Рекуррентные нейронные сети

backward pass
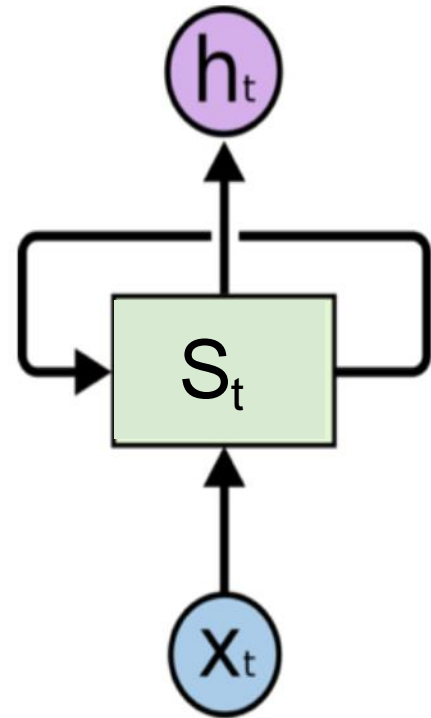
Backpropagation

$$s_t = f(\boldsymbol{U}x_t + \boldsymbol{W}s_{t-1})$$

$$h_t = softmax(\boldsymbol{V}s_t)$$

Нужно уметь вычислять градиенты
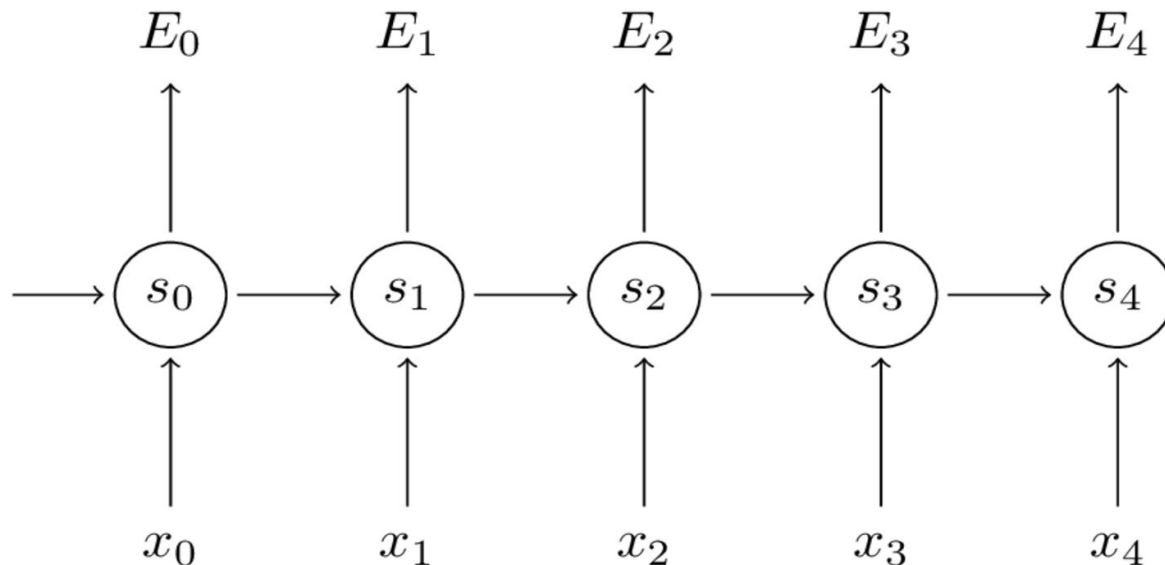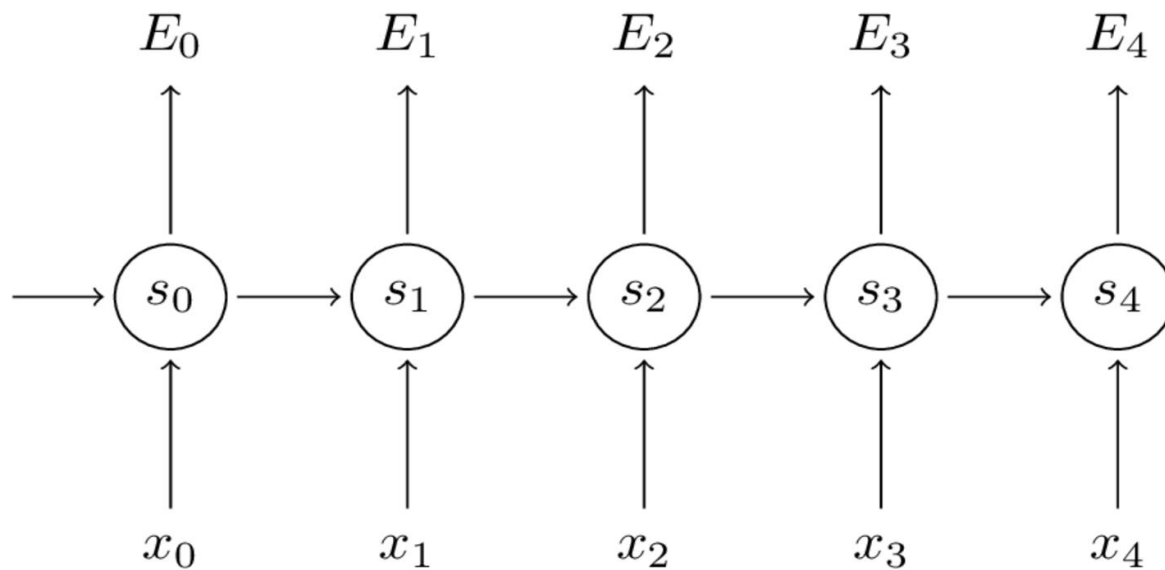
U, W, V

