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A case study of a blue brain working on the neural network concept

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Abstract
Blue brain is the name of the world's first virtual brain initiated and founded by the scientist Henry Markram at EPFL in Lausanne Switzerland. The main aim behind this project is to save knowledge of the human brain for decades. It is a well known fact that human doesn't live for thousands of years and the intelligence is also lost after a person's death. So IBM is trying to create an artificial brain that can think, response and take decisions like human brain. It is called "Blue Brain". Hence this paper consists of the concepts of Blue Brain, the requirements of the Blue Brain project, various strategies undertaken to build the Blue Brain, advantages and disadvantages and many more.

Keywords: Neurons, Nanobots, Blue Gene, Virtual mind, Neuroscience

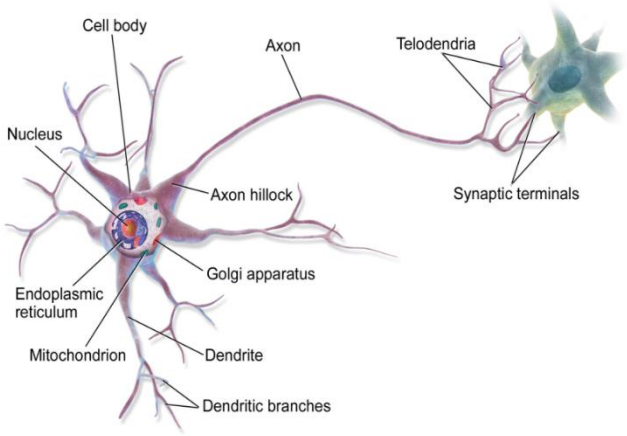
1. Introduction
As we know the human brain is most powerful creation of God and it is very complex to understand the circuit of human brain. However with the advancement in technology, now it is possible to create a virtual brain so in future, the human brains are going to be attacked by the blue brain and it is going to be very useful for all of us. This project was started in May 2005 by HENRY MARKRAM at the EPFL in Lausanne, Switzerland by using reverse engineering brain circuits in mammals [1]. After the death of the human body, the virtual brain will act as the man and we will not lose the knowledge, intelligence, feelings and memories even after the death of a person and that knowledge can be used for the development of the human society. In short, we can say that the Blue Brain is like uploading mind into a computer. Now the question is how is it possible so that a man can think and demand a choice without any hardwork? The virtual spirit can act sort of a man after the disappearance of the body. That's why, even once the death of a person, we are going to not loose the information, knowledge [2], identities, feelings, emotions and recollections of the person which will be used for the advancement of human culture.

2. Need of virtual brain
In the busy life everybody wants to be relaxed and hassle free. People often face difficulties in remembering so many things such as name of the people, their birthdays, proper grammar, history facts, important dates and many more. We are urbanized today because of the intelligence and every person have different level of knowledge and intelligency. Some people can think and imagine upto such an extent that others can't reach. We are always in need of such a brain power that could have been used for the betterment of the society. But the death of a person leads to the loss of his knowledge and intelligence as his body gets destroyed. So the solution to all these problems is Virtual Brain because it will be helpful in preserving the brain and intelligence for thousands of years even after death. And this could be achieved by either of two methods. The first method is Copy and Transfer and the second one is Slow and steady replacement of neurons. In the previous method, mind uploading would be achieved by the use of invasive and non invasive techniques which has been provided by Raymond Kurzweil, suggesting the use of nanobots [3].

3. Comparison between natural brain and simulated brain
Before start discussing with Blue Brain building, it is very important to know the working of natural brain in contrast to simulated brain. It will be easy to build the blue brain by comparing the functions of natural brain with the simulation of electrodes. And to better understand this, the following tabular comparison between the operational functions of both the brains is provided.

