Siddaganga Institute of Technology, Tumakuru

(An Autonomous institution affiliated to Visvesvaraya Technological University, Belagavi, Approved by AICTE, New Delhi, Accredited by NAAC and ISO 9001:2015 certified)

Technical Seminar Report

on " BLUE BRAIN TECHNOLOGY"

submitted
in the partial fulfillment of the requirements VII semester
Bachelor of Engineering
In
Computer Science and Engineering

by

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CERTIFICATE

This is to certify that technical seminar work entitled "Blue Brain Technology" is a bonafide work carried out by **Karthik Salera G.P(1SI18CS044)** of VII semester **Bachelor of Engineering in Computer Science and Engineering** of the **SIDDAGANGA INSTITUTE OF TECHNOLOGY** (An Autonomous Institution, affiliated to VTU, Belagavi, Approved by AICTE, New Delhi, Accredited by NAAC and ISO 9001:2015 certified) during the academic year 2021-2022.

Name of the Panel Members	Signature with Date
1. K Srinivasa	
2.	

ABSTRACT

Brain is one of the most unique and brilliant organ in the human body. Our brain gives us awareness of everything including ourselves and our environment. It controls movements of the muscles, the glands secretions, and even internal temperature and breathing. Every thought, reaction, and idea is developed by our brain.

The brain's neurons record all the memory of every action in our lives. The man is called "intelligent" because of brain but when the body is destroyed after the death, it is lost. Today scientists are in research to create a virtual brain. Here we describe how the intelligence can be preserved for thousands of years.

Blue Brain is an artificial brain which can think, take decisions, and respond as a natural brain. A super computer with high amount of storage capacity, processing power and an interface between the human brain and this virtual one can be used for creating it.

Today scientists are in research to create an artificial brain that can think, respond, take decision, and keep anything in memory. The main aim is to upload human brain into machine. So that man can think, take decision without any effort. After the death of the body, the virtual brain will act as the man. So, even after the death of a person we will not loose the knowledge, intelligence, personalities, feelings and memories of that man, that can be used for the development of the human society. Technology is growing faster than every thing. IBM is now in research to create a virtual brain, called "Blue brain". If possible, this would be the first virtual brain of the world. IBM, in partnership with scientists at Switzerland's Ecole Polytech- nique Federale de Lausanne's (EPFL) Brain and Mind Institute will begin simulating the brain's biological systems and output the data as a working 3-dimensional model that will recreate the high-speed electro-chemical interactions that take place within the brain's interior. These include cognitive functions such as language, learning, perception and memory in addition to brain malfunction such as psychiatric disorders like depression and autism. From there, the modeling will expand to other regions of the brain and, if successful, shed light on the relationships between genetic, molecular and cognitive functions of the brain.

Human brain is the most valuable creation of God. The man is intelligent because of the brain. "Blue brain" is the name of the world's first virtual brain. That means a machine can function as human brain. With the advancement in technology, human, the ultimate source

of information and discovery should also be preserved. In other words, human is does not live for thousands of years but the information in his mind could be saved and used for several thousands of years. Today scientists are in research to create an artificial brain that can think, response, take decision, and keep anything in memory. The main aim is to upload human brain into machine. So that man can think, take decision without any effort. After the death of the body, the virtual brain will act as the man .So, even after the death of a person we will not lose the knowledge, intelligence, personalities, feelings and memories of that man that can be used for the development of the human society.

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INTRODUCTION

The Blue Brain project is the first comprehensive attempt to reverse-engineer the mammalian brain, in order to understand brain function and dysfunction through detailed supercomputer-based reconstructions and simulations. The project aims to build comprehensive digital reconstructions of the brain which can be used to study the nature of the brain. This, in turn, helps in understanding how human beings process emotions, thoughts, and gives us deeper insight into the decision making power of the human brain.

Today scientists are carrying out research to create an artificial brain that can think, respond, take decisions and store information. The main aim is to upload a human brain into the computer, so that it can think, and make decisions without the presence of a human body. After death, this virtual brain can act as the man. So, even after the death of a person, we will not lose the knowledge, intelligence, emotions, and memories of a person and this can be used for various situations like to continue the pending work, to decide on something based on his/her area of expertise etc.

The human brain is a complex system consisting of recursive connectors. It is more complex than any circuitry in the world. The human brain is a multi-level system with 100 billion neurons (nerve cells) and 100 trillion synapses. A neuron is a cell designed to transmit information to other nerve cells, muscle, or gland cells whereas synapses help neurons to communicate with each other.So, the question may arise, is it really possible to create a human brain? The answer is Yes. Today it is possible because of advancement in technology. The world of technology has expanded in areas like humanoid robots, computing, virtual reality, wearable devices, Artificial Intelligence, Digital jewelry, Blue Eyes Technology, BrainGate Technology and so much more at a rapid rate. A full human brain simulation (100 billion neurons) is planned to be completed by 2023 if everything goes well. If so, this would be the first virtual brain of the world.

