Lecture 5, Problem 1

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Problem statement Design a circuit that adds 2 inputs, A and B, using neurons. In each case the inputs are individual action potentials (all or none) on A and B. Do this three ways:

- Using digital logic operations so that you have two outputs: sum and carry.
- Using entirely analog logic, so that the output is something like the firing rate or number of action potentials
- Using analog-to-digital logic, so that the computations are analog but the output is a sum and a carry.

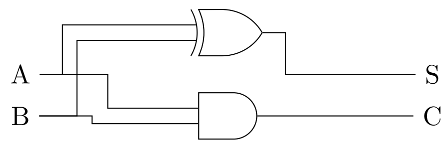
Using digital logic

The actional potential can be treated as a square pulse: resting potential representing 0 and anything above +10 mV (or many be +0 mV) as 1. We can start with following truth table. The output 'S' is sum and 'C' is carry.

A	B	S	C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Logic of S and C We can represent this circuit in standard *sum of product* terms. Just select those minterms which make the outout of S, 1. Sum $S = A'B + AB' = A \oplus B$ which is XOR gate with A and B at its input. The carry $C = AB$ which is essentially and AND gate connected to A and B.

The circuit is following.



Using analog circuit

We want to count! One popular form of counting is by addition when if each addition is equal to other additions. We assume that each synaptic input carries equal amount of change (area under the current curve). Let's say I want to design a circuit which gives an output when 10 pulse have arrived. If a pulse carries x amount of charge then we use a big enough capacitor to store this charge. Let's assume the capacity of this capacitor c; this will cause $\frac{x}{x}$ voltage across the capacitor. We need to design a "comparator" which generates output pulse whenever input to it is greater than this voltage value. Once the voltage across the capacitor has reached this value, we need to reset it. A circuit is given in lecture slide.

Using analog and digital

This is now easy. On each input line, we put our analog circuit which generates a pulse when n pulse have arrived on it. We we recieve 10 pulses on each line at the same time, the digital ciruits add them up accordin to the given truth table. Much depends on where we draw the line to distinguish 0 and 1. This arrangement can also be seen as *synchronizer*. One can split many hair in this scheme.