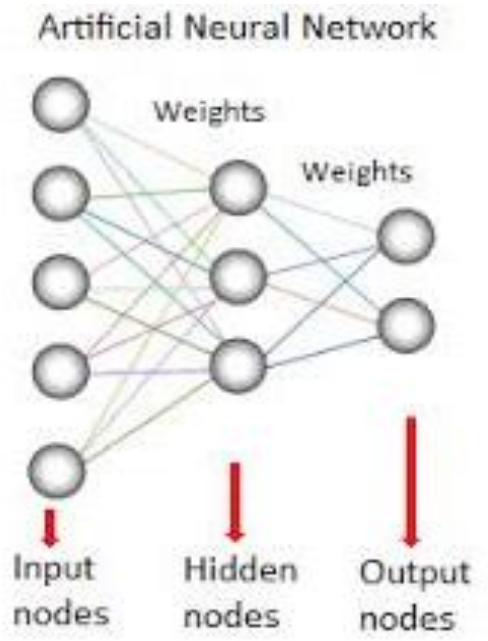
Table 1

	Natural Brain	Simulated Brain
Input	In human nervous system, the information passes through the neurons using electric impulses.	Artificial neurons created using silicon chips are used for transfer of messages with the help of sensory cells.
Interpretation	Electric impulses received by the neurons are interpreted in the brain which gives the state of the neurons.	Here the interpretation of electric impulses received by artificial neurons is done by using registers.
Output	After interpretation the electric impulses showing response is sent to sensory cells in the form of electric pulses.	Output signals are provided to the artificial neuron on the basis of state of the register means different states of the brain.
Memory	Some definite neurons help to store data permanently and it can be easily accessed whenever required.	It is not possible to store data only using secondary memory however registers make it possible to serve this purpose of storing data permanently and can be retrieved whenever needed.
Processing	Various arithmetic and logical calculations are used to alter and produce the output.	Here decision making becomes easier with the help of AI and by performing some arithmetic and logical calculations for computing output.



Source: https://www.epfl.ch

Fig 2: Neuron Anatomical Model



Source: en.wikipedia.org

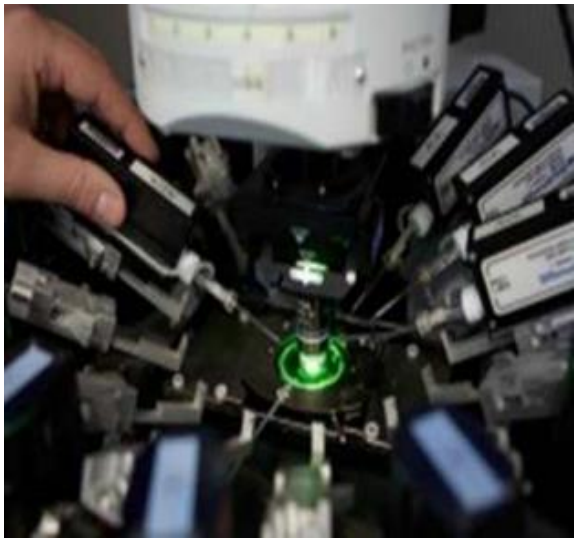
Fig 3: Artificial Neural Network

4. Steps to build a blue brain

There are basically 3 main steps involved to build a blue brain which are as follows:-

- Data Collection
- Data Simulation
- Visualization

4.1 Data Collection: This process involves microscopic study of each and every neuron by using Neurolucida software package that runs on windows workstation. In this process slices of living brain that are used for the reconstruction of the Neuronal 3D morphologies. For this project a 12 patch clamp instrument is used which studies the electrophysiological behaviour of neurons. The figure 4 shows the patch clamp technique that helps to collect the information of each neuron. During this process various information regarding each and every neuron can be gathered such as population density of neurons and synapses, connection between neurons and synapses, etc. This data helps to create a 3D model of neuron.