A virtual brain is an artificial brain. It can think like the natural brain, take decisions based on the past experience, and respond as the natural brain can. It is possible to do so by using supercomputers, with a huge amount of storage capacity, processing power and an interface between the human brain and this artificial one. Through this interface, the data stored in the natural brain can be uploaded into the computer. So the brain and the

knowledge, intelligence of anyone can be preserved and used forever, even after the death of the person.This BLUE BRAIN project was founded in May 2005 by Henry Mark ram at the EPFL in Lausanne, Switzerland. Goals of the project are to gain a complete understanding of the brain and to enable better and faster development of brain disease treatments. The research involves studying slices of living brain tissue using microscopes and patch clamp electrodes. Data is collected about all the many different neuron typesthis 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, hence the name "Blue Brain". The simulation software is based on Michael Hines's NEURON, together with other custom-built components.

LITERATURE SURVEY

- **207. Colombo, G., Cubero, R. J. A., Kanari, L., Venturino, A., Schulz, R., Scolamiero, M., Agerberg, J., Mathys, H., Tsai, L.-H., Chachólski, W., Hess, K., & Siegert, S. (2021). Microglial MorphOMICs unravel region- and sex-dependent morphological phenotypes from postnatal development to degeneration. *bioRxiv*, 1 December 2021. http://biorxiv.org/lookup/doi/10.1101/2021.11.30.470610**

  Microglia contribute to tissue homeostasis in physiological conditions with environmental cues influencing their ever-changing morphology. Strategies to identify these changes usually involve user-selected morphometric features, which, however, have proved ineffective in establishing a spectrum of context-dependent morphological phenotypes. Here, we have developed MorphOMICs, a topological data analysis approach to overcome feature-selection-based biases and biological variability. We extracted a spatially heterogeneous and sexually-dimorphic morphological phenotype for seven adult brain regions, with ovariectomized females forming their own distinct cluster. This sex-specific phenotype declines with maturation but increases over the disease trajectories in two neurodegeneration models, 5xFAD and CK-p25. Females show an earlier morphological shift in the immediately-affected brain regions. Finally, we demonstrate that both the primary- and the short terminal processes provide distinct insights to morphological phenotypes. MorphOMICs maps microglial morphology into a spectrum of cue-dependent phenotypes in a minimally-biased and semi-automatic way easy accessibility. All data are managed via the EBRAINS Knowledge Graph, thereby helping maintain data provenance, and enabling tight integration with tools and services offered under the EBRAINS ecosystem.

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Human Brain is the most complicated creature on earth that will be demolished after certain decay of years. This research paper is based on the theoritical concept -"How its intelligence can be preserved for future use and what methodology is used for preserving it. It also dicussed about its merits, demerits and lots of other things that we can do with it.

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Blue Brain Project focuses on building biologically detailed equipments and simulations of the rats, and ultimately the human brain. The supercomputer-based constructions and simulations provides a radically new way to understand the detailed structure and process of the brain. The project's strategy exploit interdependencies in the experiment's data to access dense maps of the brain, without measuring every element of its multiple levels of association. This strategy allows the project to build digital remodelling of the brain at an unprecedented level of biological detail. The working of human brain basically has three sub processes, they are: Sensory Input, When we see something or our touch a warm surface, the sensory cells or Neurons, convey a piece of information straight to the brain. Integration, is also known as the interpretation of things we have sensed, tasted and touched with our sense organs, into responses that the body identifies. Many neurons work together and understand the environment to accomplish this process in the brain. Motor output, Once our brain has interpreted everything then it conveys a message through neurons to effecter cells, muscle or gland cells, which essentially work to perform our requests and act upon our environment.

The brain transfer technology is executed by two techniques namely, Copy and transfer and Slow and relentless substitution of neurons. In the past, it is accomplished by doing with the following 3 steps Firstly examining, controlling and differentiating the cerebrum components. And secondly, duplicating, moving, storing data into computer . Now human brain is altered into the humanoid robots or in an organic body. According

to the author, we see that the focus is on the simulation method of the collected data. It is basically divided into two parts, simulation speed and simulation workflow. Simulation speed: Simulations of every cortical column execute about two hundred times slower than actual time. For one second of simulation time 5 minutes of actual time is taken. After understanding biologically important factors for a given effect it might be possible to crop constituents that don't finance in order to progress with performance. Simulation workflow: Algorithms and constraints are modified according to the disease stage of the animal being simulated, age and species. Every protein is simulated where there are millions of proteins in one cell. Taking forward the IBM tradition the Blue Gene evolved in the new era of high-performance computing. A brand new complicated multi-level schema and function of the human brain is provided by BBP.

