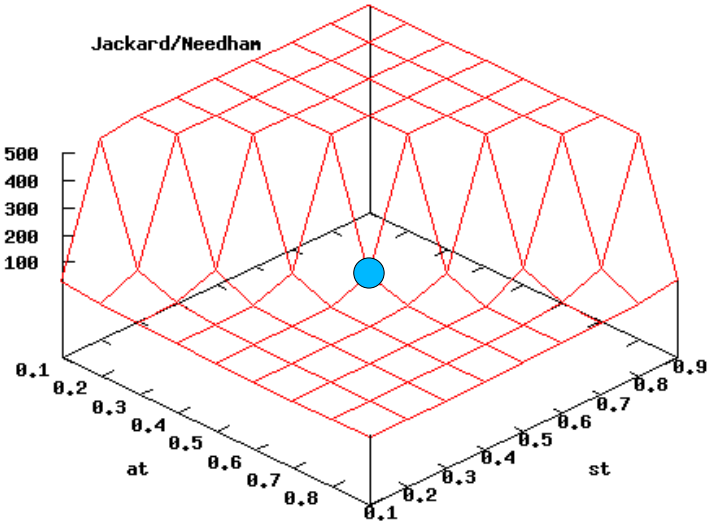


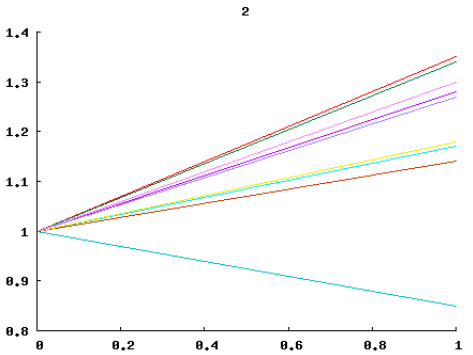


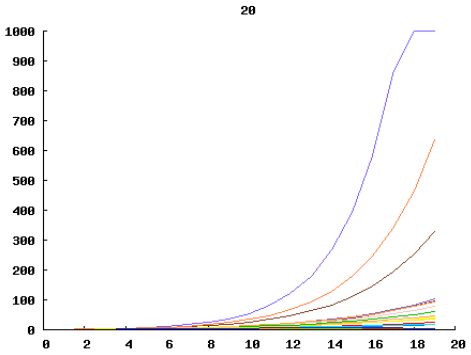


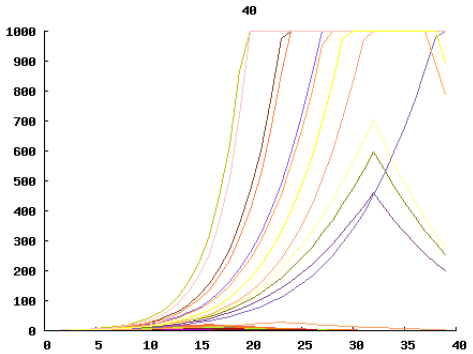


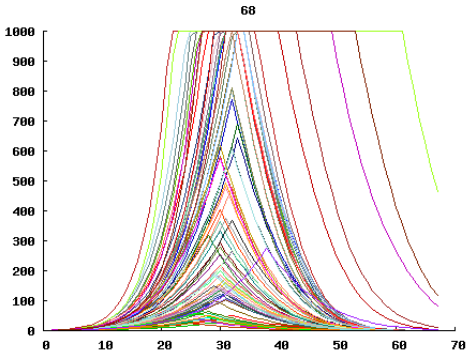
T1 – concentration levels

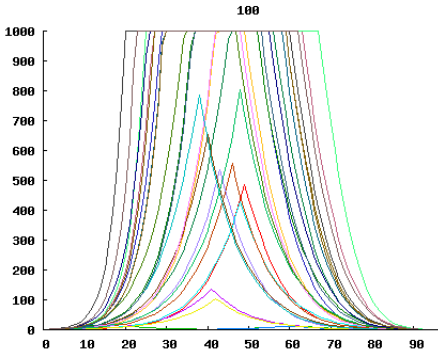


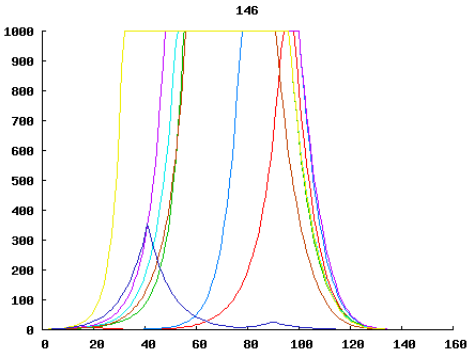


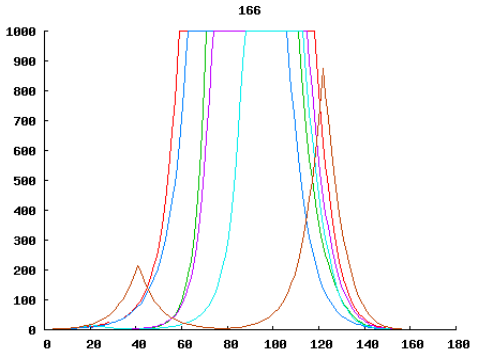


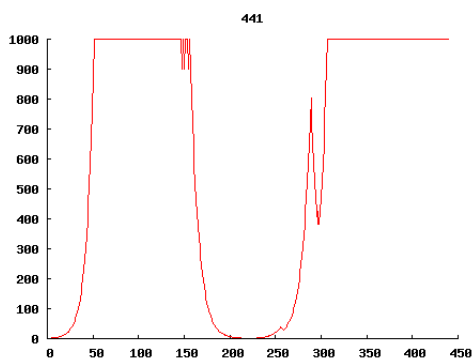


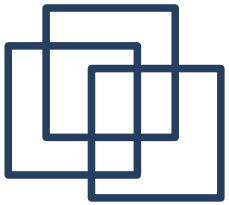








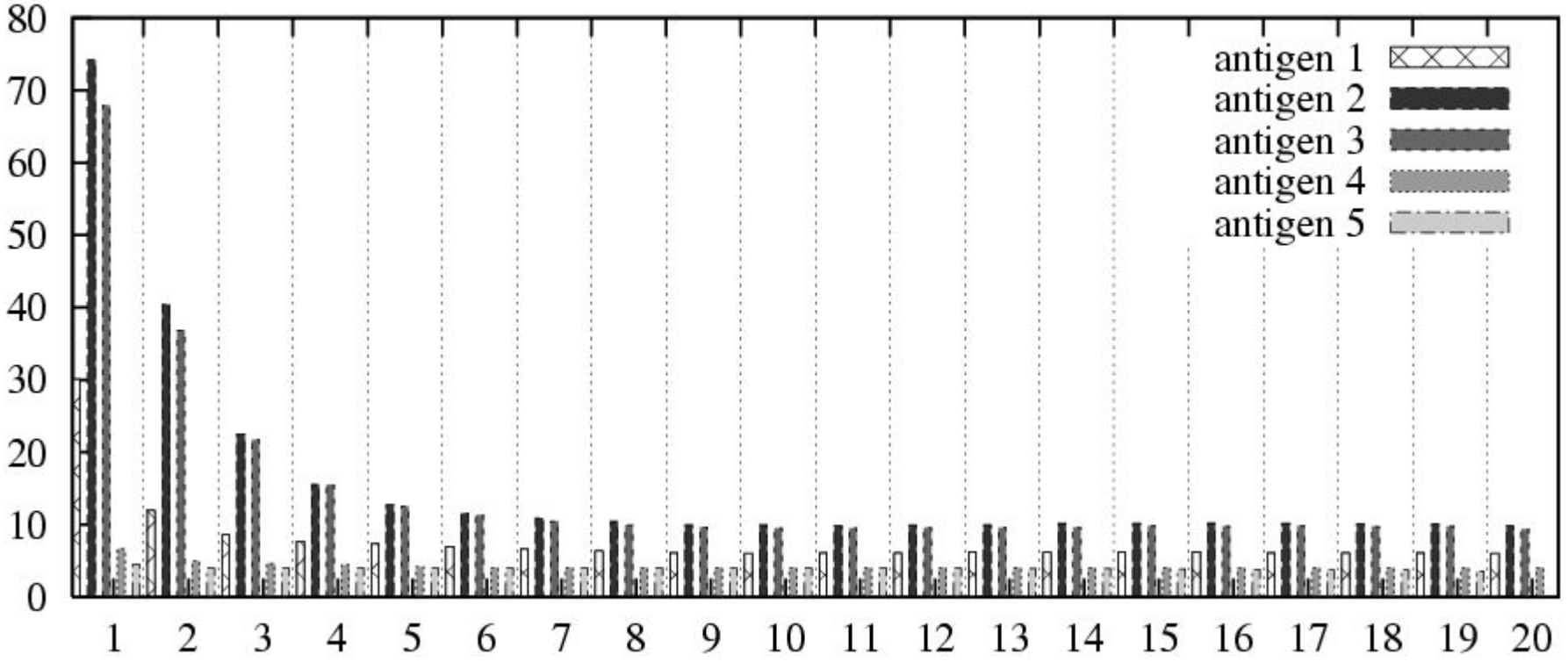




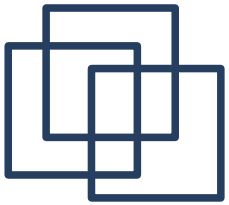
T1 - tests with antigens

- A new object representing a new type of antigens is injected into the system after every 5 iterations of the algorithm.
- After a copy of the fifth type of antigen the next injected object is a copy of the first one.

T1 - tests with antigens



Every bar in the histogram represents a life span of a single object. There are five colours of bars because these are life spans of objects of the five types of patterns.



Conclusions

A new specification of the immune network model based on the binary shape-space is proposed.

The specification differs from the others:

- the network is build of the objects representing types of antibodies and types of antigens instead of just antibodies or antigens,
- there is a constant size of repertoire of types of antibodies during the experiment,
- strength of stimulation or suppression depends on the number of different types being above the affinity threshold and does not depend on their concentration,
- the concentration is responsible only for the lifetime of the type of antibody or antigen,
- relations of stimulation and suppression between types of antibodies as well as relation between types of antibodies and types of antigens can be controlled by different affinity thresholds.

The proposed model is able to build a stable network.