DNA Computing

Uladzislau Maiseichykau
Michael Newell
Overview

- Introduction to DNA computing
- History
- Differences between DNA and traditional computing
- Potential
- Limitations
- Constructing a DNA computing experiment
- Early DNA computing
- Modern DNA computing
- Future of DNA computing
What is DNA Computing?

DNA computing uses DNA, chemistry, and molecular hardware instead of traditional silicon-based circuits to run calculations and computations.

Interest in DNA computing stems from the possibility of processing larger sets of data in a smaller space than silicon computers, and the fast-approaching physical limits to Moore’s Law.
History

- Initially developed by Leonard Adleman from University of Southern California in 1994
- Used DNA to solve the Traveling Salesman problem
- In 1997, researchers from University of Rochester used DNA to create logic gates
- Researchers from Weizmann Institute of Science unveiled a programmable computing machine that used enzymes and DNA in 2002
- 2013, the first biological transistor, the transcriptor, was created
Comparison to Standard Computing

“DNA computers are unlikely to become stand-alone competitors for electronic computers.”

Smallest most efficient computers, modifies cells

Build items vs. raw mathematics
Potential

- Ultra small devices
- Self assembly (nano) - ex: Sierpinski triangle
- Exotic and new molecular structures
- Nano-Gold + DNA = 10 smaller details on chips
Limitations

- Human involvement to set up each experiment/calculation
- Response times can be as slow as minutes, hours, or even days
- Results are much harder to read, often takes longer to find the correct answer than to compute possible solutions
Constructing a DNA Computing Experiment

Travelling Salesman Problem

- Salesman needs to visit all cities taking the shortest route possible
- First, fragments of DNA are created representing each city
- Each of these fragments are able to bond with each other representing travel to a different city
- The strands are mixed in a test tube and bonds are formed in seconds
- A chemical filter process (lasting days) eliminates invalid or overly long solutions
- The remaining strings of DNA are possible paths the salesman can take

We do not yet have the technology to read the strings of DNA efficiently, so this experiment remains a proof of concept
Early DNA Computing

- Too much lab work
- Large number of answers, manually pick the right answers from them
- 100 trillion answers in a second, most repeats or incorrect
- Several dozen more lab procedures to sift through the answers
Modern DNA Computing

- DNA Tiles (Wang Tiles)
- Edges (numbers and shapes)
- Erik Winfree
- Possible to convert to binary and sift through answers quickly
- Not yet complete
- If implemented properly, “several trillion multi-tile structures each of which has carried out an orderly addition of three binary bits”
Future of DNA Computing

- Transcriptors may make organic computers possible in the future
  - Slower than traditional transistors, but can work inside a body to monitor and affect surrounding cells
- Self-assembling nanomachines
  - Researchers used enzyme encoding to create Sierpinski triangles on DNA strands
- DNA can be used to store enormous amounts of data in a very small space
References

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