EQUATIONS GOVERNING OUR 2 MONTHS AT THE DARPA INNOVATION HOUSE

SPIKING RETINA —STDP—> LEAKY INTEGRATE-AND-FIRE NEURON WITH LATERAL INHIBITION

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Average spike count over interval τ:

$$n_i^\tau(t + \Delta t) = e^{\frac{-\Delta t}{\tau}} \left[A_i(t) + n_i^\tau(t) \right] \tag{1}$$

Average firing rate over interval τ:

$$f_i^\tau(t) = \frac{n_i^\tau(t)}{\tau} \tag{2}$$

Feed-forward weight adaptation (STDP):

$$Q_{ij}(t + \Delta t) = Q_{ij}(t) + \beta \left(\frac{\Delta t}{\tau_{oja}} \right)^2 \{ Oja * LTP - LTD - decay \}$$

i.e.

$$Q_{ij}(t + \Delta t) = Q_{ij}(t) + \beta \left(\frac{\Delta t}{\tau_{oja}} \right)^2 \{$$

$$n_{Y_j}^{\tau_{oja}}(t) \left[n_{X_i}^{\tau_{oja}}(t) - \frac{f_{pre}}{f_o} \frac{Q_{ij}(t)}{W_{scale}} n_{Y_j}^{\tau_{oja}}(t) \right] \cdot \lambda_P A_Y(t) n_{X_i}^{\tau_P}(t) - \tag{3}$$

$$\lambda_{Dj} A_{Xi}(t) n_{Y_j}^{\tau_D}(t) -$$

$$\alpha_{dec} Q_{ij}(t) \}$$

Adaptive LTD for feed-forward weights

$$\lambda_{Dj}(t + \Delta t) = \lambda_{Dj}(t) + \frac{\Delta t}{\tau_{thr}} \left[f_j^{\tau_o}(t) - f_o \right] \frac{\lambda_{Dscale}}{f_o} \tag{4}$$

where

$$\lambda_{Dj} > 0$$

$$\lambda_{Dj}(0) = \lambda_{Dinit}$$

Lateral inhibition:

$$w_{jk}(t + \Delta t) = w_{jk}(t) + \frac{\Delta t}{\tau_{inh}} \left[f_j^{\tau_{int}}(t) f_k^{\tau_{int}}(t) - f_o^2 \right] \frac{1}{f_o^2} \tag{5}$$

Current scales for τ values

$$\tau_{oja} \approx 50 - 200ms$$

$$\tau_P \approx 0 - 10ms$$

$$\tau_D \approx 20 - 40ms$$

$$\tau_{int} \approx \tau_{oja}$$

$$\tau_o = 300$$

$$\tau_{thr} \gg \tau_o$$

$$\tau_{inh} \gg \tau_{int}$$

$$\tag{6}$$

Current values for constants:

$$\lambda_P \approx 1$$

$$\lambda_{Dscale} \approx \lambda_P$$

$$\lambda_{Dinit} \approx 1$$

$$\beta = 2$$

$$\alpha_{dec} = 0$$