Blue Brain Technology: A Subway to Artificial Intelligence

A
Seminar Report

by

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Certified that this Seminar Report entitled

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Acknowledgement

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Abstract

The **Blue Brain Project - A quest to build sentient machines** is the first made comprehensive attempt to **reverse-engineer** the brain of mammalian, so that through detailed simulations the function of brain can be understood. **BLUE BRAIN** is the name of the world's first virtual brain which means, a machine that can function as **human brain**.

Today, scientists are in research to create an **artificial brain** that can think, respond, take decision, and store anything in memory. The main aim of this research is to upload human brain into machine [4]. So that man can think and 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.

The four major **motivations** behind the Blue Brain Technology:
1. Treatment of brain disfunctioning
2. Scientific curiosity about consciousness and human mind
3. A bottom up approach towards building thinking machine
4. Databases of all neuroscientific research results.

There are three main steps to build the virtual brain:
1. Data Acquisition
2. Data Simulation
3. Data Visualization of results.

What is Blue brain?

The IBM is now developing a virtual brain known as the Blue brain. It would be the world's first virtual brain. With in 30 years, we will be able to scan ourselves into the computers. Is this the beginning of eternal life?

Keywords - Blue Brain, Reverse Engineer, Human Brain, Artificial Brain.

Contents

1 INTRODUCTION

Human brain is the most valuable creation of God. The man is called intelligent because of the brain. The brain translates the information delivered by the impulses, which then enables the person to react. But we loose the knowledge of a brain when the body destroys after the death of man. That knowledge might have been used for the development of the human society. What happen if we create a virtual brain and up load the contents of natural brain into it? [8].

1.1 WHAT IS BLUE BRAIN?

The Blue Brain Project is an attempt to create a synthetic brain by reverse-engineering mammalian brain circuitry. 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 [4]. So that man can think, take decision without any effort.

The research 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. Hence the name "Blue Brain". The simulation software is based around Michael Hines's NEURON, together with other custom-built components.

1.2 ARTIFICIAL BRAIN OVERVIEW

Artificial brain is a term commonly used in the media to describe research that aims to develop software and hardware with cognitive abilities similar to those of the animal or human brain. Research investigating "artificial brains" plays three important roles in science.

- A study called cognitive neuroscience, which helps neuroscientists to make an ongoing attempt to understand how human brain works.
- A thought experiment in the philosophy of artificial intelligence (AI), which demonstrates that it is actually possible to create a machine that has all the capabilities of a human being in theory.
- A serious long term project to create machines capable of general intelligent action or Artificial General Intelligence. This idea has been popularised by Ray Kurzweil as strong AI (taken to mean a machine as intelligent as a human being).

2 HISTORY

The aim of the project, founded in May 2005 by the **Brain and Mind Institute of the Ecole Polytechnique Federale de Lausanne (Switzerland)** is to study the brain's architectural and functional principles. The project is headed by the Institute's director, Henry Markram [8]. Using a Blue Gene supercomputer running Michael Hines's NEURON software, the simulation does not consist simply of an artificial neural network, but involves a biologically realistic model of neurons. It is hoped that it will eventually shed light on the nature of consciousness [10]. There are a number of sub-projects, including the **Cajal Blue Brain**, coordinated by the supercomputing and Visualization Center of Madrid (CeSViMa), and others run by universities and independent laboratories.

2.1 GOALS

2.1.1 NEOCORTICAL COLUMN MODELLING

The initial goal of the project, completed in December 2006, was the simulation of a rat neocortical column, which can be considered the smallest functional unit of the neocortex (the part of the brain thought to be responsible for higher functions such as conscious thought). Such a column is about 2 mm tall, has a diameter of 0.5 mm and contains about 60,000 neurons in humans; rat neocortical columns are very similar in structure but contain only 10,000 neurons (and 108 synapses). Between 1995 and 2005, Markram mapped the types of neurons and their connections in such a column.

