McCulloch/Pitts Analysis

Palani Johnson
A02231136

September 12, 2021

In *A Logical Calculus of the Ideas Immanent in Nervous Activity*, W. McCulloch and W. Pitts propose a method of modeling propositional logic through nets of neurons due to their "all-or-none" nature. With a handful of assumptions, they are able to simplify the model into a language that can express cyclic and non-cyclic neuron nets. Some of the assumptions include: neuron activation is based on a function of the excited synapses and a cutoff value (i.e. the "all-or-none" nature of neurons), the structure of the nets is unchanging, and that the only significant delay is synaptic delay. To account for learning and memory, McCulloch and Pitts introduce the more complicated structure of cyclic nets. Additionally, all nets can be as powerful as Turing Machines if equip with a tape and suitable appendages to read such tape. Cyclic nets with no appendages can be nearly as powerful as a Turing Machine.

Remarks

Overall, I enjoyed this paper and found it a fascinating look into the foundations of machine learning and computer science. Any time I read a paper as old as this I am impressed by the typography and the ability to format without LaTeX. I am exceptionally grateful that I can just print '$\exists$' without having to find a typewriter with said symbol. I also found the idea of neurons that can inhibit other neurons interesting. Specifically relating to their usage in cyclic nets, I loved the ability they had to allow the system to 'learn' while also not needing the system to change in structure. While I do not know if this is actually how the brain functions, the idea if a more or less static system being able to exhibit learning behavior is something I would have never thought about.

Easily my biggest gripe with this paper is the last page on the authors' assumptions to the consequences of neuron nets in psychology. They state that "specification of the net would contribute all that could be achieved in that field". I believe this is a delusionally grand assumption to make and fails to account for so much of what the field does. They almost seem to claim the their model can perfectly translate to a human brain, even though they are making many assumptions on how a neurons work. While I do not doubt that these findings were important to psychology, I struggle to believe that this is the end-all be-all for the field. Additionally, I don't think the diagrams in Figure 1 were explained well enough and I would have liked to have a little more help in understanding what exactly was being depicted.

This paper has given me many ideas and inspirations. I would like to see how modifying the TPF could work. For example, what if a neuron was not "all-or-nothing" and instead could produce any output? What if the threshold wasn't above or below a specific value but rather on a value? I would assume that an XOR gate could be made with only one neuron using the latter assumption. Would these modification change a neuron net's computational power in any way? I would love to explore alternative neuron models, of which I assume there many, and see if they can applied to more novel use cases.