Artificial General Intelligence - Strong AI (Blue Brain)

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Abstract-The nature of consciousness, the property of some living beings to have subjective experience, has been a concern for scholars and artists for millennia. Today, A serious long term project to create machines exhibiting behavior comparable to those of animals with complex central nervous system such as mammals and most particularly humans. The ultimate goal of creating a machine exhibiting human-like behavior or intelligence is sometimes called strong AI, a new approach to cognitive science and philosophy of mind, one not centered on the human example, is needed to help us understand the challenges which we will face when a power greater than us emerges.

Keywords: Neuron, Neorocortex, Mesocircuit

I. INTRODUCTION

Many different definitions of intelligence have been proposed (such as being able to pass the Turing test) but there is to date no definition that satisfies everyone Artificial general intelligence (AGI) describes research that aims to create machines capable of general intelligent action. The term was introduced by Mark Gubrud[1] in 1997in a discussion of the implications of fully automated military production and operations. AGI research activity in 2006 was described by Pei Wang and Ben Goertzel as "producing publications and preliminary results".

For low-level brain simulation, an extremely powerful computer would be required. The human brain has a huge number of synapses. Each of the 1011 (one hundred billion) neurons has on average 7,000 synaptic connections to other neurons. It has been estimated that the brain of a three-year-old child has about 1015synapses (1 quadrillion). In August 2012 the largest simulations are of micro circuits 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. It is hoped that a rat brain neocortical simulation (~21 million neurons) will be achieved by the end of 2014. A full human brain simulation (86 billion neurons) should be possible by 2023 provided sufficient funding is received.

II. WHAT IS ARTIFICIAL GENERAL AI- BLUE BRAIN?

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, and 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 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 of a single neuron. As calculation speeds approach and go beyond the petaFLOPS 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. Turing may, after all, have provided the means by which to build the brain.

On 1 July 2005, the Brain Mind Institute [5] (BMI, at the EcolePolytechniqueFédérale de Lausanne) and IBM (International Business Machines)[4] launched the Blue Brain Project. Using the enormous computing power of IBM’s prototype Blue Gene/L supercomputer2 (Figure 1), 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.

Figure 1 Blue Gene/L supercomputer2

III. NEED OF VIRTUAL BRAIN

Today we are developed because of our intelligence. Intelligence is the inborn quality that cannot be created .Some people have this quality, so that they can think up to such an extent where other cannot reach. Human society is always in need of such intelligence and such an intelligent brain to have with. But the intelligence is lost along with the body after the death. The virtual brain is a solution to it. The brain and intelligence will be alive even after the death. We often face difficulties in remembering things such as people names, their birthdays, and the spellings of words, proper grammar, important dates, history facts, and etcetera. In the busy life everyone wants to be relaxed.

IV. BACKGROUND

The brain consists of approximately 10^{12} neurons. If each person alive today would have a thousand children, the number of people on earth would be equal to the number of neurons (Figure 3) within a single brain. The Neocortex(Figure 2) is an area of the brain that is most evolved in higher mammals. It consists of vast numbers of similarly interconnected columnar neural structures, also known as mini columns. Each column contains up to 10,000 neurons and has a width of about 500 microns. There is growing experimental evidence that the neocortex is organized in terms of its architecture into column like structures arranged in grid like formation, each consisting of ten to a hundred thousand cells. It has been suggested that each such column has a specific computational function, for instance processing the information from a specific whisker in a rat's mustache. Thus, it is tempting to think of the cortical column as a basic universal computational unit of the cortex.

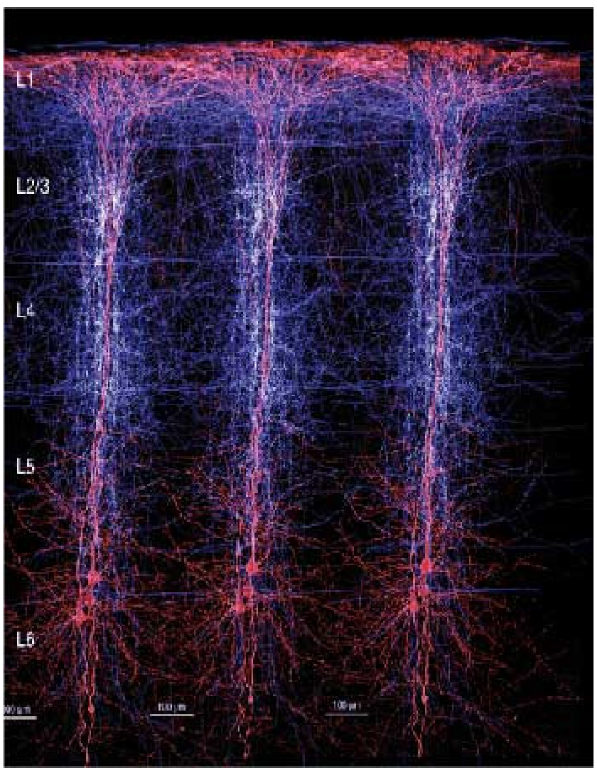

Figure 2: *Whole brain emulation - Neocortex*

The field of computational neuroscience deals amongst other things with the processing of information in neural networks. In the past decades there has been a growing understanding of the processing carried out by the single neuron.

