Can an Immuno-fuzzy Approach Detect Only a Few Non-self Cells Existed in an Enormous Amount of Self Cells?

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Our Interest here

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a NETWORK INTRUSION DETECTION SYSTEM

in which

we need a set of TEST-DATA

to TRAIN and TEST the system with.

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a consideration on such a test-data.

So many artificial data-samples have been proposed so far.

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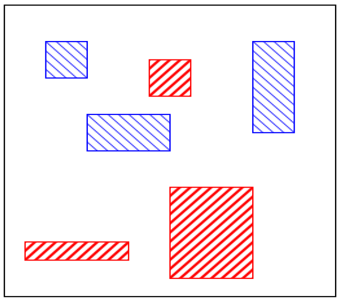
Let's categorize them

□ Fictitious 2-D pictures of test-sample — Type I

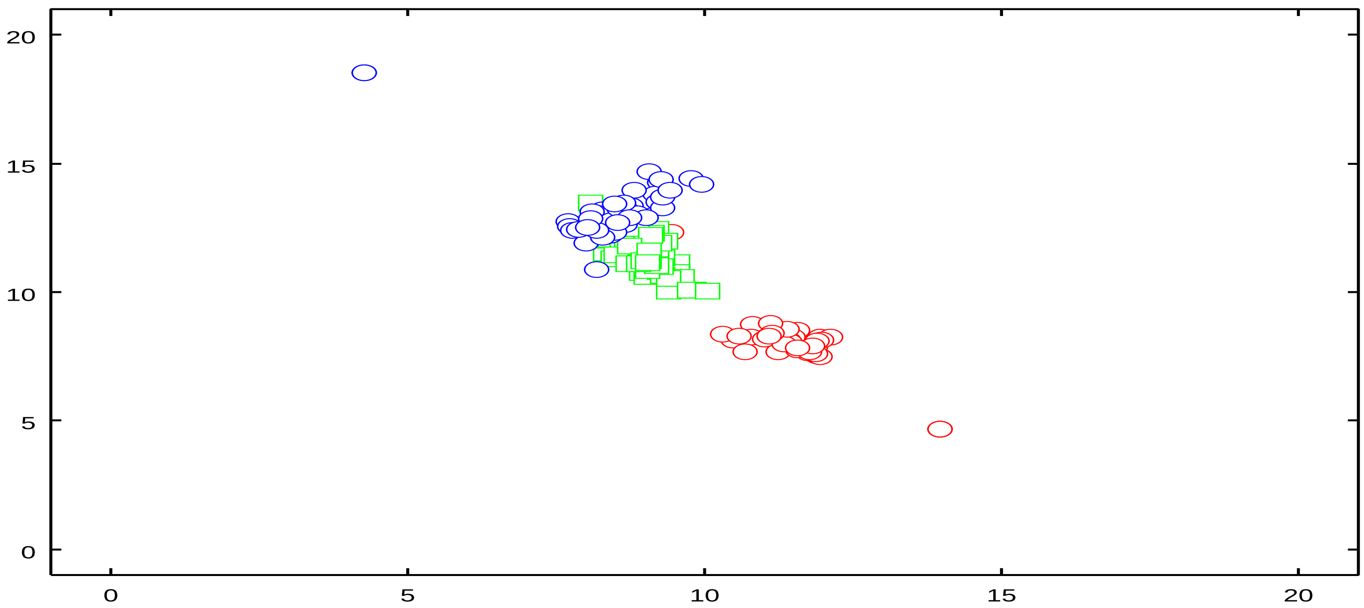
Do data cover

the whole universe?



E.g.,
Fisher's IRIS Flower
KDD-cup 1999/2003
. . .

□ A visualization of IRIS data by Sammon Mapping



□ The data from KDD challange cup 98

4,920,210 data are given

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each is made up of 42 attributes of which

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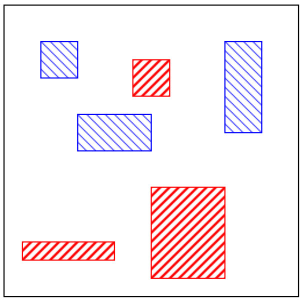
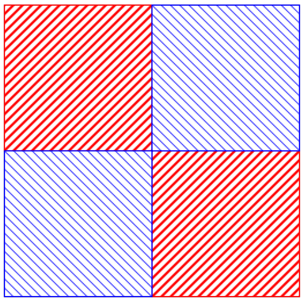
4-crisp + 17-binary + 6-integer + 15-real