PROBLEM STATEMENT WITH OBJECTIVES

Problem Statement:

Blue Brain Technology is used in many ways to store the memories of a human being, to cure a disease like parkinsons and many incurable diseases to cure and I am discussing all the advantages of this.

Objectives:

The Blue Brain Project is the First comprehensive attempt to reverse-engineer the mammalian brain, in order to understand brain function and dysfunction through detailed simulations. The mission in undertaking The Blue Brain Project is to gather all existing knowledge of the brain, accelerate the global research effort of reverse engineering the structure and function of the components of the brain, and to build a complete theoretical framework that can orchestrate the reconstruction of the brain of mammals and man from the genetic to the whole brain levels, into computer models for simulation, visualization and automatic knowledge archiving by 2015.

The main intention of this Blue Brain project is to review the purposeful principles of brain moreover as its construction in supercomputer and enables quick treatment of brain related diseases like Parkinson's disease. C. Could it be possible to create an artificial brain and stimulate it to think, feel and experience the world as 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 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.

Simulation neuroscience is an approach to mapping the brain. It is not feasible to map every detail of the brain experimentally because, there are too many parts (over 20,000 genes, more than 100,000 different types of proteins, more than a trillion organic molecules in a single cell, nearly 100 billion neurons, up to 1,000 trillion synapses and over 800 different brain regions in the human brain), too many complex relationships between all these parts, and then too many variations of the brain; across individuals, genders, age, and species. Working out how to generically fill the gaps of our knowledge from sparse data and fundamental principles is the

fundamental challenge, which will allow one to build and obtain a detailed map of any brain in the distant future.

By around 2024, the Blue Brain Project aims to have reached a cellular-level model of an entire mouse brain. It will be a first draft at the cellular-level of detail. In other words, a digital model with all the neurons (around 100 million), most of the types of neurons (around 1,000 different types) in the morphological detail (with all their tree like branches) and most of the synapses that they form (around a trillion).

Main objective behind Artificial brain is to establish a connection in between human brain and artificial brain so that machine can work like a human brain and important content of humans like knowledge, feelings, memories of a person be downloaded to artificial brain by applying high computational algorithms using supercomputers with large storage facilities which can be used forever for different purposes until erased.

DESIGN AND IMPLEMENTATION

Data Collection

It involves collecting brain portions, taking them under a microscope, and gauging the shape and electrical behavior of neurons individually. This method of studying and cataloguing neurons is very familiar and worldwide. The neurons are captured by their shape, electrical and physiological activity, site within the cerebral cortex, and their population density. These observations are translated into precise algorithms which describe the process, function, and positioning methods of neurons. Then, the algorithms are used to generate biologically-real looking virtual neurons ready for simulation.

Data Simulation

The simulation step involves synthesising virtual cells using the algorithms that were found to describe real neurons. The algorthims and parameters are adjusted for the age, species, and disease stage of the animal being simulated. Every single protein is simulated, and there are about a billion of these in one cell. First a network skeleton is built from all the different kinds of synthesised neurons. Then the cells are connected together according to the rules that have been found experimentally. Finally the neurons are functionalised and the simulation brought to life. The patterns of emergent behavior are viewed with visualisation software.

The Blue Brain SDK is a C++ library wrapped in Java and Python. The primary software used by this for neural simulations is NEURON.This software models neuronal cells by modeling fluxes of ions inside and outside the cell through different ion channels. These movement generate a difference of electrical potential between the interior and the exterior of the neuronal membrane, and modulations of this potential allows different neurons to communicate between each other. Michael Hines of Yale University and John Moore at Duke University developed this in the starting of the 1990s.It is freely available open source software. The website makes everything available including the code and the binary data freely. Michael Hines in cooperation with BBP team in 2005 ported the package into the massive and parallel Blue Gene.