Figure 3:*Model of a nerve cell*

Indeed, very detailed understanding of the electrical activity within a single neuron has been achieved by mathematical modeling of this activity. Yet so far, the activity of neuronal networks has been described in more abstract fashion, partly at least due to the computational resources required to solve the great number of equations describing the detailed activity of such networks.

V. RESEARCH METHODS

The Blue Brain uses an IBM BlueGene/L supercomputer (Figure 4) with over 8000 parallel processors. What takes the computer 1 day to simulate would take 8000 days or 20 years to simulate on a standard desktop. All in all, the network contains on the order of ten thousand neurons connected by ten billion synapses. Each processor simulates from one neuron to a few. Hence, we have the computational power to simulate each neuron and synapse in realistic detail.

Figure 4: IBM BlueGene/L supercomputer

We developed the tools to be able to generate the network model each time from scratch by directly drawing the necessary data from experimental databases. Thus, we can update the databases and generate a more refined model as often as new data becomes available. In addition, we can highlight the areas in which experimental data is lacking.

a. The Model

We model data collected over more than a decade in the labs of prof. Henry Markram and collaborators. It mainly consists of electrophysiological recordings (Figure 5) of single cell activity in rat somatosensory cortex. We are able to generate a model of one or a few cortical columns, simulate its activity in different scenarios and visualize the result. We are able to reproduce experimentally observed activity in several levels of resolution (single cell, layer, etc') and are continually seeking to find more experimental calibration methods and apply them to refine our model.

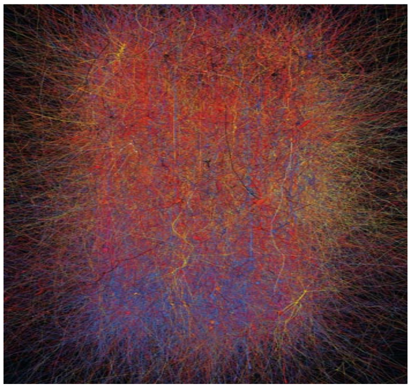

Figure 5:*Image of a simulated network in action*

VI. HIGH PERFORMANCE COMPUTING

The Blue Brain[2] workflow creates enormous demands for computational power. (Figure 6) In Blue Brain cellular level models, the representation of the detailed electrophysioloy and communication of a single can require as many as 20,000 differential equations. No modern workstation is capable of solving this number of equations in biological real time. In other words, the only way for the project to achieve its goals is to use High Performance Computing(HPC). The Blue Brain project's simulation of the neocortical column incorporates detailed representations of 30,000 neurons. A simulation of a whole brain rat model at the same level of detail would have to represent up to 200 million neurons and would require approximately 10,000 times more memory. Simulating the human brain would require yet another 1,000-fold increase in memory and computational power. Subcellular modeling, modeling of the neuro-glial vascular system and the creation of virtual instruments (e.g. virtual EEG, virtual fMRI) will further expand these requirements.

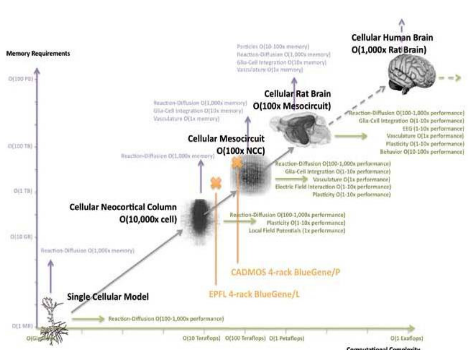

Figure 6: Computational complexity of brain

In the initial phase of its work the Blue Brain project used an IBM BlueGene/L supercomputer with 8,192 processors. Some years ago, it used a 16,384 core IBM BlueGene/P supercomputer with almost 8 times more memory than its predecessor. Today, it uses an IBM BlueGene/Q supercomputer with 65,536 cores and extended memory capabilities hosted by the Swiss National Supercomputing Center (CSCS) in Lugano.

VII. MODELING

a. *The Builder Concept*

All mathematical models used in Blue Brain virtual experiments are created by a Builder.This isa software application that generates a computer model of a particular brain structure. Models are based on the experimental data collected and organized in the first two steps of the Blue Brain workflow and on the mathematical abstractions created in the third step. The Blue Brain modeling strategy requires the construction of models representing different levels of brain organization. Each of these models requires its own builder. Below we describe the goals, characteristics and status of individual builders.

b. *Cell Builder*

The purpose of the Cell Builder is to build models of individual nerve cells. The nerve cells of the mammalian brain display great diversity in their morphology and electrical behavior. Later in this report, we suggest that this diversity makes a crucial contribution to the robust principles governing the construction and dynamic behavior of neural circuits. The design of the Cell Builder is based on a strategy of incorporating the maximum possible number of biophysical constraints from experimental data and from the results of Predictive Reverse Engineering. The remaining parameters are optimized under these constraints.

