Blue Brain

Shreya Srivastav[1] Simran Devda[2]
[1,2]Bhoj Reddy Engineering College for Women, India

Abstract— What is it that differentiates man and puts him on the throne of the entire animal kingdom? Yes, it's the human brain, and not the human, which is the most valuable creation of God. But the brain, all its knowledge and power are destroyed after the death of man. Is it possible to model a brain and upload the contents of the real natural brain into it thereby propagating life even after death? Yes, indeed. Today, organ donation is giving a new lease of life to many ailing patients; however can brain be added to the list of organs that can be donated? Imagine the marvels that would be back into existence if we could replicate and restore the brains of geniuses like Sir Albert Einstein or Newton or even our great leaders of the past like Mahatma Gandhi. This paper presents a literature survey on the Blue Brain technology that promptly answers all these sparkling questions. Scientists today are in research to take artificial intelligence to a level beyond everything, to create a virtual brain that could think, react, make decisions and also keep everything in some form of memory to do everything that a normal human brain can. To achieve this, the main approach is to upload an actual brain in a virtual brain. So that even after death the person's conscience would be able to function exactly as a normal brain in the form of a machine. IBM along with scientists at BMI (Brain and Mind Institute) École Poly technique Fédérale de Lausanne (EPFL) Research University in Switzerland are simulating the brain's biological systems into a 3D model, which would recreate the electrochemical interactions that take place inside the brain. If this simulation results in a success, the modelling would extend to different parts of the brain and make it function with all the abilities of a natural brain, thereby eliminating the chances of any brain malfunctions such as psychiatric disorders like depression and autism, which are possible in the normal brain. IBM names this project as the 'Blue Brain' project.

Keywords: BMI (Brain and Mind Institute), Blue Brain

I. INTRODUCTION

Brain of humans is the most valuable creation of God. A person is called intelligent because of his brain. The brain translates the information delivered by the impulses, which then enables the person to react. But we loss the knowledge of a brain when the body is destroyed after the death of man. That knowledge might have been used for the development of the human society. What happen if we create a brain and up load the contents of natural brain into it?

A. Motivation

A very good example of utilization of blue brain is the case "short term memory". In some movies we might have noticed that a person might be having short term memories. The Blue Brain Project aims to build a full computer model of a functioning brain to simulate drug treatments or any other brain related problems. Blue gene supercomputer constructed by IBM was a machine first used by Blue Brain Project and then a term Blue Brain was introduced.

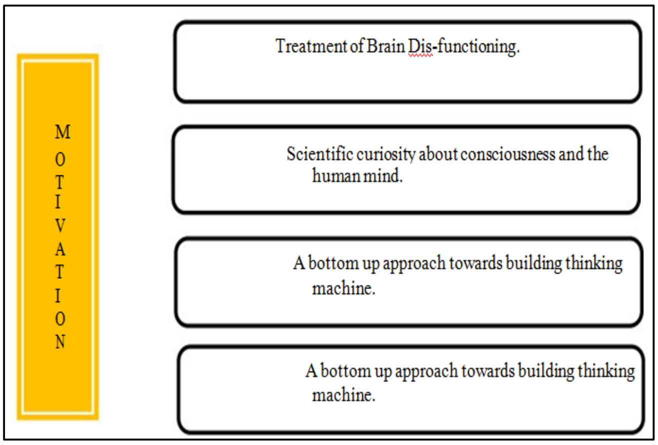

Fig. 1: Motivation

II. NATURAL BRAIN WORKING

A. History of Blue Brain

Blue brain is basically a Virtual Brain It is the creation of synthetic brain by reverse engineering, the mammalian brains down to the molecular level. That means a machine can function as human brain. No one can ever understand the complexity of human brain. It is more complex than any circuitry in the world.

Is it possible to create a virtual brain? Yes, the scientists today are in research to create an artificial brain that can think, respond, take decision, and keep everything in memory. Ultimately, it is to upload human brain into machine so that man can think, take decisions without any effort. After the death of the body, we will not lose knowledge, intelligence, feelings and memory of that man and can be used for the welfare of human society. Within 30 years, we will be able to scan ourselves into the computers.

