Recurrent Neural Networks

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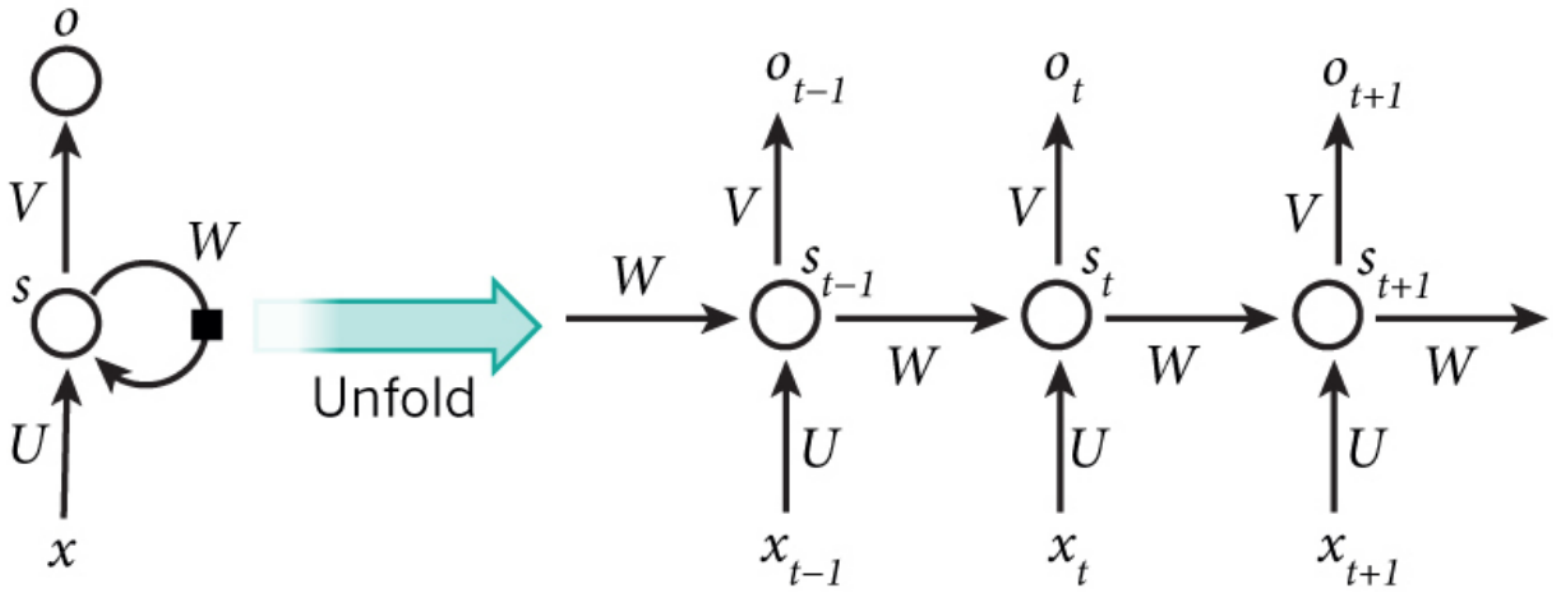
Applications

- Image / video captioning
- Text (music, etc.) completion / generation
- Machine translation (e.g. translating English to French)
- Nonlinear time series
- (http://karpathy.github.io/2015/05/21/rnn-effectiveness)