Backpropagation

Идеи:

● Ошибка сети есть сумма ее ошибок для всех t

● Общий градиент по переменной есть сумма ее градиентов для всех t
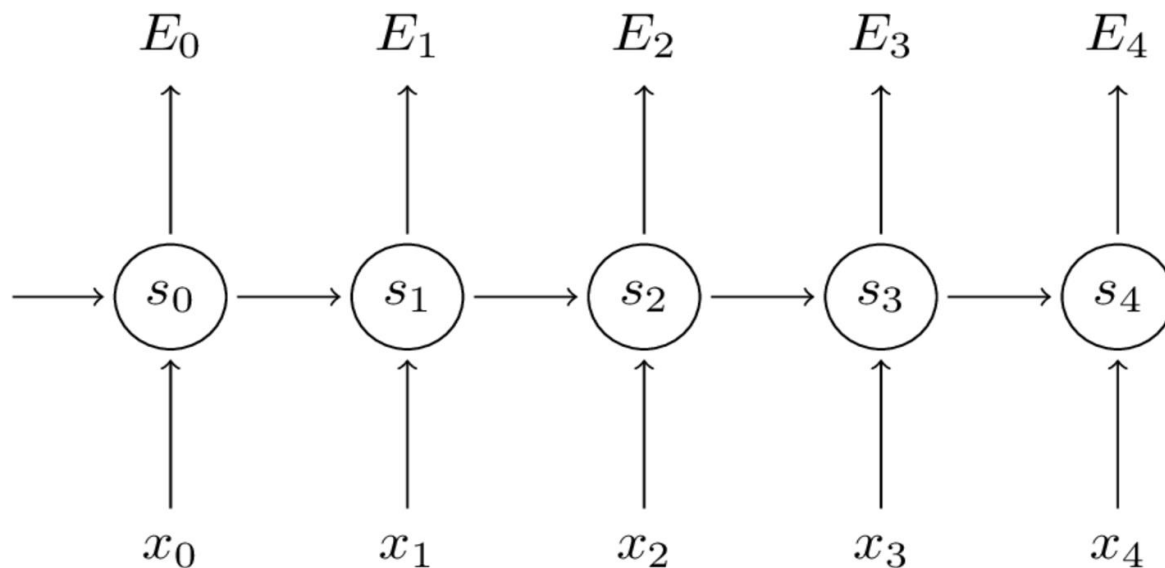
Backpropagation