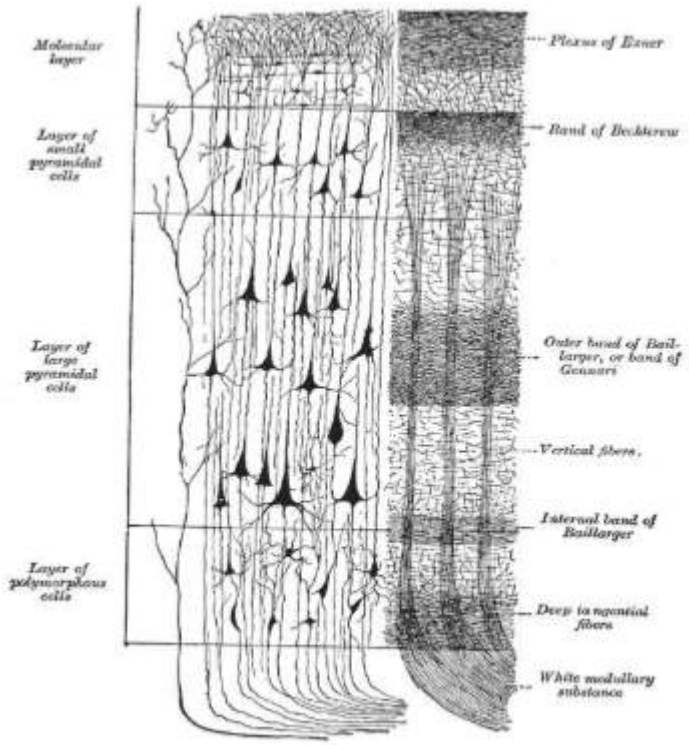


Fig.1. Representative Column of neocortex.

2.2 PROGRESS

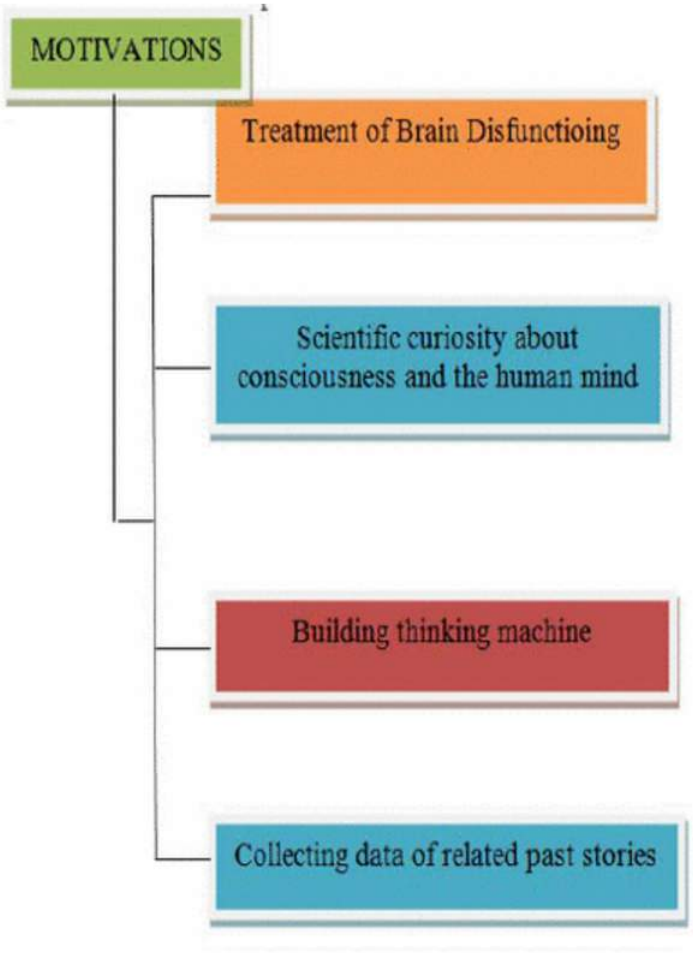
In November 2007, the project reported the end of the first phase, delivering a data-driven process for creating, validating, and researching the neocortical column.By 2005, the first single cellular model was completed. The first artificial cellular neocortical column of 10,000 cells was built by 2008. By July 2011, a cellular mesocircuits of 100 neocortical columns with a million cells in total was built. A cellular rat brain is planned [dated info] for 2014 with 100 mesocircuits totaling a hundred million cells. Finally a cellular human brain is predicted possible by 2023 equivalent to 1000 rat brains with a total of a hundred billion cells.

