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Do neurons have good memory?

Artificial neural networks have become a very hot topic, being a very versatile and innovative way to make machines learn and solve tasks. In my thesis, I have studied how two types of neural networks (namely spiking neural networks and recurrent neural networks) could be combined and I tested the obtained networks on some memory-requiring tasks, obtaining good results.

The human brain, with its 100 billion neurons and 100 trillion connections, is one of the most efficient and fascinating systems known. It can perform a huge amount of different tasks and with very little energy required and, if you think about muscle control and the high diversity and accuracy of the possible motions, or about the capability of image recognition we have, it seems logical that the research in computational science would have turned towards the branch of neuroscience and draw inspiration from the biophysical and mathematical models of the brain.

In the last few decades, in fact, a new way of doing computation has been developed, inspired by the structure of the brain. It is based on a number of computing units connected to each other, and such a system is called *artificial neural network*. There are many different types of artificial neural networks, one of which is particularly similar to the biological counterpart: the so-called *spiking neural networks* simulate really how our neurons work. They are composed by artificial neurons that send small signals (called *spikes*) to each other, the same way information is communicated by biological neurons.

Another important type of artificial networks are *recurrent neural networks*. By adding some special connections, in fact, it is possible to make a network remember important pieces of information, feature that extends the range of possibilities for these computing nets. An example of this can be seen in the word prediction system that we have in the keyboard of our mobile phones: after a few times you write the same group of words in a specific order, the keyboard will start suggesting that sequence whenever the first word is typed in.

In my diploma project, I studied if it was possible to make a spiking neural network solve some tasks that involved memory, by programming a spiking network including a special recurrent unit called *Long Short-Term Memory architecture*. Two types of tasks were involved in this project. One of the tasks I used, similarly to the word-prediction situation described earlier, consisted of predicting a sequence of vectors. The second task, instead, was more similar to when a person drives a car along a highway until their exit comes and they have to recognize it and to take it. In both cases, artificial spiking networks with the Long Short-Term Memory unit were able to correctly perform the tasks, meaning that the way biological neurons communicate information can be potentially implemented in scientific research and technology.

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