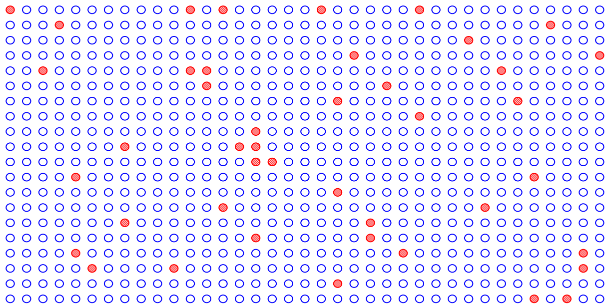
Still infinitely large area of not-defiened possible transactions remain!

GUCCI vs. GUCCI-made-in-Hong-Kong
(Yet another from Istanbul, etc.)

□ Fictitious 2-D pictures of test-sample — Type II

Do data cover the whole universe?	Is a trainning with both normal & abnormal meaningful?
	
Fisher's IRIS Flower KDD-cup 1999/2003 . . .	Ayara et al. . . .

□ Ayara's Random Anomaly in 8-bit Binary Universe



152 and 160 abnormal patterns out of $2^8 = 256$ search points.

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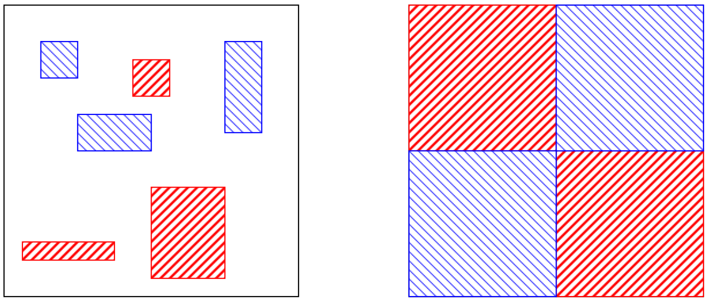
Asserted that successfully trained.

□ Fictitious 2-D pictures of test-sample — Type II

Do data cover the whole universe?

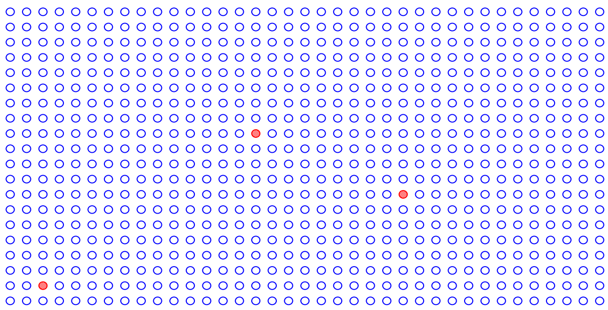
Is a trainning with both normal & abnormal meaningful?



Fisher's IRIS Flower
KDD-cup 1999/2003
. . .

Ayara et al.
. . .

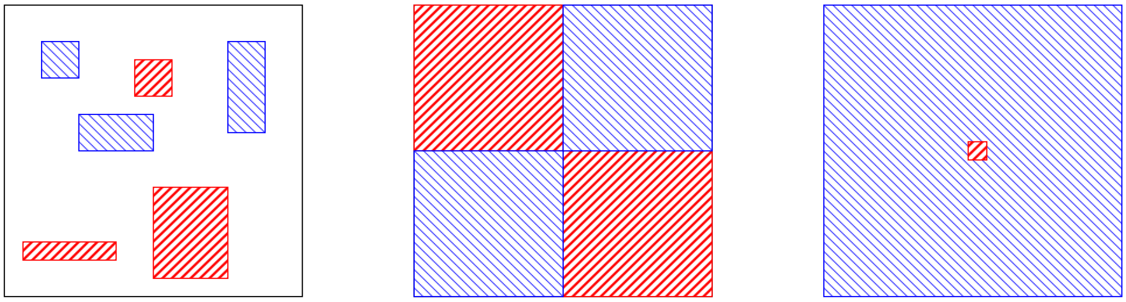
□ What if abnormal sample are only a few?



Still can we train the system with normal and abnormal sample?

