Biocomputing: Biological Computers

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Abstract: In this paper, we can introduce new trend of combined biology and technology to make the Biological computers. In we can explain the biological computers, Biocomputing and bio chips. We can also explore the various advantages and challenges to implement the biological computer technology. We can tell the reader the various applications and working of the Biological Computers. They are special kind of microcomputers that are designed to be used for medical applications.

Keywords: Biological computers; Biocomputing; DNA computers;

I. BIOLOGICAL COMPUTERS

Bio computers, genetic computers, or DNA computers might use living cells to store information and perform complex calculations. DNA has a vast amount of storage capacity. Computers might tap the vast storage capacity that enables DNA to hold the complex blueprints of living organisms. The storage capacity of a single gram of DNA can hold as much information as one trillion compact discs [1][2].

Biological computers are special types of microcomputers that are specifically designed to be used for medical applications. The biological computer is an implantable device that is mainly used for tasks like monitoring the body's activities or inducing therapeutic effects, all at the molecular or cellular level. The biological computer is made up of RNA (Ribonucleic Acid – an important part in the synthesis of protein from amino acids), DNA (Deoxyribonucleic Acid – nucleic acid molecule that contains the important genetic information that is used by the body for the construction of cells; it's the blue print for all living organisms), and proteins [3]. Biological computers are similar to quantum computers in terms of strategy. Quantum mechanics use qubits (ones and zeroes) while biocomputers use molecules that work in parallel. Biological computers are a kind of biosensors which have emerged as an interdisciplinary field that draws together molecular biology, chemistry, computer science and mathematics [4][5]. The highly predictable hybridization chemistry of DNA is the ability to completely control the length and content of oligonucleotides and the wealth of enzymes available for modification of the DNA and make use of nucleic acids an attractive candidate for all of these nanoscale applications [6][7]. "The fact that molecules are very cheap, and that we have now shown the biocomputer's calculations work, leads me to believe that biocomputers have the prerequisites for practical use within ten years. [8][9]Certainly, quantum computers can be more powerful in the long term, but there are considerable practical problems involved in getting them to work," "Another big advantage is that molecular motors are very energy efficient. A biocomputer requires less than one percent of the energy an electronic transistor needs to carry out one calculation step." The current study showed the solution to a well-known combinatorial problem, 'Subset Sum Problem'. Compared with a sequential computer, a parallel computer can take a drastically shorter time to test all the solutions for a problem (in mathematical terms: N^2 compared with 2^N, where N represents the size of the problem) [10][11].

II. BIOCOMPUTING

Humans use a variety of gadgets without realizing how the gadgets could be working on a pattern which is already patented and perfected by Mother Nature. Living organisms also carry out complex physical processes under the direction of digital information. DNA was recognized as the most important molecule of living nature. The ability to store billions of data is an important feature of the DNA and hence to biological computing [12][13].

The first major step in computation is to determine how state is to be represented physically. There are different ways to represent for example pebbles, by triangular marks pressed into a clay tablet. Polymers are molecules that consist of repeated structural units called monomers. Proteins are linear polymers based on twenty amino acid monomers hence proteins are strings on a twenty letter alphabet, thus a n individual protein molecule can be represented as state of a computation. The second step is to develop a computational technology how to transform the state i.e. how the physical representation of one computational state can be used to produce a physical representation of a successive state. To accomplish this for polymer based computers one need to devise sufficiently rich set of transformations. This leads to biochemical polymers and biological processes. The final step is to develop process for iterating those state transformations which is very risky process[14].

III. BIOCHIPS - THE BIOLOGICAL MACHINE

Biochip is the result of marriage of microchips business with biotechnology. In future, there is the possibility of developing biological computers.

[15][16]Until the development of silicon microchips, setting up of computers was very costly and space occupying. But recently, one can have a computer to be fit on desk top. These affordable prices are mainly due to the development of silicon microchips which brought into a rapid revolution in technology. Further reduction in size of computers and improvement in computing powers will not be possible because the silicon microchip technology has certain limitations as below:

(i) There is inherent limit beyond which circuits cannot be squeezed onto a silicon chip. For example the width of the circuit cannot be shorter than the wavelength of light. Light is used to etchout circuits during the manufacturing of silicon chips.
(ii) Close placing beyond a limit of many electrical circuits on the same microchip results in 'electron tunnelling' which creates short circuits ruining the whole system.
(iii) After cramming together of a large number of circuits, heat is generated by the electric current. This may cause total failure of the system.

A. Advantages Of Biochips

One of the important features of macromolecules *(e.g.* proteins) is their self shaping into predetermined three dimensional structures. This property of proteins helps in biochip designing because the circuits can be crammed around three dimensional protein structures. While designing the biochips, a semiconducting organic molecule is inserted into a protein frame work; the whole unit is fixed onto a protein support. In biochips the electrical signals can pass through the semiconducting organic molecule in the same way as in silicon microchip. It has many advantages over silicon microchip as below :
(i) In biochip the width of electrical circuits should not be more than that of one protein molecule which is smaller than the smallest silicon microchip.
(ii) The problem of electron tunnelling would be to certain extent less acute in biochip than silicon microchip.
(iii) The protein molecule possess less electrical resistance, therefore, less heat will be generated during the course of production of electrical signals. Consequently, a large number of circuits can be placed together as it is not possible in silicon microchips.