Now that the column is finished, the project is currently busying itself with the publishing of initial results in scientific literature, and pursuing two separate goals:

- Construction of a simulation on the molecular level, which is desirable since it allows studying the effects of gene expression;
- Simplification of the column simulation to allow for parallel simulation of large numbers of connected columns, with the ultimate goal of simulating a whole **neocortex** (which in humans consists of about 1 million cortical columns).[contradictory]

In 2015, scientists at Ecole Polytechnique Federale de Lausanne (EPFL) developed a quantitative model of the previously unknown relationship between the glial cell astrocytes and neurons. This model describes the energy management of the brain through the function of the neuro-glial vascular unit (NGV). The additional layer of neuron-glial cells is being added to Blue Brain Project models to improve functionality of the system.

3 MOTIVATION



Nowadays, a number of people are suffering from brain diseases, it is an alarming stage to fight against these diseases and finding suitable treatments. Practically, it is very difficult to study a living brain. So, a virtual brain makes it possible for implementation and performing justification, to our experiments.

4 POSSIBILITY

Many people believe firmly those we possess a soul, while some very technical people believe that quantum forces contribute to our awareness. But we have to now think technically. Really this concept appears to be very difficult and complex. First, it is helpful to describe the basic manners in which a person may be uploaded into a computer. Raymond Kurzweil [7] 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 Nanobot. All that is required is a computer with large enough storage space and processing power.

5 HARDWARE AND SOFTWARE REQUIREMENTS

- A Super computer
- Memory with a very large storing capacity
- Processor with a very high processing power.
- A very wide network.
- A program to convert the electric impulses from the brain to input signal, which is to be received by the computer and vice versa.
- Very powerful Nanobots.

5.1 BLUEGENE/P SUPERCOMPUTER

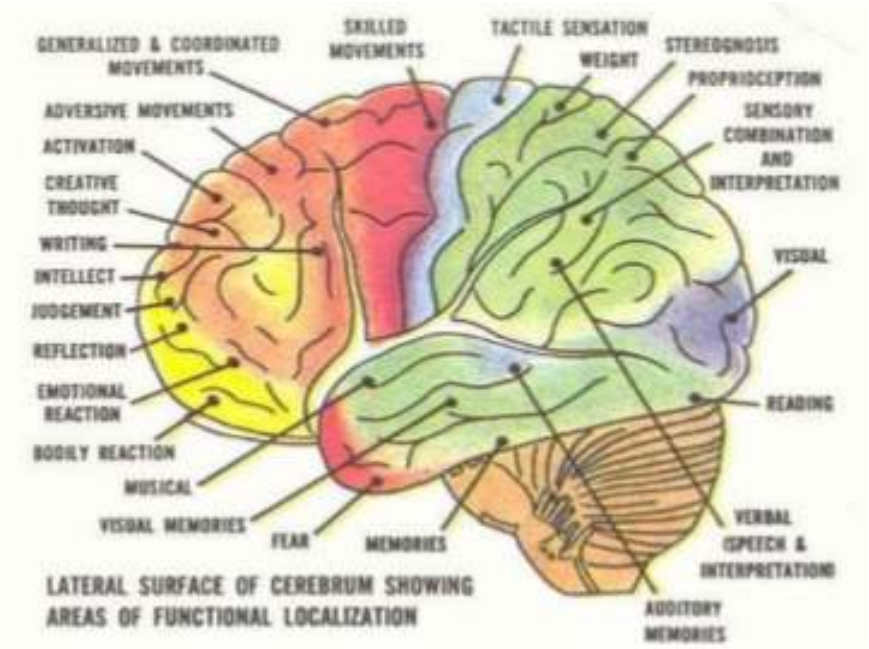
In June 2010 this machine was upgraded to a Blue Gene/P. The machine is **installed on the EPFL campus** in Lausanne and is **managed by CADMOS** (Center for Advanced Modeling Science). The computer is used by a number of different research groups, not exclusively by the Blue Brain Project [9].The brain simulations generally run all day, and one day per week (usually Thursdays). The rest of the week is used to prepare simulations and to analyze the resulting data. The supercomputer usage statistics and job history are publicly available online - look for the jobs labeled as "C-BPP".

Blue Gene/P 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 SLES10
- 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 RTNeuron software.

