Can a learning robot solve a 2-D jeep problem?

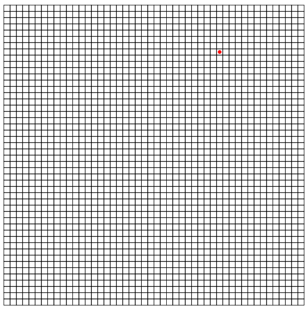
Akira Imada

Brest State Technical University

Belarus

Looking for "a-needle-in-a-haystack"

A needle hidden in a huge grid world

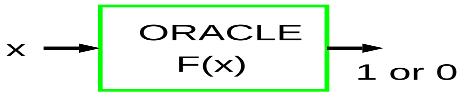


Can a navigation robot reach it?

$\Downarrow$

A 2-D version of a-needle-in-a-haystack.

What is a-needle-in-a-haystack



"Find x (among N items) such that $F(x) = 1$"

when

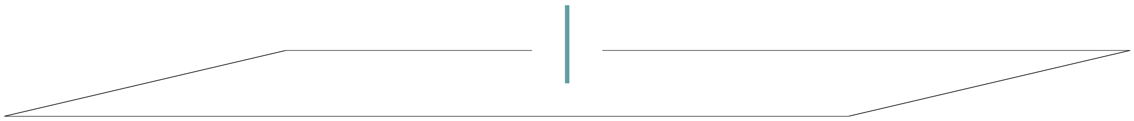
only x fulfills $F(x) = 1$ while $F(x) = 0$ for all others.

(We might call $F(x)$ a fitness function of this problem.)

$O(N)$ steps are necessary!

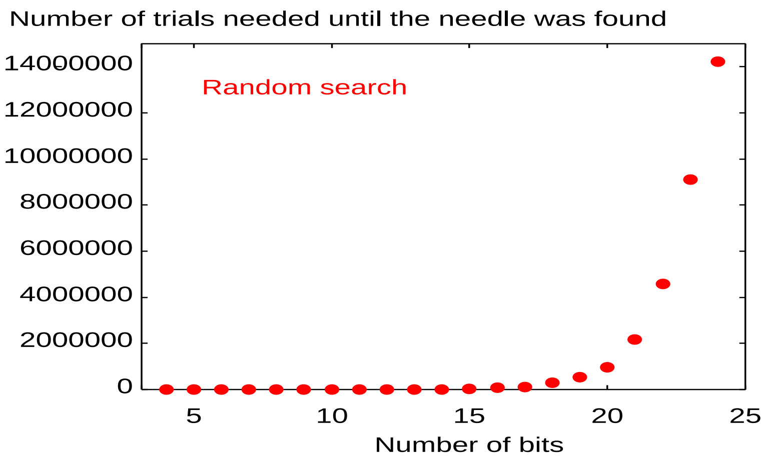
How we look for it as efficient as possible?

Hinton & Nowlan's Needle (1987)



- A-needle $\Rightarrow$ Just one configuration of 20-bit binary strings.
- Haystack $\Rightarrow$ $2^{20} - 1$ search points.

Their choice of 20-bit was a good one!



Hence, their experiment was not a very difficult one.

How we evolve all-fitness-0 chromosomes?

(1011 1001011001001001)

(1000 1011011111011111)

crossover

$\Rightarrow$ (1011 1011011111011111)

$\Downarrow$ mutation

(1011 1011011111 1 11111)

- What about the task called "All-one-problem?"

$(9 \times 14 \Rightarrow 16 \Rightarrow 17 \text{ vs. } 0 \times 0 \Rightarrow 0 \Rightarrow 0)$

Hinton & Nowlan's brilliant trick

Evolution under Baldwin effect

— Lifetime learning of phenotype

A genotype:

(10901099011001001091)

Its phenotype:

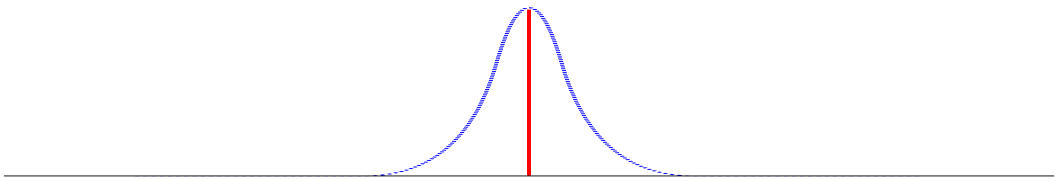
(10101001011001001001)
(10001011011001001011)
...

