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Blue Brain Technology

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Abstract

Human brain, the command centre for the central nervous system controls all the functions of the human body and stores memory whereas Blue Brain, the world's preliminary virtual machine is the one that may perform as an appropriate application of a synthetic human brain. Through Reverse engineering, cellular level implementation and recreation of the human brain within an entire simulation are often made possible. With technological advancements, humans, the ultimate source of data and discovery are often preserved in order that intelligence is rarely lost. IBM's blue gene supercomputer allows a quantum jump in the stage of detail at which the brain can be modelled. This technology identifies the fundamental principles of the brain, its functions and capabilities. This review paper consists of detailed information about the comparison of natural and simulated brain, implementation of artificial brain and various steps in creating simulated brain using Artificial Intelligence.

Keywords--Artificial brain, supercomputer, blue gene, nanorobots, virtual machine, brain simulation, artificial intelligence.

I. Introduction

Blue Brain technology aims to create a virtual brain at cellular level to develop and acquire knowledge of our brain and enable quick treatment of brain related disease.

This project was begun by a scientist at EPEL, Switzerland named Henry Markram. In 2005.

The primary machine for this project is the supercomputer engineered by IBM named 'Blue Gene'. hence the project was named Blue Brain Michael Hine's NEURON, along with other custom-built components used as simulation software [3].

With this scientific technology, we can preserve knowledge and intelligence of a person even after death. A full human brain simulation is expected to be possible by 2023

I. Blue Brain

Blue Brain is the first virtual brain in the world. Though it is not an actual brain, it is modulated with hardware and software through which it can think, process, memorize, store and respond. Reverse engineering [5] is the foremost idea of implementing this virtual brain recreated within the computer with complete simulation. The Blue Brain gives the clear clarification to keep the intelligence of such great persons like Steve Jobs and Stephen Hawking for future use.

The mission undertaken by the Blue Brain technology is to collect the existing records of the brain and to make an entire theoretical framework inside a computer.

A. Need For Blue Brain:

Intelligence is associated with nursing inborn quality, which cannot be created and stored for future use. After death, all our intelligence is destroyed and we often have problems remembering important dates, people's names, and Historical facts and so on. Virtual brain could be a smart answer to the problem where someone needs to live within a PC as a program so that it might be simple to recollect all the facts in such a busy era.

B. Aim Of This Project:

The main intention of this Blue Brain project is to review the purposeful principles of the brain moreover as its construction in supercomputers and enables quick treatment of brain related diseases like Parkinson's disease.

C. Possibility:

Is it possible to create an artificial brain and stimulate it to think, feel and experience the world like a normal human brain? **Yes**, it is possible. Raymond Kurzweil [28], an American inventor, in his paper narrated the full details about the invasive and non-invasive methods using

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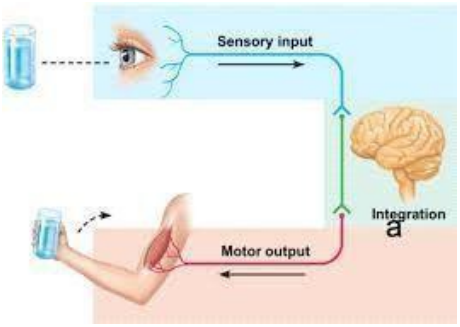
Nanobots (Nanorobots) which are terribly little and are needed to travel around the spine and brain to provide the structure and activity of Central Nervous System (CNS). A Supercomputer with giant space for storing and processing power is required to process the collected information. These Supercomputers and Nanorobots can provide an interface with the human mind.

Iii. Natural Brain And Simulated Brain

A. Functions of Natural Brain:

Before getting to know about the building and functions of Blue Brain, it is important to grasp information regarding the working of the human brain.

The human ability to observe, clarify and respond [17] is controlled by the nervous system. The nervous system is quite a magical one which works through electric impulses from the human brain.



The following are the steps of working the natural brain.