6 HUMAN BRAIN



6.1 FUNCTIONING OF 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 the body. One of the world's most "intricately organized" electron mechanisms is the nervous system. Not even engineers have come close for making circuit boards and computers as delicate and precise as the nervous system [6]

The three simple functions that it puts into action:

6.1.1 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.

6.1.2 INTEGRATION

Integration 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 neurons work together to understand the environment.

6.1.3 MOTOR OUTPUT

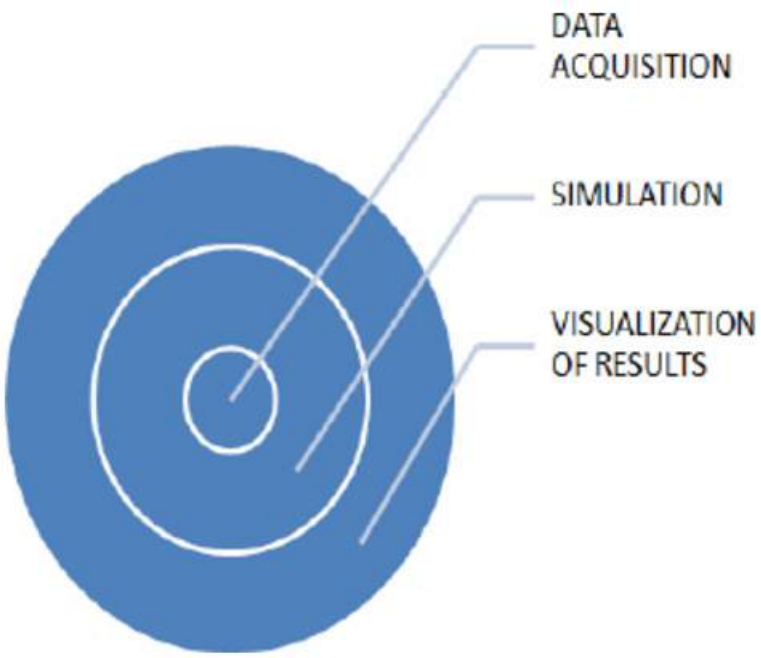
Once our brain has interpreted all that we have learned, either by touching, tasting, or using any other sense, then our brain sends a message through neurons to effecter cells, muscle or gland cells, which actually work to perform our requests and act upon the environment.

Now the question is how to implement this entire natural thing by using artificial things.Here is a comparative discussion.

Natural Brain	Simulated Brain
INPUT In the nervous system in our body the neurons are responsible for the message passing. The body receives the input by sensory cells. This sensory cell produces electric impulses which are received by neurons. The neurons transfer these electric impulses to the brain.	**INPUT** In a similar way the artificial nervous system can be created. The scientist has created artificial neurons by replacing them with the silicon chip. It has also been tested that these neurons can receive the input from the sensory cells. So, the electric impulses from the sensory cells can be received through these artificial neurons.
INTERPRETATION The electric impulses received by the brain	**INTERPRETATION** The interpretation of the electric impulses

from neurons are interpreted in the brain. The interpretation in the brain is accomplished by means of certain states of many neurons.	received by the artificial neuron can be done by means of registers. The different values in these register will represent different states of brain.
OUTPUT Based on the states of the neurons the brain sends the electric impulses representing the responses which are further received by sensory cell of our body to respond neurons in the brain at that time.	**OUTPUT** Similarly based on the states of the register the output signal can be given to the artificial neurons in the body which will be received by the sensory cell.
MEMORY There are certain neurons in our brain which represent certain states permanently. When required, this state is represented by our brain and we can remember the past things. To remember things we force the neurons to represent certain states of the brain permanently or for any interesting or serious matter this is happened implicitly.	**MEMORY** It is not impossible to store the data permanently by using the secondary memory. In the similar way the required states of the registers can be stored permanently and when required these information can be received and used.
PROCESSING When we take decision, think about something, or make any computation, logical and arithmetic computations are done in our neural circuitry. The past experience stored and the current inputs received are used and the states of certain neurons are changed to give the output.	**PROCESSING** In the similar way the decision making can be done by the computer by using some stored states and the received input and the performing some arithmetic and logical calculations.

