Finding a Needle in a Haystack: from Baldwin Effect to Quantum Computation

Akira Imada

Brest State Technical University, Belarus

Alora's proposition (2007)

Brilliance = Ability to find a needle in a haystack.

He said,
"Art is to create satisfying assignments to neural circuts in our brain for an appreciation."

Could endlessly typing monky happened to create Shakespear?

Hopefully not!

Then what about *haiku*?

Might be more likely.

ふるいけや
かわずとびこむ
みずのおと

How many possible different Haiku's?

$$50^{17} \approx 10^{18}$$

It's like a search for *a-needle-in-a-haystack*
for a mokey to create one of them.

Computational analogue of needle-in-haystack

deteting oil spill from satelite image
specific data from a huge database
cryptography

……

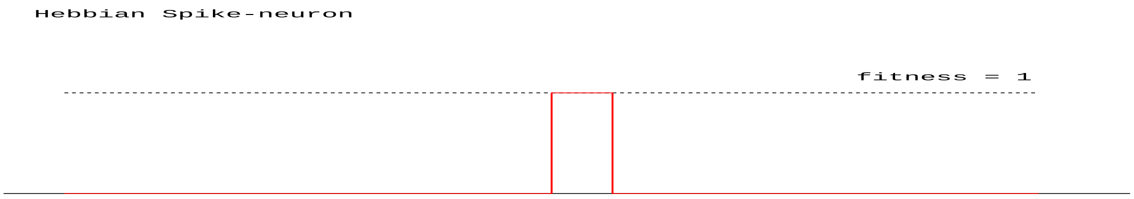
$\Downarrow$

Such searches are very important for us.

First motivated

Fitness landscape
of associative memory by a neural network.
$\Downarrow$
Classical Hopfield network
vs.
Spiking neurons

Its fictitious 1-D fitness landscape



KDD-cup-99 winner's result

Detection rate for 4 attack types:

Probe	DoS	U2R	R2L
83.3%	97.1%	13.2%	8.4%

Detection rate by Sabhnani et al. (2003)

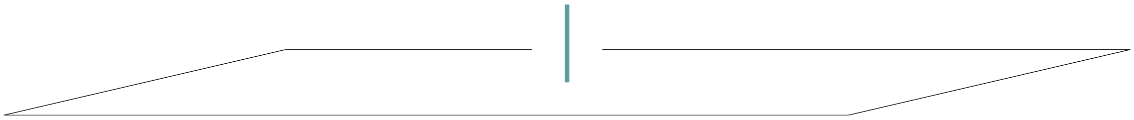
	Probe	DoS	U2R	R2L
Multi-layer Perceptron	88.7	97.2	13.2	5.6
Gaussian Classifier	90.2	82.4	22.8	9.6
K-mean Clustering	87.6	97.3	29.8	6.4
Nearest Cluster Algorithm	88.8	97.1	2.2	3.4
Radial Basis Function	93.2	73.0	6.1	5.9
Leader Algorithm	83.8	97.2	6.6	1.0
Hypersphere Algorithm	84.8	97.2	8.3	1.0
Fuzzy Art Map	77.2	97.0	6.1	3.7
C4.5 Decision Tree	80.8	97.0	1.8	4.6

Some Intrusions are immune to be detected by any Machine learning Techniques

"If a class is very rare, e.g., 0.5% prediction of non-target will be 99.5%." (Joshe et al. 2001) however we have still many inocent reports of success

- Hinton & Nowlan's experiment
- Reduced even-parity problem as a benchmark
- Robot navigation
- Quantum computation

Hinton & Nowlan's Needle (1987)



- A-needle ⇒ Only one configuration of 20 bits of binary strings.
- Haystack ⇒ $2^{20} - 1$ search points.