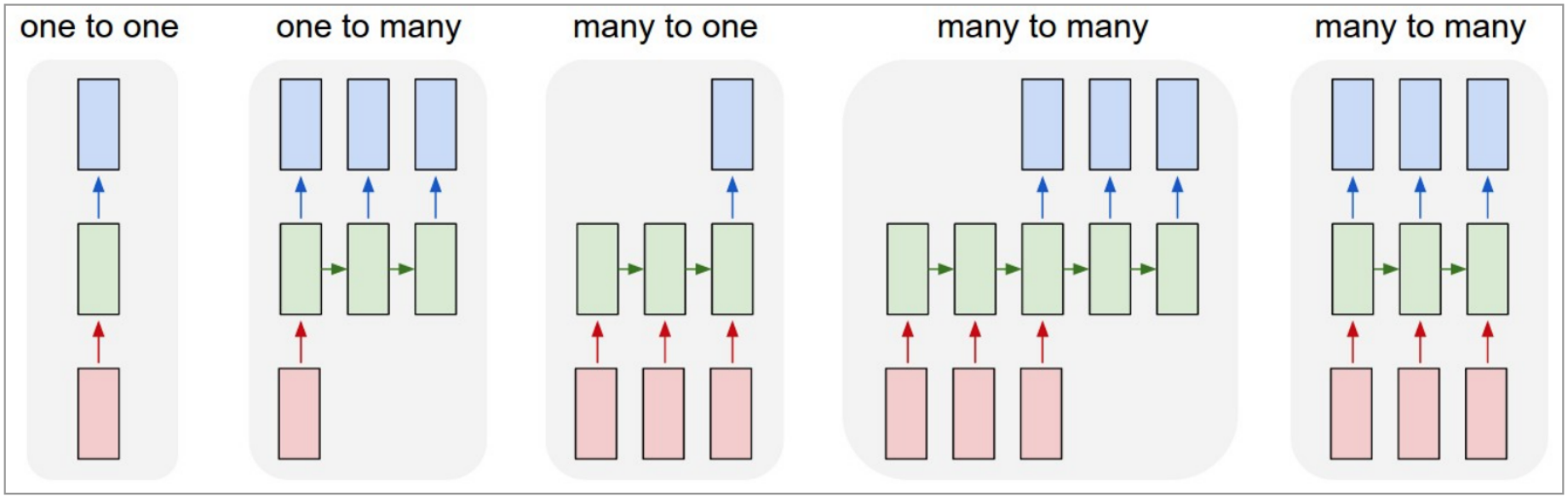
Recurrent Neural Networks



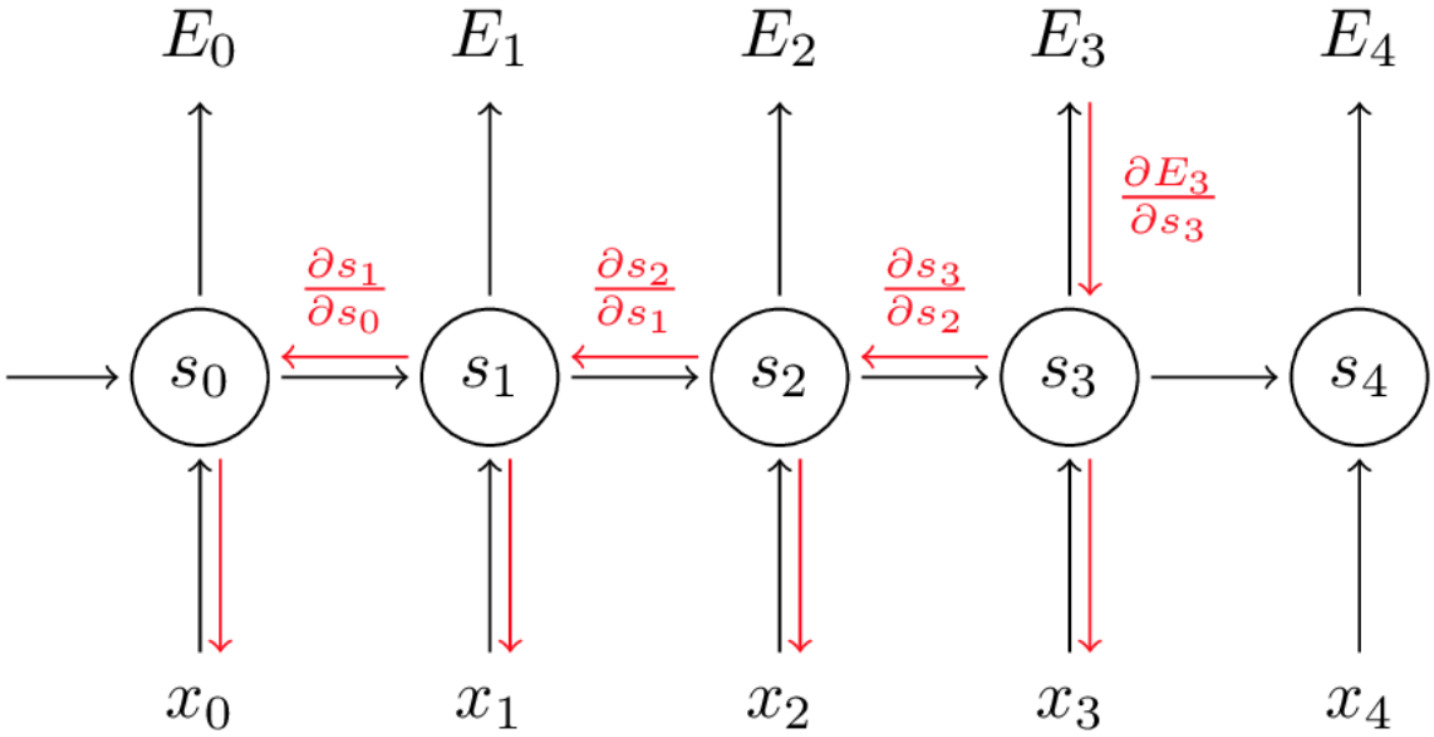
$$o_t = softmax\left(Vs_t\right)$$

$$s_t = tanh\left(Ws_{t-1} + Ux_t\right)$$

Typical Architectures



Backpropagation Through Time (BPTT)