The primary machine used by the Blue Brain Project is a Blue Gene supercomputer built by IBM. This is where the name "Blue Brain" originates from. IBM agreed in June 2005 to supply EPFL with a Blue Gene/L as a "technology demonstrator". The IBM press release did not

disclose the terms of the deal. In June 2010 this machine was upgraded to a Blue Gene/P. The machine is installed on the EPFL campus in Lausanne (Google map) and is managed by CADMOS (Center for Advanced Modelling Science). Blue Gene/P technical specifications:

- 4096 quad-core nodes (16,384 cores in total)
- Each core is a PowerPC 450, 850 MHz
- Total: 56 teraflops, 16 terabytes of memory
- 4 racks, one row, wired as a 16x16x16 3D torus
- 1 PB of disk space, GPFS parallel file system
- Operating system: Linux SuSE SLES 10
- Public front end: bluegene.ep.ch and processing log

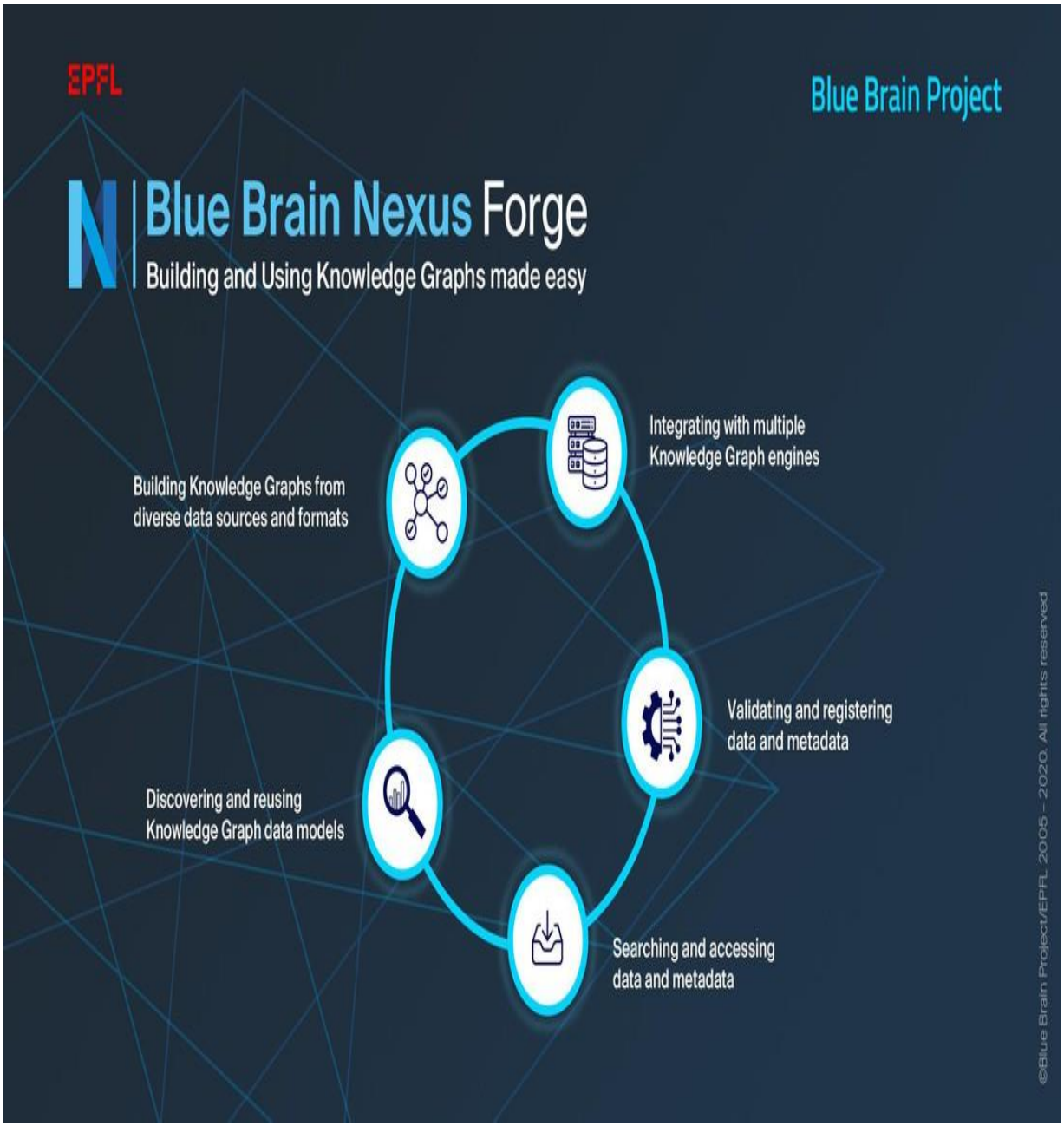
Blue Gene :

Blue gene is the primary hardware used in the Blue Brain Project built by IBM. On June 2005 IBM agreed to supply the blue gene super computer to EPFL. It is installed in EPFL at Lausanne and managed by CADMOS (Centre for Advanced Modeling Science).This super computer is used by number of research group for computing and brain simulation. The brain simulation is done one day per week and the rest of the day the data is gathered and cells are studied so that new things could be found out that would help in their research and also in analyzing all the data gathered.

