

# RECURRENT NEURAL NETWORKS

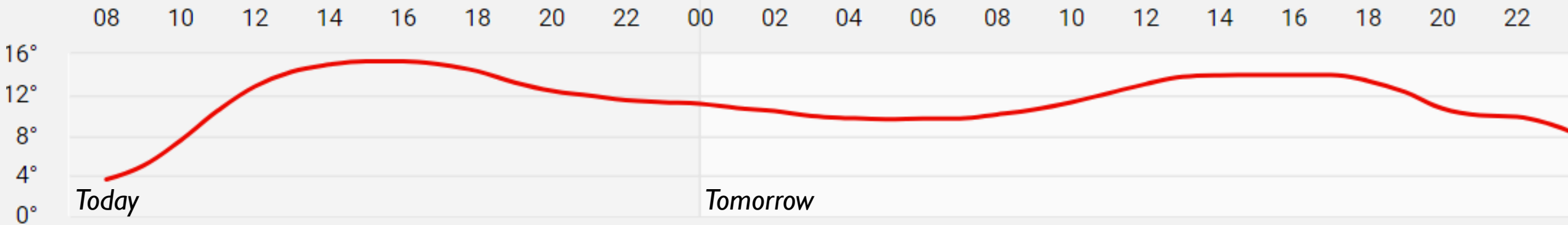
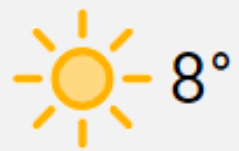
Lecture 6

MAL2, Spring 2025

# RECURRENT NEURAL NETWORKS

- Weather forecasts
- Recurrent neural networks
- Implementing an RNN
- The short-term memory problem
- Weather forecasts (again)