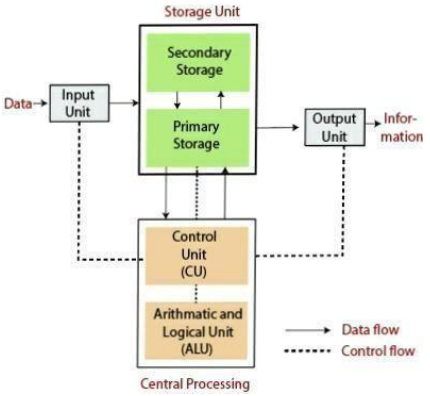
Input: The action of obtaining information from the atmosphere through sensory cells is named Sensory input (i.e.) when the human eye sees something (or) the hands touch something, the sensory cell sends associated information to the brain.

Integration: Understanding the acquired input with the help of the brain is called Interpretation. During this process, billions of neurons work along to recognize the environment.

Output: As soon as the things get interpreted, the brain sends messages to effector cells, muscles or glands via neurons which respond to the environment .

Processing: The decision making is completed by arithmetic and logical calculations in neural circuitry. The beyond experience stored and present inputs acquired are used to make decisions.

Memory: With the help of certain neurons in the brain, we can remember things.



B. Functions of Simulated Brain:

As seen in above diagram, the following are the steps of working of simulated brain

Input: The scientists have created artificial neurons with silicon chips in the similar manner as actual neurons. These artificial neurons will receive input from secondary cells and also the electrical impulses from secondary cells are sent to supercomputers via artificial neurons for interpretation.

Interpretation: The electric impulses that are obtained from synthetic neurons are interpreted by the way of a set of registers. The various values in the register represent different states of the brain.

Output: After being interpreted, the output signals are given to sensory cells present within the artificial neuron.

Memory: It is possible to store the records permanently with the help of secondary memory [Hardware]. By this way, the sets of registers will be stored permanently and the information in it could be retrieved and used when it is needed.

Processing: The processing is done by computer by some stored information and by the inputs received. Artificial brain will perform some arithmetic and logical calculations as performed by our human brain using the concept of artificial intelligence.

Comparison between Natural and Simulated Brain

Parameters	**Natural Brain**	**Simulated Brain**
INPUT	Through Sensory cell/Neurons.	Through Silicon chip of artificial neurons.
INTERPRETATION	By states of neurons.	By means of set of bits in register.
OUTPUT	Through Sensory cell/Neurons.	Through Silicon chip of artificial neurons.

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MEMORY	Permanent state of neuron.	Secondary memory [hardware].
PROCESSING	Arithmetic and logical calculation in neural circuitry.	Arithmetic and logical calculation using the concept of artificial intelligence.

Iv. Project Description

The steps for creating a simulation of virtual brain are divided into 3 major sections:

1) Data collection.
2) Data simulation.
3) Visualization of results.

A. Data Collection:

Data collection is a process of collecting individual slices of the brain and analyzing the electrical activity and the shape of neurons under a microscope . Neurons are captured consistent with their structure, position in cortex, populous density and electrophysiological behavior. From figure 5, the topology of structural brain networks at micro-, meso- and macro-scales can be seen.

The electrophysiological behavior of neurons is studied in a 12-patch clamp as shown in figure 6 especially designed for this Blue Brain project. Twelve numbers of living neurons are synchronously patched and their electrical activities are recorded.

The collected observations are then converted into algorithms that narrate the function, positioning and type of neurons. These algorithms will be used to generate synthetic virtual neurons that are prepared for consequent phase (i.e.) simulation phase.

B. Data Simulation:

Blue Brain Project-Software Development Kit **[**BBPSDK]: The main software employed by this Blue Brain project for neural simulation is a software package known as NEURON which was developed in the 1990s by Michael Hines [Yale University] and John Moore [Duke University]. This software is written in C, C++, and FORTRAN programming language .It is an open-source network (i.e.) the codes and binary are freely offered within the website. It is a C++ library wrapped in JAVA and PYTHON. In 2005, Michael Hines and the BBP [Blue Brain Project] team collaborated to port the bundle to the massively parallel Blue genetic Supercomputer.

Data simulation is bothered with 2 major aspects: [18]

1) Simulation speed
2) Simulation workflow

Simulation speed: Simulation of one cortical column [around 10,200 neurons] runs approximately at 200xs very slower than the original time . The simulation doesn't show even line scaling. It exhibits doubling of the dimensions of the neural network, which doubles the time it takes for simulation. The initial intent is to supply biological accuracy.