Baldwin effect — Lifetime learning

a genotype

(109010990110010010091)

$\Downarrow$

its phenotype

(109010990110010010091)

(109010990110010010091)

(109010990110010010091)

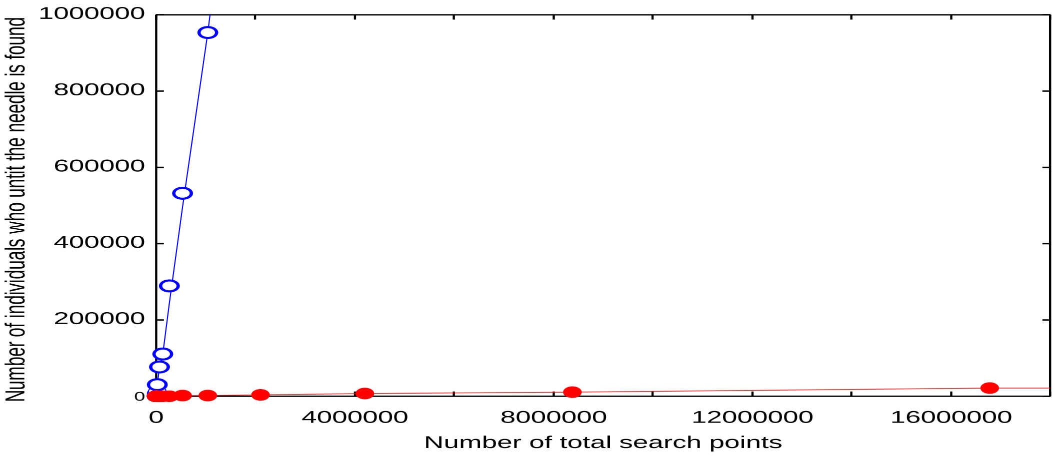
…

Hinton & Nowlan's GA implementation

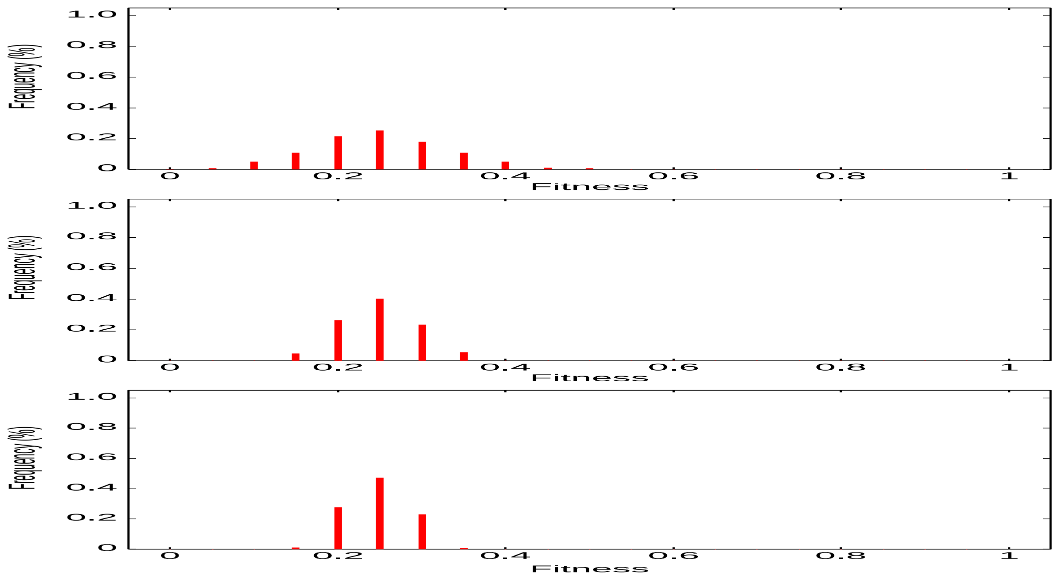
1000 genotypes
1000 lifetime learnings
25% flexible genes

……

Impressive improvement?



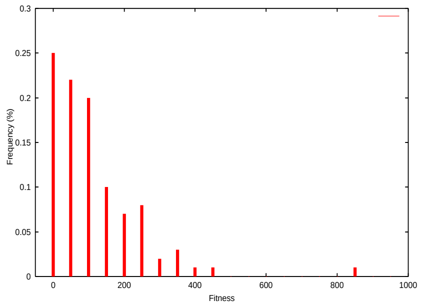
How ar they evolved?