Their assumption

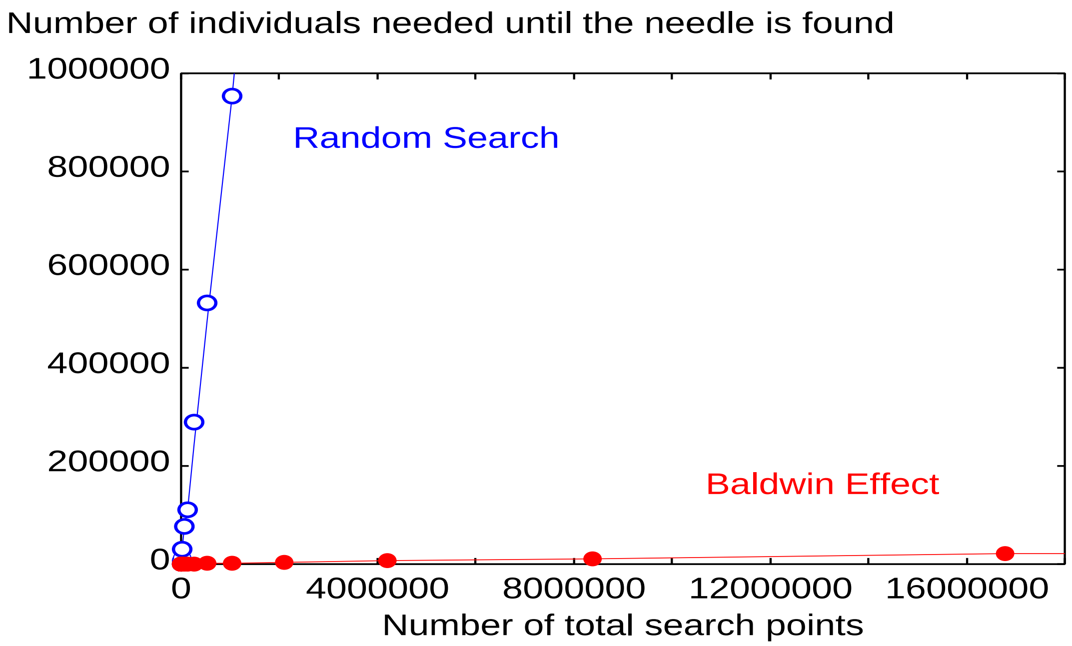
The closer the *genotype* to the needle
the faster the learning of *phenotype.*

$\Downarrow$

This makes the sharp-fitness-peak a more smooth one.



Baldwin effect looks great!



Are we really happy with this?

Why should we continue evolution
when lifetime-learning already has found the needle?