□ Fictitious 2-D pictures of test-sample — Type III

Do data cover the whole universe?	Is a trainning with both normal & abnormal meaningful?	What if the size of known abnormal sample is extremely tiny?



Fisher's IRIS Flower KDD-cup 1999/2003 . . .	Ayara et al. . . .	None so far

□ Three of our claims.

1. Data should cover the whole universe.

   $\Rightarrow$ We could miss crucial abnormal in no-defined area.

2. Abnormal Sample should be assumed extremely tiny.

   $\Rightarrow$ This is of usual case.

3. Can we train the sytem only by NORMAL data?

A sommelier who is trained only by real champagne can tell the difference when given a bootleg or other sparkling wine?

How about Caviar?

Forgery coins recognition?

Our Goal is

to search for only a few ABNORMAL (no-self) pattern

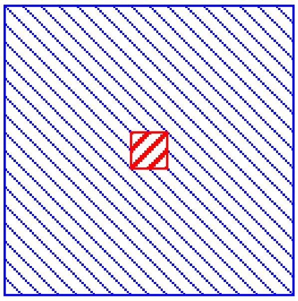
hidden in

an enormous amount of NORMAL (self) patterns

by

training using only NORMAL patterns

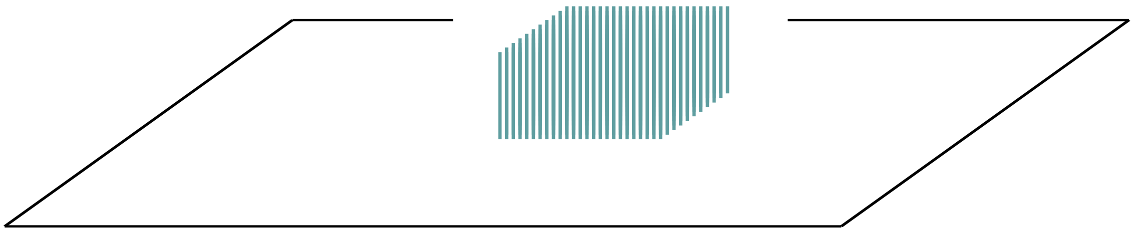
□ A test-sample – A tiny-flat-island-in-a-huge-lake



- Lake $\Rightarrow$ n-D Hypercube where $x_i \in [-1, 1]$ $\quad (i = 1, \ldots, n)$
- Island $\Rightarrow$ $x_i \in [-a, a]$ $\quad (a < 1)$.

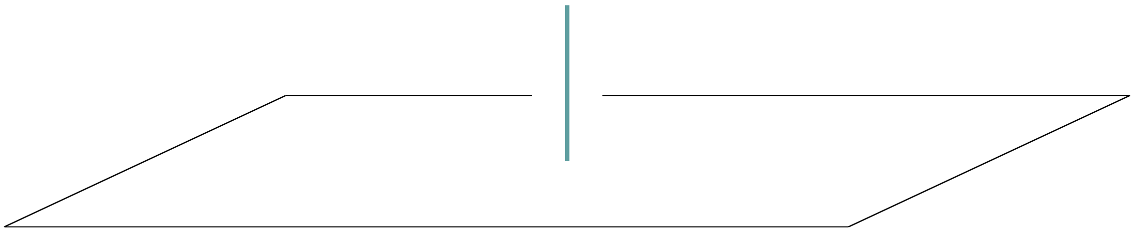
— We can control the complexity by changing the size.

□ From a fitness landscape point of view



□ A Needle in a Haystack

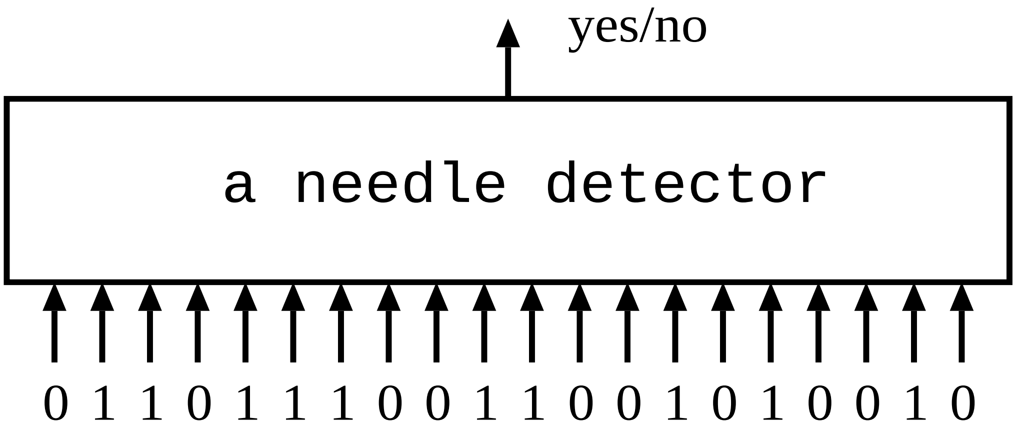
A schematic skecth on fictitious 2D-space