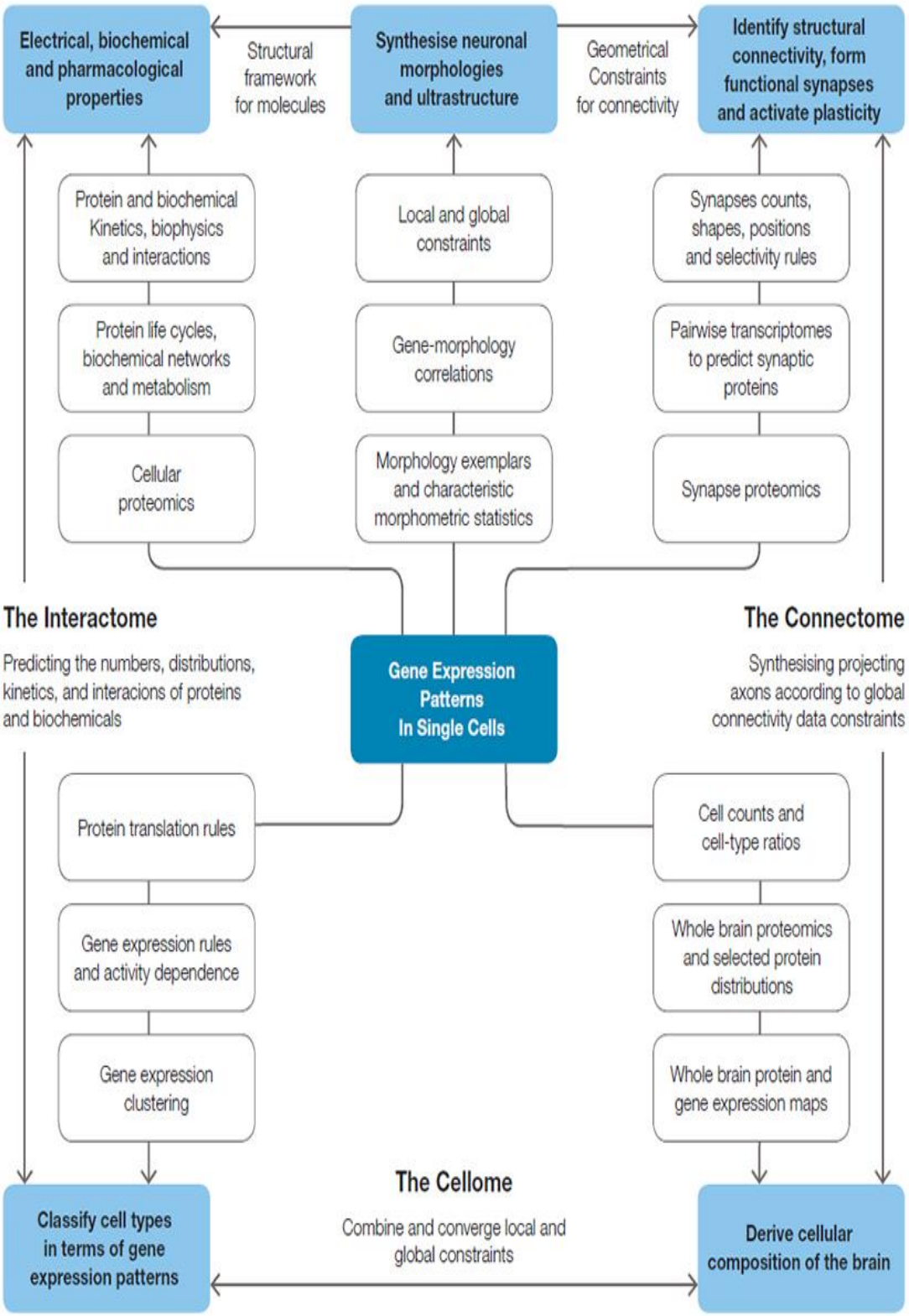
Silicon Graphics:

Silicon Graphics Inc. (SGI) 32 bit-processor with 300 Gb of shared memory is used in visualization of results. It helps in studying the working of the neurons. It is also used in storing the state so that it could be used to remember things. It acts as an artificial neuron in the blue brain technology.In the visualization the 3D model of the neurons is created such that the researchers can use this to study the structure and working of neuron. For this scientist uses a software known as RT Neuron. This software was created by BBP development team. This software is very useful for the researchers to study the functioning of the neurons and synopses. One of the example of the visualization software is RT Neuron. RT NEURON is the application used by Blue Brain project for visualization of the neural simulations. It is coded using in C++ and OpenGL by the BBP team internally. It is an ad-hoc software developed specially for neuron simulation. RT Neuron takes output of Hodgkin-Huxley simulations as an input in

NEURONS and delivers them in 3D. this also helps researchers & programmer to view as activation potentials propagate between neurons. This 3D model can be stopped, paused & start to completely study the neurons.

