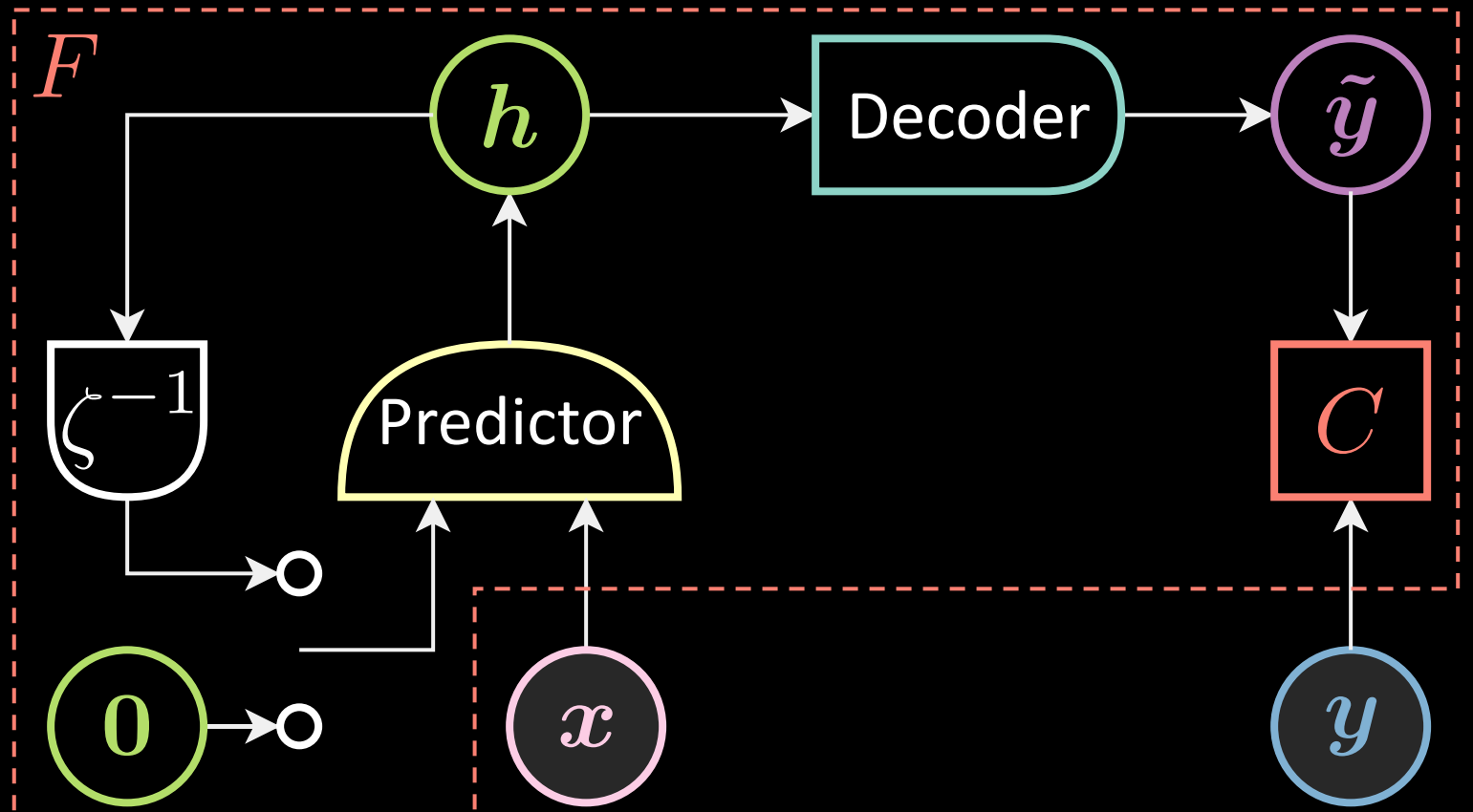
Recurrent Neural Nets

Handling sequential data

RNN diagram

$$F(\boldsymbol{x}, \boldsymbol{y}) =$$

$$\sum_{t=1}^{T} C(\boldsymbol{y}[t], \tilde{\boldsymbol{y}}[t])$$

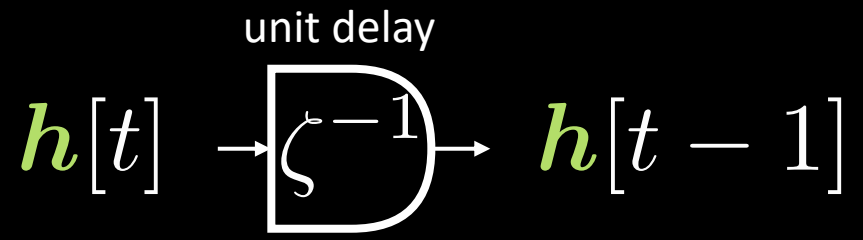


