$$x(t) \longrightarrow \bigcirc \longrightarrow A_t = \begin{cases} 1 & P_t \\ 0 & 1-P_t \end{cases}$$

$$h(s,1,\theta) - h(s,0,\theta) = \theta^T x(s)$$

$\boxed{\text{Part A}}$

$$\pi(a|s,\theta) = \frac{e^{h(s,a,\theta)}}{\sum_b e^{h(s,b,\theta)}}$$

$$P_t = \pi(1|s_t,\theta_t) = \frac{e^{h(s_t,1,\theta_t)}}{e^{h(s_t,1,\theta_t)} + e^{h(s_t,0,\theta_t)}}$$

$$= \frac{1}{1 + e^{\underbrace{h(s_t,0,\theta_t) - h(s_t,1,\theta_t)}_{-\theta_t^T x(s_t)}}} = \frac{1}{1 + e^{-\theta_t^T x(s_t)}}$$

$$\theta^{t+1} = \theta^t + \alpha \underbrace{\nabla_\theta \log \pi(a_t | s_t, \theta_t)}_{\text{need to calculate this!}} G_t$$

$\boxed{\text{Part B}}$

$$\pi(1|s_t,\theta_t) = \frac{1}{1 + e^{-\theta_t^T x(s_t)}}$$

$$\pi(0|s_t,\theta_t) = 1 - \frac{1}{1+e^{-\theta_t^T x(s_t)}} = \frac{e^{-\theta_t^T x(s_t)}}{1+e^{-\theta_t^T x(s_t)}} = \frac{1}{1+e^{\theta_t^T x(s_t)}}$$

$$\log \pi(1|s_t,\theta_t) = -\log\left(1+e^{-\theta_t^T x(s_t)}\right)$$

$$\log \pi(0|s_t,\theta_t) = -\log\left(1+e^{\theta_t^T x(s_t)}\right)$$

$$\nabla_\theta \log \pi(1|s_t,\theta_t) = + \frac{x(s_t)\, e^{-\theta_t^T x(s_t)}}{1+e^{-\theta_t^T x(s_t)}} = x(s_t)\, \pi(\overbrace{0}^{1-\pi(1|s_t,\theta_t)}|s_t,\theta_t)$$

$$\nabla_\theta \log \pi(0|s_t,\theta_t) = - \frac{x(s_t)\, e^{\theta_t^T x(s_t)}}{1+e^{\theta_t^T x(s_t)}} = -x(s_t)\pi(1|s_t,\theta_t)$$

$$\Rightarrow \nabla_\theta \log \pi(a_t | s_t, \theta_t) = \left(a_t - \pi(1 | s_t, \theta_t)\right) x(s_t)$$

$\Rightarrow$ Update Rule :

$$\theta^{t+1} = \theta^t + \alpha \left(a_t - \pi(1 | s_t, \theta_t)\right) x(s_t)\, G_t$$

$\boxed{\text{Part C}}$

I think I did it in Part B !

$$\nabla \ln \pi(a | s, \theta) = \left(a - \pi(1 | s, \theta)\right) x(s)$$

Sorry for the delay! ☺