The original Hinton & Nowlan's Needle:

- A-needle ⇒ Only one configuration of 20 bits of binary string.
  - ⋆ We don't know where the needle locates, but God knows.
- Haystack ⇒ $2^{20} - 1$ search points

□ **How can we train the detector?**



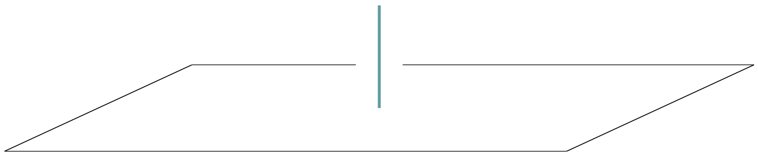
Can we train it with most likely haystack points?

□ How difficult?

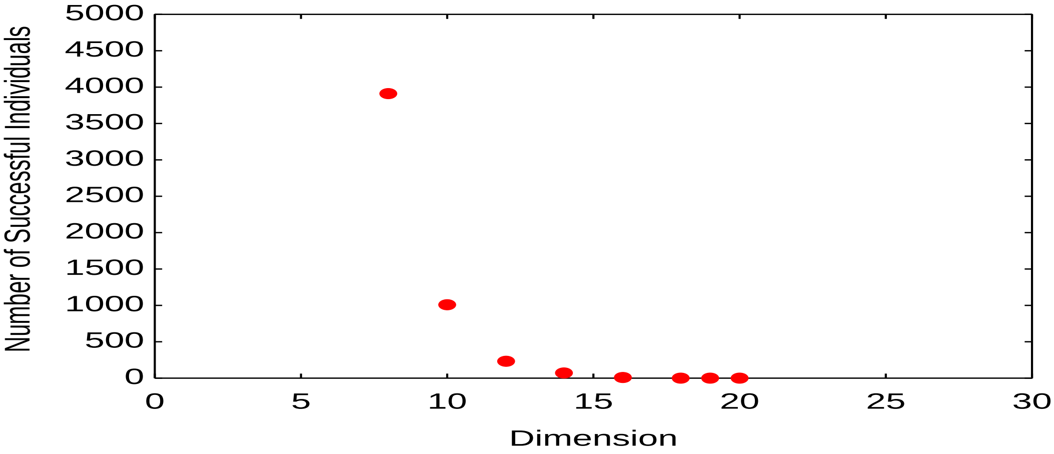
- Random Search

$$2^{20} = 1,048,576$$

- Lifetime Learning – Baldwin Effect (Hinton & Nowlan 1993)



□ Random Search



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Placebo $\Rightarrow$ Criteria of Comparison

□ **We have attacked this problem with lately reported approaches**

- Artificial Immune System
- Evolutionary Computation
- Fuzzy Rule
- Data-mining Technique
- etc

each of which claims very SUCCESSFUL.