RNN equations

$$\boldsymbol{h}[0] \doteq \mathbf{0}$$

$$\boldsymbol{h}[t] = \mathrm{Pred}(\boldsymbol{h}[t-1], \boldsymbol{x}[t])$$

$$\tilde{\boldsymbol{y}}[t] = \mathrm{Dec}(\boldsymbol{h}[t])$$



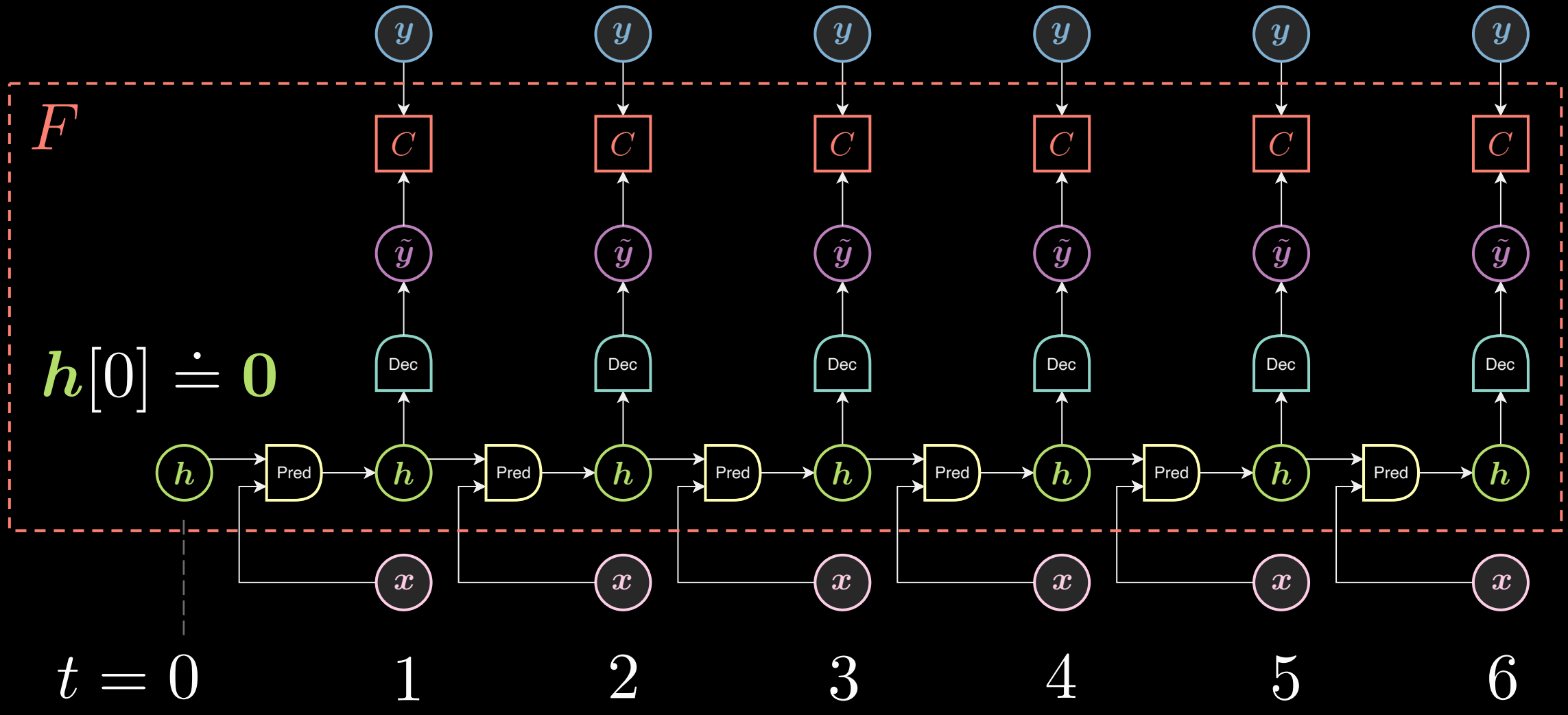
RNN training

