Insanely Cool Algorithms

Playing at the edge of AI

Ron Zacharski

ACM talks …

TACC Stampede   6,400 nodes -- 32 cores per node

Traveling Salesman Problem

Traveling Salesman Problem

Suppose we want to find the shortest path from Las Cruces that leads to Dulles, San Francisco, Seattle, Las Vegas, Los Angeles, Boston, and then returns to Cruces.

The goal is to start in Cruces and visit each city once and return taking the shortest route.

How many possible route are there?

Traveling Salesman Problem

- How many possible routes? 6! = 720
- Can solve this with search algorithms
- For 7 cities it is 7 times that number: 5,040
- For 10, 3.6 million
- For 15: 1,307,674 million
- For 20: 2 million times more than the 15 city problem (38 years)

Traveling …

- For 50 cities 10^{63} or

  1,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000

- This is larger than the number of seconds in the history of the universe

- Roughly the number of electrons in the universe

Traveling …

- For 50 cities 10^{63} or

  1,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000

- This is larger than the number of seconds in the history of the universe
- Roughly the number of electrons in the universe
- Meaning, this is sort of a big number

You need some big iron to find the best solution.

Finding the perfect solution to a problem may be futile.

We want a solution that is good enough.
~99% of the best

I am good enough and fast enough.

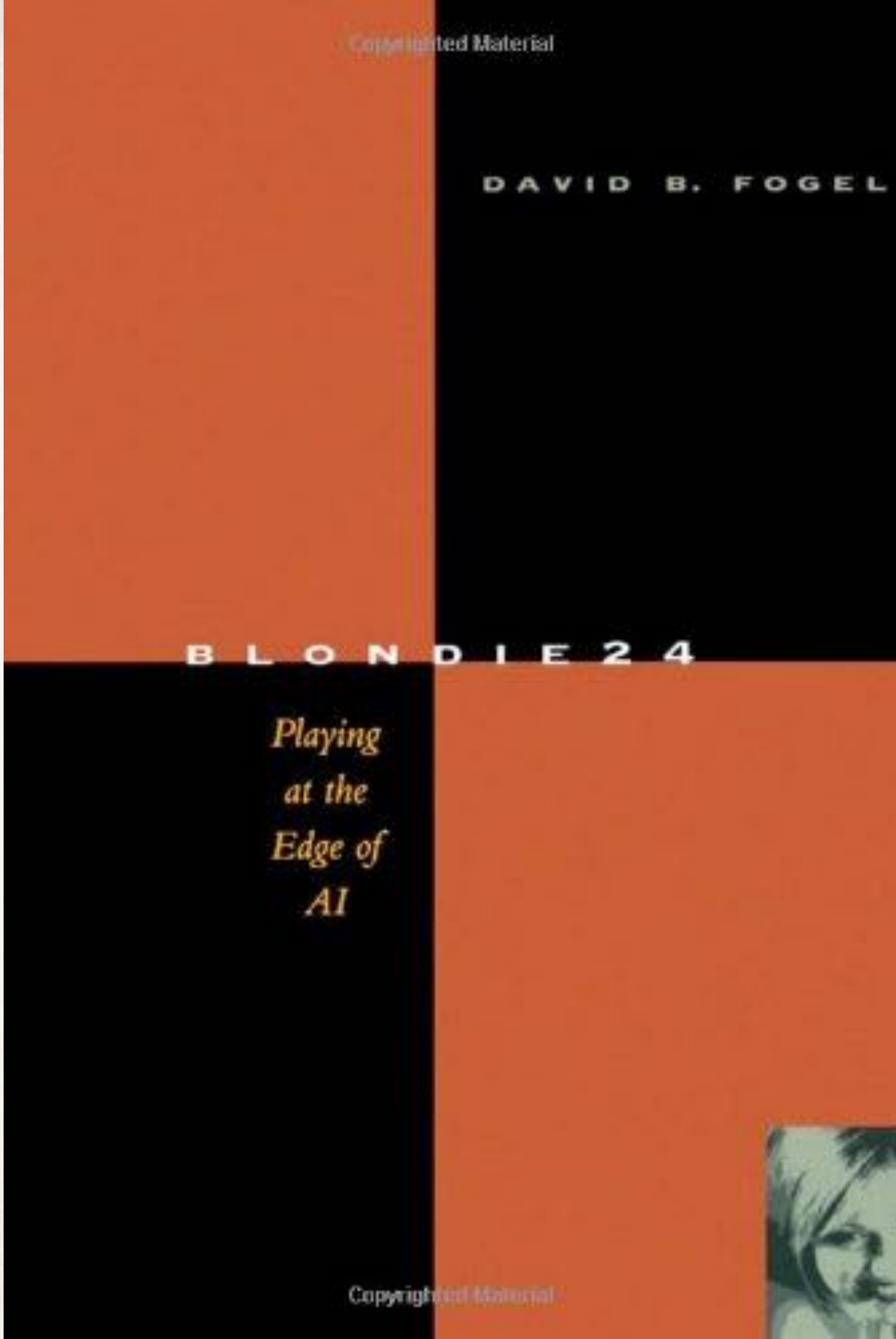
My plan to solve the traveling salesman problem