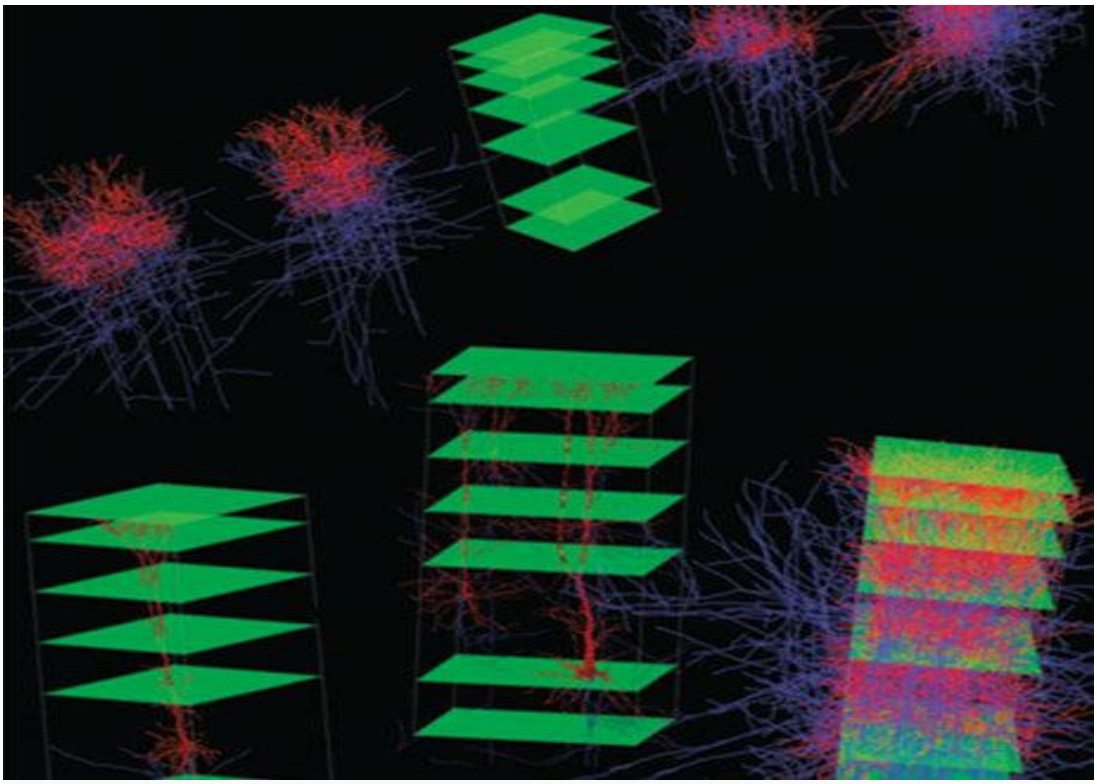


Building brains based on genes



The scheme shows the minimal essential building blocks required to recon- struct a neural microcircuit. Microcircuits are composed of neurons and synaptic connections. To model neurons, the three-dimensional morphology, ion channel composition, and distributions and electrical properties of the different types of neuron are required, are composed of neurons and synaptic connections. To model neurons, the three-dimensional morphology, ion channel composition, and distributions and electrical properties of the different types of neuron are required, as well as the total numbers of neurons in the microcircuit and the relative proportions of the different types of neuron. To model synaptic connections, the physiological and pharmacological properties of the different types of synapse that connect any two types of neuron are required, in addition to statistics on which part of the axonal arborization is used (presynaptic innervation pattern) to contact which regions of the target neuron (postsynaptic innervations pattern), how many synapses are involved in forming connections, and the connectivity statistics between any two types of neuron.