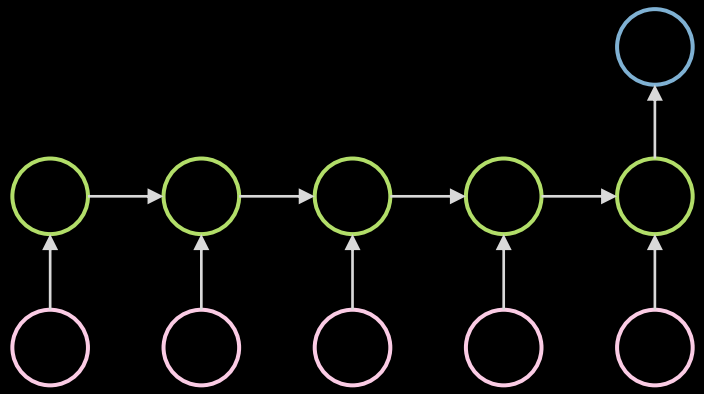
- backprop through time
- SGD wrt model's params to match ***x*** and ***y***

RNN training

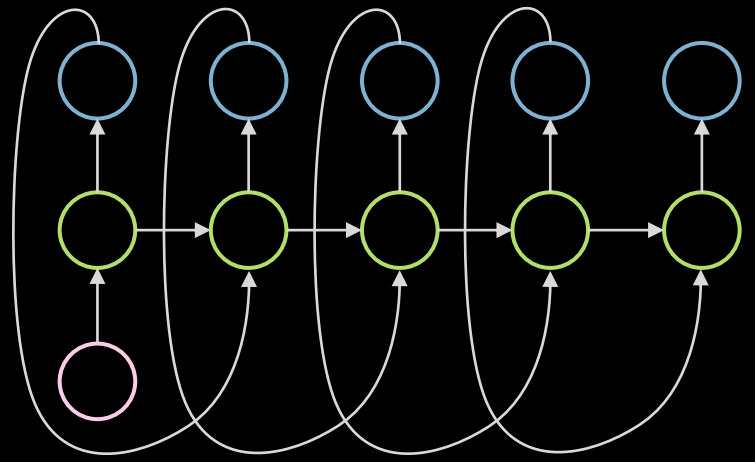
$$\boldsymbol{h}[t] = \mathrm{Pred}(\boldsymbol{h}[t-1], \boldsymbol{x}[t])$$