2) Simulation workflow: Simulation workflow includes virtual cell synthesizing using algorithms that were found to explain real neurons. There are millions of proteins in a single cell and each single protein is simulated. The algorithms are customized on the basis of their lifetime; species and unhealthiness stage of the simulated animal The cells are connected with one another according to the experimental rules. The behavior of nerve cells is envisioned by Visualization software.

The basic unit of the cerebral cortex is the cortical column. There is an idea to couple the brain simulations with avatars that live within the virtual surroundings and additionally with the robots that are interacting with the actual world. The primary target is to grasp the information and reproduce the human consciousness.

V Hardware Used

The primary hardware utilized by the Blue Brain project is the Blue Gene supercomputer, engineered by IBM. It had been installed on the EPEL campus in Lausanne, Switzerland and was managed by CADMOS.

A. *Requirement:*

1) A large amount of memory (i.e.) 16 terabytes is required as there are billions and billions of neurons. The storage needed for such a massive simulation is terribly huge.
2) A high-speed processor of 256 MB to 512 MB memory per processor to simulate billions of neurons.
3) A program that converts the electric impulses from the brain into an input signal to be obtained by the Supercomputer and vice versa .
4) A nanorobot to act as the interface medium between the supercomputer and natural brain.

B. List of Supercomputers used since 2005:

1) Blue Gene/L as shown in figure 8 was used till 2009.

2) Blue Gene/P as shown in figure 9, an upgraded version from Blue Gene/L was used till 2011.
3) JuQUEEN [Blue Gene/Q] as shown in figure 10, an upgraded version from Blue Gene/P in 2012 was ranked 8th in the world in terms of speed.
4) Blue Brain 5 as shown in figure 11, installed in 2018 will take over from the predecessor.

C. Brain chip:

Mathew Nagle designed a brain chip that provided the balance among safety, durability and functionality. The chip was small enough that it didn't hinder normal brain function. Using integrated CMOS circuitry [an array of recording electrodes]; Nagle's chip recorded the brain signals. He improved the reliability of the recorded data using multiple electrodes.

Vi. Benefits, Drawback And Applications Of Bbp

Every Scientific technology has its own portion of Positive and negative effects.

A. Positive Effects:

1) Blue Brain will store and utilize human intelligence and data even after the person dies.
2) With the help of past experiences, Self decisions can be made by computer.
3) Blue Brain is helpful for people with hearing disorders and for paralyzed people to communicate to the world via nerve stimulation.
4) Research and studies related to the brain of living beings can lead us to communicate to their brain as easily as a normal conversation with a human being.
5) The electrical impulses interpreted from the brain of animals can be helpful in understanding their activities and thoughts.
6) Storing the data in a computer could be useful for memory lost patients to recall it.

B. Negative Effects:

1) Humans will become more dependent on computers.
2) Since this Blue Brain project is based on Computer technology, there is a dread of hacking and virus attacks.
3) Restoring memory back into the computer is quite expensive.
4) Huge amount of electric power is required to power up the machine.

C. Application:

1) Curiosity about the conscious and subconscious mind gets a major breakthrough.
2) Blue Brain may serve as a foundational and physiological model for whole brain simulation.
3) Data around hundreds of years can be collected and tested. [14]
4) Cracking of Neural code can be done.
5) Blue brain is the leading drug discovery tool for brain disorders.

Vii. Future Prospect

This Blue Brain project is an inevitable phase triggered in Neuroscience. It will permit us to take the principles of our intelligence and an entire model of the cellular level brain will be generated in the next century.

We can also hope to learn about functions and dysfunctions of the brain from the precise models. Detailed models will be used to arrange all the knowledge of the brain and it lets quick diagnosis of brain dysfunctions and their treatment.

After the release of Blue Brain technology, there can be advancement in the field of Artificial Intelligence, Psychology and Inter-Communication between species. By deeper research of brain structure and function, it will offer a rapid effect on new findings on pre-existing knowledge.

Viii. Conclusion

Using Blue gene supercomputers, as much as one hundred cortical columns, 1 million neurons and 1 billion synapses [20] may be simulated right away. This is roughly similar to the brain power of a human bee. Humans have 2 million Columns within the cortices. In conclusion, we will be able to convert ourselves into computers some time in the future. The vision behind this virtual brain will shed some light on the aspects of Human recognition. Very quickly, this technology can be common everywhere in the world.