The Blue Brain Technology: Study and Application Review

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Abstract — Since the beginning of time the human brain has been the ultimate source for new information and ideas, that needs to be archived which is lost with time. With the advancements in sciences we are able to conduct this by the technology of Blue Brain to convert real mind data into virtual supercomputer memory. In this paper I discuss on the Blue Brain Project and its strategies, requirements, advantages and limitations. Also, further we discuss its future applications in which the technology can be used after further development of this technology.

*Keywords-*Blue Brain, Supercomputer, Artificial Intelligence,Neurocomputing, Blue Brain Project, Blue Gene Supercomputer.

I. INTRODUCTION

Undoubtedly the human brain and its functioning is the most complex systems in the universe with nearly 85.5 billion neurons which communicate through the releasing and detecting of chemicals known as neuro-transmitters. The Blue Brain Project as the name suggest is a project to blueprint an actual functioning Human Brain. In simple words, it is an attempt to establish and integrate a connection between a real human brain and a virtual super computer brain and further its storage. This project was founded in 2005 at École Polytechnique Fédérale de Lausanne (EPFL), Switzerland to study the working and simulation of a human brain. Further this technology is supported by IBM's Blue Gene Supercomputer which help in computing the working of an actual brain.

Brain supercomputing and simulation is undoubtedly a vast subject spreading its applications and research in inter-disciplinary fields like Brain Imaging, Neuroscience, Computer Science, Nanotechnology, Artificial Intelligence, Biotechnology, Mechatronics, Psychology, Philosophy and many more. It has further many future applications like mind uploading, scanning and transferring and also analytics and decision making sytems that are self-evolving and independent.

For example, IBM's Deep Blue Computer was the first prototype on the Blue Brain tecnology to defeat (eventually beat) Garry Kasparov at chess which was not just the work of a simple algorithm-based program but with the memory of past games to evolve the computer into a tougher competition.

The outline of the paper ahead is Building of a Blue Brain in Section II. In Section III, we discuss its Advantages and Limitations. Further, the future applications of this technology are explained in Section IV.

Section V concludes the paper and all the necessary references for this paper are explained in Section VI.

II. BUILDING A BLUE BRAIN

The steps for building a working prototype or creating a simulation of a virtual synthetic brain can be majorly divided into 4 main sections, i.e.

A. Data Collection

This step involves taking an actual brain portion under a microscope to understand and reverse engineer its working by studying the shape and electrical behavior of different neurons and cataloguing them. Neurons can be catalogued by their shape, electrical and physiological activities, its location inside the cerebral cortex and its population density in the brain portion under study.

All This Data is then translated into its equivalent algorithms which describe the process, function and position methods of the neurons on the basis of its type. This data is then further converted into virtual neurons that are ready for simulation.

B. Data Simulation

The 3 main aspects of the simulation of this data string of neurons are:

- Simulation Speed: Currently the simulation of 1 cortical column (about 100-500 neurons) runs about 100 to 150 times slower than a real time human brain. That is, it takes the simulation about 3 minutes to complete a task a human brain could have done in 1 second. Thus, to advance and fasten the simulation speed we are researching the

biologically significant factors of the brain processing so as to remove the rest of the part from the simulation making it faster in performance.

- Simulation Technique: The simulation technique in practice is firstly, building of skeleton from the different kinds of synthesized neurons found. After this, these skeletons are joined as per the experimental rules and test aim. Finally, these neurons are given its respective functionalities and properties thus making the simulation active. Later, these resultant blueprints are viewed and experimented on through a visualization software and the algorithms for a blue brain can be tested on this software.

- BBP-SDK: BBP-SDK stands for Blue Brain Project – Software Development Kit. It is a development software in C++ library SDK packed inside Java and Python which uses C, C++ and FORTRAN and is freely available on the internet using a primary software NEURON. This SDK allows researchers to audit and test different simulations and prototypes of a Blue Brain.