$$\tilde{\boldsymbol{y}}[t] = \mathrm{Dec}(\boldsymbol{h}[t])$$

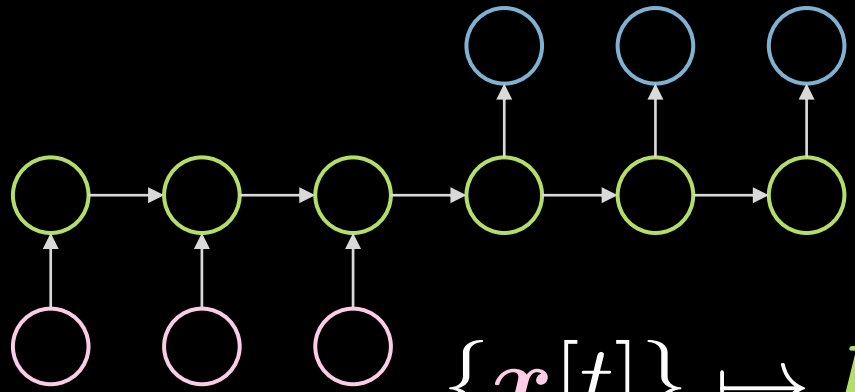




$\{\boldsymbol{x}[t]\} \mapsto \boldsymbol{y}[T]$ seq $\mapsto$ vec

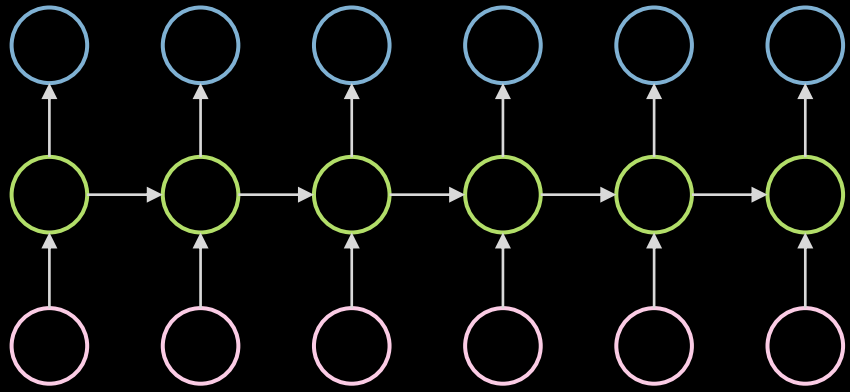


$\boldsymbol{x}[1] \mapsto \{\boldsymbol{y}[t]\}$ vec $\mapsto$ seq



$\{\boldsymbol{x}[t]\} \mapsto \boldsymbol{h} \mapsto \{\boldsymbol{y}[t]\}$

seq $\mapsto$ vec $\mapsto$ seq



$\{\boldsymbol{x}[t]\} \mapsto \{\boldsymbol{y}[t]\}$ seq $\mapsto$ seq

A person riding a motorcycle on a dirt road.

Two dogs play in the grass.

A skateboarder does a trick on a ramp.

A dog is jumping to catch a frisbee.

A group of young people playing a game of frisbee.

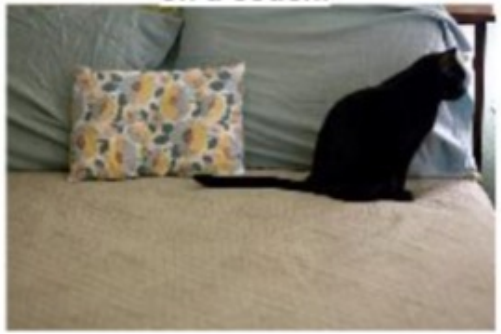
Two hockey players are fighting over the puck.

A little girl in a pink hat is blowing bubbles.

A refrigerator filled with lots of food and drinks.

A herd of elephants walking across a dry grass field.

A close up of a cat laying on a couch.



A red motorcycle parked on the side of the road.

A yellow school bus parked in a parking lot.

Describes without errors	Describes with minor errors	Somewhat related to the image	Unrelated to the image

Vinyals *et al.* (2016) Show and Tell: Lessons learned from the 2015 MSCOCO Image Captioning Challenge

Learning to execute

- Input:

```
j=8584
for x in range(8):
    j+=920
b=(1500+j)
print((b+7567))
```