Reconstructing the neocortical column:



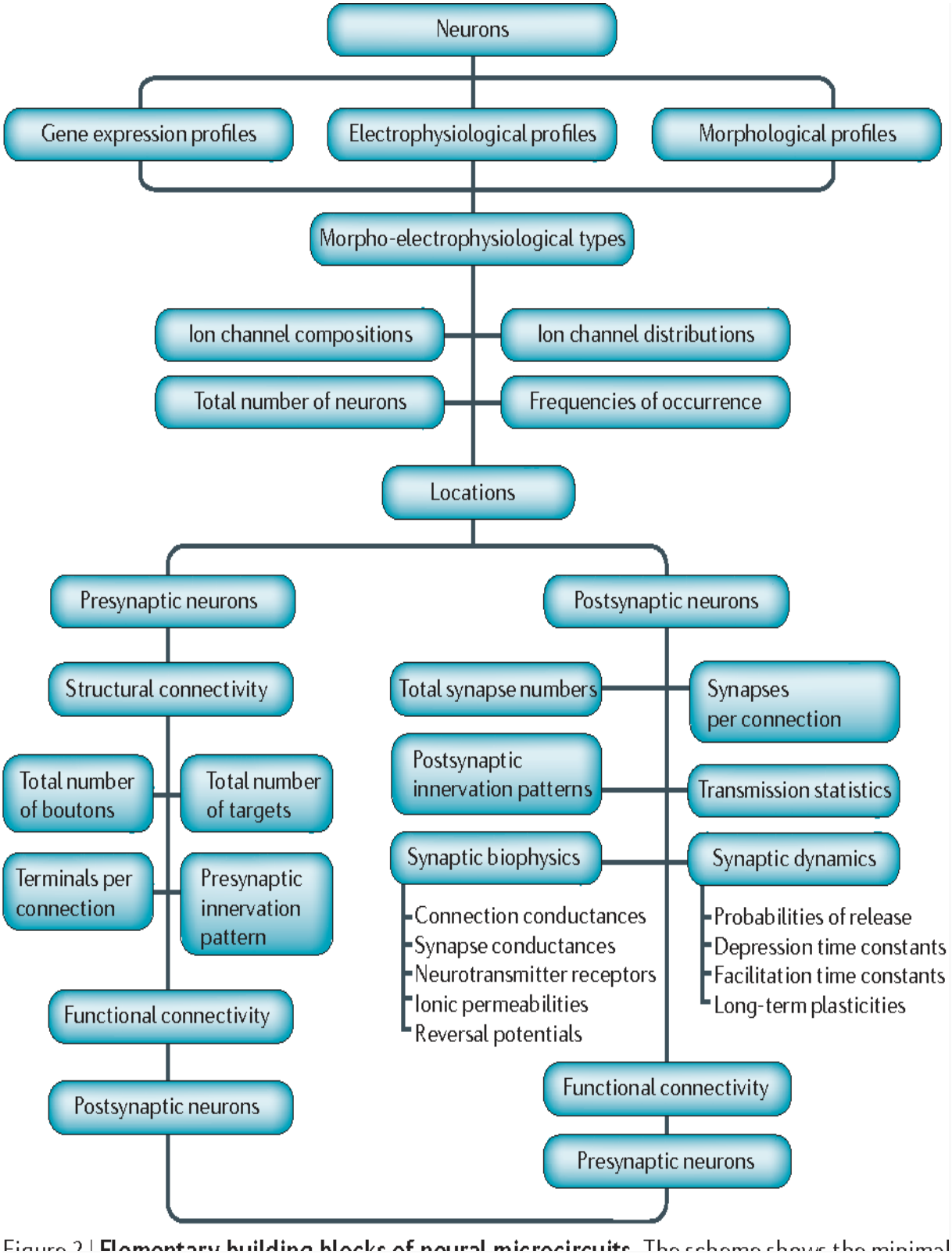


Figure 2 | **Elementary building blocks of neural microcircuits.** The scheme shows the minimal

Neurons receive inputs from thousands of other neurons, which are intricately mapped onto different branches of highly complex dendritic trees and require tens of thousands of compartments to accurately represent them. There is therefore a minimal size of a microcircuit

and a minimal complexity of a neuron's morphology that can fully sustain a neuron. A massive increase in computational power is required to make this quantum leap - an increase that is provided by IBM's Blue Gene supercomputer. By exploiting the computing power of Blue Gene, the Blue Brain Project1 aims to build accurate models of the mammalian brain from first principles. The first phase of the project is to build a cellular-level (as opposed to a genetic- or molecular-level) model of a 2-week-old rat somatosensory neocortex corresponding to the dimensions of a neocortical column (NCC) as defined by the dendritic arborizations of the layer 5 pyramidal neurons. The combination of infrared differential interference microscopy in brain slices and the use of multi-neuron patch- clamping allowed the systematic quantification of the molecular, morphological and electrical properties of the different neurons and their synaptic pathways in a manner that would allow an accurate reconstruction of the column. Over the past 10 years, the laboratory has prepared for this reconstruction by developing the multi-neuron patch- clamp approach, recording from thousands of neocortical neurons and their synaptic connections, and developing quantitative approaches to allow a complete numerical breakdown of the elementary building blocks of the NCC. The recordings have mainly been in the 14 to 16-day-old rat somatosensory cortex, which is a highly accessible region on which many researchers have converged following a series of pioneering studies driven by Bert Sakmann. Much of the raw data is located in our databases, but a major initiative is underway to make all these data freely available in a publicly accessible database. The so-called 'blue print' of the circuit, although not entirely complete, has reached a sufficient level of refinement to begin the reconstruction at the cellular level. Highly quantitative data are available for rats of this age, mainly because visualization of the tissue is optimal from a technical point of view. This age also provides an ideal template because it can serve as a starting point from which to study maturation and ageing of the NCC. As NCCs show a high degree of stereotypy, the region from which the template is built is not crucial, but a sensory region is preferred because these areas contain a prominent layer 4 with cells specialized to receive input to the neocortex from the thalamus; this will also be required for later calibration with in vivo experiments. The NCC should not be overly specialized, because this could make generalization to other neocortical regions difficult, but areas such as the barrel cortex do offer the advantage of highly controlledin vivo data for comparison.