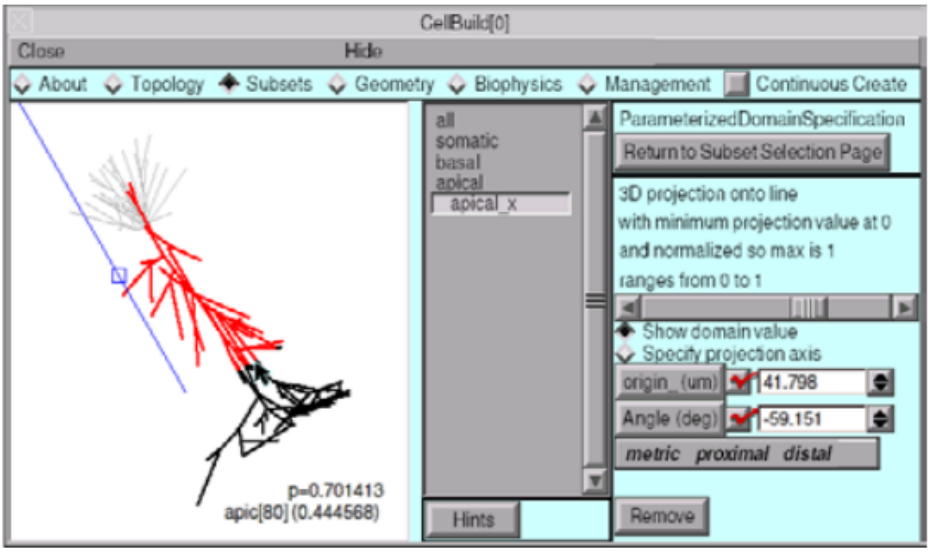


Source: https://www.epfl.ch

Fig 4: The 12 patch clamp

4.2 Data Simulation: For neural simulation a software package known as NEURON is used that was developed by Michael Hins. This software is written in languages like C, C++ and FORTAN by which we can study the cells using various algorithms and parameters. These algorithms and parameters are adjusted for the age, species and disease stage of animal being simulated. There are about a billion of proteins in one cell and each and every single protein is simulated. During this process first a network skeleton is built from the different kinds of synthesized neurons and then these cells are connected with each other as per the rules that they have been found experimentally. Finally neurons are functionalized and simulation brought to life.

Blue Brain Project-Software Development Kit
BBP-SDK is an open source software wrapped in Java and Python. This software uses C, C++ and FORTAN and the primary software used by this for neural simulations is NEURON. This kit helps the researchers to use and audit prototypes and simulations. It was developed by Michael Hins of Yale University and John Moore at Duke University in 1990s. In 2005, Michael Hins and BBP team ported the package into massive and parallel Blue Gene [4].



Source: Researchgate.net

Fig 5: Neuron Cell Builder Window

4.3 Visualization: RT Neuron is an ad-hoc software written specially for neural simulations. It is the main application that BBP project uses for visualization of neural simulations and not generalizable to other kinds of simulation. The Blue Brain Project team developed this software internally using C++ and OpenGL[5]. RT Neuron takes the output from Hodgkin-Huxley simulations as input in NEURON and produces them in 3D, making it easy for the programmers and researchers to view as activation potentials propagate through or between neurons. The animations can be postponed [6], paused, stopped, zoomed and started so that the researcher can then interact with the model. A 32-processor Silicon Graphics Inc. (SGI) system with 300Gb of shared memory is used for visualization of results and the visualizations are multiscale.

Source: https://www.epfl.ch

Fig 6: Visualization of Neuron

NeuroMorphoVis: NeuroMorphoVis is a framework that allow neuroscientists to build, visualize and analyze digital reconstructions of neuronal morphology skeletons that are extracted from optical microscopy stacks. King Abdullah University of Science and Technology (KAUST) boosted NeuroMorphoVis by the CRG grant number 2131. It comes with an interactive and user-friendly interface that allow scientists to visually examine and validate regenerated neuronal morphologies. The tool provides various techniques for visualizing morphology skeletons either as a stream of connected lines or as a disconnected set of sections to facilitate debugging the connectivity of the morphology. It also provides the ability to construct highly realistic 3D neuronal somata on a physically plausible basis, even with classical morphology skeletons that do not have any 3D data of their somata. This strategy uses the physics engine of Blender relying on Hooke's law and mass spring models. NeuroMorphoVis provides neuroscientists with a *robust, interactive* and *multi-purpose* toolset that would allow them to sketch, visualize, analyze and repair the morphologies like never before [7].