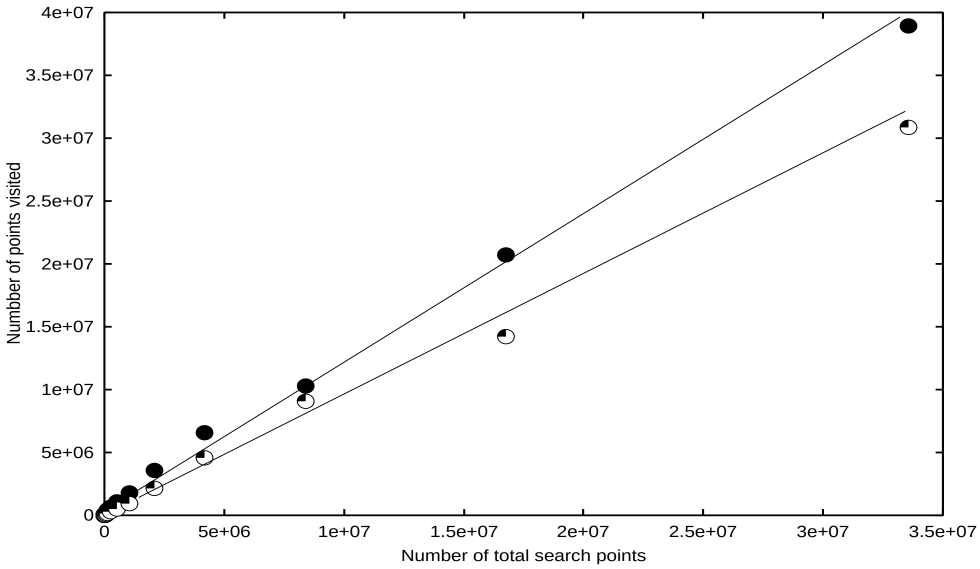
$\Downarrow$

(Turney 1987)

"Not from an engineering but a biological interest."

Still we are not so happy.

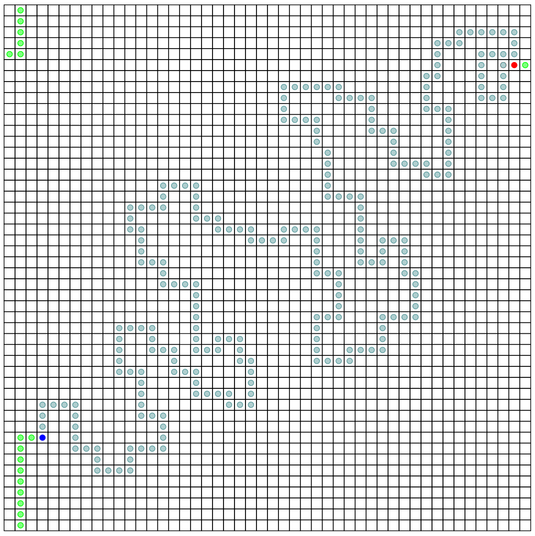
The number of total points visited VS. *the number of individuals*



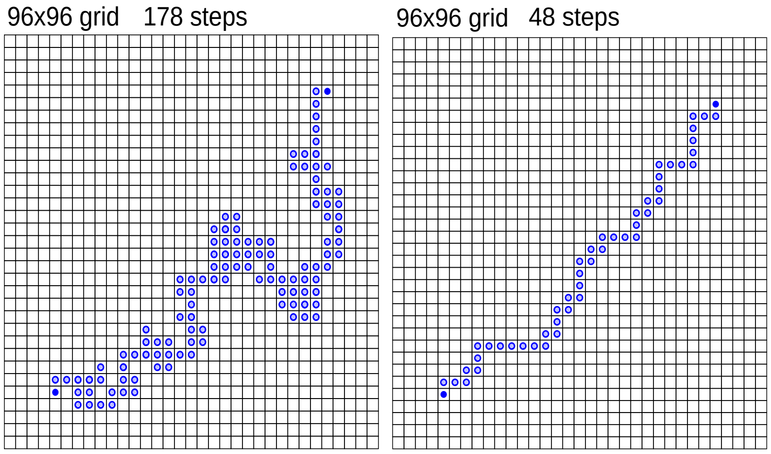
Like to hear what we'd like to here?

Success at a small scale is not a royal road to a real success.