1. Have a fast computer (for ex., a Macbook Air) ✓

2. Have an insanely great book.

Blondie 24 Playing at the edge of AI

David Fogel



Evolutionary Approach to the Traveling Salesman Problem

- Fogel attempted to find a solution to the traveling salesman problem with 100 cities.
- over 10^{150} different solutions.
- step one: get the fastest computer available

Pentium II 350MHz computer

new iPhone 1.5GHz 64 bit

Chip

A11 Bionic chip with 64-bit architecture

Neural engine

Embedded M11 motion coprocessor

Evolutionary Approach to the Traveling Salesman Problem

- Fogel attempted to find a solution to the traveling salesman problem with 100 cities.
- over 10^{150} different solutions.
- step one: get the fastest computer available
- step two: be creative and smart

The algorithm - roughly...

1. start with a population of 100 randomly generated solutions

2. each parent creates one offspring by copying itself and then introducing some random variation, a reverse ordering of randomly selected cities.

3. now we have 200 solutions.

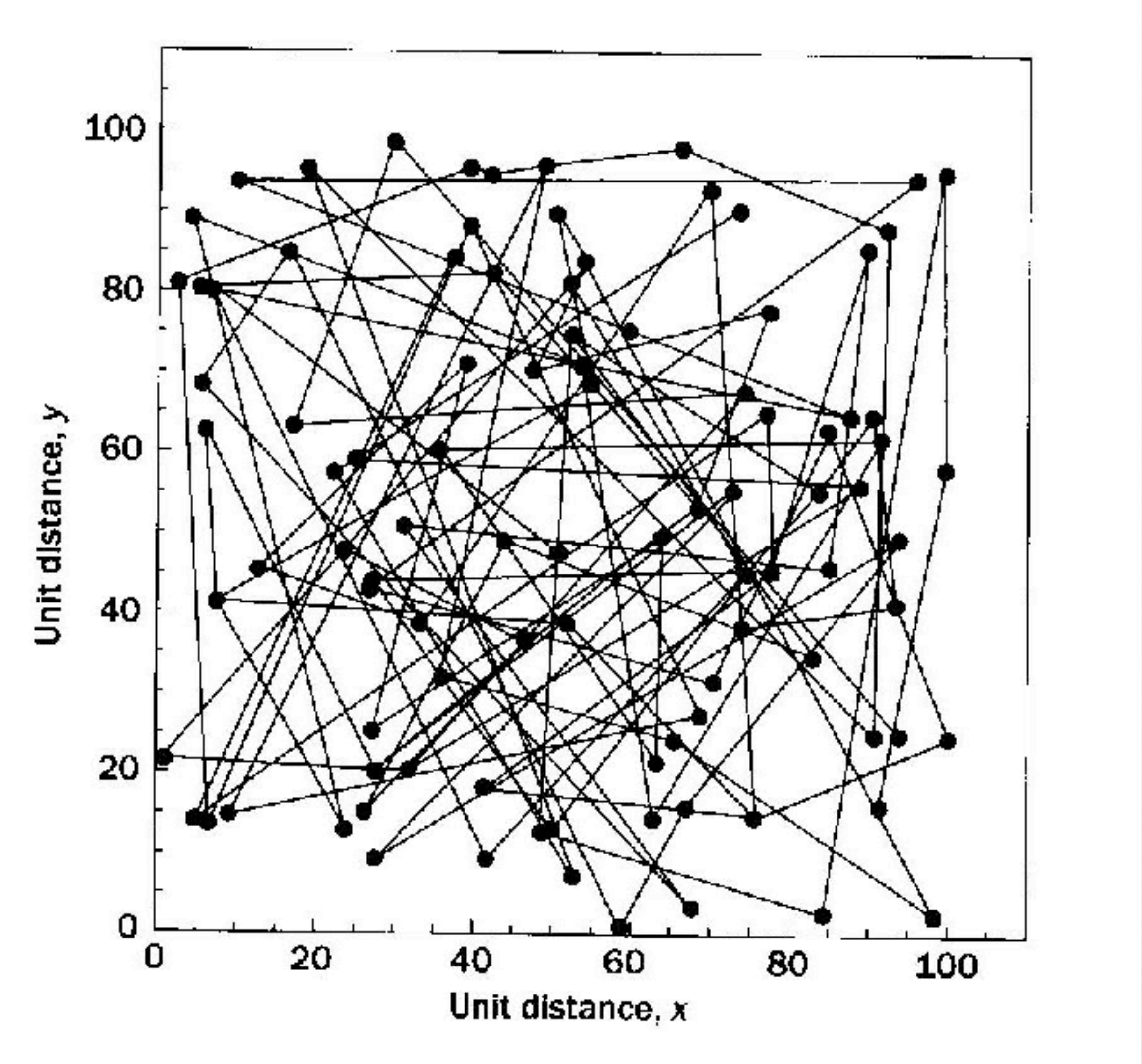
4. calculate the total length of every solution