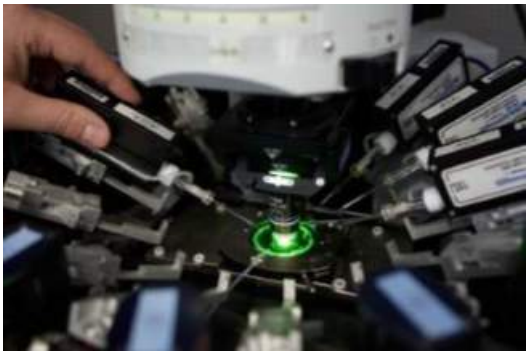
7 STEPS TO BUILD VIRTUAL BRAIN



[2]

7.1 DATA ACQUISITION

Under data acquisition, the brain slices are placed under microscope and the shape as well electrical activity of individual neurons are measured [9]. The neurons are examined by their shape called as morphology.These observations are translated into mathematical algorithms which describe the form, functions and position of neurons. The algorithms are then used to generate biologically-realistic virtual neurons ready for simulation [3].To study the electrophysiological behavior of the neurons, the main tool required is **12 patch clamp**. It allows twelve living neurons to be concurrently patched.



The 12 patch-clamp close view

Around 200 different types of ion channel *(Ion channels are pore-forming membrane proteins whose functions include establishing a resting membrane potential, shaping action potentials and other electrical signals by gating the flow of ions across the cell membrane, controlling the flow of ions across secretory and epithelial cells, and regulating cell volume. Ion channels are present in the membranes of all cells.)* are found in the cell membranes of cortical neurons. Different types of neuron have different mixes of channels - and this contributes to differences in their electrical behaviour. The genes for these channels are cloned at the lab, overexpressed in cultured cells, and their electrical behaviour recorded. Over 270 genes are known to be associated with voltage-gated ion channels in the rat. The results of this work are publicly available online at Channelpedia [3].

7.2 DATA SIMULATION

Simulation refers to the use of a mathematical model to recreate a situation, so that the likelihood of various outcomes can be more accurately estimated. The main focus for the creation of virtual brain is on the neurons and **the primary software used for neural simulation is a package called NEURON** which was developed in 1990 by Michael Hines and John Morey [5]. It is written in C, C++ and FORTRAN and is free, open source software. Neural simulation is basically used for building and using computational models of neurons and network of neurons.For blue brain, the current version of neuron which is being used is 7.2.

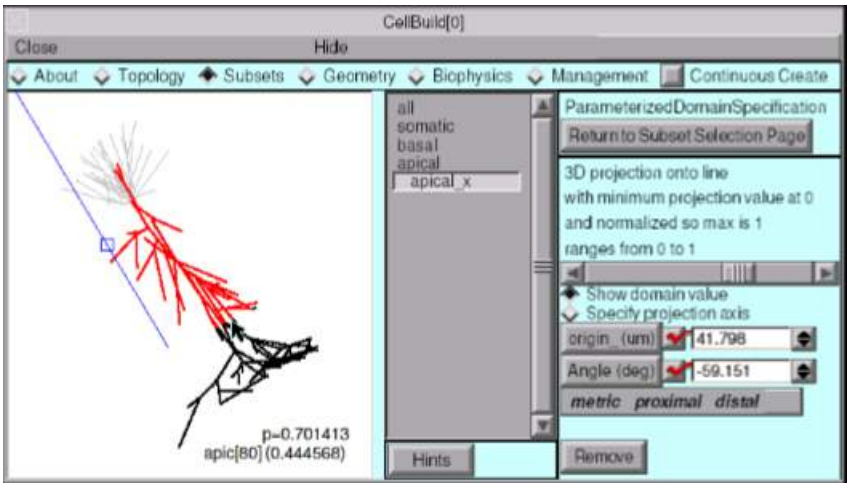
The main factors on which the simulation depends are:

- **Simulation Speed**: The simulations show approximately linear scaling - that is, doubling the size of the neural network doubles the time it takes to simulate.The simulation time step or the numerical integrations is 0.025ms and the time step for writing the output to disk is 0.1ms.

- **Workflow**: 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.

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.



