A Review on Application and Challenges of Blue Brain Project

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Abstract- *Man is said to be the most wonderful creation of the God. But, has anyone wondered what makes him different from all the other species. It is the human brain. This brain makes the man capable of doing all the activities which no other species is capable of. It would come as a surprise that researchers today are working to preserve the human brain even after its death. IBM is working on a project named Blue Brain which is said to be a human brain in a supercomputer.*

The main approach is to have an actual brain inside a virtual brain which could work, respond, contemplate and take decisions just like any other normal brain is capable of doing. Idea is to create electrochemical interactions that occur inside a normal brain thereby eliminating any chances of brain disorders like autism, etc. Also, the main aim is to preserve the human brain after death so that the data, intelligence, personalities, feelings and memories of that person should not be lost [1].

Keywords- neurons, nanobots, computational modeling, supercomputers

I. INTRODUCTION

Today we are able to witness the development in the society because of the intelligence. But what if we want to use the intelligence of a man even after his death? Answer to that problem is having a virtual brain. Blue Brain project is an attempt to create a virtual brain through reverse engineering. By this we will be able to scan the natural brain and use the knowledge for further development of the society. The project involves studying slices of living brain tissue using microscopes and patch clamp electrodes. Data is collected about all the many different neuron types. This data is used to build biologically realistic models of neurons and networks of neurons in the cerebral cortex. The simulations are carried out on a Blue Gene supercomputer built by IBM [2].

1.1 History

The Blue Brain was launched on July 1, 2005 by the name "Blue Brain Project 1" by IBM and the Brain and Mind Institute in Ecole Polytechnique Federale de Lausanne, Switzerland. The director of this institute, Henry Markram is heading this project along with the co- directors Sean Hill and Felix Schurmann. The fundamental motive behind this ambitious initiative is the simulation of mammalian brain with biologically high level of accuracy, and eventually, study the steps involved in inception of biological level of intelligence with the aid of computing power of Blue Gene/L supercomputer which is a prototype of IBM [3].

1.2 Working

The functioning of blue brain basically involves the process of human brain uploading. The uploading is done with the use of small robots called Nanobots. These nanobots are so small that they can travel throughout our circulatory system. Thus, these robots can monitor the central nervous system by moving through the spine and brain and while still residing in the biological form, they act as an interface with the computer. In this way, nanobots will provide a complete readout of the connection by scanning the entire structure of brain. This information regarding the connection obtained, when input in the computer, could then continue to function like a human being. Hence, the data stored in the human brain will be uploaded in the computer.

The virtual brain is built using three main steps:

1. Data acquisition
2. Simulation
3. Visualization

Data acquisition- In this step, the 3D Neurological Morphologies are reconstructed by taking slices of the human brain. The data acquisition step is done on Windows workstation running Neurolucida software package. In order to study the electrophysiological behavior of neurons, a 12-patch clamp was invented for this project.

Simulation- In this step, a software called NEURON is used which is uses various algorithms to study the cells. This software is written in C, C++ and FORTRAN. Different algorithms are defined for simulation of different age and breed of the human beings. Blue Brain Project Software

Development Kit or BBP- SDK is then used to collect the data from the nanobots.

Visualization- For visualization of the results, the RT Neuron application is used. This application is written in C++ and openGL. Also, the animations can be stopped, started and zoomed [4].

Using these developments, an experiment was performed using a South American sparrow. A computer model of the bird's lungs was developed. Just as the bird sings forcibly through the folds of tissues, these impulses were transferred to the model which started singing like the bird. These European neuroscience project researchers conducted an experiment and published their first major result i.e. a digital imitation of circuitry in a sand grain-sized chunk of rat brain. The work models some 31,000 virtual brain cells connected by roughly 37 million synapses.

II. APPLICATIONS

This project has tremendous applications. The most important application is to gather and test data of up to 100 years. This can be achieved by providing a working model into which the past 100 years knowledge about the microstructure and workings of the neocortical column can be gathered and tested. The Blue Column's job will be to access all the research relating to the functioning and structure of the neocortex while producing a virtual library to explore in 3D the microarchitecture of the neocortex. Crackling of neural code is also one of the applications. How the object is built by the brain with the help of electrical patterns is known as the Neural Code. The NCC is the primary network used for computing in the neocortex. To know how the neocortex stores the information as well as process and reveals it there is a need to create a correct replica of the NCC that produces the electric dynamics of the real microcircuit.

One of the most Nobel uses of this blue brain project is in drug discovery for human brain disorders. If we comprehend the functioning of dissimilar elements of the NCC, it will be very helpful in exploring the cellular and synaptic bases of an array of psychiatric as well as neurological diseases. We can test the influence of ion channel, receptor, synaptic and cellular deficits in simulations. The optimal experimental tests can also be determined.