5. keep the 100 best ones

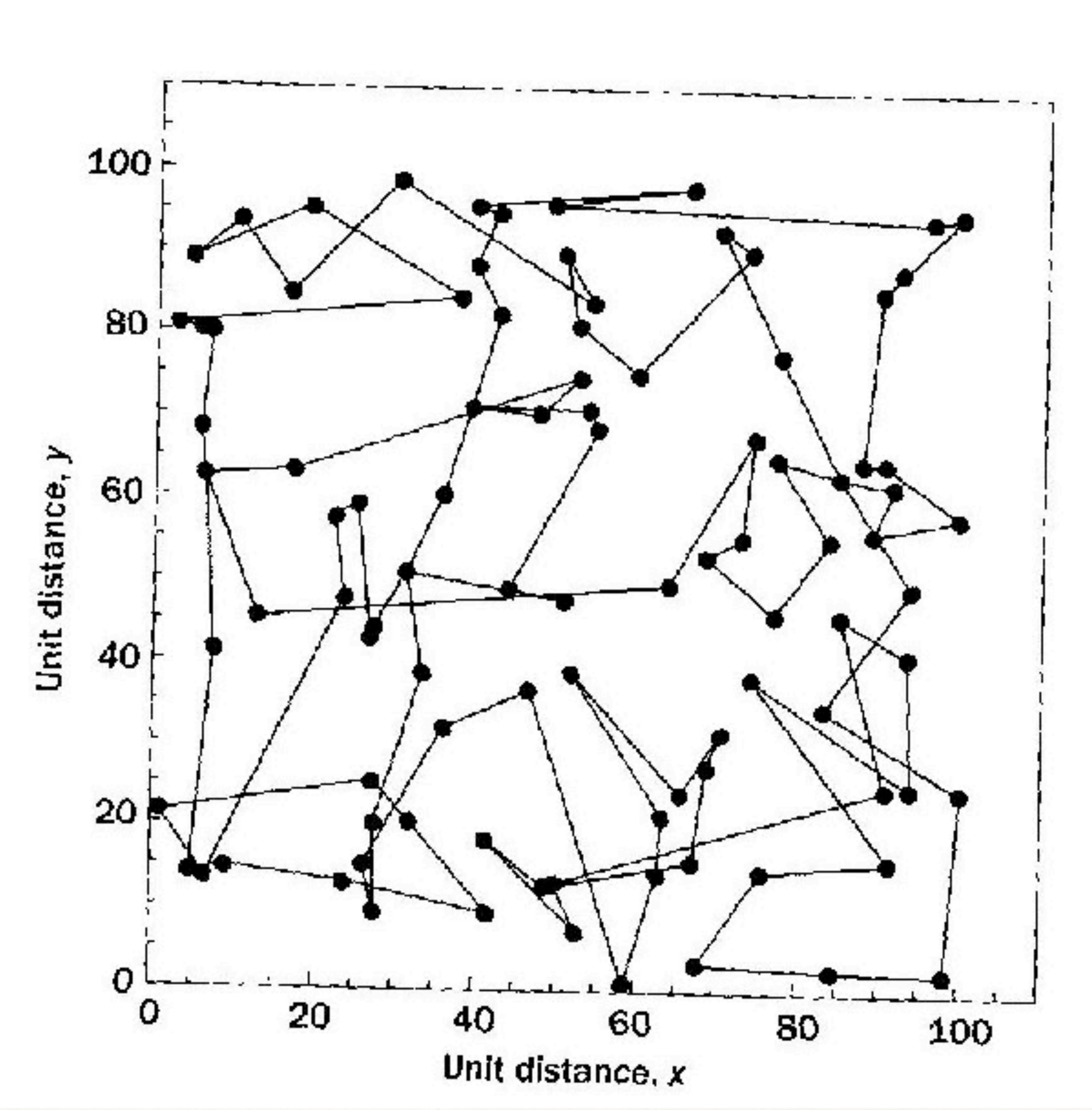
6. repeat

How did that work out?