# WEATHER FORECASTS

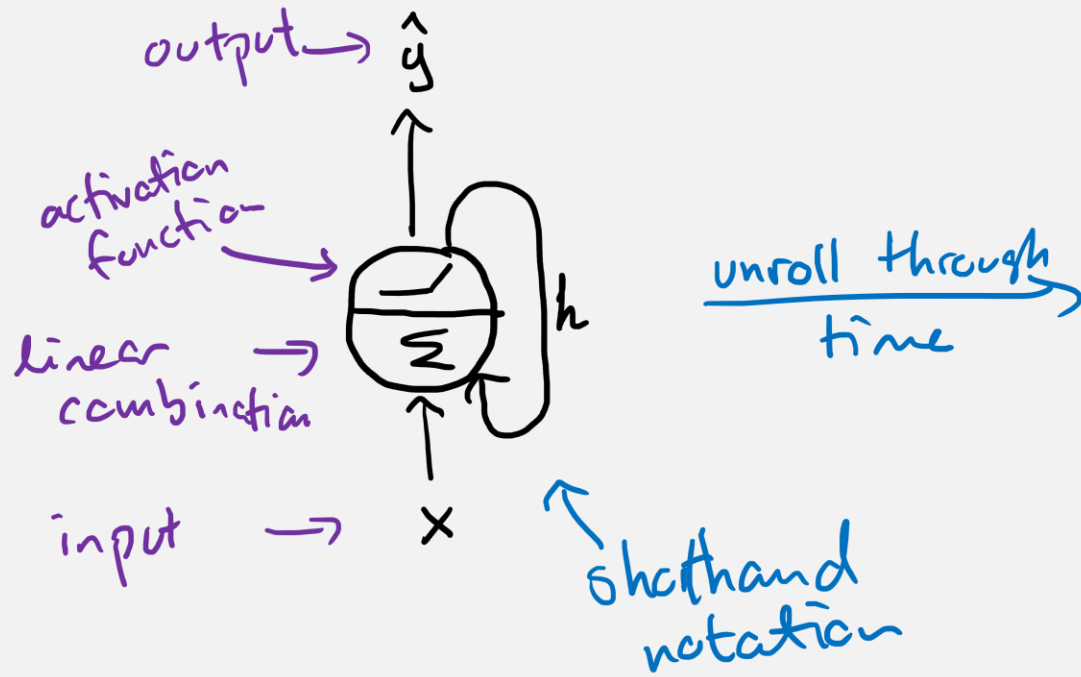


# RECURRENT NEURAL NETWORKS

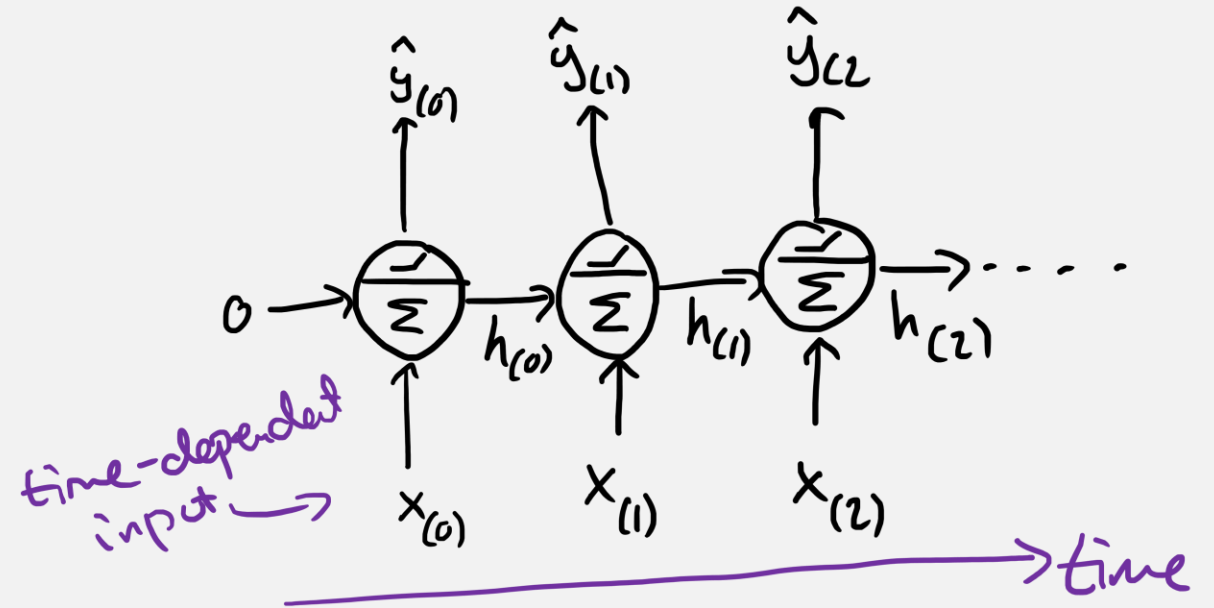
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# RECURRENT NEURONS