$$E_t = -o_t \log(\widehat{o}_t) + -(1 - o_t) \log(1 - \widehat{o}_t)$$

$$E = \sum_t E_t$$

Backpropagation Through Time (BPTT)

$$\frac{\partial E_t}{\partial V} = (\widehat{o}_t - o_t) \otimes s_t$$

$$\frac{\partial E_t}{\partial U} = \frac{\partial E_t}{\partial \widehat{o}_t} \frac{\partial \widehat{o}_t}{\partial s_t} \frac{\partial s_t}{\partial U}$$

$$\frac{\partial E_t}{\partial W} = \sum_{k=0}^{t} \frac{\partial E_t}{\partial \widehat{o}_t} \frac{\partial \widehat{o}_t}{\partial s_t} \frac{\partial s_t}{\partial s_k} \frac{\partial s_k}{\partial W}$$

LSTM: Long-Short Term Memory

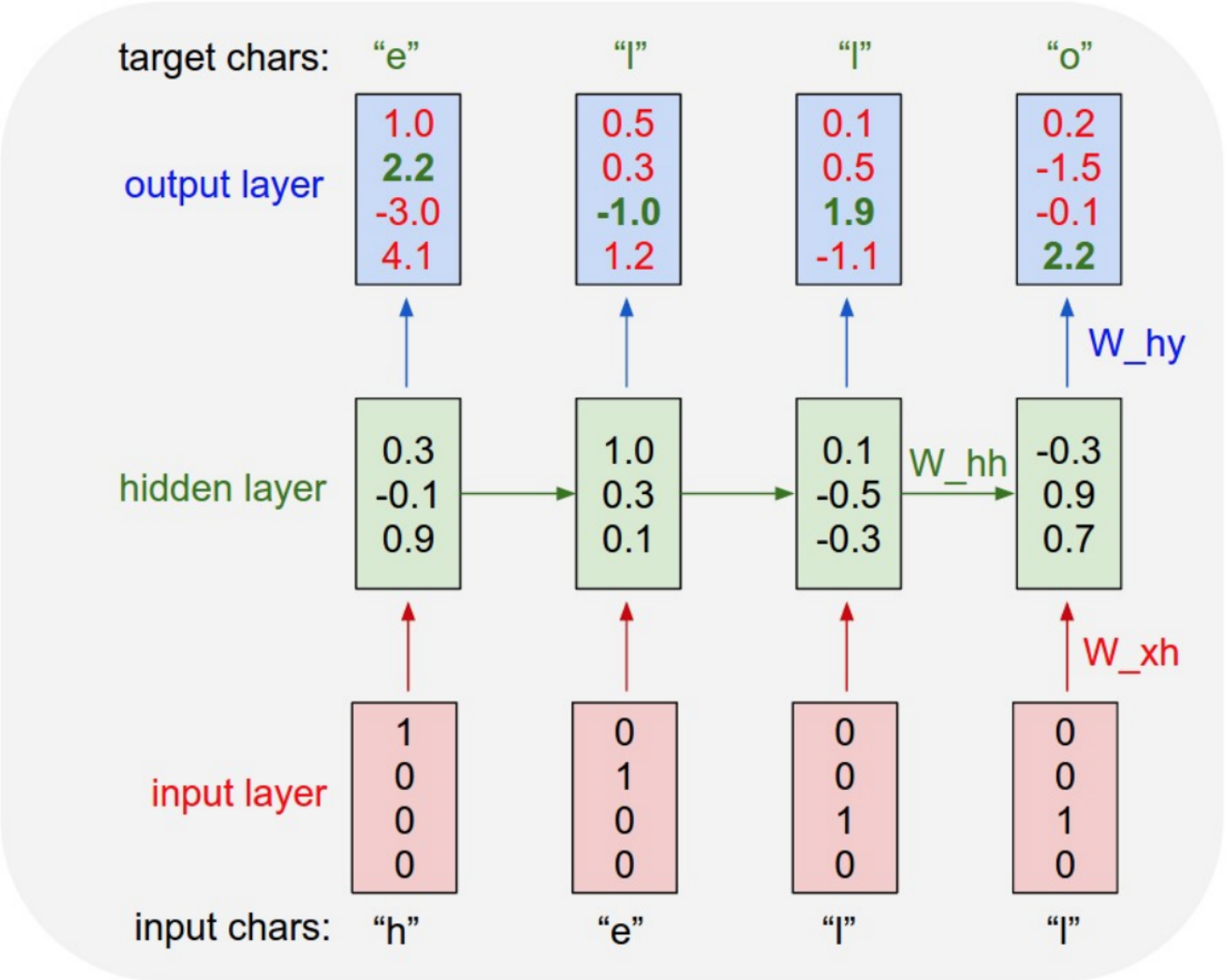
$$
\begin{aligned}
i &= \sigma(x_t U^i + s_{t-1} W^i) \\
f &= \sigma(x_t U^f + s_{t-1} W^f) \\
o &= \sigma(x_t U^o + s_{t-1} W^o) \\
g &= \ tanh(x_t U^g + s_{t-1} W^g) \\
c_t &= c_{t-1} \circ f + g \circ i \\
s_t &= \tanh(c_t) \circ o
\end{aligned}
$$