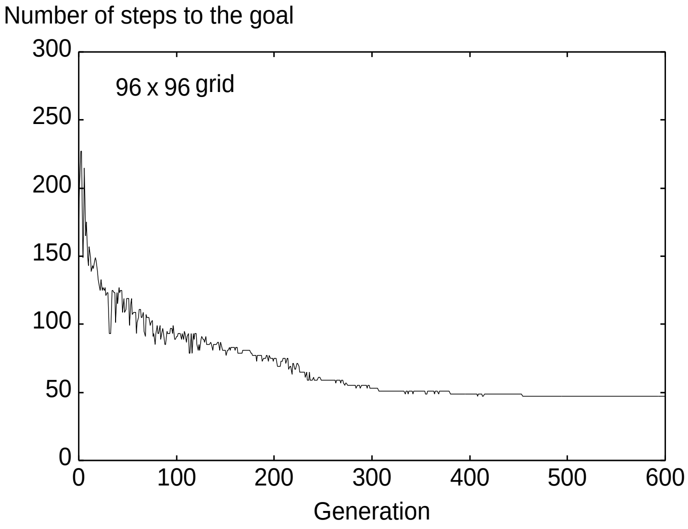
A random walk to the needle



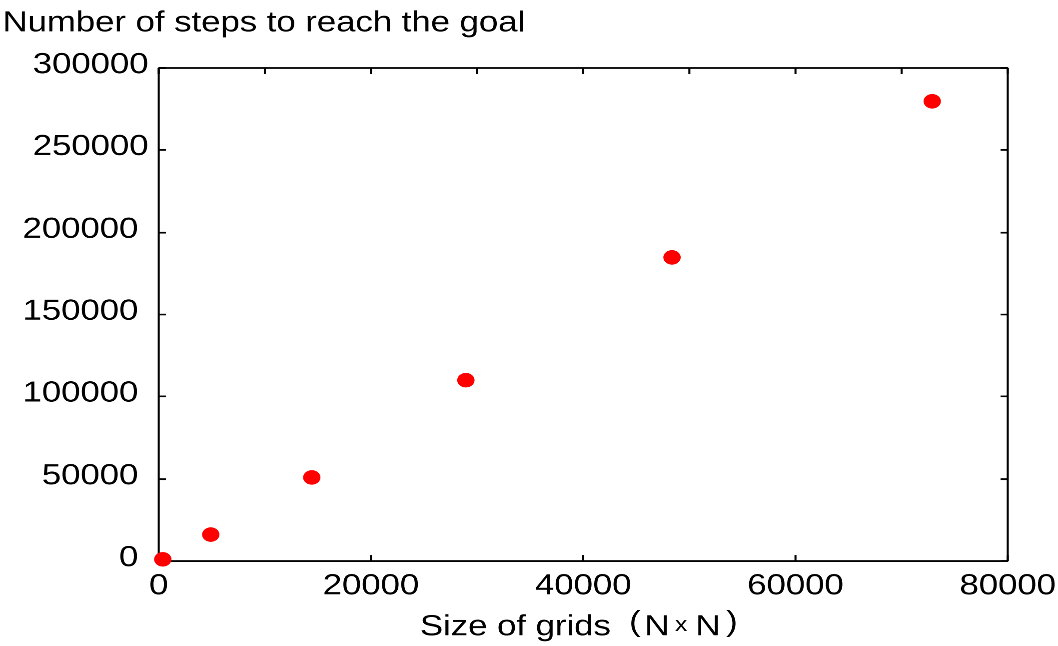
Random walk evolved to be minimized



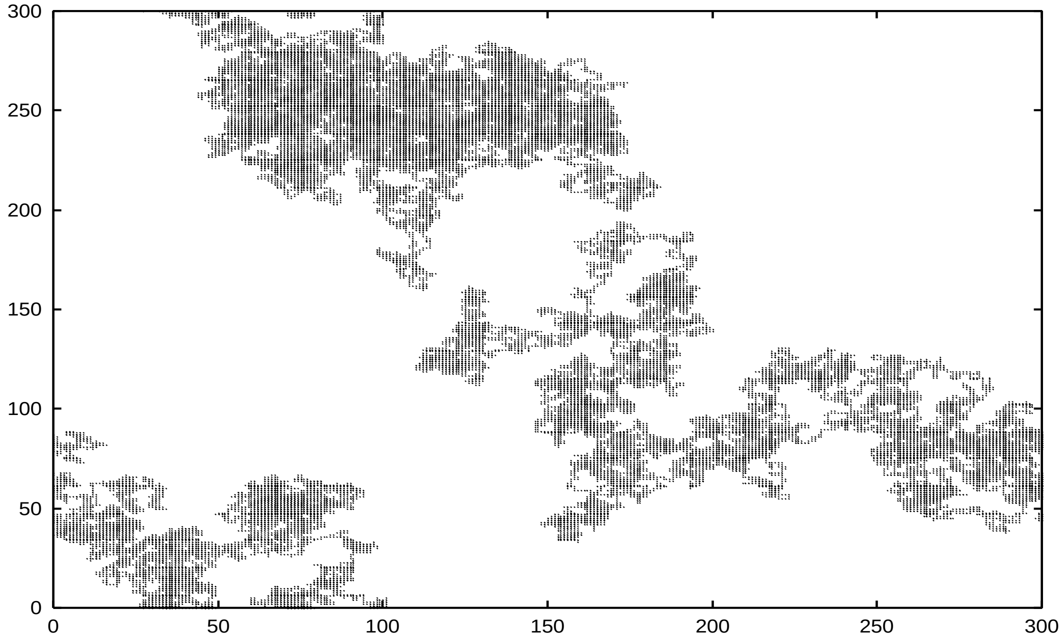