RESULT ANALYSIS

The uploading is possible by the use of small robots known as the Nanobots .These robots are small enough to travel throughout our circulatory system. Travelling into the spine and brain, they will be able to monitor the activity and structure of our central nervous system. They will be able to provide an interface with computers that is as close as our mind can be while we still reside in our biological form. Nanobots could also carefully scan the structure of our brain, providing a complete readout of the connections. This information, when entered into a computer, could then continue to function as us. Thus the data stored in the entire brain will be uploaded into the computer.

With the blue brain project the things can be remembered without any effort, decisions can be made without the presence of a person. Even after the death of a man his intelligence can be used. The activity of different animals can be understood. That means by interpretation of the electric impulses from the brain of the animals, their thinking can be understood easily. It would allow the deaf to hear via direct nerve stimulation, and also be helpful for many psychological diseases.

Detailed, biologically accurate brain simulations offer the opportunity to answer some fundamental questions about the brain that cannot be addressed with any current experimental or theoretical approaches. Understanding complexity At present, detailed, accurate brain simulations are the only approach that could allow us to explain why the brain needs to use many different ion channels, neurons and synapses, a spectrum of receptors, and complex dendritic and axonal arborizations.

APPLICATIONS:

1. Gathering and Testing 100 Years of Data.
2. Cracking the Neural Code
3. Understanding Neocortical Information Processing
4. A Novel Tool for Drug Discovery for Brain Disorders
5. A Global Facility

6. A Foundation for Whole Brain Simulations

7. A Foundation for Molecular Modeling of Brain Function

FUTURE SCOPE OF ADVANCE AI:

Blue Brain is a futuristic technology. For doing it we will first have to upload human brain to the targeted super computer. We can do it easily with help of small robots called Nano robots. These robots can travel through inner parts of our body (circular system) without damaging them. They can monitor and analyse human's central nervous system and with this detail we can easily create and function a blue brain (from a super computer). Blue Brain can make us excel in each and every field of human kind. Be it engineering, medical or artistic, we can easily get guidance (proper one) with master blue brains of respective fields (and the best thing is their forever nature means blue brains will be there forever and future generation can also get benefited from them). Blue brains will be able to treat mental disorders related to human brains also. With this technology we can use someone's brain even after his/her death. So Blue Brain is a futuristic technology which will let us proceed with real pace and quality. Please share your views about this upcoming technology.

CONCLUSION

In conclusion, we will be able to transfer ourselves into computers at some point. Most arguments against this outcome are seemingly easy to circumvent. They are either simple minded, or simply require further time for technology to increase. The only serious threats raised are also overcome as we note the combination of biological and digital technologies.

We will be able to transfer ourselves into computers at some point. Most arguments against this outcome are seemingly easy to circumvent. They are either simple minded, or simply require further time for technology to increase. The only serious threats raised are also overcome as we note the combination of biological and digital technologies. While the road ahead is long, already researches have been gaining great insights from their model. Using the Blue Gene supercomputers, up to 100 cortical columns, 1 million neurons, and 1 billion synapses can be simulated at once. This is roughly equivalent to the brain power of a honey bee. Humans, by contrast, have about 2 million columns in their cortices. Despite the sheer complexity of such an endeavor, it is predicted that the project will be capable of this by the year 2023.

The blue brain project, if implemented successfully, would indeed change many things around us and it will boost the area of research and technology. Certain research and development take decades or even centuries to complete, so the knowledge and efforts of a scientist can be preserved and used further in his absence. At the same time, it is not an easy task to replicate the convoluted brain system into a computer. It may take several years to decades to accomplish this.

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