□ **When a species of IRIS flower is normal then are others abnormal?**

E.g., Kim & Bentley (2001) claimed

assuming one family of IRIS is abnormal while other two normal

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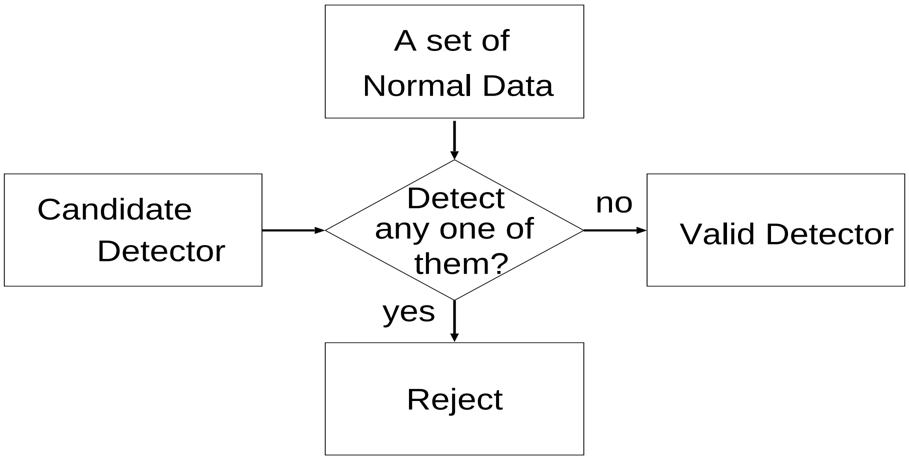
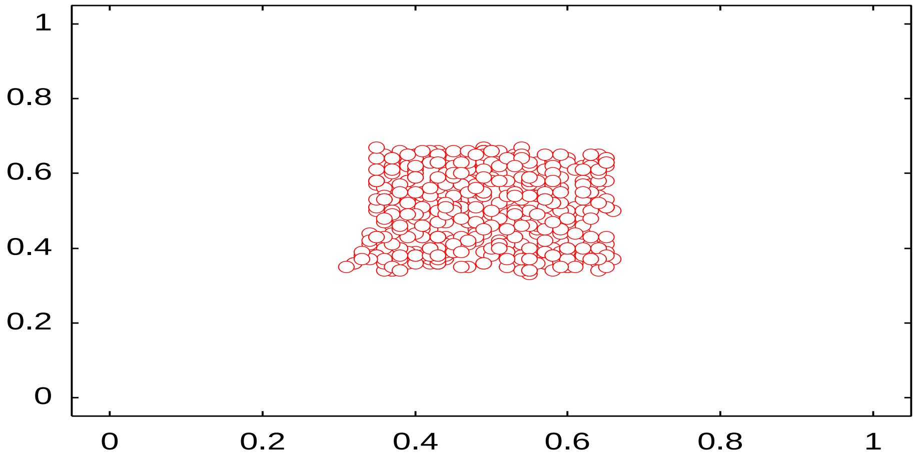
TP (Successful Detection Rate) reached 100%
FP (False Alarm Rate) was only 1%.

□ A snapshot of our ongoing works

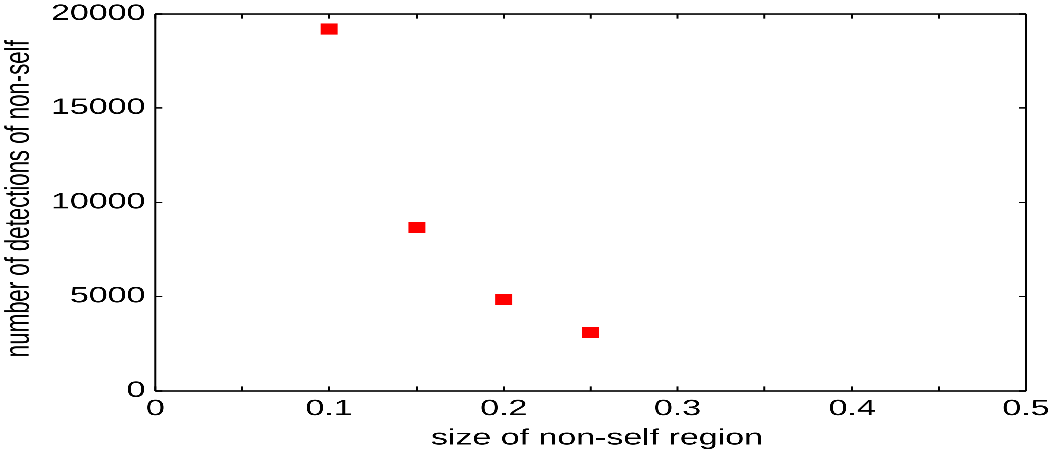
An immune approach — Constant-sized hyper-shpere Detectors