Evolution successful



Number of steps grows linearly.



What if the grid is ultra-huge?

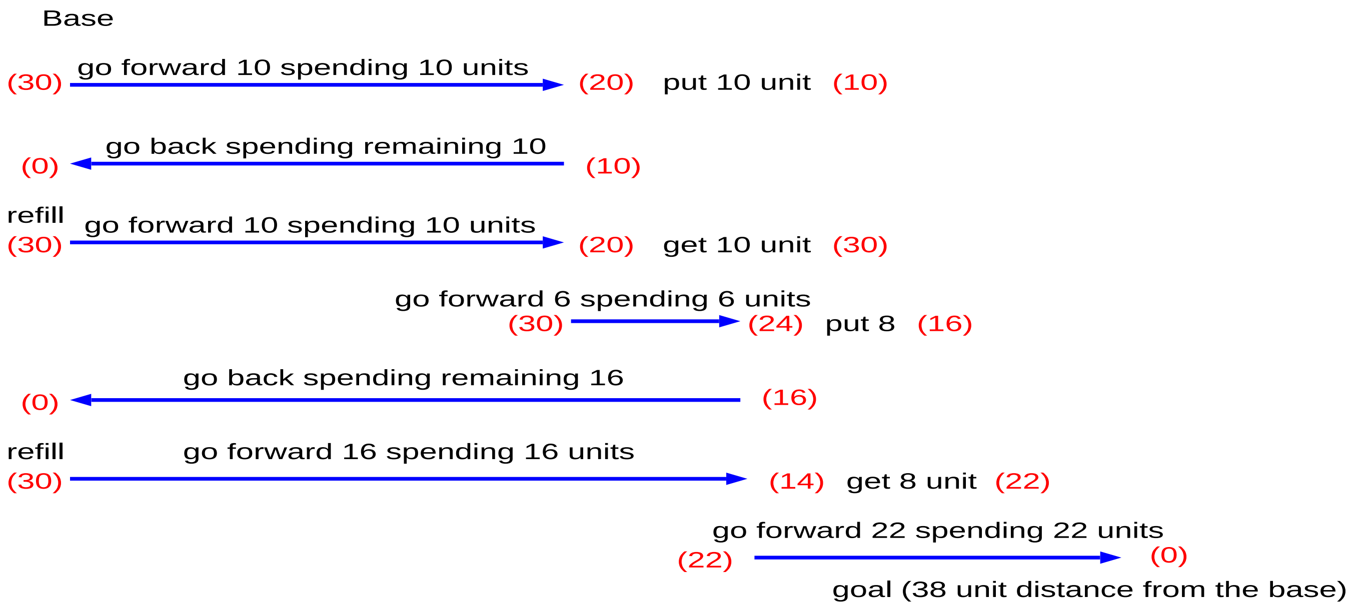


The Jeep Problem

Maximize the distance a Jeep can penetrate into 1-D desert.