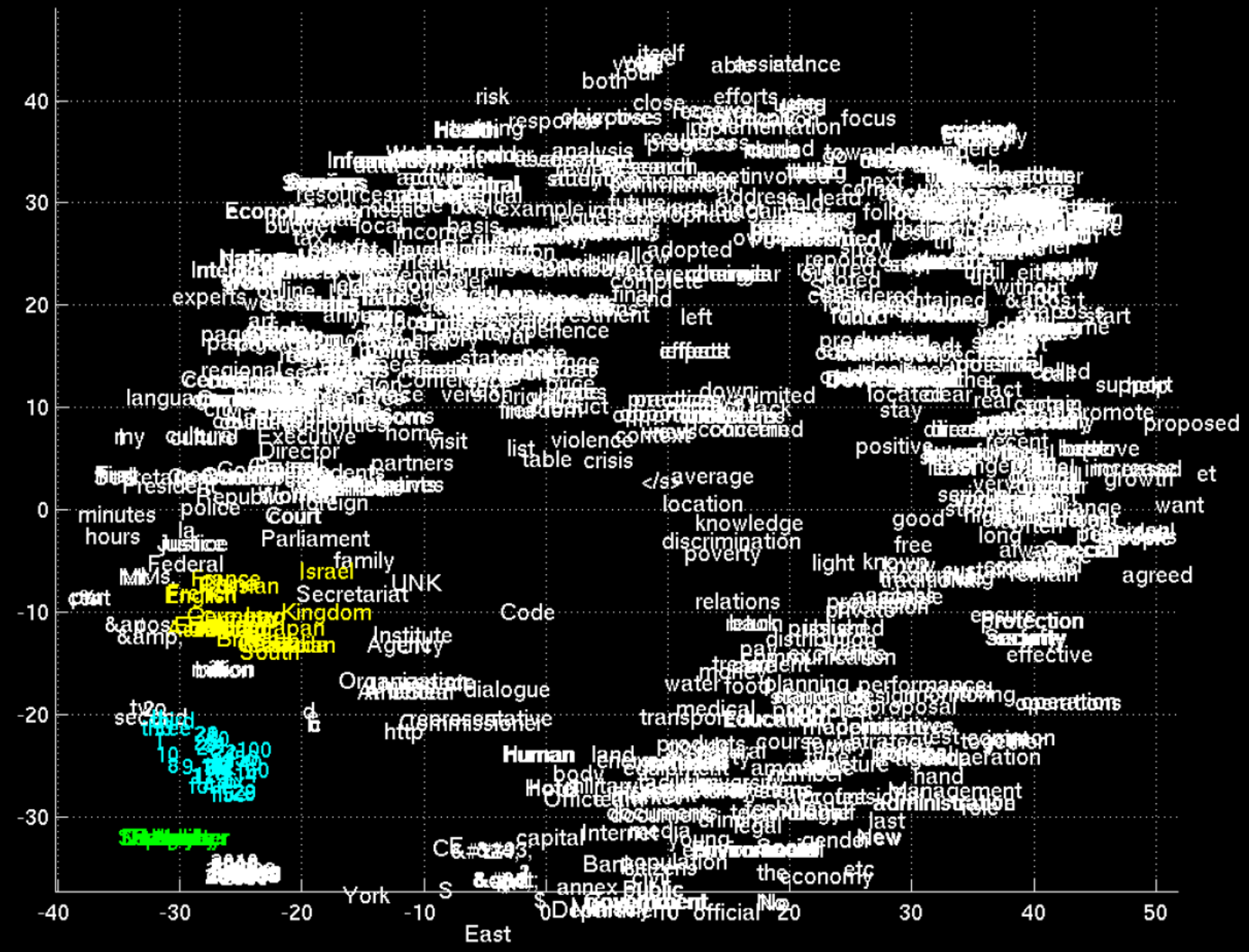
- Target: 25011.

- Input:

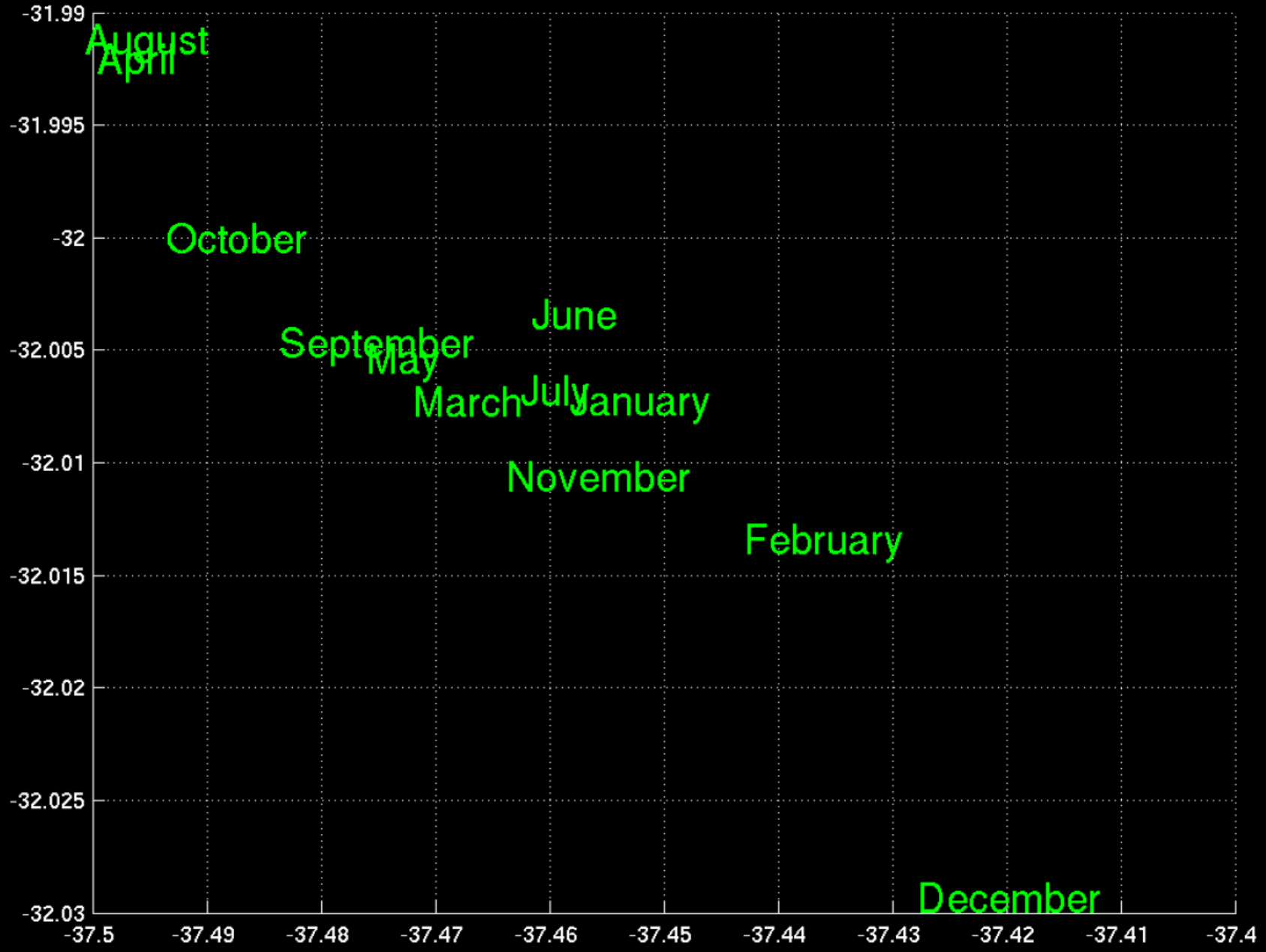
```
i=8827
c=(i-5347)
print((c+8704) if
2641<8500 else 5308)
```

- Target: 12184.

Zaremba & Sutskever (2015) Learning to Execute



Cho et al. (2014) Learning Phrase Representations using RNN Encoder–Decoder for Statistical Machine Translation