Best of initial pool

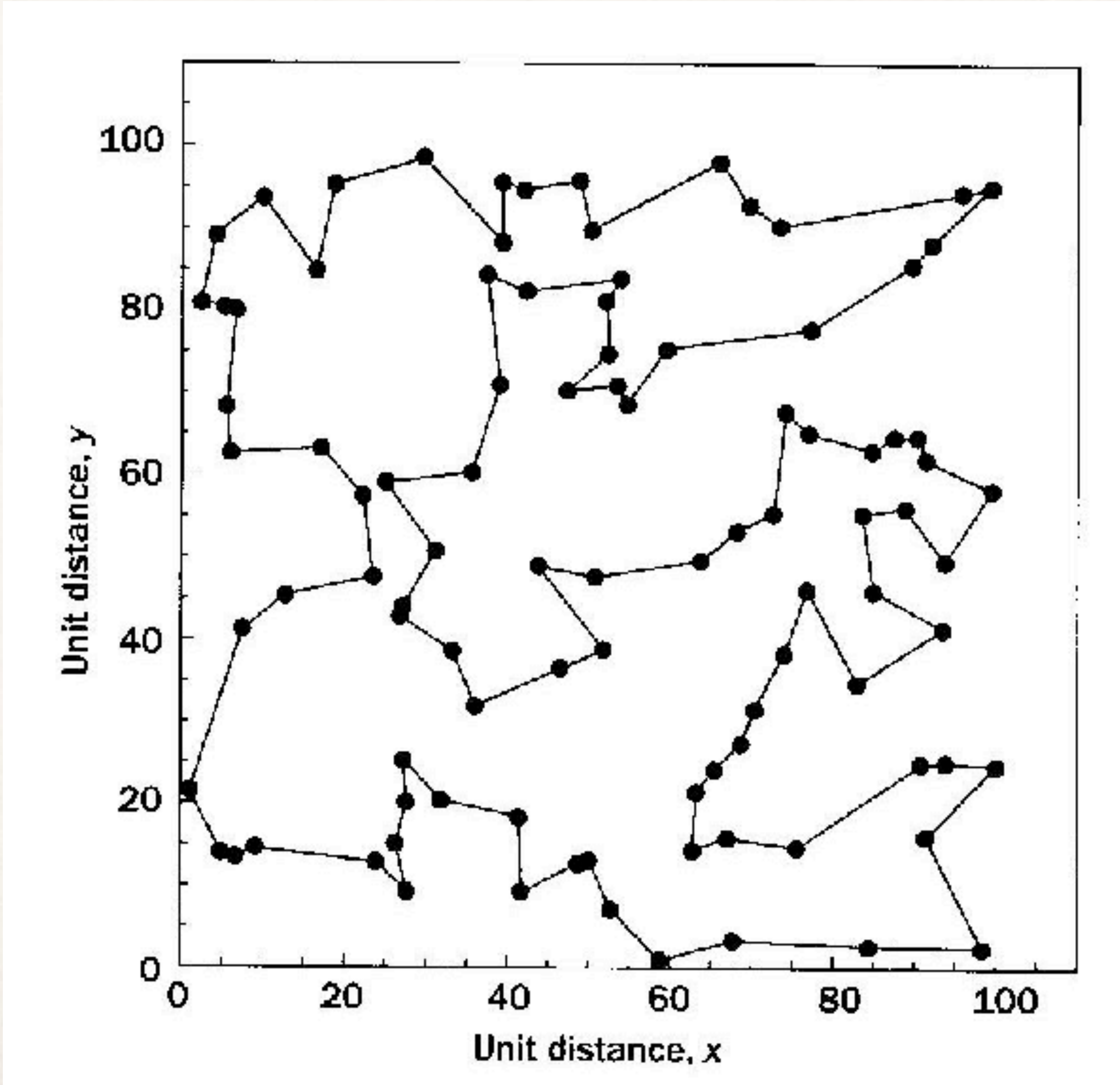


After 500 generations



After 4,000 generations
(3 minutes on a 350MHz Pentium

After 4,000 generations (3 minutes on a 350MHz Pentium