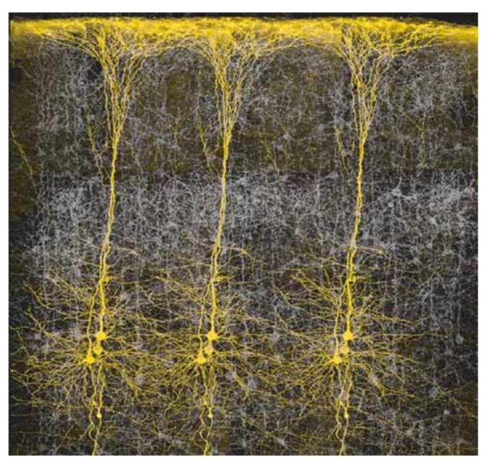

Figure 7: *Cell Builder*

c. Microcircuit Builder

The purpose of the Microcircuit Builder[3] is to build models of neural microcircuits in any part of the brain. The integration and processing of information by the mammalian brain depends in an essential way on structured interconnectivity among nerve cells. At the microcircuit level, circuits appear to be determined primarily by the composition of a given area of the brain in terms of different types of cell, by the positions of these cells, and by their respective morphologies. The Microcircuit Builder uses this data to faithfully model neuronal micro circuitry.

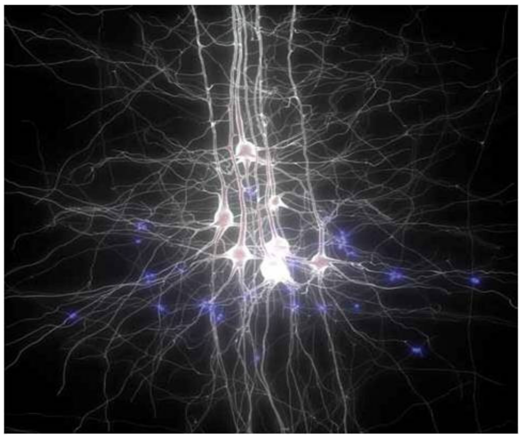

Figure 8: *Micro circuit Builder*

d. Mesocircuit Builder

The purpose of the Mesocircuit[3] Builder is to model mesoscale neural circuitry i.e. circuits spanning several neocortical columns, modules or microcircuits. Every region of the neocortex contains multiple replicas of neuromicrocircuits, which are basically similar but variable in their details, allowing diversification and specialization. These microcircuits are highly interconnected. The Mesocircuit Builder, currently in the exploration phase, will make it possible to build models of the connections among microcircuits. The planned models will include experimental data on projections formed by neurons within a brain area (e.g. S1 of the somatosensory cortex), models of mid-range fiber growth, models of the ways fibers penetrate a microcircuit, And the detection of touches between incoming fibers and the rest of the circuit.

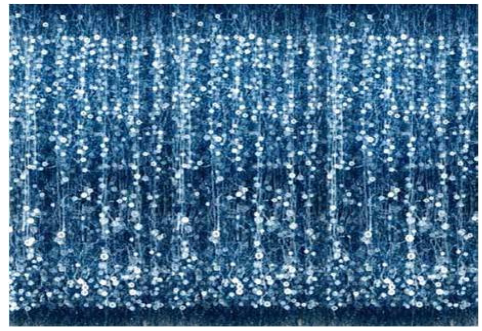

Figure 9: *MesoCircuit Builder*

VIII. CONCLUSION

The brain's extreme complexity makes it one of the most difficult subjects to study. For example, it is totally impossible to observe what is happening within a small group of neurons while at the same time imaging the activity of the whole brain. A virtual model would make such observations possible. Today, every new drug put on the market costs an average of 1.3 billion francs to develop[7]. Neurological diseases are destined to represent an ever-increasing share of health-care budgets, and are a source of considerable suffering for those afflicted and their family and friends. The Blue Brain project[8] sets out to make neuroscientific research more efficient and in the long run will help to limit the need to use laboratory animals.

IX. ACKNOWLWDGEENT

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X. REFERENCES

[1] The Blue brain project, Hil, sean: Markram Henry, International conference of IEEE 2008.

[2] Henry Markram, "The Blue Brain Project", Nature Reviews Neuroscience, 7:153-160, 2006 February. PMID 16429124.

[3] http://bluebrainproject.epfl.ch.

[4] http://research.ibm.com/bluebrain.

[5] Reconstructing the Heart of Mammalian Intelligence, Henry Markram's lecture, March 4 2008.

[6] Henry Markram builds a brain in supercomputer, TED conference July 2009

[7] Indian startup to help copy your brain in computers, Silicon India 2009

[8] http://thebeutifulbrain.com/2010/02/bluebrain-film-preview/