C. Visualization of the Results

RT Neuron is an available application for visualizations of neural simulation results. It is an ad-hoc software written specially for neural simulations, coded using C++ and OpenGL. It is one of the best software available as it allows researchers to not only visualize but pause, stop, restart, zoom and interact with the transmitted 3D model and is multi-scaled i.e. it can be used to study 1 neuron or even 1 cortical column.

D. Hardware

- Till 2009, IBM's Blue Gene/L Supercomputer was used.

- Till 2011, IBM's Blue Gene/P Supercomputer was used. This supercomputer had more than 4000 PowerPC Quad nodes of 4.5 or 8.5 Ghz. It had a disk space of 1 PetaByte and more than $6*〚10〛^{13}$ flops that total to a 15TB memory and runs on Linux SuSE SLES 10 operating system.

- Currently IBM's Blue Gene/Q Supercomputer is used which was upgraded in 2012 and is ranked 8th in the world in terms pf speed.

III.   ADVANTAGES AND LIMITATIONS

A. Advantages of Blue Brain Technology

- It acts as a supercomputer improving its processing speed and memory allocation.

- It can be helpful in storing, accessing and even deleting particular data memory from and to a real human brain.

- It can make its own decisions and thus evolve its interface as per specific user's requirements and also decrease the machine factor in a decision-making process.

- With advancements it may be used for faster decision making in critical situations.

B. Limitations of Blue Brain Technology

- The dependency on the human brain decreases and will increase our dependency on machines.

- After a machine is made self-learning, the reliability on such systems is still a question.

- Since it can store and edit a real human brain, the risk of mind hacking is possible which means there can be algorithms made for affecting a real human through this technology.

- Even the slightest of calculation error or technical error in a supercomputer can cause an adverse effect in the real world.

IV.   FUTURE APPLICATIONS

After the release of such technology there can be advancements in many other fields where this technology's growth can be a catalyst.

A. Artificial Intelligence

With development in Blue Brain technology we can easily relate the advancements in Artificial Intelligence as we would no more have to derive and code complex algorithms for a machine to make decisions instead we will have a machine which can make more intelligent decisions once it starts thinking like a human being which can find its applications in many sectors of technology like Man-less vehicle navigation, Automatic defense systems and different types of researches and analytics.

B. Psychology

With the ability to access a real human's brain and the access to edit and read it we can further help treat many psychological problems by simple replacing, erasing of memories and also it will be easier for doctors to understand and calculate the amount of trauma an event might have caused.

C. Inter-Species Communication

With developments in this technology there can be applications in conversion of brain data into binary bits

inside a computer memory. This process can not only help us understand the thoughts of an individual human being but also understand the thoughts and access different parts of brain memory of different organisms helping us establish an inter-species communication.

D. Treatments of some permanent disabilities

Some natural disabilities like the ability to listen sounds or vision can be repaired as we can replace an electronic system which capture images or sound from the surrounding and converts it into a format more suitable for the human brain thus bypassing the original error cause by the natural neurons in that particular location.

E. Security and Military

This technology can be widely used a decision maker for military purposes thus decreasing the on-field death casualties caused. Also, it can be used as a technology for a lot of unmanned technologies like drones and missiles as it can accept data and process it in a much-advanced order.

CONCLUSION

This paper presented the working, functioning and architectural properties of an experimental technology i.e. Blue Brain Project started in 2005. Also, further we understand its advantages, limitations and future applications with the current status of IBM's supercomputers used to compute such prototypes and simulations. Also, we understand the current software in use for practice of this technology. Thus, the Blue Brain Technology is surely a big advancement in science as it helps us create a system with consciousness that is self-learning and evolving with every string of instruction processed and further will have the capability to think like a real human brain and communicate with one to access and edit real time brain data inside a human being's brain.

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Mr Harsh Ghelani is the final year student enrolled *at KJ Somaiya College of Engineering, Mumbai* for the course of Undergraduate degree in technoloogy. He is actively involved in research and industrial projects and extra-curricular courses in cryptography, data mining, finance and power electronics.