Total length within 10% of the expected best.

Counts as insanely cool!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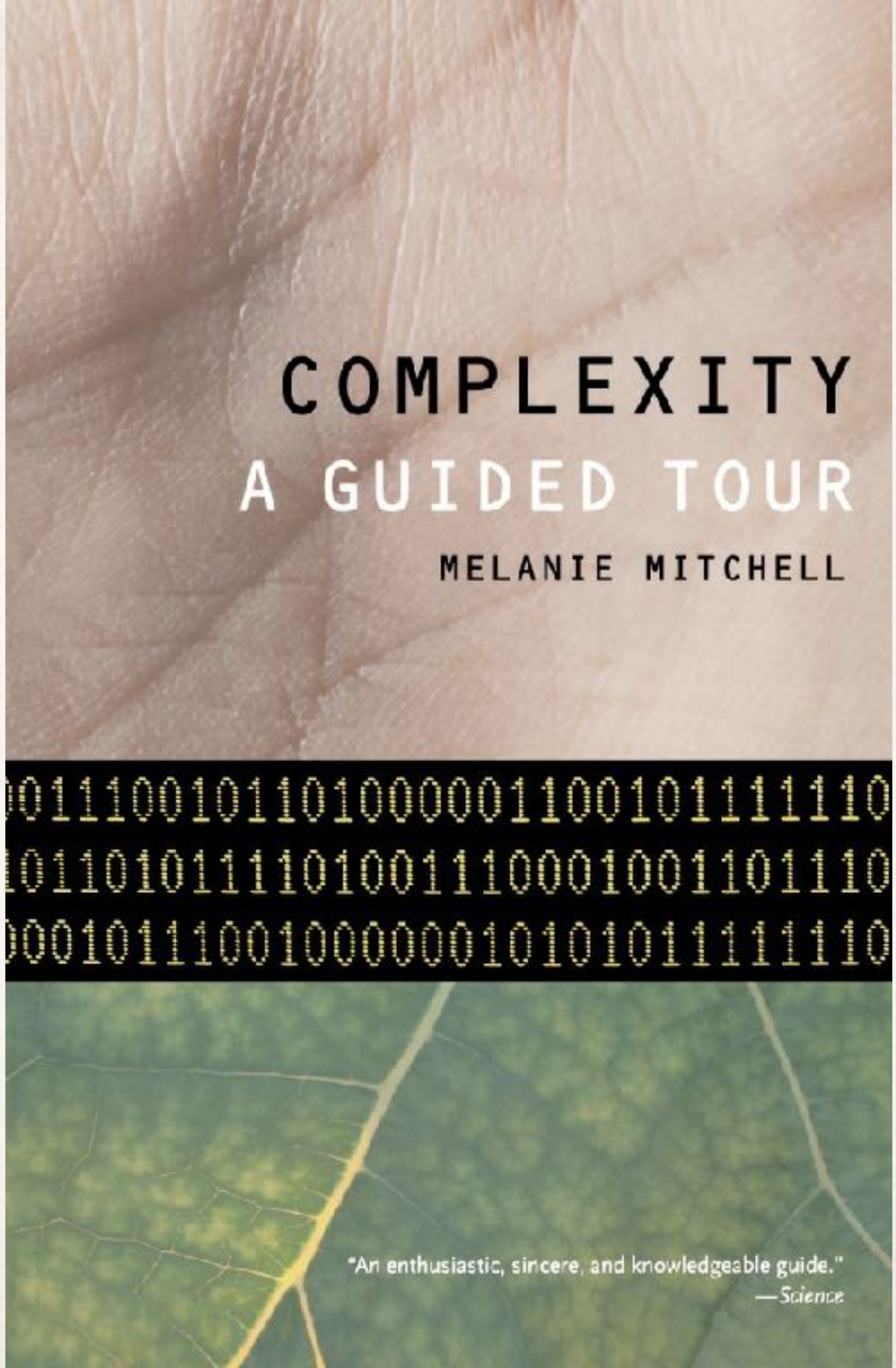
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—Science