Alan Turing (1912-1954) started off by wanting to "build the brain" and ended up with a computer. In the 60 years that have followed, computation speed has gone from 1 floating point operation per second (FLOPS) to over 250 trillion – by far the largest man-made growth rate of any kind in the ~10,000 years of human civilization. This is a mere blink of an eye, a single generation, in the 5 million years of human evolution and billions of years of organic life. What will the future hold – in the next 10 years, 100 years, 1,000 years? These immense calculation speeds have revolutionized science, technology and medicine in numerous and profound ways. In particular, it is becoming increasingly possible to simulate some of the nature's most intimate processes with exquisite accuracy, from atomic reactions to the folding of a single protein, gene networks, molecular interactions, the opening of an ion channel on the surface of a cell, and the detailed activity a single neuron. As calculation speeds approach and go beyond the peta FLOPS range, it is becoming feasible to make the next series of quantum leaps to simulating networks of neurons, brain regions and, eventually, the whole brain. During may, after all, have provided the means by which to build the brain.

On 1 July 2005, the Brain Mind Institute and IBM (International Business Machines) launched the Blue Brain Project1. Using the enormous computing power of IBM's prototype Blue Gene/L supercomputer2 the aims of this ambitious initiative are to simulate the brains of mammals with a high level of biological accuracy and, ultimately, to study the steps involved in the emergence of biological intelligence. Nevertheless, this defeat of a human master by a computer on such a complex cognitive task posed the question of whether the relevant world of an organism could simply be described by enough if-then conditions. Adaptation and learning algorithms have massively enhanced the power of these systems, but it could also be claimed that these approaches merely enable the system to automatically acquire more if-then rules. Regardless of the complexity of such an operation, the quality of the operation is much the same during any stage of the computation, and this form of intelligence could therefore be considered as 'linear intelligence'.

B. *Natural Brain*

The brain essentially serves as the body's information processing center. It receives signals from sensory neurons (nerve cell bodies and their axons and dendrites) in the central and peripheral nervous systems, and in response it generates and sends new signals that instruct the corresponding parts of the body to move or react in some way. It also integrates signals received from the body with signals from adjacent areas of the brain, giving rise to perception and consciousness. The brain weighs about 1,500 grams (3 pounds) and constitutes about 2 percent of total body weight. It consists of three major divisions:

– The massive paired hemispheres of the cerebrum.
– The brainstem consisting of the thalamus, hypothalamus, epithalamiums, sub thalamus, midbrain, Pons, and medulla oblongata.
– The cerebellum.

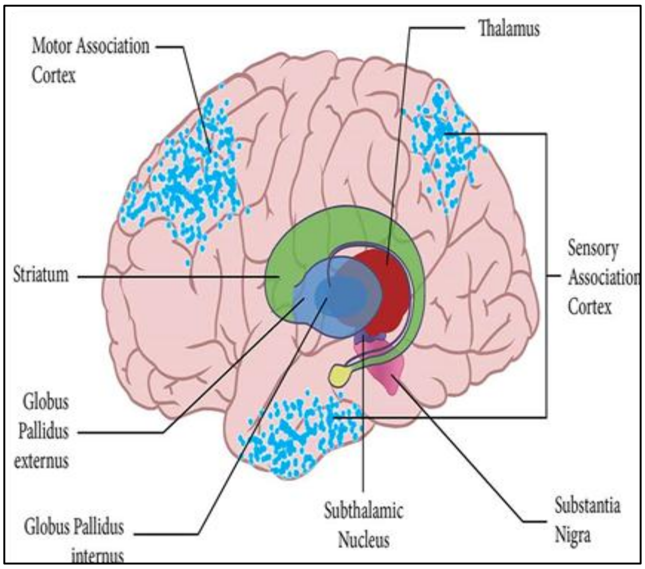

Fig. 2: Natural Brain

The human ability to feel, interpret and even see is controlled, in computer like calculations, by the magical nervous system. The nervous system is quite like magic because we can't see it, but its working through electric impulses through your body. One of the world's most "intricately organized" electron mechanisms is the nervous system. Not even engineers have come close to making circuit boards and computers as delicate and precise as the nervous system. To understand this system, one has to know the three simple functions that it puts into action; sensory input, integration & motor output.