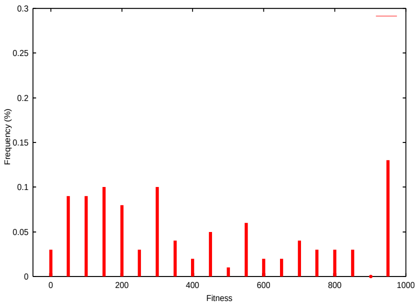


Descrepancies from their result

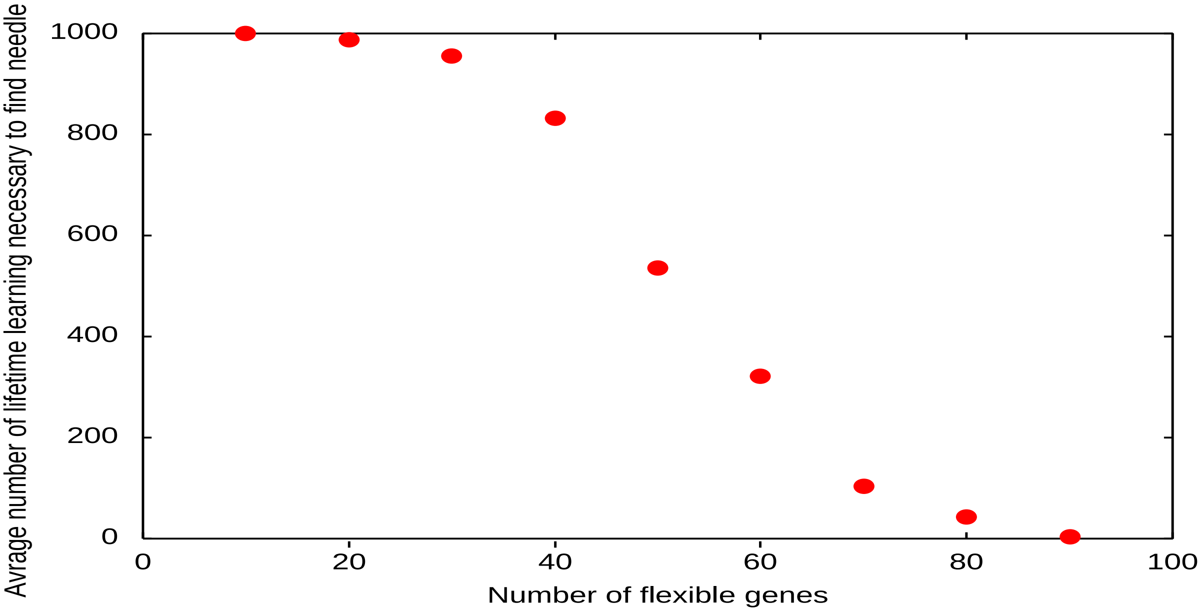
- Why should we continue when lifetime-learning finds needle?
    - not engineering but a biological interest (Turney 1987)
- Is Learning gene decreasing?

How many learning genes are necesarry?