5. How do Neurons process information?
The roadmap of a single neuron for processing information is never the same. In a paper published in the journal Cell Reports, researchers at EPFL's Blue Brain Project, a Swiss Brain Research Initiative, have developed a new structure to work out how a single neuron in the brain administers. The survey was performed using cells from the Blue Brain's virtual rodent cortex. To operate in the similar way, the researchers assume other types of neurons – non-cortical or

human. Their conclusions show that when a neuron receives input, the branches of the elaborate tree-like receptors extending from the neuron, known as dendrites, functionally work together in a way which is adjusted to the convolutions of the input. The power of a synapse shows how strongly a neuron feels an electrical signal coming through other neurons, and thus the behaviour of learning changes this strength. By examining the "connectivity matrix" that determines how these synapses interact with each other, the algorithm establishes when and where synapses group into independent learning units from the structural and electrical characteristics of dendrites [7].

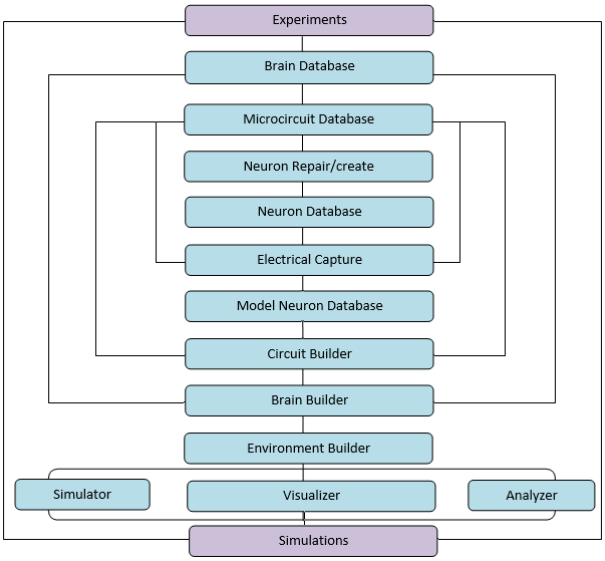


Fig 7: Flow chart of brain simulation by using neural network

On the other hand, the new algorithm shows how the dendrites of neurons functionally divide up into separate computing units and finds that they work together dynamically, depending on the work pressure, to process and manage information. The analyst liken their results to the functioning of computing technology already applied on 12.07.2019. This newly observed dendritic functionality behaves like parallel computing units which means that a neuron is able to process different aspects of the input in parallel, like supercomputers. Every parallel computing unit can independently learn to adjust its output, much like the nodes in deep learning networks used in artificial intelligence (AI) models today. Similar to cloud computing, a neuron dynamically splits up into the number of separate computing units demanded by the work pressure of the input. "In this Project, this mathematical tactic helps to ascertain functionally applicable clusters of neuronal input which are inputs that feed into the identical parallel processing unit. This then permit us to work out the extent of complication at which to model cortical networks as we digitally reconstruct and simulate the brain," explains Marc-Oliver Gewaltig, Section Manager in Blue Brain's Simulation Neuroscience Division.

6. Neuron_Reduce: A fresh tool to facilitate complex neuron models

'Neuron_Reduce' might even be a replacement process tool that offers the scientific community with a straightforward capability to alter complicated vegetative cell models of any cell sort and still reliably preserve its input-output properties whereas considerably reducing simulation run-time. Reduced models of neurons and networks type a link between the extremely elaborated models capturing minute experimental info and so the easier models that lend themselves a lot of simply to theoretical interpretation at the worth of missing crucial details. These bridging models considerably scale back the number of computation time conjointly as storage that ar required for elaborated vegetative cell models (and the networks they form) and cause quicker simulation time and a much bigger somatic cell circuits that will be simulated. Neuron_ Reduce could also be a replacement analytical tool that offers a singular multi-cylindrical reduced model for complicated nonlinear vegetative cell models, each in terms of reducing the morphological quality and reducing process time. The tool analytically maps the elaborated nerve fibre tree into a reduced multi-cylindrical tree, supported Rall's cable theory and linear circuit theory. Synapses and particle channels are appointed to the reduced model serving to their transfer electrical resistance to the soma (cell body); synapses with similar transfer electrical resistance are incorporated into single vegetative cell method all the whereas holding their freelance activation times. Prof. Idan Segev, David & Inez Myers professor in process neurobiology and head of the Department of biology at the Hebrew University of Jerusalem (HUJI) explained that Neuron_Reduce could also be a big innovation in analytically modelling nerve fibre computations. "The decisive reduced model controls Associate in Nursing large set of sub threshold and suprathreshold characteristics of the difficult model, as well as the identification of every stem dendrites, their biophysical properties conjointly because the standing of individual synapses and therefore the sort of excitable particle channels, and it enhances the process speed of the model by tons of folds," Segev enthuses. one of the key advantage of the reduction algorithmic rule, conjointly exhibiting its solidity, is that it preserves the magnitude of the transfer electrical resistance from every nerve fibre location to the soma. Oren Amsalem, biologist at the Hebrew University of national capital explains why it is so crucial, "since in linear systems the transfer electrical resistance is reciprocal, Neuron_Reduce conjointly preserves the transfer electrical resistance at intervals the somato-dendritic direction for passive nerve fibre trees. for example, Associate in Nursing injection of current at the soma can finish within the same voltage response at the individual nerve fibre sites at intervals the elaborated and reduced models, so conserving the biface communication between the soma and therefore the dendrites," Amsalem confirms [7].