1) *Sensory Input*

When our eyes see something or our hands touch a warm surface, the sensory cells, also known as Neurons, send a message straight to your brain.

This action of getting information from your surrounding environment is called sensory input because we are putting things in your brain by way of your senses.

2) *Integration*

It is best known as the interpretation of things we have felt, tasted, and touched with our sensory cells, also known as neurons, into responses that the body recognizes. This process is all accomplished in the brain where many, many neurons work together to understand the environment.

3) *Motor Output*

Once our brain has interpreted all that we have learned, either by touching, tasting, or using any other sense, then our brain sends a message through neurons to effecter cells, muscle or gland cells, which actually work to perform our requests and act upon our environment. Treatment of Brain Dis-functioning.

III. BLUE BRAIN WORKING

A. *Introduction*

In this chapter we will learn about the working of the Blue Brain .The Blue Brain working consists of three steps:

1) Data Acquisition
2) Simulation
3) Visualization of Results

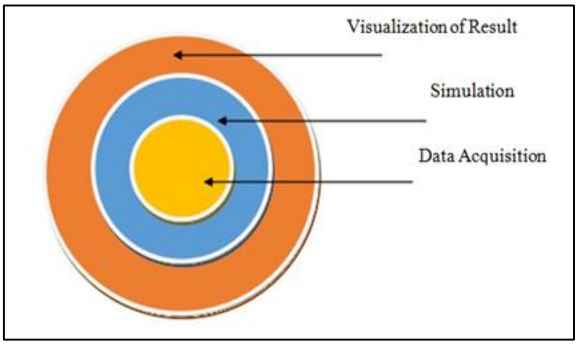

Fig. 3: Working Steps

B. *Data Acquisition*

We need to study different types of neurons and catalogue them. In involves taking brain slices and placing them under a microscope, measuring the shape and electrical activity of individual neurons.

1) *Morphology*

A branch of biology dealing with the study of form and structure of organisms and their specific structural features, Comparative morphology. Functional morphology and Experimental morphology are different branches of morphology.

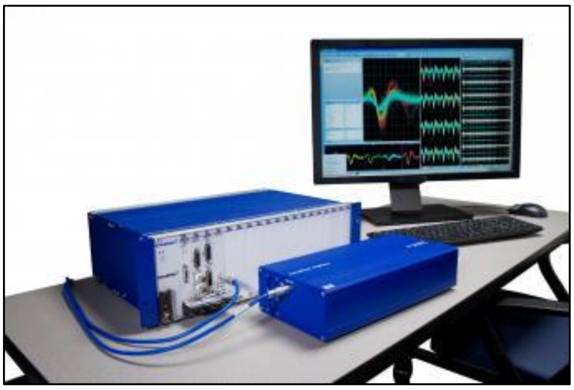

Fig. 4: Data Acquisition

Electrophysiology behaviour (A minimally invasive procedure which test the electrical conduction system of the heart to assess the electrical activity and conduction pathways of the heart, it enables twelve living neurons to be concurrently patched and their electrical activity recorded), location within the cortex and their population density are the different factors by which neurons are typed. Form, function and positioning of neurons are obtained by translating these observations into mathematical algorithms. By the help of these algorithms, biologically-realistic virtual neurons ready for simulation are generated.

C. *Simulation*

Digital reconstructions of brain tissue represent a snapshot of the anatomy and physiology of the brain at one moment in time. BBP simulations use mathematical models of individual neurons and synapses to compute the electrical activity of the network as it evolves over time. This requires a huge computational effort, only possible with large supercomputers. Simulations of larger volumes of tissue, at ever higher levels of detail, will need ever more powerful computing capabilities.

