Final Exam

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$$P(\mathbf{s}|\mathbf{o}) = \frac{1}{Z_{\mathbf{s}}} \exp\left(\sum_{t=1}^{T} \sum_{k} \lambda_k f_k(s_{t-1}, s_t, o_t)\right) \tag{1}$$

$$Z_{\mathbf{s}} = \sum_{\mathbf{s}} \exp\left(\sum_{t=1}^{T} \sum_{k} \lambda_k f_k(s_{t-1}, s_t, o_t)\right) \tag{2}$$

$$L = \sum_{n=1}^{N} \log P(\mathbf{s}^{(n)}|\mathbf{o}^{(n)}) - \sum_{k} \frac{\lambda_k^2}{2\sigma} \tag{3}$$

$$\frac{\partial L}{\partial \lambda_k} = \sum_{n=1}^{N} \left(F_k(\mathbf{s}^{(n)}, \mathbf{o}^{(n)}) - \sum_{\mathbf{s}} P(\mathbf{s}|\mathbf{o}^{(n)}) F_k(\mathbf{s}, \mathbf{o}^{(n)})\right) \tag{4}$$

$$\sum_{\mathbf{s}} P(\mathbf{s}|\mathbf{o}^{(n)}) F_k(\mathbf{s}, \mathbf{o}^{(n)}) = E_{p(\mathbf{s}|\mathbf{o}^{(n)})}[F_k(\mathbf{s}, \mathbf{o}^{(n)})] \tag{5}$$

$$E_{p(\mathbf{s}|\mathbf{o}^{(n)})}[F_k(\mathbf{s}, \mathbf{o}^{(n)})] = \frac{\sum_{t=1}^{T} \sum_{s_{t-1}, s_t} \alpha(t-1, s_{t-1}) f_k(s_{t-1}, s_t, o_t^{(n)}) \exp^{\lambda_k f_k(s_{t-1}, s_t, o_t^{(n)})} \beta(t, s_t)}{Z_{\mathbf{s}}} \tag{6}$$

$$Z_{\mathbf{s}} = \beta(1,0) + \beta(1,1) = \alpha(N,0) + \alpha(N,1) \tag{7}$$

$$V(t,s) = \begin{cases} \max_{s'}(V(t-1,s') \exp\left(\sum_k \lambda_k f_k(s',s,\mathbf{o}_t)\right)) & t > 1 \\ s == 1 & t = 1 \end{cases} \tag{8}$$

$$V(t,s) = \begin{cases} \max_{s'}(V(t-1,s') + \sum_k \lambda_k f_k(s',s,\mathbf{o}_t)) & t > 1 \\ V(1,0) = -\infty,\ V(1,1) = 0 & t = 1 \end{cases} \tag{9}$$

$$\alpha(t,s) = \sum_{s'} \alpha(t-1,s') \exp\left(\sum_k \lambda_k f_k(s',s,\mathbf{o}_t)\right) \tag{10}$$

$$\beta(t,s) = \sum_{s'} \beta(t+1,s') \exp\left(\sum_k \lambda_k f_k(s,s',\mathbf{o}_{t+1})\right) \tag{11}$$