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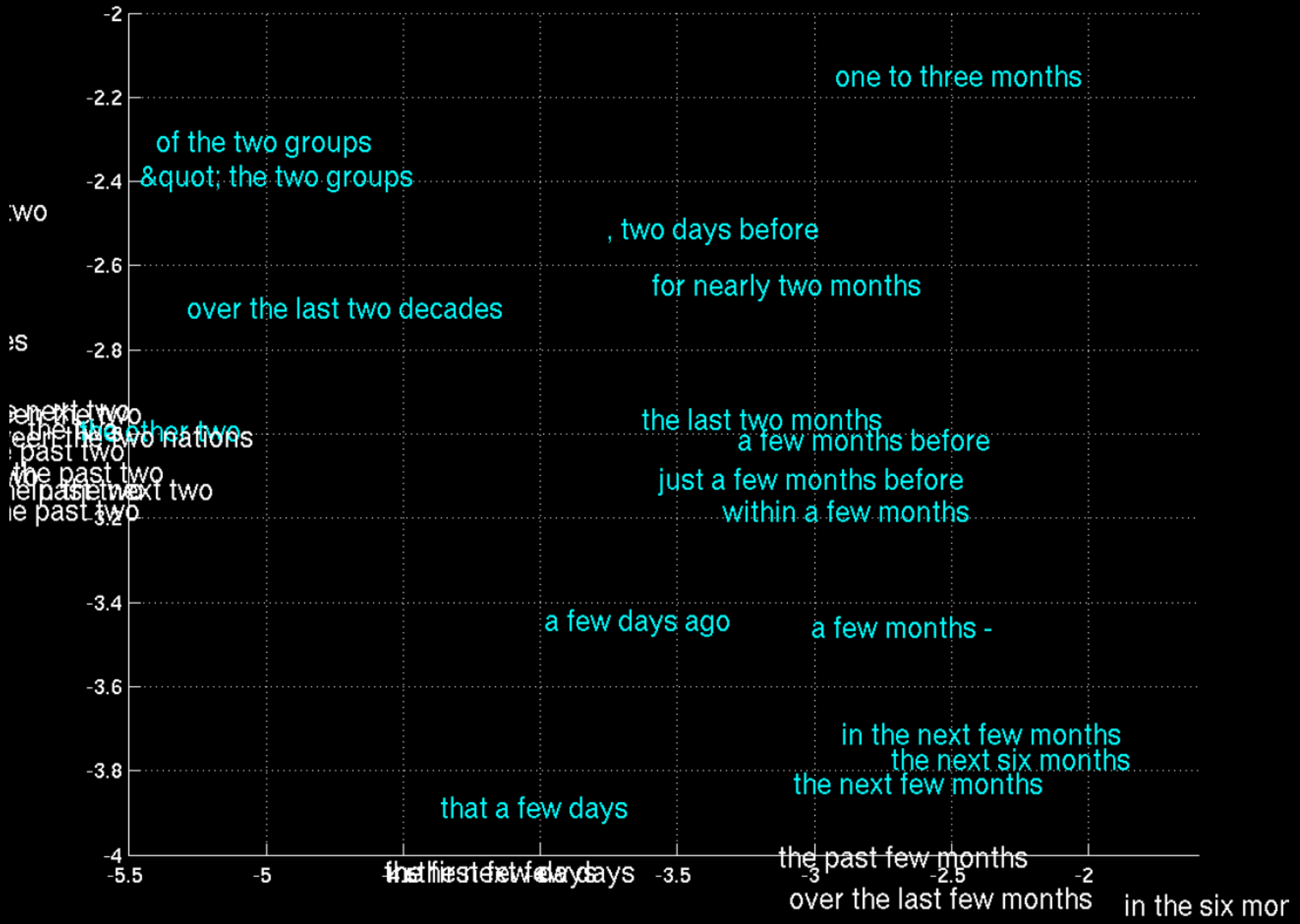