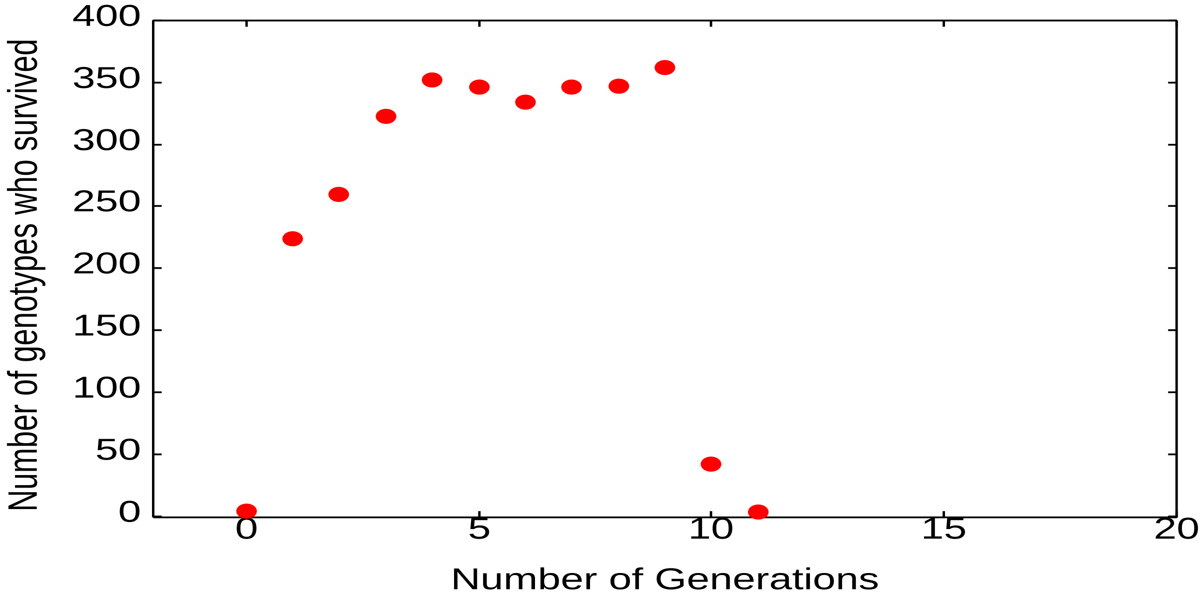




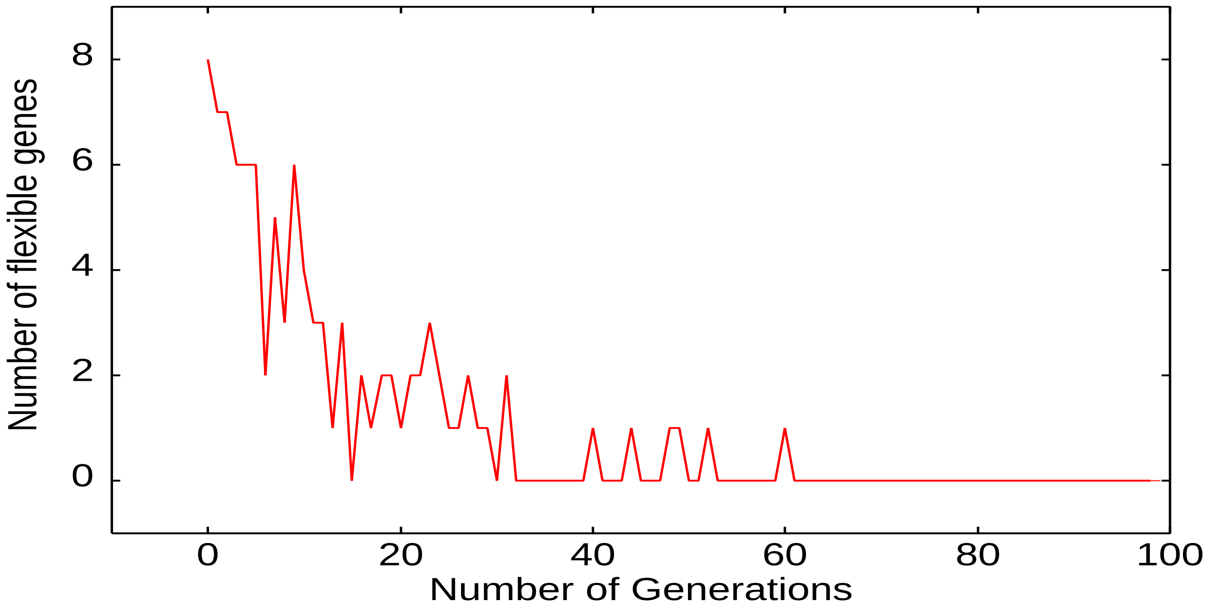
How many learning genes are necesarry?



An extinction!