i: "input gate", f: "forget gate", o: "output gate", g: candidate hidden state

Text Generation Example

- Learn to generate lyrics (500kb lyric data textttlyrics.csv)
- Character level model: predict next character from previous character for 50 characters at a time
- Fit 2 layer LSTM with 512 hidden nodes `lyric_generation.py`
- Sample from model every iteration

Text Generation Example



Text Generation Example Ctd.

```
Hidden neurons: 512, Hidden layers: 2
Number of batches:  84
--------------------------------------------------
Epoch: 0
--------------------------------------------------
--------------------------------------------------
Batch loss: 2.966191
--------------------------------------------------
 om sawrau' ebbc'ttae motlkptehy n
 ttawsogiym  a 's  eharank'n'oitaklrg
ism'ontareeeble
e,vyitl oomukyg  edopr[vonitnwrrtai sayudsmnacd- sknhin'
non ysfee o idal it ottuywslntattscot
gtw do 'y  hh

--------------------------------------------------
Epoch: 2
--------------------------------------------------
--------------------------------------------------
Batch loss: 1.781387
--------------------------------------------------
 icridst?

the wrish flay that is goome
cathing on, sen't weantaon
i'm con't know wateed
i'm wech ittoraonal

tho back dor itthe
the you crouged
the halk waoky way the hamy hone
'waus
un dolk a woreta
```

Text Generation Example Ctd.

```
Epoch: 5
--------------------------------------------------
--------------------------------------------------
Batch loss: 1.637449
--------------------------------------------------
al off treys youh not you cading up leat
ou con't ucp dististering bite chays on rud here

and your call, sem ne mlow

that i's liking you we wey my liber
your mopencersed tound uttay

i dinit like it
--------------------------------------------------
Epoch: 7
--------------------------------------------------
--------------------------------------------------
Batch loss: 1.562407
--------------------------------------------------
 oroflre
wasen whot munced
wete dabberty re
you we hould al tanna on girl
no the drimp?
wish mp,, to don't leady somess that if to
wets the drownnopay fordy

clack you for my hiw, i'm walkens for it w
```

Text Generation Example Ctd.

```
Epoch: 9
--------------------------------------------------
--------------------------------------------------
Batch loss: 1.639500
--------------------------------------------------
 liflruones onteoling i stald
i'm whone in it cally herw when do i'm night i'd stalling yo
whold ouh is what, brick buris
them ghy will
never que w
furtiyn
--------------------------------------------------
Epoch: 11
--------------------------------------------------
--------------------------------------------------
Batch loss: 1.569297
--------------------------------------------------
wautawhead
twe onet bagelmerur

just dangand frear it got every one they's a wishing hope
i along oncer danneth!
thats are back on arfints
and no pididainigsts,
wey our troub
i'm nothin's my haves
wh
need i l
```

Text Generation Example Ctd.

```
--------------------------------------------------
Epoch: 13
--------------------------------------------------
--------------------------------------------------
Batch loss: 1.336237
--------------------------------------------------

'cause i see you now
oh you're fighing alone, though
you won't wait

haven't heard your phone?
oh i loved you
it's good, but it breaks me!
```