## The basic idea

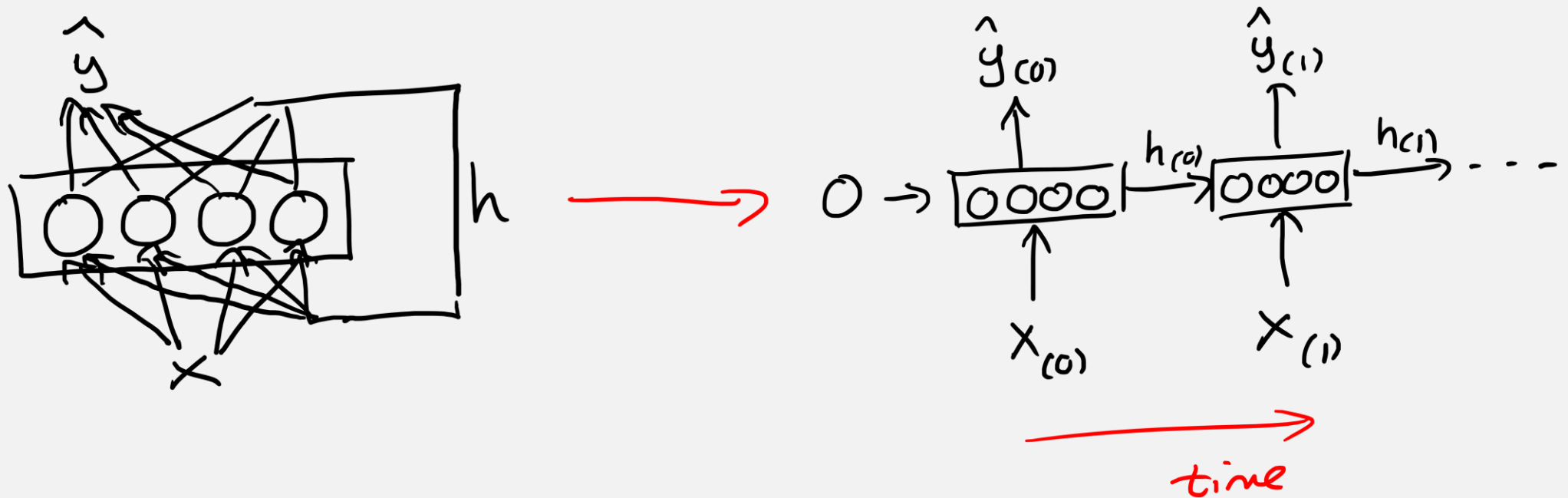


a single recurrent neuron/  
memory cell

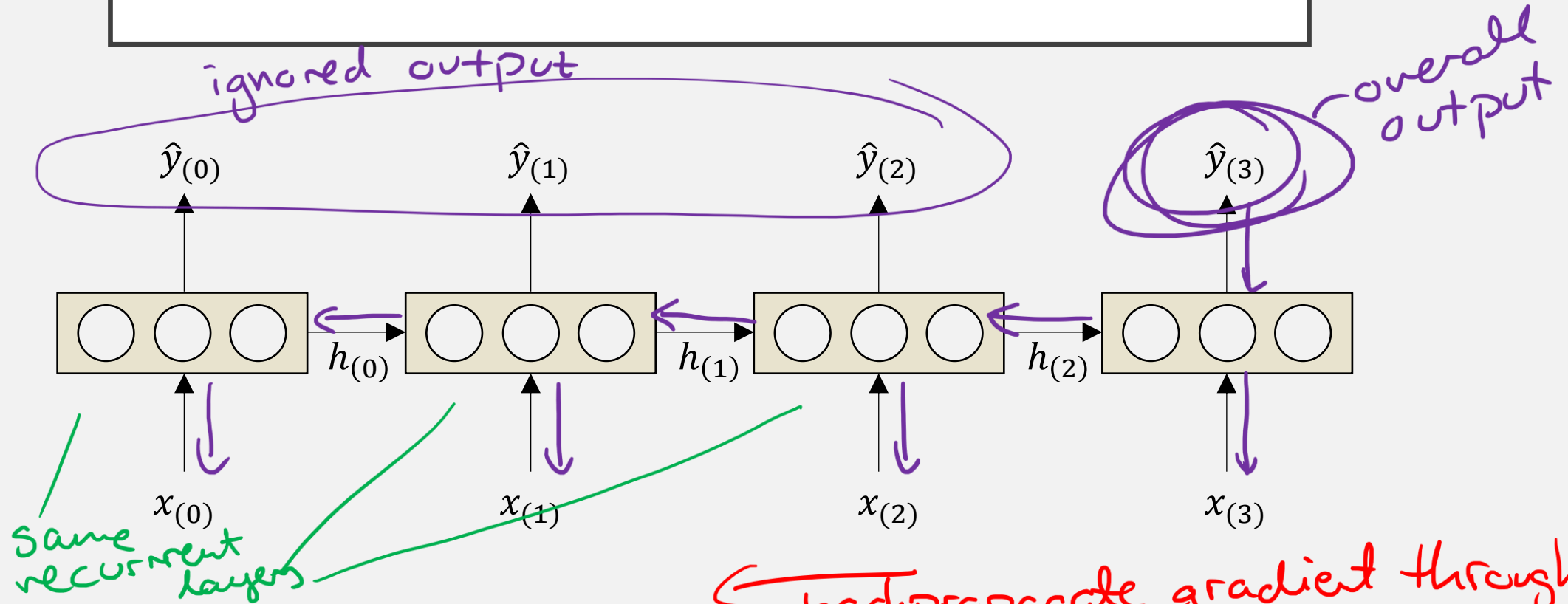


(hidden) output of previous  
time step as input  
 $h_{(t)}$  may equal  $\hat{y}_{(t)}$