Hinton & Nowlan's Needle

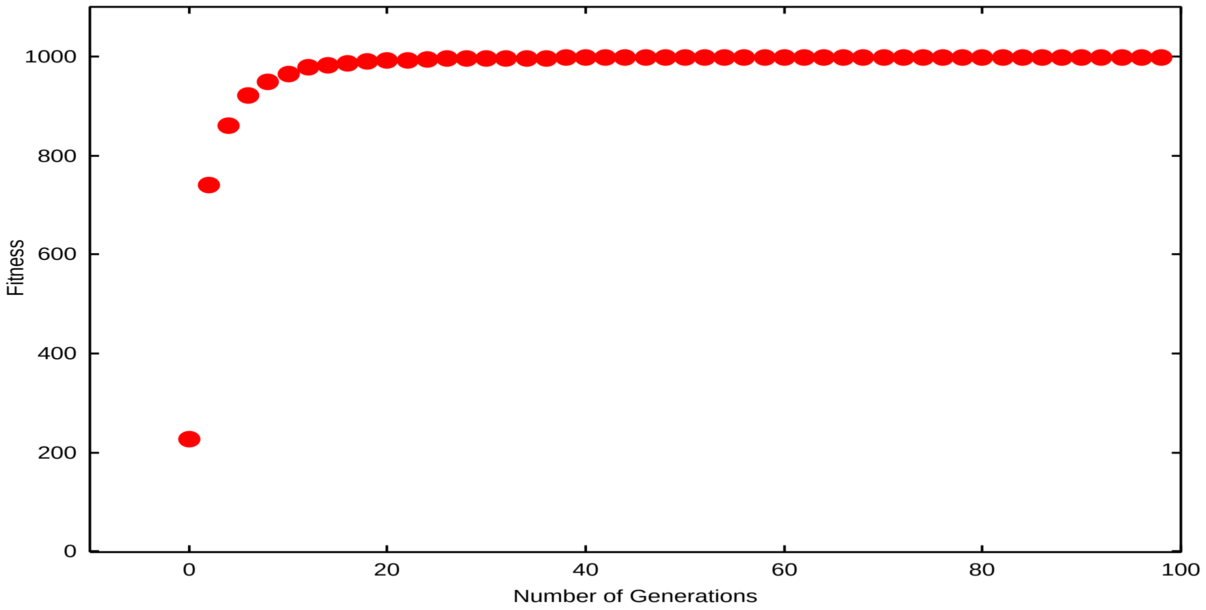


What about Lamarckian Inheritance?

Turney (1996)

"Lamarckian evolution requires an inverse mapping from phenotype and environment to genotype ... We believe that computing this mapping is intractable in general,"

What about Lamarckian Inheritance?



- Hinton & Nowlan's experiment
- Reduced even-parity problem as a benchmark
- Robot navigation
- Quantum computation

A discussion

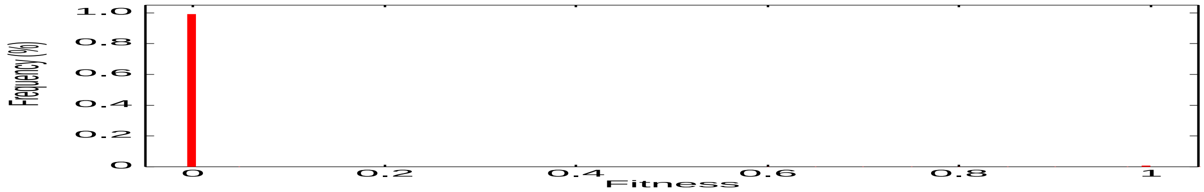
"Finding Needles in Haystacks Is Not Hard with Neutrality."
(Yu & Miller, 2002)

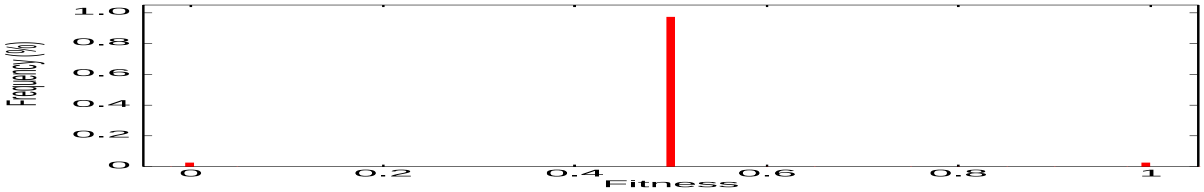
vs.

"Finding Needles in Haystacks is Harder with Neutrality."
(Collins, 2005)