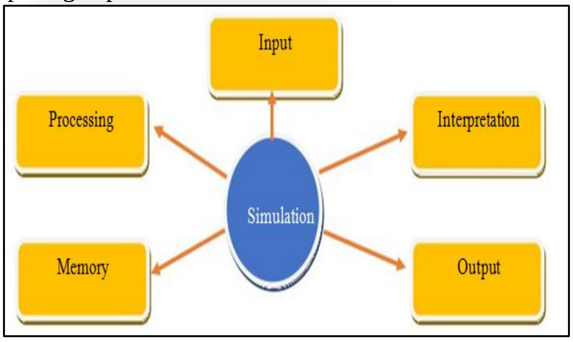

Fig. 5: Simulation

1) *Input*

In the nervous system of our body, neurons are responsible for message passing. Sensory cells convey the input to our body. Electric impulses are produced by sensory cells which are received by the neurons. Further, electric impulses (through the silicon chips of artificial neurons) are transferred to the brain by neurons.

2) *Interpretation*

Brain receives the electric impulses from the neurons which are interpreted by means of registers. Different states of brain can be accomplished by the different values in these registers.

3) *Output*

On the basis of the states of the registers, the electric impulses are sending by the brain representing the responses which are then received by the sensory cells to respond .The sensory cells of which part of our body is going to receive that, it depends on the state of the neurons in the brain at that time.

4) *Memory*

We can store certain information (states) permanently in our brain by certain neurons .On the basis of our requirement, the brain interprets those states and thus past things can be gathered. To do so we demand the neurons, to permanently show the clear vision of the Brain's States.

5) *Processing*

By the use of some stored states, computation will be performed by the computer. Logical and arithmetic calculations are done in our neural circuitry. To produce the output stored past experiences and current input received are used.

D. *Visualization of Results*

Huge amount of data are generated by running the Blue Brain simulation. Thousands of times analyses of individual neurons must be repeated.

Data can be analysed by using massively parallel computers where it is created (server-side analysis for experimental data, online analysis during simulation).

A visual exploration of the circuit is an important part of the analysis (given the geometric complexity of the column). It is invaluable for an immediate verification of single cell activity by mapping the simulation data onto the morphology. The Blue Gene has been translated into a 3D visual representation the column to design a visualization interface.

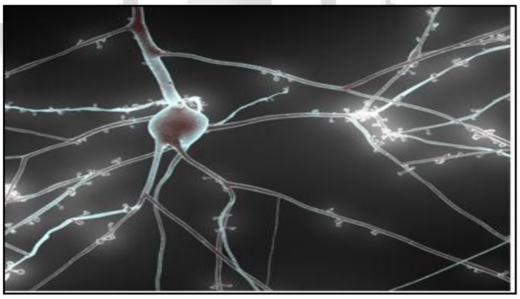

Fig. 6: Visualization of result

A challenging task is the visualization of the neurons given the fact that a series of ten thousand neurons clustered in high quality mesh accounts for essentially 1 billion triangles for which about hundred GB of management data is required. To study in detail using further simulations, visual interface makes it easy to quickly identify those areas and to show electrical activity in the brain, a visual representation could be also used.

IV. HUMAN BRAIN IN CHIP

A. *Nanobots*

Nanobots, a very small robot, are the most promising factor for uploading. Emerging technology fields creating machines or robots whose components are nearly close to the scale of a nanometer. These nanoids are so small that it can travel throughout our circulatory element. To accomplish these uploading, small robots known as nanobots are used.

Fig. 7: Nanobots

The activity and structure of our central nervous system will be monitored by them by travelling into the spine and the brain. An interface will be provided with computers that is very close as our mind can be while we still reside in our biological form.

Carefully scanning the structure of the brain is the additional function of the nanobots which provides a complete readout of the connections. Further, this information helps the machine to function as the human functions. Finally, by using nanobots, the data stored in the entire brain will be uploaded into the computer.

B. *Neurons*

A neuron (also called neurone or nerve cell) is a cell that carries electrical impulses. Neurons are the basic units of the nervous system and its most important part is the brain. Every neuron is made of a cell body (also called a soma), dendrites and an axon. Dendrites and axons are nerve fibres.