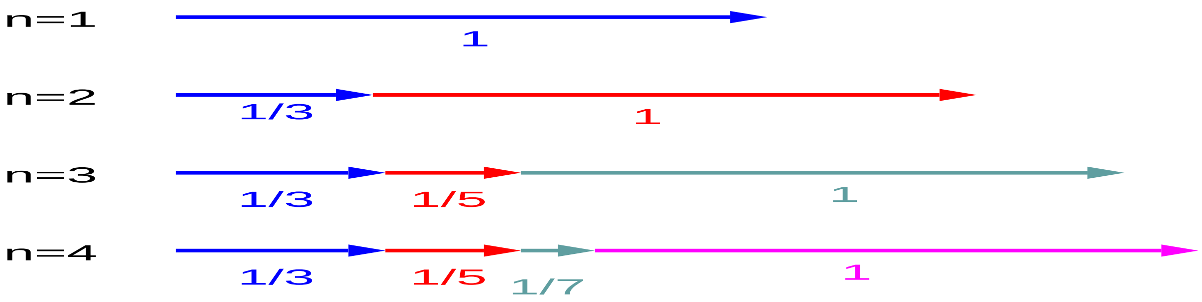
- Jeep can move a unit ditance with a unit fuel.
- Jeep has a container to put its fuels somewhere in the desert.
- Fuels can be filled only at the base.
- Jeep can go back n times to the base to re-fill its tank.

The Solution



The Solution

$$d = \frac{1}{2n+1} + \sum_{i=1}^{n} \frac{1}{2i-1}$$



A GA implementation

An extention to 2-D Desert

"Maximize the penetration" or "Find the needle"
by repeating the procedure:

(1) Start the base.

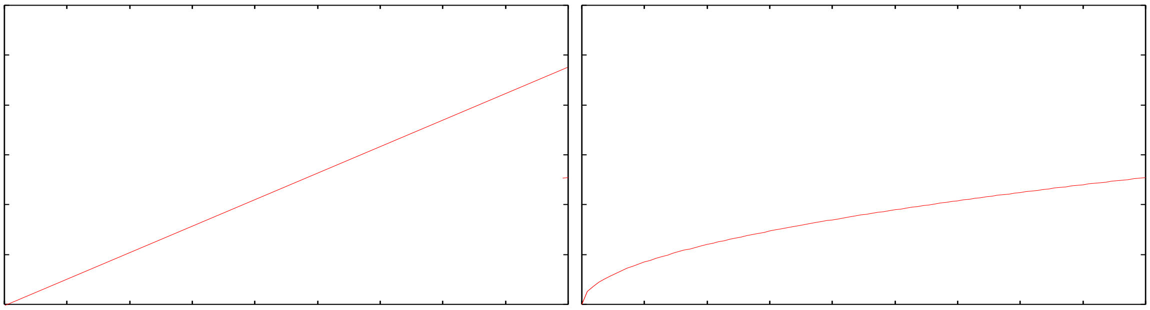
(2) Navigate the desert.

(3) Put fuels somewhere or find the fuels to get.

(4) Return to the base.

Grover's quantum search (1997)

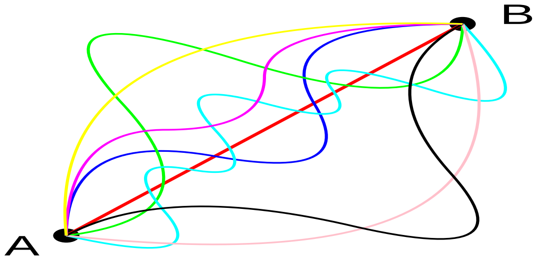
A speed up from $O(N)$ to $O(\sqrt{N})$.



A strange path of quantum computation

When a particle goes from A to B,

it takes all possible paths at the same time.



Quantum Robot

Summary

- Two challanges:
  - A needle hidden in a huge grid world
  - 2-D Jeep Problem by a learning navigation robot.

- We have to be careful about an effect of
  like-to-hear-what-we-would-like-to-hear.
  Success at a small scale is not a royal road to a real success.