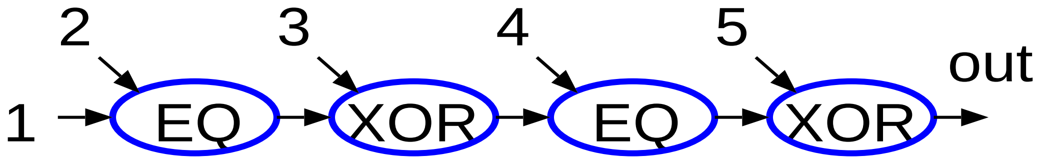
Reduced Even-n-Parity Problem

Fitness distribution

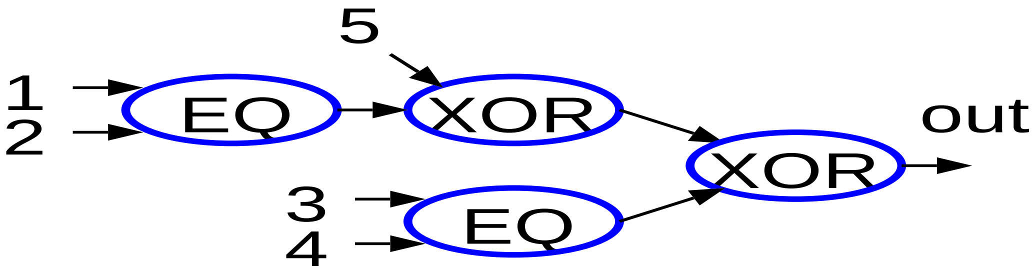




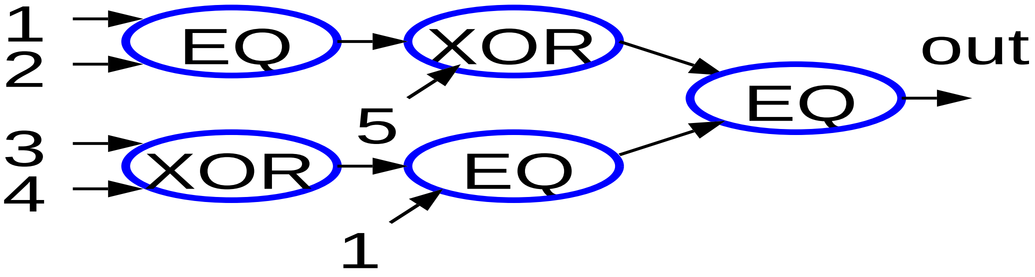
Reduced Even-n-Parity Problem



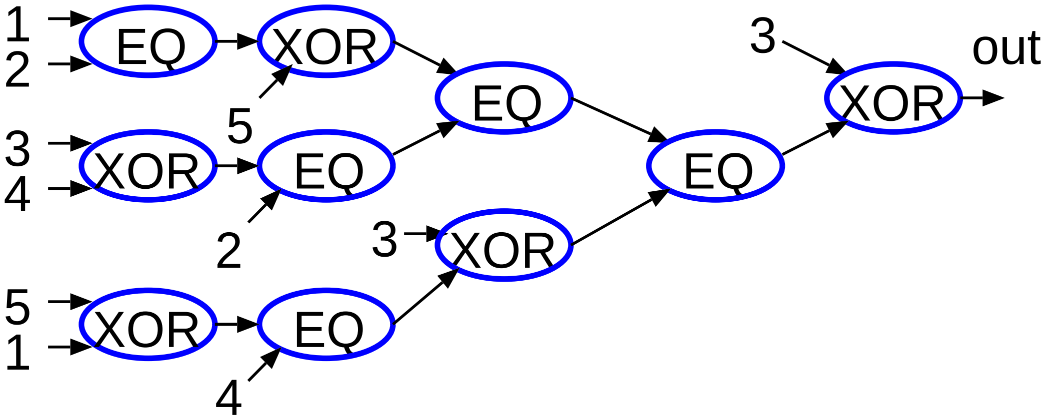
Reduced Even-n-Parity Problem



Reduced Even-n-Parity Problem

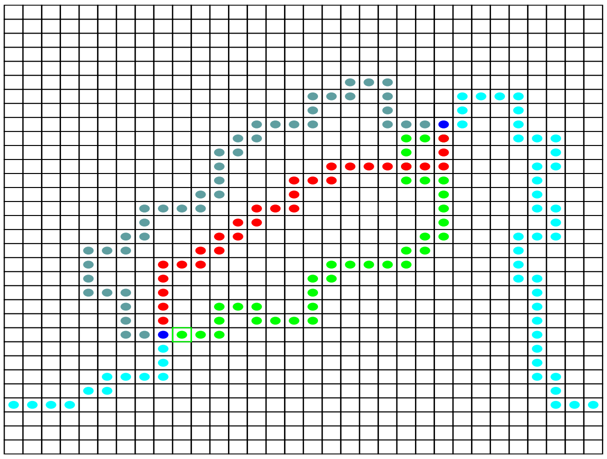


Reduced Even-n-Parity Problem



- Hinton & Nowlan's experiment
- Reduced even-parity problem as a benchmark
- Robot navigation
- Quantum computation