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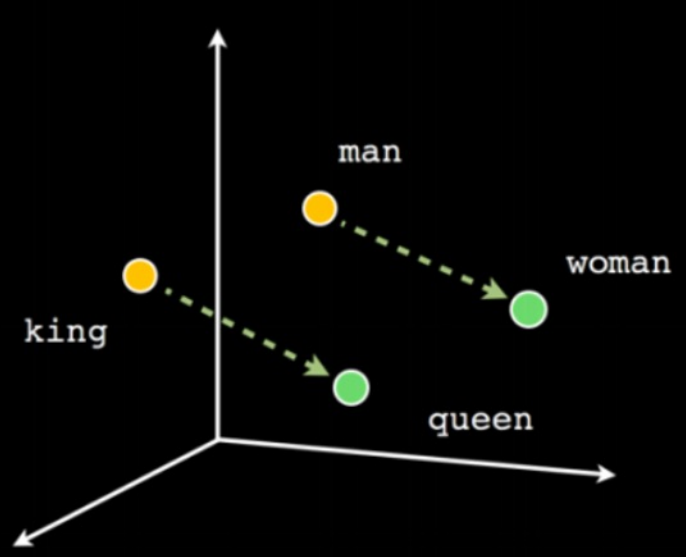
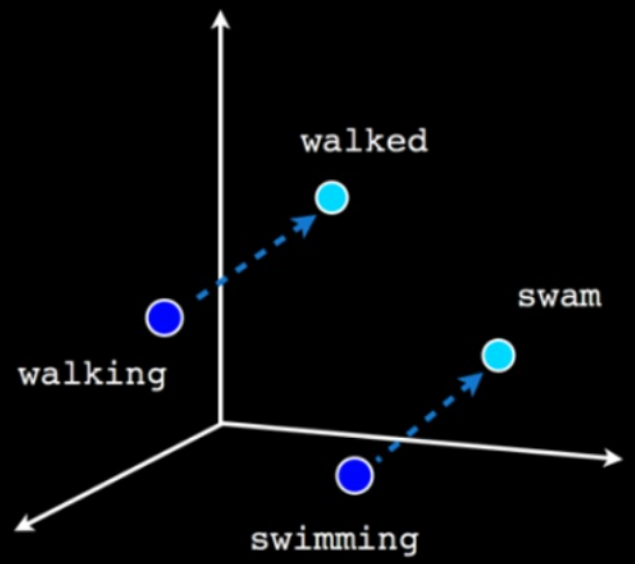
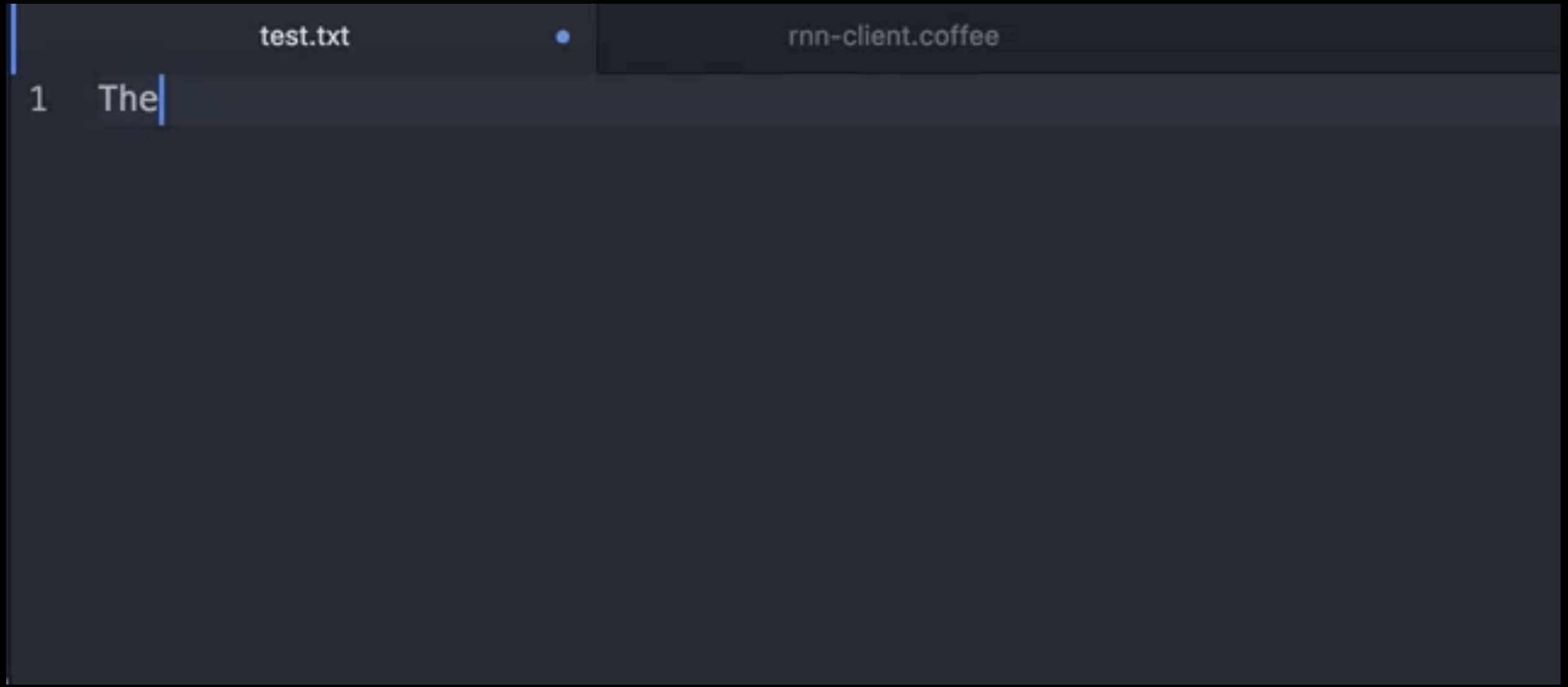


Male-Female



Verb tense

Country-Capital



Sloan (2016) rnn-writer – github.com/robinsloan/rnn-writer

RNN training

Back propagation through time (BPTT)

RNN training

$$\boldsymbol{h}[t] = \mathrm{Pred}(\boldsymbol{h}[t-1], \boldsymbol{x}[t])$$

$$\tilde{\boldsymbol{y}}[t] = \mathrm{Dec}(\boldsymbol{h}[t])$$