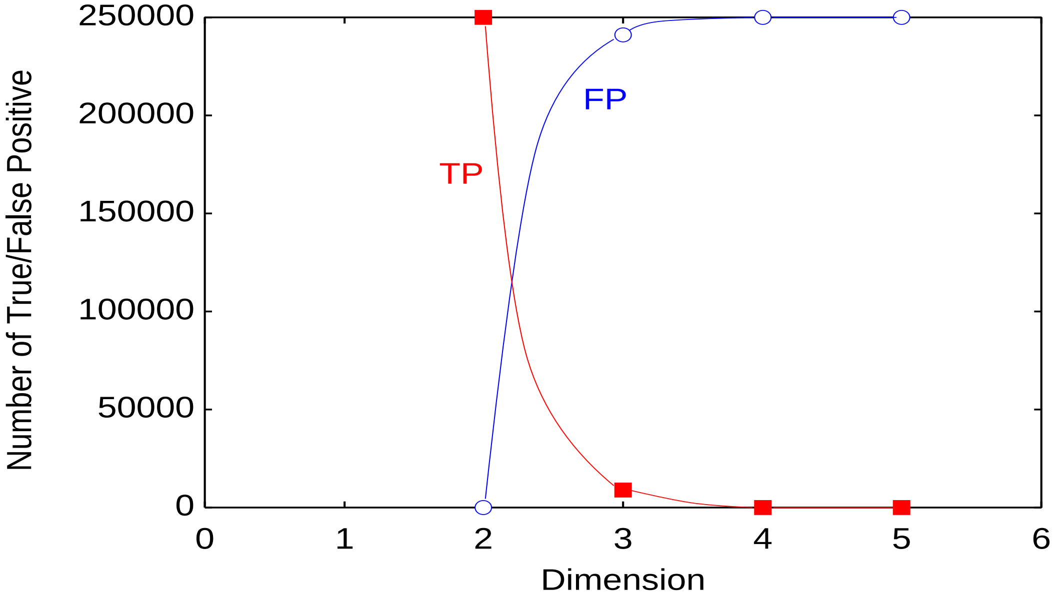
□ A result in 2-D space



□ What if top area shrinks to zero?

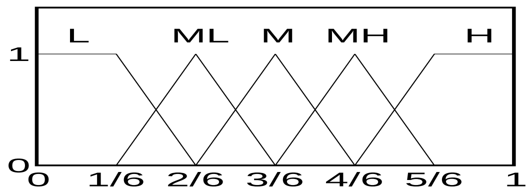


□ Alas! As dimension grows...



□ Yet another snapshot

A Fuzzy Rule approach — Can a fuzzy rule find an island?



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How many rules we need?

$$(MMMMMM \cdots M)$$

$$\Downarrow$$

IF $\{x_1$ is Middle$\}$, $\cdots$, and $\{x_{20}$ is Middle$\}$ THEN no-self.

□ Island in the 6-D lake

Fairly large island ($x_i \in [0.25, 0.75]$) vs. Small island ($x_i \in [0.45, 0.55]$)