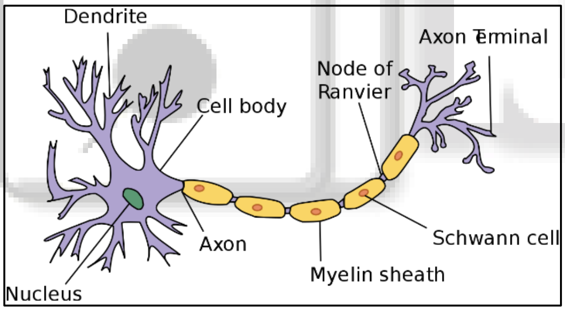

Fig. 8: Neuron

There are about 86 billion neurons in the human brain, which comprises roughly 10% of all brain cells. The neurons are supported by glial cells and astrocytes.

Neurons are connected to one another and tissues. They do not touch and instead form tiny gaps called synapses. These gaps can be chemical synapses or electrical synapses and pass the signal from one neuron to the next.

C. *Workflow of Neuron*

The simulation step involves synthesizing virtual cells using the algorithms that were found to describe real neurons. The algorithms 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 synthesized neurons. Then the cells are connected together according to the rules that have been found experimentally. Finally the neurons are functionalized and the simulation brought to life. The patterns of emergent behavior are viewed with visualization software. A basic unit of the cerebral cortex is the cortical column. Each column can be mapped to one function, e.g. in rats one column is devoted to each whisker.

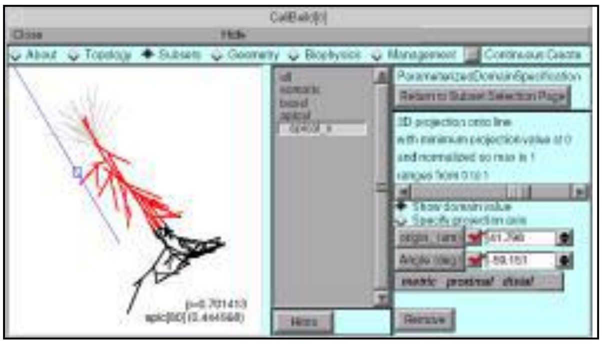

Fig. 9: Workflow of Neuron

A rat cortical column has about 10,000 neurons and is about the size of a pinhead. The latest simulations, as of November 2011, contain about 100 columns, 1 million neurons, and 1 billion synapses. Areal life rat has about 100,000 columns in total, and humans have around 2 million. Techniques are being developed for multi-scale simulation whereby active parts of the brain are simulated in great detail while quiescent parts are not so detailed. Every two weeks a column model is run.

The simulations reproduce observations that are seen in living neurons. Emergent properties are seen that they require larger and larger networks. The plan is to build a generalized simulation tool, one that makes it easy to build circuits. There are also plans to couple the brain simulations to avatars living in a virtual environment, and eventually also to robots interacting with the real world. The ultimate aim is to be able to understand and reproduce human consciousness.

D. *BBP-SDK*

The BBP-SDK (Blue Brain Project - Software Development Kit) is a set of software classes (APIs) that allows researchers to utilize and inspect models and simulations. The SDK is a C++ library wrapped in Java and Python.

The primary software used by the BBP for neural simulations is a package called NEURON. This was developed starting in the 1990s by Michael Hines at Yale University and John Moore at Duke University. It is written in C, C++, and FORTRAN.

The software continues to be under active development and, as of July 2012, is currently at version7.2. It is free and open source software; both the code and the binaries are freely available on the website. Michael Hines and the BBP team collaborated in 2005 to port the package to the massively parallel Blue Gene supercomputer.

V. REQUIREMENTS AND CHALLENGES

A. *Requirements*

- A supercomputer with high processing power processor
- A very large storing capacity
- A very wide interconnection network.
- A program to map electric impulses from human brain to input signal that can be received by the computer.