7. Funding

The project is funded primarily by Swiss Government and therefore the Future and Emerging Technologies (FET) Flagship grant from the European Commission, and secondarily by the grants and donations from private individuals. The EPFL purchased the Blue Gene computer at a lesser cost because it had been still a prototype and IBM was curious about examining how applications would perform on the machine. BBP was marked as a validation of the Blue Gene supercomputer notion.

8. Hardware and Software Requirements

- Blue Gene/L mainframe (initially until 2009).
- Blue Gene/P (upgraded from Blue Gene/L and brought in use until 2011).
- JuQUEEN (Blue Gene/Q upgraded from Blue Gene/P in

2012 with additional racks and presently performs at over one.7 Petaflops).
- 22.8 TFLOPS peak process speed.
- 8096 CPUs at 700MHz (downgraded to handle huge parallel processing).
- 256MB to 512MB memory per processor.
- Linux and C++ software package.

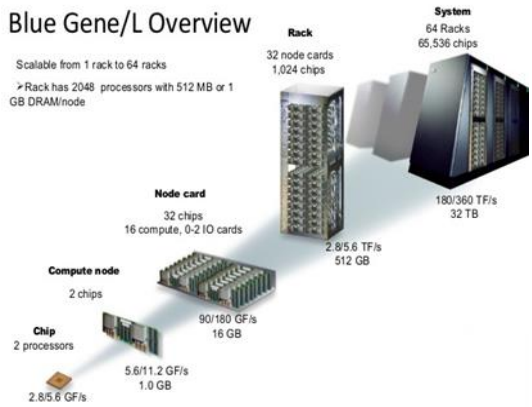
- 100 kilowatts power consumption.
- Very powerful Nanobots to act because the interface between the natural brain and therefore the laptop. • A program to convert the electrical impulses from the brain to signalling that is to be received by the pc, and the other way around.

9. Advantages and Disadvantages

Advantages	Diadvantages
1. One can remember and recollect anything without any effort. 2. Decision can be made by the computer without the presence of a person. 3. Used to know and understand the communication between animals and to study more about them. 4. Good remedy for deaf persons as well as for many more psychological disorders. 5. Helpful for Polygraph testing.	1. Increased risk of dependency of a person on this technology all the time. 2. Computer viruses will increase the risk of hacking. Data could be manipulated and used in a wrong way. 3. This may lead to human cloning and it'll increase the risk of machines conducting war against humans and we cannot imagine how big this threat would be against nature.

Source: http://curiosity.discovery.com/question/blue-

Fig 8: JuQUEEN



Source: https://bluebrain.epfl.ch/

Fig 9: Blue Gene/L Supercomputer

10. Conclusion

Concisely, the Blue Brain Project is an endeavour to reverse engineer the human brain and reform it at molecular level within a theoretical account. The mixture of biological and digital technologies would supply an impetus for the general growth and development. However, it'd be a lot of possible if this technology is completely developed for the treatment of chronic and psychological feature neurologic disorders because it would actually convince be magic within the field of medication. As aforesaid by Henry Markam (director of the Blue Brain Project), "As with Deep Blue, Blue Brain can permit North American nation to challenge the foundations of our understanding of intelligence and generate new theories of consciousness."

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