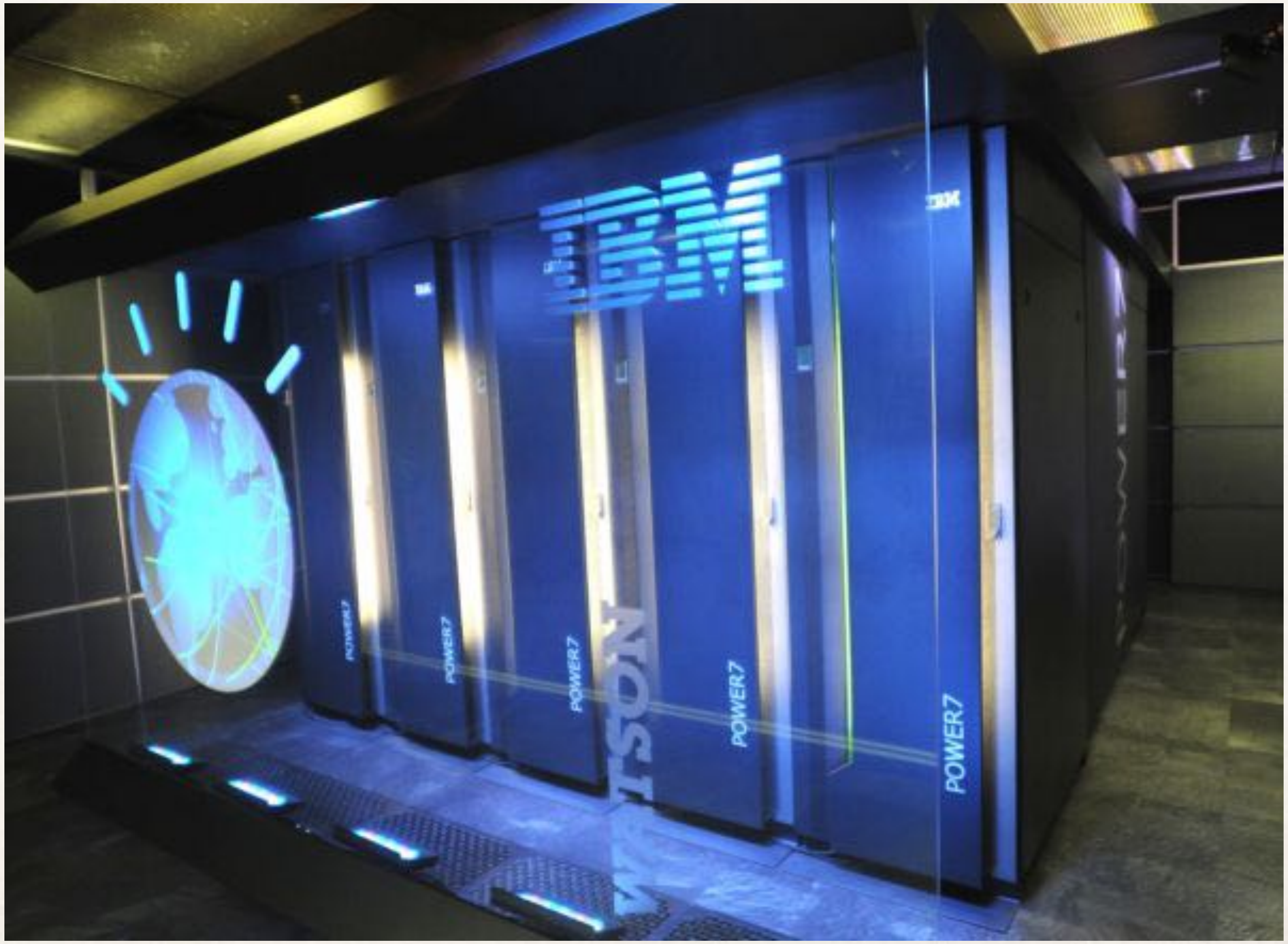
A challenge - implement this

60XP good solution

100XP if you also find a way to display the results.

a few more minutes on this topic

ever hear of IBM's Deep Blue?