IV. ADVANTAGES OF BIOLOGICAL COMPUTERS

The main advantage of this technology over other like technologies is the fact that through it, a doctor can focus on or find and treat only damaged or diseased cells. Selective cell treatment is made possible.
The biological computer can also perform simple mathematical calculations. This could enable the researcher to build an array or a system of biosensors that has the ability to detect or target specific types of cells that could be found in the patient's body. This could also be used to carry out or perform target-specific medicinal operations that could deliver medical procedures or remedies according to the doctor's instructions[17].
This not only makes the healing process easier. It also allows the doctors to focus only on the damaged, diseased or cancerous cells found in the patient's body without causing stress to other healthy and normal cells.

V. WORKING OF BIOLOGICAL COMPUTERS

Biological computers are made inside a patient's body. The researchers or doctors merely provide the patient's body with all of the necessary information or a "blueprint" along which lines the biological computer would be "manufactured." Once the "computer's" genetic blueprint has been provided, the human body will start to build it on its own using the body's natural biological processes and the cells found in the body [18][19].
As of today, reading signals produced by cell activity is not yet possible due to technological limitations. However, through the use of a tiny implantable biological computer, these cellular signals could easily be detected, translated and understood using existing medical and laboratory equipment.
Through boolean logic equations, a doctor or researcher can easily use the biological computer to identify all types of cellular activity and determine whether a particular activity is harmful or not. The cellular activities that the biological computer could detect can even include those of mutated genes and all other activities of the genes found in cells.
As with conventional computers, the biological computer also works with an output and an input signal. The main inputs of the biological computer are the body's proteins, RNA, and other specific chemicals that are found in the human cytoplasm. The output on the other hand could be detected using laboratory equipment [15].

VI. APPLICATIONS OF BIOCOMPUTERS

The implantable biological computer is a device which could be used in various medical applications where intercellular evaluation and treatment are needed or required. It is especially useful in monitoring intercellular activity including mutation of genes.
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Following are the noted applications of Biocomputers:
(i) Biocomputers can respond to natural nerve impulses making looks more natural when implanted into the artificial limbs.
(ii) It is also possible that they can also be used as a heart-heat regulator. This will solve the problems of users of costly pace makers.
(iii) It can also help blind or deaf. It can be designed in such a way that can sense light and sound, and convert them to electrical signals. These signals after reaching brain stimulate sight and sound,
(iv) It can be designed in accordance with the need of military. It can keep immune to the disastrous effects of electromagnetic waves which are generated due to nuclear explosion.

VII. CHALLENGES FOR BIOCOMPUTING

[17] Biological computing has played a big role in modern medicine and will continue to do so, but to see a computer being solely powered by microorganisms/DNA is far away. We feel that we are not even close enough to say that the next years will see the dawn of biological computing where CPU is replaced by DNA.

Some of the challenges that stare us in our face to eventually replace silicon chips with DNA include:

a) Ability to control the DNA.

b) How to make the various altered DNA's to communicate with each other.

c) Can the programmed DNA or microorganism go wrong?

d) Can it impact health?

Maybe the above may not be an issue at all but still they need to be answered.

VIII. CONCLUSION

The future for biological computing is bright. Biological computing is a young field which attempts to extract computing power from the collective action of large numbers of biological molecules. CPU being replaced by biological molecules remains in the far future. Biological computer is a massively parallel machine where each processor consists of a single biological macromolecule. Large numbers of such macromolecules in parallel, one can hope to solve computational problems more quickly than the fastest conventional supercomputers. It seems like a good idea to look to real biological systems for solutions to particular problems. A computational microarchitecture based on membrane justifies the name biological as opposed to merely molecular computing. Companies and scientist that are involved in the biological computing work need to take care of legal, moral regulations.

IX. FUTURE PROSPECTS

For all those hard core computer professionals who are wedded to silicon chips it is time to look at the future and prepare for the next big thing in computers. The future for biological computing is bright. Already some of the medical/industrial products like Vaccines, Insulin (for diabetes treatment) are benefiting from this research. Most of the design/patterns coming out of various software companies have already been in existence in nature (DNA) and all we need to do to effectively use the DNA is to reverse engineer, understand the inner workings and make it fit to work to our requirements[20][21].

With 64 neurons, a drone can have a powerful sense of smell. What's next? By Agabi's approximations, a Koniku chip with….

- 500 neurons can power a driverless car
- 10,000 neurons enables real-time image processing, at the level of the human eye
- 100,000 neurons enables robotics with multiple sensory inputs
- 1 million neurons will give us a computer that can think for itself.

Now, think about this: there are 100,000 neurons in a piece of brain matter the size of a grain of sand.

It's not hard to see the potential here, yet there are sure to be significant challenges along the way. There has been much work done in attempting to build a brain-inspired machine but that's very different than actually using biological matter like live neurons for computing at scale.

As magnificent as our advances in technology are— biology is a far more advanced technology than anything ever created by man. It is only in striving to replicate biological processes that we understand how much we have to learn from nature's billions of years of evolution.

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