B. Blue Gene / Super Computer

Blue Gene/P technical specifications:

- 4,096 quad-core nodes
- 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

This machine peaked at 99th fastest supercomputer in the world in November 2009.

Silicon Graphics: A 32-processor Silicon Graphics Inc. (SGI) system with 300 GB of shared memory is used for visualization of results. Commodity PC clusters: Clusters of commodity PCs have been used for visualization tasks with the RT Neuron software.

Fig. 10: Blue Brain Storage Rack

JuQUEEN is an IBM Blue Gene/Q supercomputer that was installed at the Jülich Research Center in Germany in May2012. It currently performs at 1.6 peta flops and was ranked the world's 8th fastest supercomputer in June 2012. It's likely that this machine will be used for BBP simulations starting in 2013, provided funding is granted via the Human Brain Project.

In October 2012 the supercomputer is due to be expanded with additional racks. It is not known exactly how many racks or what the final processing speed will be. The JuQUEEN machine is also to be used by the research initiative. This aims to develop a three-dimensional, realistic model of the human brain.

Fig. 11: JuQUEEN Super Computer in Germany

C. DEEP - Dynamical Exascale Entry Platform

DEEP (deep-project.eu) is an exascale supercomputer to be built at the Jülich Research Center in Germany. The project started in December 2011 and is funded by the European Union's 7th framework program. The three-year prototype phase of the project has received €8.5 million. A prototype supercomputer that will perform at 100 peta flops is hoped tobe built by the end of 2014.

The Blue Brain Project simulations will be ported to the DEEP prototype to help test the system's performance. The DEEP prototype will be built using Intel MIC (Many Integrated Cores) processors, each of which contains over 50 cores fabricated with a 22 nm process. These processors were codenamed Knights Corner during development and subsequently rebranded as Xeon Phi in June 2012.

The processors will be publicly available in late 2012 or early 2013 and will offer just over 1 teraflop of performance each.

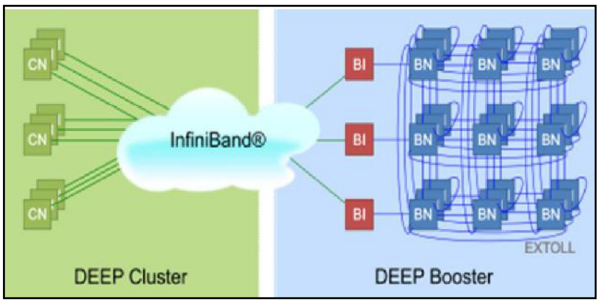

Fig. 12: DEEP Cluster Booster Architecture

D. Challenges

1) Neural Complexity

Complex dendritic computations affect the probability and frequency of neural firing. These computations include linear, sub linear, and superliner additions along with generation of dendritic spikes, and inhibitory computations that shunt internal cell voltage to resting potentials or decrease the potential, essentially subtracting voltage.

2) Scale

A massive system is required to emulate the brain: none of the projects we discuss have come close to this scale at present. The largest supercomputers and computer clusters today have thousands of processors, while the human cortex has tens of billions of neurons and a quadrillion synapses. We are a long way from cortex scale, even if one computer processor could emulate thousands of neurons, and, as we will see, it is unclear whether that emulation would be sufficiently accurate.

3) Interconnectivity

Emulation of the cortex in hardware represents a massive "wiring" problem. Each synapse represents a distinct input to a neuron, and each postsynaptic neuron shares synapses with an average of 10,000 (and as many as 100,000) other presynaptic neurons. Similarly, the axon emerging from each neuronal cell body fans out to an average of 10,000 destinations. Thus each neuron has, on average, 10,000 inputs and 10,000 outputs. If the connections were mostly local, the wiring would not be so complicated.

4) Plasticity

The strength of the excitatory or inhibitory connection must change with learning, and neurons must also be able to create new synapses and hence new connections during the learning process. Research on the mechanisms by which neurons learn, make and break connections, and possess memory is on-going, with hypotheses and supporting data appearing frequently. These studies have led to a basic understanding of synaptic and structural plasticity.