the first machine to win a chess game against a reigning world

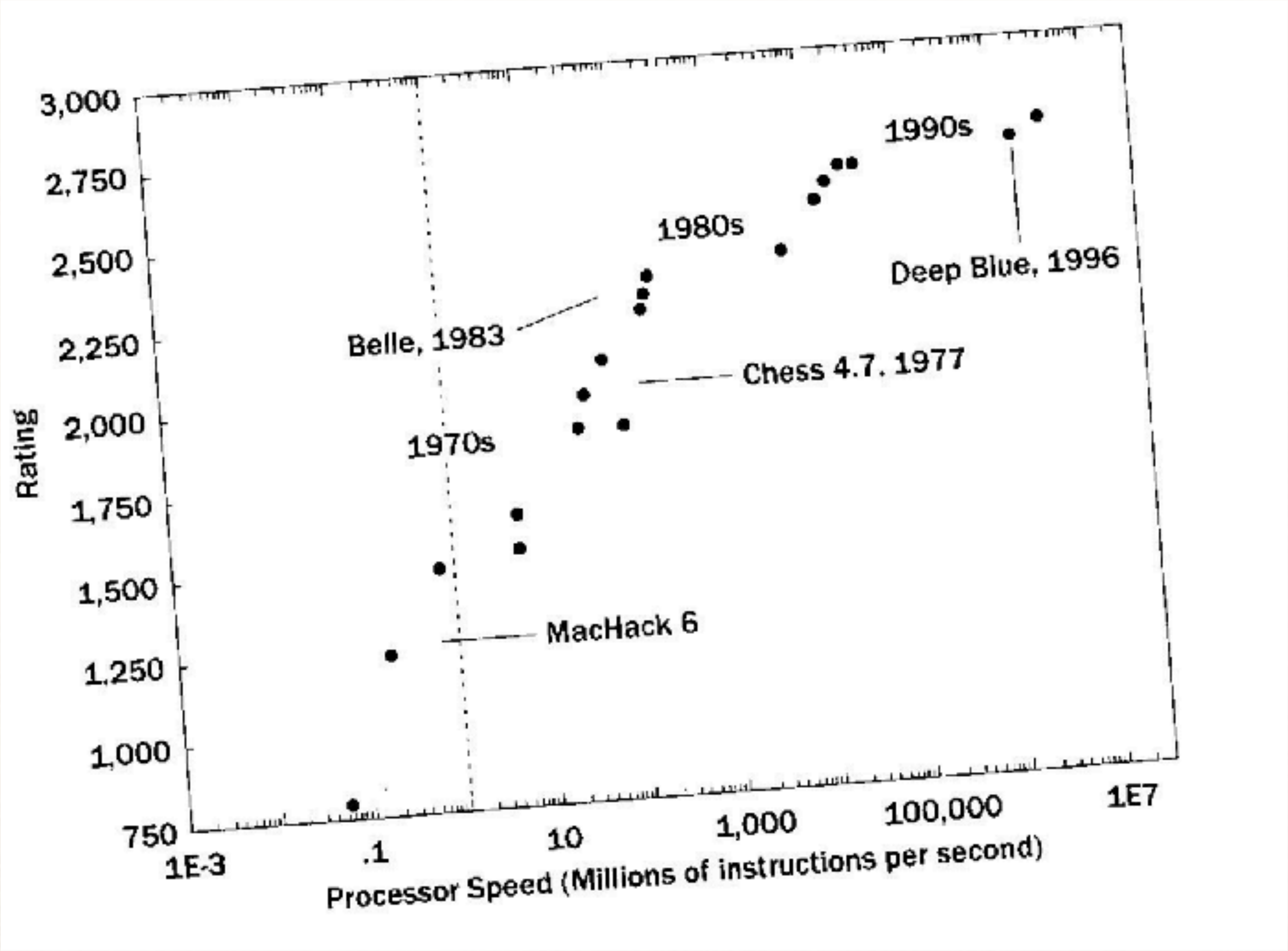
the first computer system to defeat a reigning world champion in a match under standard chess tournament time controls.

