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DNA Computing: Hope for New Era

Shalini Sharma
QC Executive, Sun Pharmaceutical Industries Ltd.

Garima Sharma
Assistant Professor, Maiit

Shubham Shree Sharma
QA engineer, GSG Telecom

Abstract: DNA computing is an advanced technology with combination of computer science, molecular science and biochemical science. It uses DNA as a biological material which is building blocks for construction of living computational machines to solve complex problems is that different possible solutions are created all at once. This is known as parallel processing .Researchers has new interest in this field because it has some benefits like speed, cheap, large memory capacity and energy efficient resource.
Keywords: molecular, computational machines, parallel processing, energy efficient, complex problems.

DNA Computing-An Idea

DNA computing is an emerging field at the interface of computer science, biological science. It uses DNA and other biological materials as the building blocks for construction of living computational machines to solve difficult combinatorial problems.
DNA computing**,** the performing of computations using biological molecules, rather than traditional silicon chips.

History

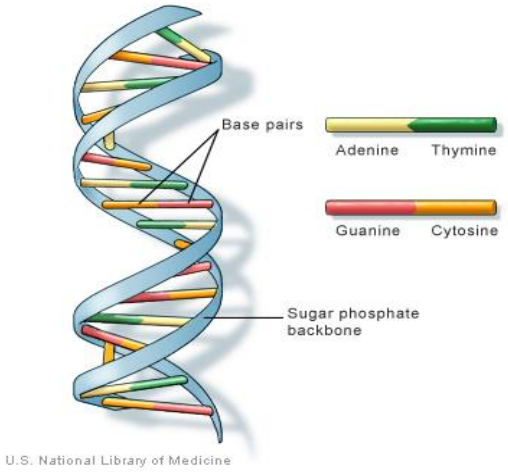
First computation dates to 1959, when American physicist Richard Feynman presented his ideas on nanotechnology.

Leonard Adelman

This idea was first experimented by computer scientist Leonard Adelman, University of Southern California in 1994. He demonstrates a proof of concept use of DNA as form of computation which was used to solve the seven point Hamilton path problems. First practical computer was unveiled in 2002 which is used in gene analysis MAYA-II. On april 28, 2004 Ehud Sharpio and researchers at Weizmann institute announced in the journal Nature that they constructed a DNA computer.

How it works

DNA has property of parallel computation which is used for this technology. The structure of DNA is double stranded helix. These strands are anti parallel to each other and this is made up of millions of nucleotides or bases. There is four types of nucleotides Adenine (A), Guanine (G), Cytosine(C), Thiamine (T).



DNA is a double helix formed by base pairs attached to a sugar-phosphate backbone.

Methods

There are some methods for make up a computing device based on DNA. Most of these build the basic logic gates (AND, OR, NOT) associated with digital logic from a DNA basis. DNAzymes, deoxyoligonucleotides, enzymes, toehold exchange-these are different bases.

DNAzymes

Catalytic DNA , catalyze a chemical reaction when interacting with the appropriate input, such as a matching oligonucleotide. These DNAzymes are used to create logic gates analogous to digital logic in silicon. Two common DNAzymes are named E6 and 8-17 is used.

A design which consist a single strand of DNA called a *stem loop*, it has a loop at an end, are a dynamic structure that opens and closes when a piece of DNA bonds to the loop part. This effect has been exploited to create several logic gates. These logic gates(AND,OR,NOT) have been used to create the computers MAYA I and MAYA II which can play tic-tac-toe to some extent.

Enzymes

Benenson, Shapiro and colleagues have experimented their research on a DNA computer using the FokI enzyme and require transition molecules Enzyme based DNA computers are usually of the form of a Turing machine; there is analogous hardware, in the form of an enzyme, and software, in the form of DNA.

Toehold exchange

Another technique to build a simple catalytic reaction is toehold exchange**.**

In toehold exchange system, an input DNA strand binds to a sticky end, or toehold, on another DNA molecule, which allows it to displace another strand segment from the molecule. This allows the creation of modular logic components such as AND, OR, and NOT gates and signal amplifiers, which can be linked into arbitrarily large computer.

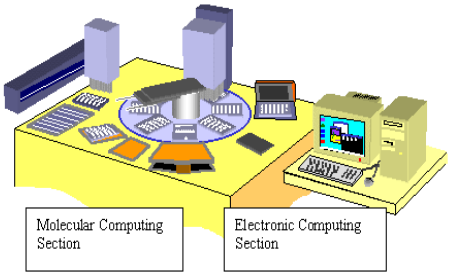
BENEFITS over silicon computer

1. Silicon computer has limited speed.
2. DNA can hold so much data in memory than silicon chip hence DNA Computers conduct multiple operations at once, thus solving decomposable problems much faster.
3. DNA computer are light weight computer than traditional computers**.**
4. Electricity required by the DNA computers are very less, power is needed only to prevent the DNA from denaturation.
5. It is cheaper than silicon computers.

Drawbacks

1. DNA has half life. Their solution could dissolve before end result generated.
2. Takes much time for simple calculations.
3. Sometimes it has error in pairing so assurance of result not reliable.

4. A critical matter in DNA computing is to test protocol.



Computations performed with DNA as input/output data; DNA reactions, capture of DNA results and DNA detection all performed automatically.

Information processing program performed; output includes DNA reaction calculations and an analysis of results.

Journey of research

The smallest programmable DNA computer was developed at Weizmann Institute in Israel by Prof. Ehud Shapiro with uses of enzymes to process DNA molecule.

1. Future aspects in the area of Medical Application, Genetic Programming, Cryptography, and DNA chip.
2. DNA computer moved from test tubes on to gold plates. First practical DNA computer prepared in 2002, which is used in gene analysis.
3. Self powered DNA computer invented in 2003. First program autonomous computing machine in which the input, output, software and hardware are all made of DNA molecules can perform a billion operations /second with 99.8% accuracy.

Fact

A single gram of dried DNA, about the size of a 1/2 inch sugar cube can hold as much information as a trillion compact discs.

1. A single gram of dried DNA, about the size of a 1/2 inch sugar cube can hold as much information as a trillion compact discs.
2. 1 gram of DNA can store about 1*1014 MB of data.
3. The number of CDs required to store this amount of data, lined up edge to edge would circle to earth 375 times and would take 163,000 centuries to listen.
4. Energy efficiency 1 Joule =2*1019 operations.
5. Taiwan prepared world's 1st DNA chip. They are planning to use this chip on ID card to crack down frauds using fake ID cake.
6. Not completely accuracy at this moment in time. During an operation, 95% chance a specific DNA molecule will "Compute" correctly.

Conclusion

1. DNA computing is new technology, has so much scope to make a new era with combination of bimolecular technology and computer engineering.
2. DNA computing is in initial stage that is why scientist face some difficulties to set up.
3. DNA computing has speedily improved in recent years, and future advances may make DNA computing technology more efficient.
4. DNA computers are unlikely to feature word processing, emailing and solitaire programs. Instead of, their powerful computing power will be used for areas of encryption, genetic programming, language systems, and algorithms or by airlines wanting to map more efficient routes. Hence better applicable in only some promising areas.

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