A robot navigation – 2-dimensional needle

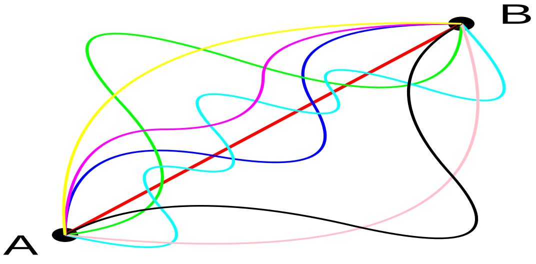


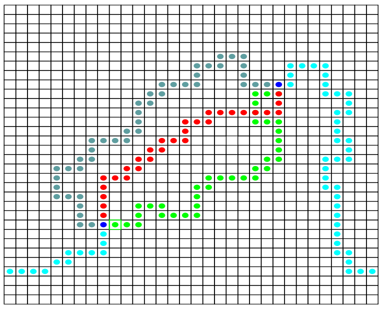
- Hinton & Nowlan's experiment
- Reduced even-parity problem as a benchmark
- Robot navigation
- Quantum computation

A strange tenet of quantum computation

When a particle goes from A to B,

takes all possible paths all at the same time.





A quantum walk on the line

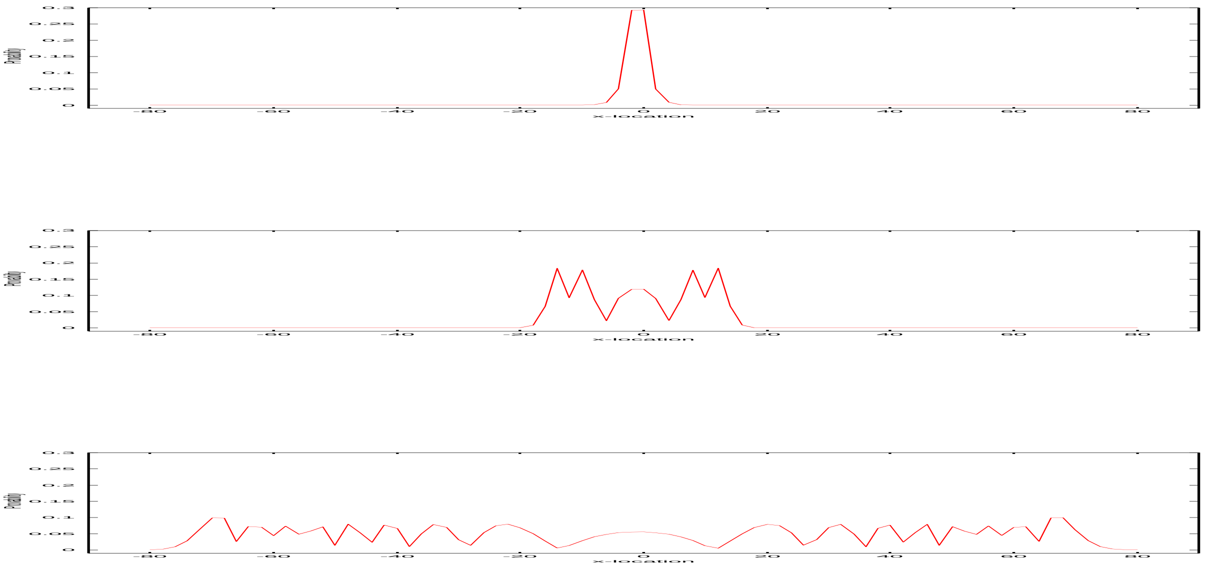
$$p(n,t) = \|\psi_L(n,t)\|^2 + \|\psi_R(n,t)\|^2$$

where

$$\psi_L = \frac{1+(-1)^{n+t}}{2} \int_{-\pi}^{\pi} \frac{dk}{2\pi} (1 + \frac{\cos k}{\sqrt{1+\cos^2 k}}) \exp\{-i(\omega_k t + kn)\}$$

$$\psi_R = \frac{1+(-1)^{n+t}}{2} \int_{-\pi}^{\pi} \frac{dk}{2\pi} \frac{\exp(ik)}{\sqrt{1+\cos^2 k}}) \exp\{-i(\omega_k t + kn)\}$$

A quantum walk on the line



Concluding Remarks

we have to avoid an effect of

like-to-hear-what-we-would-like-to-hear.