Example NEURON cell builder window

Simulation process

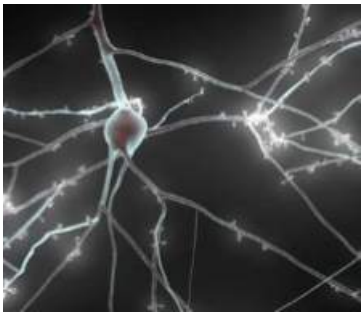
Every single protein is simulated, and there are about a billion of these in one cell. First a network skeleton is built from all the different kinds of synthesized neurons. Then the cells are connected together according to the

rules that have been found experimentally. Finally the neurons are functionalized and the simulation brought to life. The patterns of emergent behaviour are viewed with visualization software.

Every two weeks a column model is run. The simulations reproduce observations that are seen in living neurons. Emergent properties are seen that 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.**

7.3 VIZUALIZATION OF RESULTS

RT Neuron is the primary application and the software was developed internally by the BBP team. It is written in C++ and OpenGL

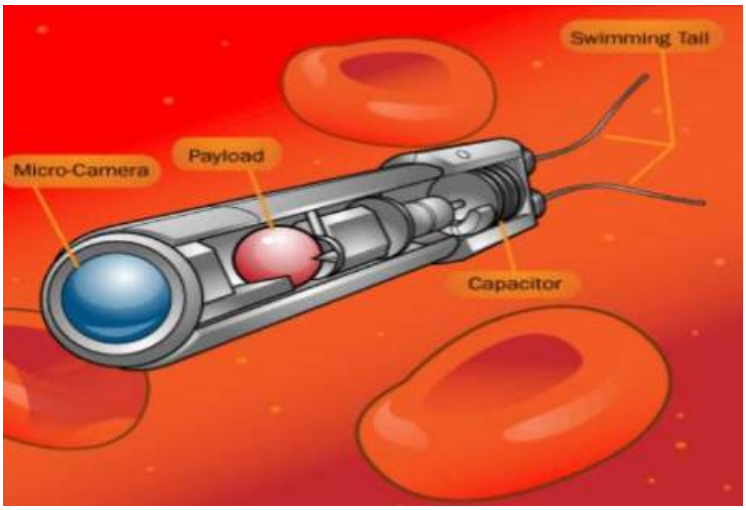


RTNeuron visualisation of a neuron

RT Neuron takes the output from Hodgkin-Huxley simulations in NEURON and render them in 3D [1].This allows researchers to watch as activation potentials propagate through a neuron and between neurons. The animations can be stopped, started and zoomed, thus letting researchers interact with the model. The visualizations are multi-scale that is they can render individual neurons or a whole: cortical column.The image right was rendered in RT Neuron.

8 UPLOADING CONSCIOUSNESS

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. Traveling into the spine and brain, they will be able to monitor the activity and structure of our central nervous system [3]



Uploading the brain by nanobots

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.

9 CONSEQUENCES

9.0.1 POSITIVE

- We can remember things without any effort.
- Making decision without the presence of a person is possible.

- We can Use the intelligence of a person after his/her death.
- By downloading the contents of the brain that was uploaded into the computer, the man can get rid of from the madness.
- Allowing the deaf to hear via direct nerve stimulation is achievable

9.0.2 NEGATIVE

- We become dependent on the Computer.
- Others may use technical knowledge against us.
- Another fear is found today with respect to human Cloning.

10 APPLICATIONS

- Gathering and testing of 100 years data.
- Cracking the neural code.
- Understanding the neocortical information processing.
- A novel tool for drug discovery for brain disorders.
- A global facility.
- A foundation for whole brain simulations.
- A foundation for molecular modelling of brain function

11 FUTURE PERSPECTIVE

The first version of the Blue Brain, having around ten thousand neurons, has already been created and simulated by some of our great researchers; it is the selection of our deep properties and efficiency of the circuit that takes time. We can aim about deep learning of brain components with its functioning, disfunctioning and impact of a component on another by analyzing

different data sets.The digital era in neurosciences begin with the launch of the human brain project. Fundamentally, there is no problem in modeling a brain and it is therefore likely to be done in the near future. To accomplish this, and hypothesis testing, on our databases can be performed and it is a step into reality.

12 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 can also be overcomed by the combination of biological and digital technologies. It is predicted that the project will be capable of this by the year 2023.

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