Brute force

- Massively parallel machine
- 30 nodes
- 480 special purpose VLSI chess chips
- 259th most powerful computer

Deep Blue - not really AI

brute force approach



“Working with international grandmaster Joel Benjamin, the development team has spent the past several months educating Deep Blue about some of the finer points of the game.”

“Last year, Deep Blue averaged about 100 million chess positions per second. This means it examined and evaluated 100 million different chess positions every second. This year, the developers estimate that Deep Blue will work about twice as quickly - that is, 200 million chess positions per second.”

Does Deep Blue use artificial intelligence?

“The short answer is "no." Earlier computer designs that tried to mimic human thinking weren't very good at it. … Deep Blue relies more on computational power and a simpler search and evaluation function.”

“The long answer is no.”

Fogel

- decided to try a genetic approach to checkers
- generate a pool of random checker player programs
- select next generation by natural selection
- repeat

Checkers

- eventually, to learn, you will need lots and lots of people to play online against your program.
- how do you get lots and lots of people to play?

Checkers

- eventually, to learn, you will need lots and lots of people to play online against your program.

- how do you get lots and lots of ~~people~~ young men to play?

Checkers

- eventually, to learn, you will need lots and lots of people to play online against your program.

- how do you get lots and lots of ~~people~~ young men to play?

- name it Blondie24 and come up with backstory.

Blondie 24

- 24 year old female graduate student in mathematics at the University of California at San Diego
- Natural Blonde
- Athletic - skis, surfs
- Ace in mathematics

Blondie 24

- imagine that you are seated at a table in front of a checkers board and you don't have a clue as to how to play checkers.
- I'm seated across from you and tell you we are going to play the game.
- The pieces are set up in their usual configuration

I describe the basic movement rules

- You can move diagonally forward one square.
- If you are next to an opposing piece and there is an empty space behind that piece you are required to jump that piece. You then remove my piece from the board.
- If any of your pieces make it to my end it becomes a 'king' and can move in either direction.

Let’s play

- I say let's play. You say wait—what's the object of the game.
- I ignore you and make a move. You—following the rules—also make a move.
- We continue taking turns moving pieces until at some point I say the game is over.
- You ask who won? And I respond I'm not telling let's play again.

Game Over

- Finally, after playing 5 games, I tell you that you earned 7 points for playing those 5 games.
- QUESTION: How long would it take for you to become an expert?

Newell’s Challenge

Allen Newell, AI Pioneer and winner of the National Medal of Science (i.e., no dummy) said

It is extremely doubtful whether there is enough information in “win, lose, or draw” when referred to the whole play of the game to permit any learning at all over available time scales.

Fogel's response

- let's give it a shot
- can the computer learn to play?

Algorithm

- Initialize a population of 30 random neural networks to play checkers.
- Each program played five games as the red player. After five games each program received a score. The best 15 programs were retained.
- Each retained program generates an offspring.
- REPEAT

Evolution

- After 2 days of running on a Pentium II 400MHz machine racked up 10 generations.
- The best generation 10 program beat both of its programmers.
- After one week—generation 100

Checkers Categories

Grand Master	2400+
Master	2200-2399
Expert	2000-2199
Class A	1800-1999
Class B	1600-1799
Class C	1400-1599
... Class J	below 200

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First match against a person rated 1800 - Blondie won!

After 100 games Blondie was rated 1750

Blondie Version 2

- With Alpha-Beta pruning could now run 100 generations in just 2 days.
- Trained for 5 days & completed 250 generations
- This version played 90 games and was rated around 1,900
- After 840 generations Blondie was rated over 2,000: human expert level

totally, “pull your hair out” amazing

- What is impressive is Blondie learned this from minimal input.
- No human experts feeding in rules.
- Just a simple program on a slow box.