Neural Networks

7. Recurrent Networks

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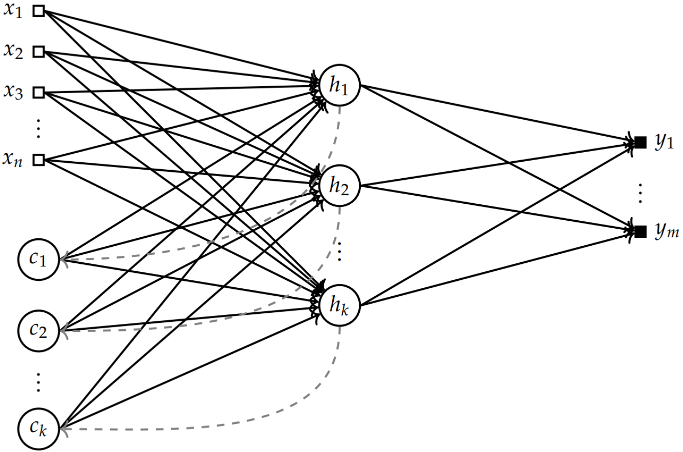
Tuesday 9th April, 2024

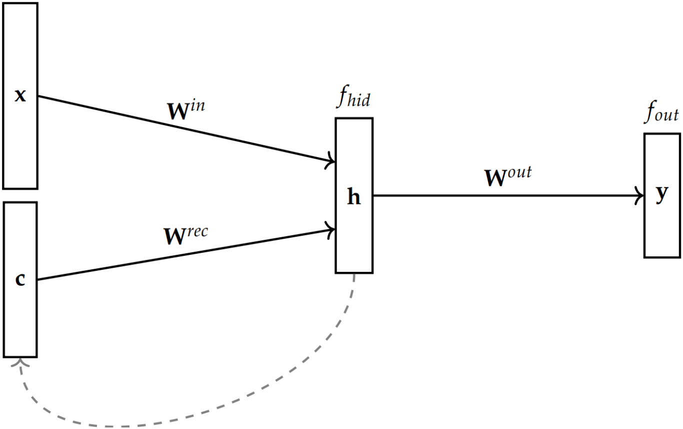
Simple Recurrent Network (SRN) – architecture



x - input ***c*** - context ***h*** - hidden layer ***y*** - output

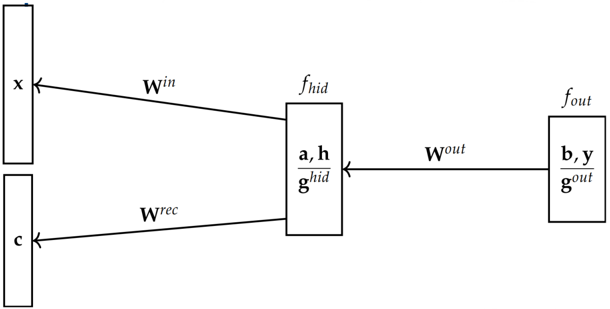
* bias terms applied on ***x***, ***c*** and ***h***

Simple Recurrent Network (SRN) – forward pass



$$\boldsymbol{c}(t) = \boldsymbol{h}(t-1) \quad \boldsymbol{h} = f_{hid}(\boldsymbol{W}^{in}\boldsymbol{x}' + \boldsymbol{W}^{rec}\boldsymbol{c}') \quad \boldsymbol{y} = f_{out}(\boldsymbol{W}^{out}\boldsymbol{h}')$$

Simple Backpropagation



$$\boldsymbol{g}^{out} = f'_{out}(\boldsymbol{b}) \odot (\boldsymbol{d} - \boldsymbol{y})$$
$$\boldsymbol{g}^{hid} = f'_{hid}(\boldsymbol{a}) \odot \boldsymbol{W}^{out^T} \boldsymbol{g}^{out}$$

$$\Delta \boldsymbol{W}^{in} = \boldsymbol{g}^{hid} \boldsymbol{x}'^T$$
$$\Delta \boldsymbol{W}^{rec} = \boldsymbol{g}^{hid} \boldsymbol{c}'^T$$
$$\Delta \boldsymbol{W}^{out} = \boldsymbol{g}^{out} \boldsymbol{h}'^T$$

$\boldsymbol{u} \odot \boldsymbol{v}$ – element-wise multiplication of vectors $\boldsymbol{u}$ and $\boldsymbol{v}$

Simple Recurrent Network – task

- **one-step prediction:**
  - given a sequence of inputs $\boldsymbol{x}(1), ..., \boldsymbol{x}(T)$
  - predict the next value $\boldsymbol{x}(T+1)$
  - context-based regression $\boldsymbol{x}(t) \rightarrow \boldsymbol{x}(t+1)$
- we need to reset the context to neutral activation before each run, e.g.
  - set $\boldsymbol{c}(1) = \boldsymbol{h}(0)$ as if $\boldsymbol{x}(0) = \boldsymbol{c}(0) = \mathbf{0}$

Task

- elman.py TODO:
    - initialize weights (can be sensitive)
    - initialize context by feeding zero input
    - forward pass & backward pass
    - weight adjustment