1 Neuronal Circuit

Figure 1. depicts the neuronal circuit that I will be employing. In the circuit the synapse and the neuron are boxed separately. The 1’s in the synapse coming from the PIC represent the number of ions arriving passing through the post-synaptic membrane. The membrane potential thus collects and builds up, and can decay over time (possibly with the inclusion of another resistor).
The spike coming from the previous neuron / sensor is input into the pic which then 'releases a series of neurotransmitters that open up more and more ion channels' (or results in the flow of charge through the membrane). The processing that is done on the pic is to use the digital pulses coming from the previous neuron to produce a number of charges at a varying rate.

This variation in the charge release is modeled by the alpha function:

$$\alpha(t) = g_{\text{max}} \frac{t}{t_0} \exp(1 - t/t_0) \quad (1)$$

To simulate the varying rate, the firing frequency is set equal to the $\alpha$ function. This allows us to control the maximum firing frequency with $g_{\text{max}}$ and the rate at which the frequency decays with $t_0$. To simulate learning in the neuron, the maximum firing frequency is made a linear function of the frequency of spikes arriving at the potential.

$$g_{\text{max}}(\nu_{\text{pre}}) = A + B\nu_{\text{pre}} = A + B/\Delta T_{\text{pre}} \quad (2)$$

Here $\Delta T_{\text{pre}}$ is the time from the last spike to the current spike. Figure 2 shows the alpha function for different $g_{\text{max}}$'s and $t_0$'s. What I still need to do is research realistic responses to firing frequency to decide on useful values for $g_{\text{max}}, t_0$ and the parameters (and possibly function) used to model $g_{\text{max}}$'s dependence on the presynaptic neuron’s firing frequency.