Basics of Neural Networks (Deep Learning)

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Preliminaries

One of the examples discussed in the lecture on the first mathematical model of neural networks by McCulloch and Pitts has to do with a control of signals passing through a gate. Figure 1 depicts this example. Recall that here we use an inhibition fibre to block the output when we want to block it. This means that is the input signal is coming constantly, and we want to stop its flow, all we need to do is to send pulses through our control fibre, and that will stop the output from sending a pulse.

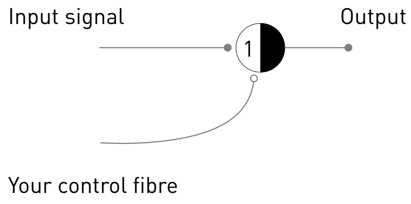

Figure 1: The inhibition gate.

Problem 1: Control

Using what you know about McCulloch and Pitts networks, design a network architecture that allows you to receive an input signal from a transmitter T, and transfer the signal to one two receivers $R1$ and $R2$. In other words, you need to have a control fibre. When it is not active, the input signal is sent to $R1$ (and not to $R2$) but when it is active (you control it) the signal travels to $R2$ (and not to $R1$).

Problem 2: Feedback and memory

Considering the gating network in the preliminaries, think of a gating architecture that has an input and output signal, all identical to Figure 1 but in which your control fibre has a start, and stop button that you need to press only once to activate or deactivate the control. Remember that in the examples above, you need to keep the control fibres constantly active to keep getting their effect. That means that the control fibre has no memory.

Problem 3: Bigger challenge

An interesting neural network module for computation is the so-called *binary scaler.* This architecture only has to send an output pulse for every two pulses it receives as input. In many computers, binary scalers are used for counting, as well as other arithmetic operations. Consider the binary scaler in Figure 2. Analyse it, and respond (a) does it work? if it does, (b) how does it work and how you make sure it always works? If it does not work, (b) why not? Can you figure out what needs to be done to fix it? Hint. Remember that in this type of neural network, time is discrete, it means that the machine is checking what is firing and what is not firing at $t = 1$, $t = 2$ and so on.

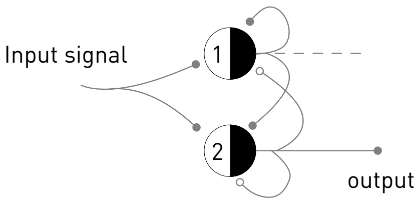

Figure 2: Experimental Binary Scaler.