The Amalgamation of Neuroscience and Computation.

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Introduction

The human brain can be compared to a “black box” – a system which can be viewed in the terms of inputs and outputs, without any knowledge of its internal workings.

As in the artificial neural network, there can be many outputs and many inputs, yet the workings of code are relatively unknown to the average person. The first such artificial neural network, “Perceptron”, designed in 1952 by F. Rosenblatt was capable of image and pattern recognition, a skill which the human brain has evolved to master.

Since Perceptron, various new artificial neural networks have evolved, and since all artificial neural networks are based on the working of the human brain, it brings forth the question, are human brains comparable to a computer?

As the computer is a device which has input, output, control unit, memory, similarly the human brain is central to various types of functions that are similar to computing. The stimuli received by the neurons act as the sensory inputs and produce desired output, the artificial neural network is based on the functioning of the human brain.

The article, “Face It, Your Brain Is A Computer” (Marcus, 2015) states that scientists often resist the idea of the brain as a computer. Too many scientists have given up on the computer analogy and far too little has been offered in its place, but the analogy is due for a rethink.

Article's Impact on the General Population.

The media report by G. Marcus discusses the idea of comparing the human brain to the technology of the day. In the past, many scientists have attempted to compare the working of the brain to various machines that existed during their times, a hydraulic pump that propels the spirits of the nervous system, a steam engine, or a holographic storage device. Today, many artificial neural networks are based on the design of the neurons and their stimulation – it is, therefore, logical to compare the working of the brain to that of a modern computer.

Many neuroscientists, however, discard this idea as just another analogy without a lot of substance, brain's nerve cells are too slow and variable to be comparable to the transistors and logic gates used in modern computers. The author, however, proposes the idea of comparing the workings of the human brain with those of a field programmable gate array.

The field programmable gate array consists of a large number of logic blocks that can be configured and reconfigured to do a wide range of tasks. The logic blocks can do arithmetic, signal processing, and various other tasks, often executed in parallel – much like what happens in the brain.

The brain, while not exactly a field programmable gate array, similarly consists of highly orchestrated sets of fundamental building blocks. Constructing sequences, retrieving information from memory, and routing information between different locations in the brain.

Identifying those building blocks could be the 'Rosetta stone' that unlocks the brain. Neurons, akin to computer hardware, can be linked to behaviors, akin to the actions a computer performs, through computation -- "the glue that binds the two."

According to the author, "the real payoff in subscribing to the idea of a brain as a computer would come from using that idea to profitably guide research."

The fifth generation of computers is based on parallel processing hardware and artificial intelligence – the improvement in understanding the functioning of the brain will help in the development of more efficient artificial intelligence.

Analysing Scientific Reliability of the Article.

The article “The atoms of neural computation” by G. Marcus et al. begins with the question, “Does the brain depend on a set of elementary, reusable computations?”

The authors proceed to question the basic logic behind the human cerebral cortex, which still remains unknown. One hypothesis of cortical neurons forming a single, massively repeated “canonical” circuit, characterized as a kind of a “nonlinear spatiotemporal filter with adaptive properties” is still considered a hypothesis as there is no consensus about whether such a canonical circuit exists, even after four decades.

The authors believe there is little evidence that such uniform architectures can capture the diversity of cortical functions, let alone characteristically human processes such as language and abstract thinking.

Analogous software implementations in artificial intelligence (e.g., deep learning networks) have proven effective in certain pattern classification tasks, but likewise have made little inroads in areas such as reasoning and natural language understanding.

“Is the search for a single canonical cortical circuit misguided?” the authors present this question. Ever since the pivotal work of Korbinian Brodmann a century ago it has been known that there are substantial differences between cortical areas. For the cortex to be diverse rather than uniform, the idea of a single canonical circuit is not plausible.

The authors therefore propose the idea of a broad array of reusable computational primitives – elementary units of processing akin to sets of basic instructions in a microprocessor, wired together in parallel – as in the reconfigurable integrated circuit type known as the field programmable gate array.

Computational primitives may include circuits for different processes. Cortical regions would differ not only in terms of their inputs, but also as a function of their inherent structures – the sensory cortex, for example, might be rich in circuits that underlie computational primitives useful for hierarchical pattern recognition and for mediating the effects of attention, whereas the prefrontal cortex might rely heavily on circuits supporting sequence production, decision making and variable binding.

There is an emphasis on the need of a greater understanding of neural underpinnings of variable binding. This process appears to be outside the scope of uniform pattern recognition systems yet are likely to be central both in language and deductive reasoning.

While several candidate neural mechanisms for variable binding have been proposed, relatively little experimental work has focused on choosing among these possibilities, the authors point out, partly because the earlier techniques were too ‘coarse-grained’, Emerging techniques give hope that specific questions about the microcircuitry if variable binding might be addressed. Ultimately, an adequate account of the mechanisms of variable binding may be indispensable for drawing firm connections between neurons and higher-level cognitive processes.

Several recently discovered biological mechanisms could underwrite the development of a diverse set of computational building blocks, differently arrayed across the cortex.

The authors conclude by stating that neuroscience must develop precisely the sorts of experimental tools, detailed brain maps, and computational infrastructures that today's brain initiatives aim to support.

Conclusion

The media report published in the New York Times (Marcus, 2015) abstains from indulging in the more scientific terms used in the peer reviewed journal (Marcus et al., 2014, p. 551), however, the essence of both these articles is the unchanging.

The main focus of the article is to compare the brain to the technology of our time, in this instance, to the field programmable arrays. While the proposition is not entirely faultless, a field programmable array resembles the workings of the brain much more precisely than any other machines the brain has been compared to.

The articles point out the scope of the amalgamation of neuroscience and computation, and while the field is relatively new, there have been many substantial developments in it, and many more dimensions can be explored in the near-future.

References

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