$$w_{i,\ell}^{(1)} = \{ \ 12n \text{ if } \ell \text{ is the correct class (if } y_{i,\ell} = 1), \frac{1}{2n(k-1)} \text{ otherwise (if } y_{i,\ell} = -1).$$

n

k

μ

$$
\begin{aligned}
\mu_{\ell+} &= \sum_{correct} w_{i,\ell}^{(t)}, \\
\mu_{\ell-} &= \sum_{incorrect} w_{i,\ell}^{(t)}, \\
\mu_{\ell 0} &= \mu_{\ell-} + \mu_{\ell+}
\end{aligned}
$$

$v = 0$

$\mu_{\ell+}$

$\mu_{\ell-}$

$\mu_{\ell 0}$

w

$$w_{i,\ell}^{(t+1)} = \frac{w_{i,\ell}^{(t)} \exp\left(-\alpha^{(t)} h_{\ell}^{(t)}(x_i) y_{i,\ell}\right)}{Z^{(t)}}$$

$$Z^{(t)} = \sum_{j=1}^{n} \sum_{\ell=1}^{k} w_{j,\ell}^{(t)} \exp\left(-\alpha^{(t)} h_{\ell}^{(t)}(x_j) y_{j,\ell}\right)$$

α

$h_\ell(x_i)$

x_i

$^{(t)}()\$ f after t iteration. Then the weights of the$

$$Z = 2\sqrt{\epsilon_+\epsilon_-} + \epsilon_0$$

$$Z = \sum_{i=1}^{n} \sum_{\ell=1}^{k} w_{i,\ell} \exp\left(-\alpha_\ell h_\ell(x_i) y_{i,\ell}\right),$$

$$Z = 2\sum_{\ell=1}^{k} \sqrt{\mu_{-,\ell}\mu_{+,\ell}}$$

$\theta > 0$

$$Z = \mu_0 + 2\sum_{\ell=1}^{k} \sqrt{\mu_{-,\ell}\mu_{+,\ell}},$$

$$v_\ell = \{ +1 \text{ if } \mu_{\ell+} > \mu_{\ell-} - 1 \text{ otherwise.}$$

$$\alpha = \frac{1}{2} \log \left(\frac{\epsilon_+ + \delta}{\epsilon_- + \delta} \right)$$

δ

$$\alpha = \{ \ln \left(-\frac{\theta \epsilon_0^{(t)}}{2(1+\theta)\epsilon_-^{(t)}} + \sqrt{\left(\frac{\theta \epsilon_0^{(t)}}{2(1+\theta)\epsilon_-^{(t)}} \right)^2 + \frac{(1-\theta)\epsilon_+^{(t)}}{(1+\theta)\epsilon_-^{(t)}}} \right) \text{ if } \epsilon_-^{(t)} > 0, \ \ln \left(\frac{(1-\theta)\epsilon_+^{(t)}}{\theta \epsilon_0^{(t)}} \right) \text{ if } \epsilon_-^{(t)} = 0.$$

$$\left\{ v_1^{(t)}, v_2^{(t)}, \cdots, v_K^{(t)}, \phi^{(t)}(\mathbf{x}_1), \phi^{(t)}(\mathbf{x}_2), \cdots, \phi^{(t)}(\mathbf{x}_n) \right\}$$

t