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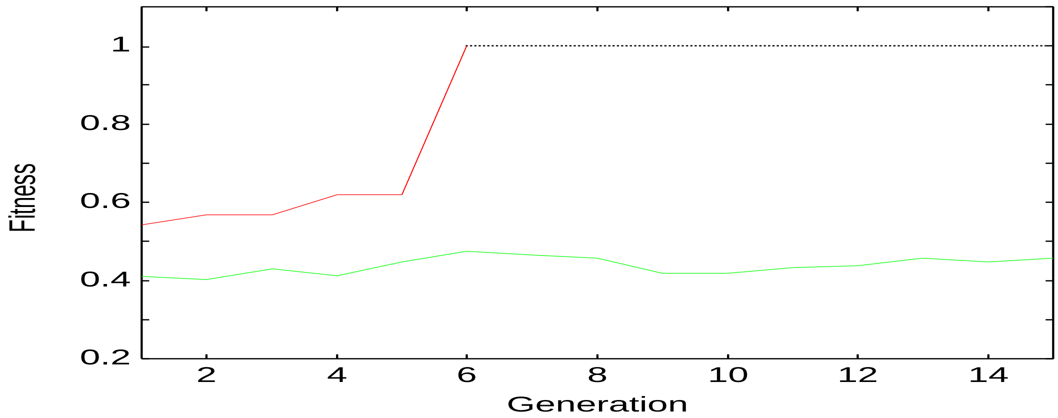
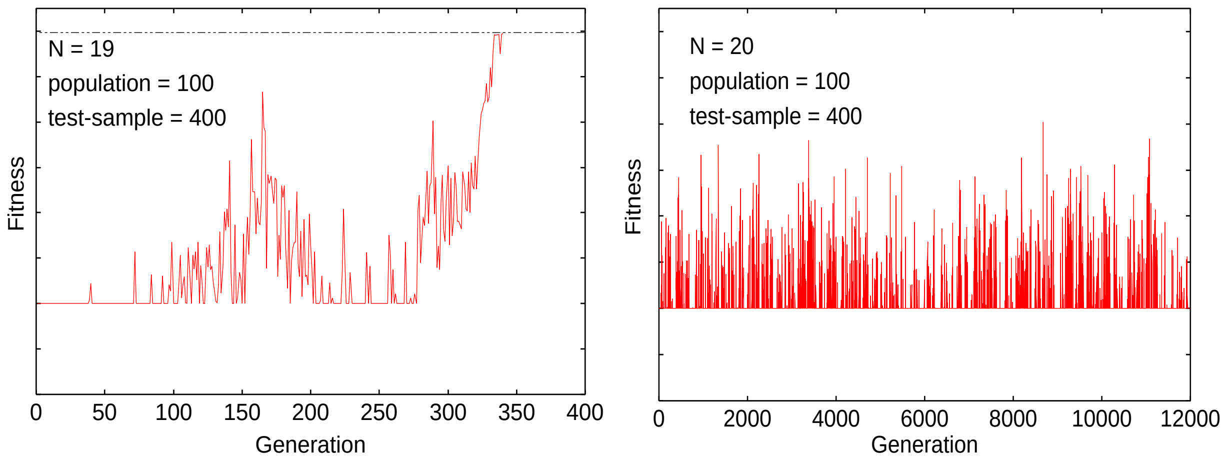
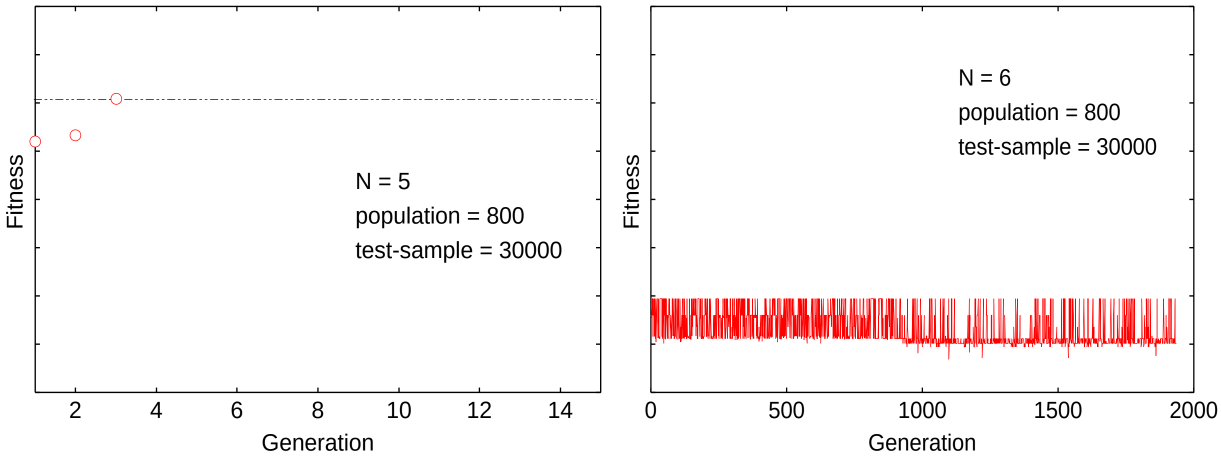


□ Training with Non-self



□ Training with Self



□ A curse of dimension

For the island $x_i \in [0.45, 0.55]$ in the 20-D lake

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$$(0\ 1\ 3\ 4\ 0\ 4\ 4\ 1\ 4\ 4\ 1\ 1\ 4\ 1\ 4\ 3\ 0\ 0\ 0\ 2)$$

While usually we have huge NORMAL samples,
we don't know many ABNORMAL samples
(when we know them it's too late)

$\Downarrow$

Can training be performed only by using NORMAL samples?

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a-needle or tiny-island
as test-data to design a network intrusion detector.

□ Conclusion

Results have not been wonderful at all AS THEY CLAIMED.

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Worse than Placebo experiment?

Or, experiments have sometimes reversed our expectations.

We now are negative more or less, but still want to be neutral.