5) Power Consumption
A final, indirect problem is the power consumed by a brain emulation with50 billion neurons and 500 trillion connections, and the dissipation of the associated heat generated. The human brain evolved to use very little power, an estimated 25 watts. We do not have computing technology anywhere near this power efficiency, although nanotechnology and ultra-low power design offer promise.

VI. EXPERIMENTAL RESEARCH

A. Research

- As of August 2012 the largest simulations are of microcircuits containing around 100 cortical columns. Such simulations involve approximately 1 million neurons and 1 billion synapses. This is about the same scale as that of a honey bee brain.
- A rat brain neocortical simulation (~21 million neurons) achieved in the end of 2014.
- A full human brain simulation (86 billion neurons) should be possible by 2023 provided sufficient funding is received

B. Workflow of Blue Brain Technology

First, it is helpful to describe the basic manners in which a person may be uploaded into a computer. Raymond Kurzweil recently provided an interesting paper on this topic. In it, he describes both invasive and non-invasive techniques. The most promising is the use of very small robots, or nanobots.

These robots will be small enough to travel throughout our circulatory systems. Traveling 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 between each neuron.

They would also record the current state of the brain. This information, when entered into a computer, could then continue to function like us. All that is required is a computer with large enough storage space and processing power

C. Things to Learn from Blue Brain

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.

VII. APPLICATIONS, ADVANTAGES AND DISADVANTAGES

A. Applications

1) Gathering and Testing 100 Years of Data
The most immediate benefit is to provide 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 will therefore also produce a virtual library to explore in 3D the microarchitecture of the neocortex and access all key research relating to its structure and function.

2) Cracking the Neural Code
The Neural Code refers to how the brain builds objects using electrical patterns. In the same way that the neuron is the elementary cell for computing in the brain, the NCC is the elementary network for computing in the neocortex.

Creating an accurate replica of the NCC which faithfully reproduces the emergent electrical dynamics of the real microcircuit, is an absolute requirement to revealing how the neocortex processes, stores and retrieves information.

3) Understanding Neocortical Information Processing
The power of an accurate simulation lies in the predictions that can be generated about the neocortex. Indeed, iterations between simulations and experiments are essential to build an accurate copy of the NCC. These iterations are therefore expected to reveal the function of individual elements (neurons, synapses, ion channels, and receptors), pathways (mono-synaptic, disynaptic, multi synaptic loops) and physiological processes (functional properties, learning, reward, and goal oriented behaviour).

4) A Novel Tool for Drug Discovery for Brain Disorders
Understanding the functions of different elements and pathways of the NCC will provide a concrete foundation to explore the cellular and synaptic bases of a wide spectrum of neurological and psychiatric diseases. The impact of receptor, ion channel, cellular and synaptic deficits could be tested in simulations and the optimal experimental tests can be determined.

5) A Global Facility
A software replica of a NCC will allow researchers to explore hypotheses of brain function and dysfunction accelerating research. Simulation runs could determine which parameters should be used and measured in the experiments. An advanced 2D, 3D and 3D immersive visualization system will allow “imaging” of many aspects of neural dynamics during processing, storage and retrieval of information. Such imaging experiments maybe impossible in reality or maybe prohibitively expensive to perform.

6) A Foundation for Whole Brain Simulations
With current and envisage able future computer technology it seems unlikely that a mammalian brain can be simulated with full cellular and synaptic complexity (above the molecular level). An accurate replica of an NCC is therefore required in order to generate reduced models that retain critical functions and computational capabilities, which can be duplicated and interconnected to form neocortical brain regions. Knowledge of the NCC architecture can be transferred to facilitate reconstruction of subcortical brain regions.

7) A Foundation for Molecular Modelling of Brain Function
An accurate cellular replica of the neocortical column will provide the first and essential step to a gradual increase in model complexity moving towards a molecular level description of the neocortex with biochemical pathways being simulated. A molecular level model of the NCC will

provide the substrate for interfacing gene expression with the network structure and function.

