Acta Scientific COMPUTER SCIENCES
Volume 3 Issue 12 December 2021

Editorial

Is it Possible to Implement Artificial Consciousness?

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Received: October 21, 2021
Published: November 01, 2021
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The problem of consciousness is, probably, one of the most difficult problems in the whole philosophy. Many philosophers believe that either this mystery cannot yet be explained or that it can never be explained, and this last statement is obviously an exaggerated claim given that no one can predict what will happen in the future. They claim that our sensations, or *qualia*, are indefinable, so they cannot be described using a computer algorithm. Therefore, consciousness is not computable and human brain cannot be build using the hardware of a traditional computer.

Other philosophers believe that conscious machines can be built. They believe that an artificial brain endowed with consciousness must have a high level of complexity and must be able to learn through a long process of evolution.

We have shown in [1] that, in our opinion, the hardware resources required for a project of this kind are enormous, but that in principle an artificial brain hardware structure, of complexity comparable to the human brain, can be realized in the near future. This project can be done either using a classic technology that uses silicon integrated circuits, or an innovative one, which could appear in the future.

But the most difficult problem remains software development. The plasticity of the brain should be modeled with the programmable connections in programmable integrated circuits (such as FPGAs), by their reprogramming during the evolution. How can be interconnected all these programmable cells to initiate a function of this brain and how the conscience emerge in such a huge network? Moreover, the author of the book [2] quotes David McCormick with a paragraph in the fifth edition of Gordon Shepherd's book The Synaptic Organization of the Brain: "Information-processing depends not only on the anatomical substrates of synaptic circuits but also on the electrophysiological properties of neurons... Even if two neurons in different regions of the nervous system possess identical morphological features, they may respond to the same synaptic input in very different manners because of each cell's intrinsic properties".

There are now many elaborate models of the neuron, starting with the classic Hodgkin-Huxley model and ending with the simpler but no less efficient model of Izhikevich. In [3] the authors set out to make a model of the thalamocortical system in mammals to understand in depth how synaptic and neuronal processes interact to produce the collective behavior of the brain. The authors started with the thalamocortical system because it is necessary for human consciousness. The model simulates one million multicompartmental spiking neurons with half a billion synapses that use the neuronal dynamics given by Izhikevich's model. The program simulating the model is run on a Beowulf cluster of 60 processors with 1.5 GB of RAM each. The working frequency of the processors is 3 GHz. The model is initialized in about 10 minutes, and for one second of operation in the simulation, one minute of calculations is required. Experiments with this model indicate a distribution of firing rates among various types of neurons similar to that recorded *in vivo*. The model spontaneously generated rhythms and propagating waves that had frequency distributions and propagation velocities similar to those observed *in vivo* recordings, including fMRI observations. It has been found that disturbances on a single spike cause the complete reorganization of the network in half a second or that the patterns that appear are interpreted in a statistical sense because the individual spikes are too volatile. The authors of the paper conclude: "Knowing the state of every neuron and every synapse in such a model, one may analyze the mechanisms involved in neural computations with a view toward development of novel computational paradigms based on how the brain works. Finally, by reproducing the global anatomy of the human thalamocortical system, one may eventually test various hypotheses on how discriminatory perception and consciousness arise".

The book [4] has an attractive title, which gives the impression that there are already hardware solutions for building conscious machines. The author uses here relatively simple circuits, sensors, artificial neural networks with feedback loops, associative memories, which simulate some conscious behaviors. Mental content, seen as an immaterial element, appears available via introspection, which is realized via the feedback loops that return the results of the inner processes back to the perception points. Analyzing different aspects of consciousness, the author proposes the elaboration of other criteria for recognizing the appearance of the conscious state in a robot. The Turing test is not useful in this context, because it can be easily fooled. However, the book does not mention at all the possibility of learning an artificial brain through evolution.

Very interesting ideas about evolution are discussed in the book [5] and they allow finding analogies between the evolution of some scientific theories over time and the construction of an artificial consciousness. We believe that evolution is absolutely necessary in explaining consciousness. Evolution is the way biology works, the central organizing principle of life on earth, as the famous geneticist Theodosius Dobzhansky showed in his paper "Nothing in Biology Makes Sense Except in the Light of Evolution".

It seems very strange that Darwin developed his theory of evolution so late, more than two hundred years after Newton formulated the theory of universal gravity, including calculus, the mathematical support needed to describe Newton's theory. However, Darwin hesitated for years to publish his ideas based on the results of his observations, a major difficulty for him being the age of the Earth, accepted at that time at less than 20-40 million years old, according to the calculations of the physicist William Thompson (Lord Kelvin). This error was corrected by John Perry, Kelvin's former assistant only 13 years after Darwin's death. He estimated the age of the Earth to be between 2 and 3 billion years, long enough for the evolution of the living world.

After the publication of his theory, Darwin began to receive letters reminding him of various authors who were concerned with the problem of evolution. Although Darwin always justified the priority of his theory, by the fourth edition of The Origin of Species he also published a list of authors containing thirty-seven names, the first of which was that of Aristotle. Darwin was delighted to add Aristotle to his list but he could not see how any one in ancient Greece could have foreseen natural selection without microscopes to study single-celled organisms, without taxonomic theories to understand the various families of animals or the relationship between the plants and animals, without studies based on dissections and so on.

In Physics Aristotle created many wrong theories, which delayed the development of science in the Middle Ages. That's because his theories were based on reasoning and not experiment. Only Galileo corrected many of Aristotle's theories about the motion of bodies, using the experimental method. But it is surprising that in the study of animals Aristotle even used a scientific method, based on observations. He collected detailed facts about plants, lizards, birds and fish. He dissected snakes or birds to study their internal organs. He understood that the different forms of fish were due to their adaptation to the environments in which they lived. Without being able to explain the appearance of life, he believed that there was no beginning, no origin. The world in all its variety has always been and would always be.

As the author of the book [5] writes: "Aristotle saw corals spawn and dogfish mate, he saw the stages of the development of a chick in its egg, he saw bees dance and chameleons change color, but he did not see what we would call evolution or natural selection".

What prevented Aristotle from imagining that living organisms evolve through continuous adaptation to the environment? Probably, again, the age of the Earth, the ancients being convinced that it can not exceed a few thousand years. Perfect geometers, the Greeks were not good at calculations because they did not have the positional numbering system with base ten and for this reason, large numbers, of the order of tens of thousands, were considered something almost infinite.

Just as Aristotle had information about the living world, today we have information about neurons and their associated structures. What prevents us from seeing further the connection between neurons and consciousness? Maybe the fact that we do not yet have the necessary knowledge to understand what it is about. Or maybe, on the contrary, we know something that is not true, but that we consider true and that confuses us in our reasoning. From my point of view, I think the first hypothesis is more plausible.

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Volume 3 Issue 12 December 2021
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