A replica of a NCC will allow researchers to explore hypothesis of brain function and dysfunction accelerating research. Simulation can be used to determine the parameters can be used and measured in the experiments. Having an advanced 2D and 3D immersive visualization system we will be able to study the "imaging" of many aspects of neural dynamics during processing, storage and retrieval of information. With the advent of computing technology, it seems that a mammalian brain cannot be simulated with entire cellular and synaptic complexity. In order to facilitate reconstruction of subcortical brain regions, NCC architecture's knowledge can be transferred and thus, constructing a foundation for complete brain simulation.

A precise cellular clone of the neocortical column will provide a gradual surge in model complexity stimulating towards a description of molecular level of the neocortex with simulation of biochemical pathways. The neocortical column is placed right at the interface between complex cognitive functions and genes. This level of simulation will become a reality with the most advanced phase of Blue Gene development [3].

III. ADVANCING THE BRAIN SCIENCES

This remarkable project by Henry Markram proves to be a next level of research that being done in the field of neuroscience. The technology that is adapted by this project is really very advanced. In the local microcircuits resting state, the persistence of neuronal firing is a big question in the project. But with reference to the perturbations of the neuronal connectivity, these resting states are invariant and stable. The data synthesis process of computing gives the outcome on its own and also tells about the gnome of cortical connectivity. Whether cortical neurons will be connected or not under the influence of oppositions of structure in the 3D space of the cortical column is one such instance. A detailed study of fundamental parameters of neurons and their morphological electric features is being studied under the Blue Brain Project at the most fundamental level of any species also known as a single cell level. A very good approach known as transcriptomics of a single cell is developed to reduce the lo w accuracy of single cell transcriptome sequencing due to fewer number of the transcript molecules. Lone cells taken from samples of homogenised brain from various areas are veneered in 96 well plates as single cells. Then we lyse them and alter the mRNAs with the help of terminal addition of a hexamer which is unique to each well. With the use of unique sequences of hexamer, following the process of reverse transcription, we pool, sequence and then sort the cDNAs into batches. These are the references for the subsequent steps. We identify the soma of cells under the microscope; determine the electric morphology for these cells which are"blown out" and then sequence the transcripts. Then we compare the profile of transcriptome with the standard library and then determine and associate the gCode of these transcriptomic cells with its electric morphology. This approach permits the project to link

the project evaluation and Human Brain project 8 gene expressions. Thus, helps in linking channel and receptor expression to other properties of each neuron class that is analyzed. Prediction of gamma oscillation in a single cortical column without gap junctions between the neurons is also the result of the significant study of the Blue Brain Project which shows the relevance of threshold-dependent activation and of NMDA receptors of the cortical column for gamma oscillations [5].

IV. CHALLENGES FOR BLUE BRAIN PROJECT

Researchers are facing some challenges during the smooth execution of Blue Brain project.

In Future there are some important advanced scientific questions for the blue brain project. Can the model be extended up to the state where with multiple cortical columns, whole lot of brain areas, and even the groups of connected brain areas? Approach of findings in a slice of cortex for enrichment be utilized? The Approach which is mainly based on findings in P10 (very young) rats be successfully extended to the rats which are older to them, in which their might be a possibility of modified cortical circuitry due to synaptic pruning?

According to the discovered details of cortical connectivity, can we produce some reduced computational models that grant the major functional operational properties to the cortical circuitry which is to be incorporated? So it will give a valuable bridge to the theoretical models of brain activity, in which the central aspects of the circuitry is towards quantitatively investigated for a particular computation.

The major budget was concentrated towards two components, acquisition personnel and new modern hardware. Advanced facility has a better state of the art machine the CADMOS IBM BlueGene/P. Additional machinery with 300GB of shared memory was included in an aging SGI machine. As per the thought upcoming plans for this project it is safe to consider that this facility needs to stay state-of-the-art. The group has huge expertise to drive the upcoming exascale data intensive computing and computing agenda in Switzerland and other parts of Europe at large scale, and the thought for the acquisition of new computing hardware are well justified. With advancing Science it is necessary to have an industrial strength towards science-software co-development. This project currently is under-staffed. Up scaling it is necessary that the project personnel rise to support both the engineering and administrative requirements [5].

To maintain top notch research and to assure the stability of the project certain strong initiatives must be taken. The first step is the proper creation of tenure track positions mainly for key research personnel, starting with Felix Schürmann and Sean Hill. Newly formed administration and engineering personnel, at the same time must take responsibility which is carried currently by Schürmann and Hill so that they can devote more time to carry out commensurate activities with their academic appointment.

One of the particular requirements is for the new team to support the circulation of curated tools and data among scientific community uptodate for at least time frame of 1 to 2 years, it is an aim of extremely importance as stated by the evaluation committee.

The final budget has to show both the acquisition of the new hardware as well as the recruiting to support the software development and the science in the project [6].

V. CONCLUSION

The research of the Blue Brain Project is a very innovative and unique in the area of neuroscience. Through this project it would be possible for us to scan our brain and preserve it even after the death. The only major concern regarding the project is the amalgamation of the biological and the digital technology. Still there is a long way ahead and it is hoped that by 2013 Henry Markram along with his team would be able to transform his dream into a reality.

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