$$\frac{\partial E}{\partial W} = \sum_t \frac{\partial E_t}{\partial W}$$

Backpropagation

$$\frac{\partial E_3}{\partial W} = \frac{\partial E_3}{\partial \hat{y_3}} \frac{\partial \hat{y_3}}{\partial s_3} \frac{\partial s_3}{\partial W}$$
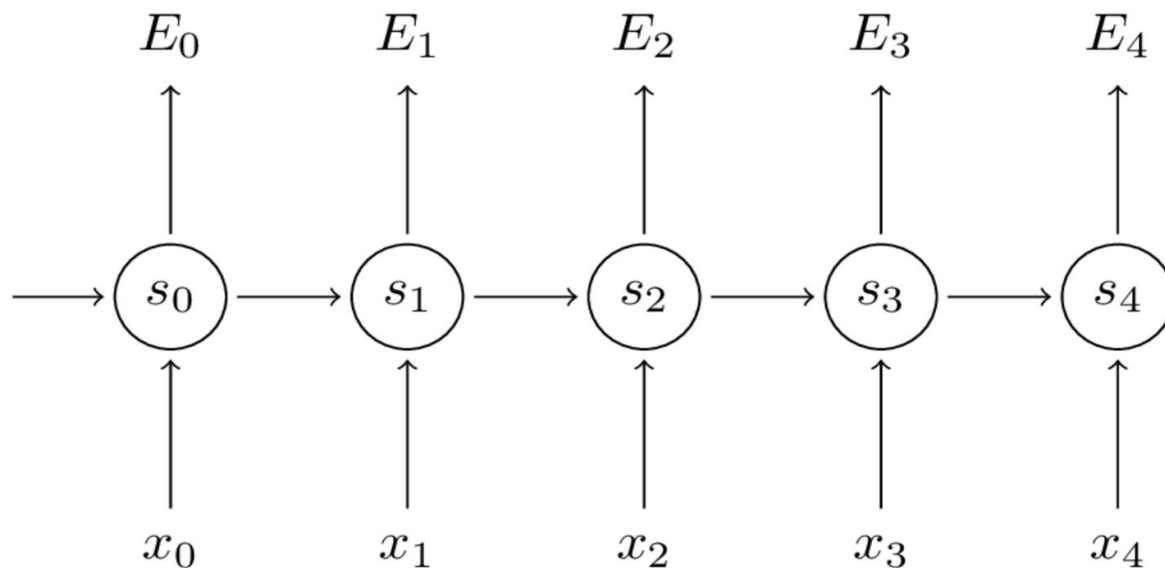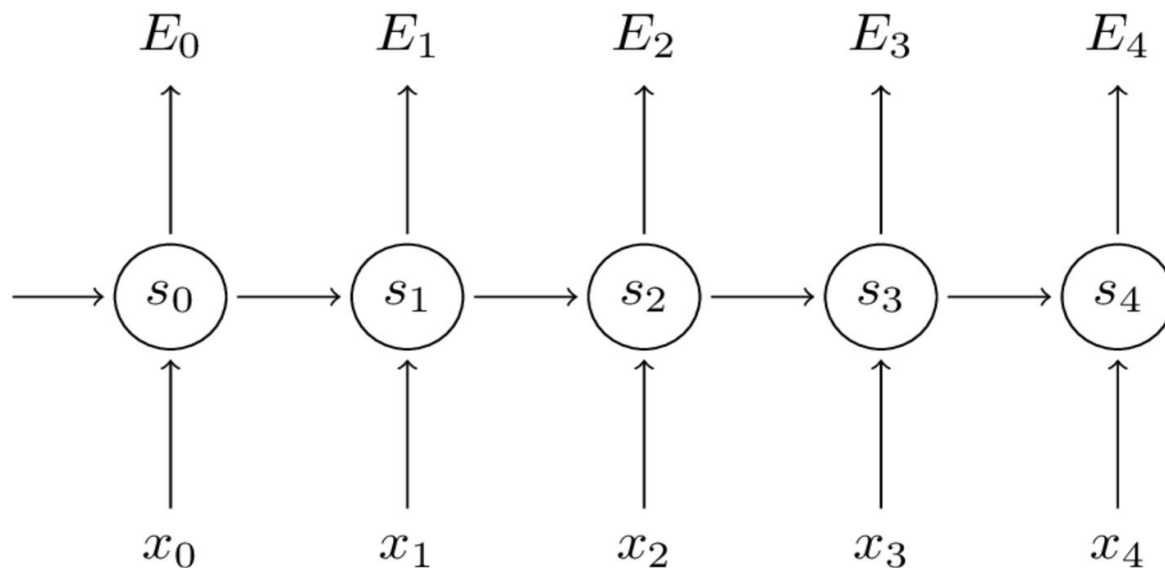
Backpropagation

$$\frac{\partial E_3}{\partial W} = \frac{\partial E_3}{\partial \hat{y}_3} \frac{\partial \hat{y}_3}{\partial s_3} \frac{\partial s_3}{\partial W}$$

$$s_3 = f(Ux_3 + Ws_2)$$

Backpropagation

$$\frac{\partial E_3}{\partial W} = \frac{\partial E_3}{\partial \hat{y_3}} \frac{\partial \hat{y_3}}{\partial s_3} \frac{\partial s_3}{\partial W} = \sum_{k=0}^{3} \frac{\partial E_3}{\partial \hat{y_3}} \frac{\partial \hat{y_3}}{\partial s_3} \frac{\partial s_3}{\partial s_k} \frac{\partial s_k}{\partial W}$$

Backpropagation

$$\frac{\partial E_3}{\partial W} = \frac{\partial E_3}{\partial \hat{y}_3} \frac{\partial \hat{y}_3}{\partial s_3} \frac{\partial s_3}{\partial W} = \sum_{k=0}^{3} \frac{\partial E_3}{\partial \hat{y}_3} \frac{\partial \hat{y}_3}{\partial s_3} \frac{\partial s_3}{\partial s_k} \frac{\partial s_k}{\partial W}$$