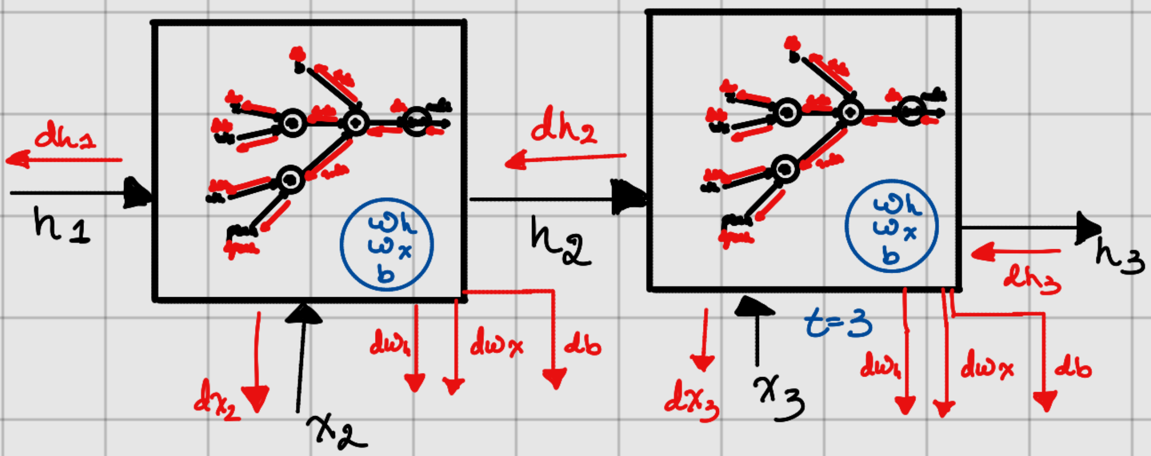

since we've already made a rnn_step_backwards, we can visualize each RNN cell as a blackbox with: - an internal state of $\underbrace{W_x, W_h, b}_{\text{shared between ALL cells}}$

- inputs: h_{t-1}, x_t
- outputs: h_t

• since the internal state is shared between all RNNs,

- $dW_x = \sum_{t=1}^{T} dW_x(t)$, where $dW_x(t) = x_{(t)}^{T} \cdot da_{(t)}$ transpose (see eq 3 in rnn_step_backprop)
- $dW_h = \sum_{t=1}^{T} dW_h(t)$, where $dW_h(t) = \text{prev\_h}_{(t)}^{T} da_{(t)}$, see eq 5
- $db = \sum_{t=1}^{T} db(t)$, $db(t) = \sum_{n=1}^{N} da_{(t)}$, eq 6

or, if we were to model this as a for loop,

$$\boxed{\begin{array}{l} \bullet\ dW_x(t) \pm dW_x(t-1) \\ \bullet\ dW_h(t) \pm dW_h(t-1) \\ \bullet\ db(t) \pm db(t-1) \end{array}}$$

(D, H)

(H, H)

(H,)

- using same logic as before,
  - $\underline{dh(t) = dh + \overset{(N,H)}{prev\_h}}$, where $prev\_h(t) = da \cdot W_h^T$, check eq 4

    (N,H)

    $\therefore \underset{(N,T,H)}{dh(:,t,:)} = \underset{(N,H)}{dh(t)}$

- $dx_{(t)}$ would simply be the same as that of rnn_step_back, stored over T steps

  $\therefore \underset{(N,T,D)}{dx(t)} = da \cdot W_x^T$, eq 2

in summary, accumulate all the outputs from rnn_step_back except for dx
(since $x_t \neq x_{t-1}$)