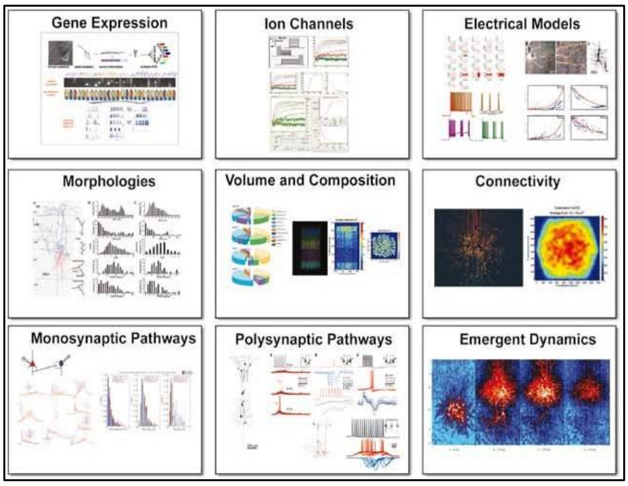

Fig. 13: Modelling

The NCC lies at the interface between the genes and complex cognitive functions. Establishing this link will allow predictions of the cognitive consequences of genetic disorders and allow reverse engineering of cognitive deficits to determine the genetic and molecular causes. This level of simulation will become a reality with the most advanced phase of Blue Gene development.

B. Advantages

– We can remember things without any effort.
– Decision 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.
– It would allow the deaf to hear via direct nerve stimulation, and also behelpful for many psychological diseases.
– By down loading the contents of the brain that was uploaded into the computer, the man can get rid from the madness.

Fig. 14: Advantages

C. Disadvantages

– There are many new dangers these technologies will open. We will be susceptible to new forms of harm.
– We become dependent upon the computer systems.
– Others may use technical knowledge against us.
– Computer viruses will pose an increasingly critical threat.
– The real threat, however, is the fear that people will have of new technologies.
– That fear may culminate in a large resistance.
– Clear evidence of this type of fear is found today with respect to human cloning.

VIII. Conclusion and Future Scope

A. Future Scope

The synthesis era in neuroscience started with the launch of the Human Brain Project and is an inevitable phase triggered by a critical amount of fundamental data. The data set does not need to be complete before such a phase can begin. Indeed, it is essential to guide reductionist research into the deeper facets of brain structure and function. As a complement to experimental research, it offers rapid assessment of the probable effect of a new finding on pre-existing knowledge, which can no longer be managed completely by any one researcher.

Detailed models will probably become the final form of databases that are used to organize all knowledge of the brain and allow hypothesis testing, rapid diagnoses of brain malfunction, as well as development of treatments for neurological disorders. In short, we can hope to learn a great deal about brain function and dis-function from accurate models of the brain .The time taken to build detailed models of the brain depends on the level of detail that is captured. Indeed, the first version of the Blue Column, which has 10,000 neurons, has already been built and simulated; it is the refinement of the detailed properties and calibration of the circuit that takes time.

A model of the entire brain at the cellular level will probably take the next decade. There is no fundamental obstacle to modelling the brain and it is therefore likely that we will have detailed models of mammalian brains, including that of man, in the near future. Even if overestimated by a decade or two, this is still just a ’blink of an eye’ in relation to the evolution of human civilization. As with Deep Blue, Blue Brain will allow us to challenge the foundations of our understanding of intelligence and generate new theories of consciousness.

B. 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.

References

[1] Hill, Sean: Markham Henry, Blue brain project, 2008, International conference of IEEE.
[2] Henry Markram, "The Blue Brain Project", Nature Reviews Neuroscience, 7:153-160, 2006 February.
[3] Reconstructing the Heart of Mammalian Intelligence, Henry Mark ram’s lecture, March 4 2008.

[4] Henry Mark ram builds a brain in supercomputer, TED conference July 2009“Research paper 2014 Fourth International Conference on Communication Systems and Network Technologies by Swati Sharma, Nitisha Payal, Ankur Kaushik, Nitin Goel from MIET, Meerut”.