# RECURRENT LAYERS



# BACKPROPAGATION THROUGH TIME

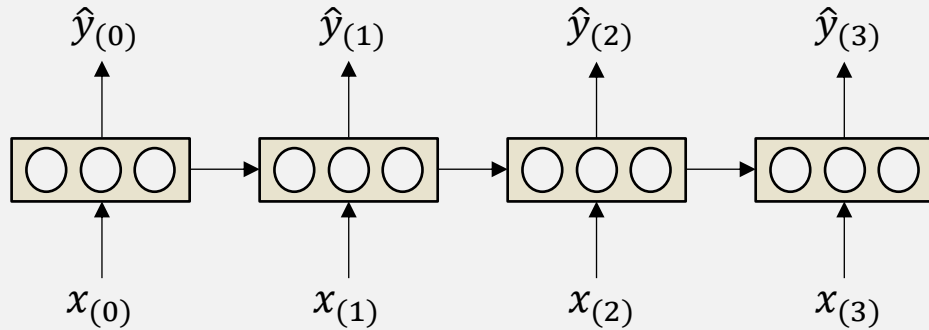


Since the same set of weights and biases are used at each time step, RNNs are more susceptible to vanishing and exploding gradients

← backpropagate gradient through time  
→ many get factors like  $w^{\text{\#timesteps}}$   
→ tanh default act. function

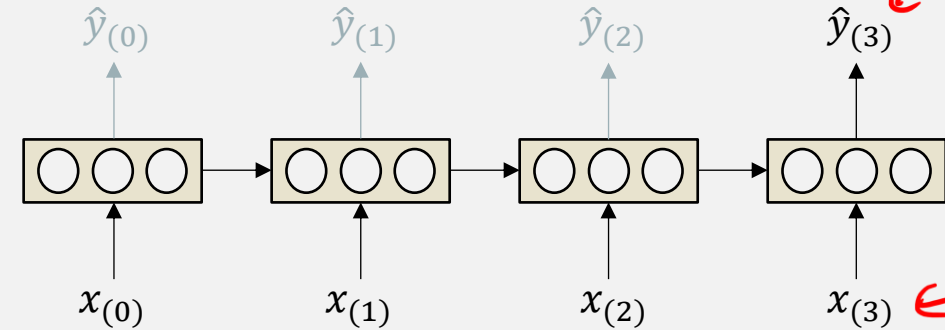
# THE VERSATILITY OF RECURRENT NEURAL NETWORKS

sequence-to-sequence network



shifted forecasting/predict next day

sequence-to-vector network



sentiment analysis

positive  
negative

words  
in review

vector-to-sequence network

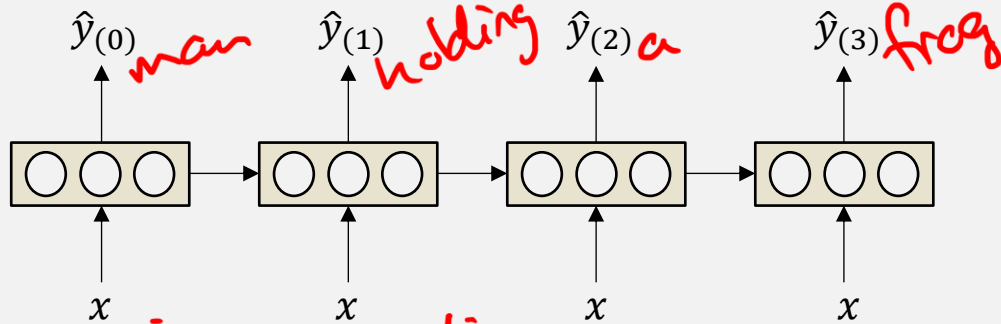
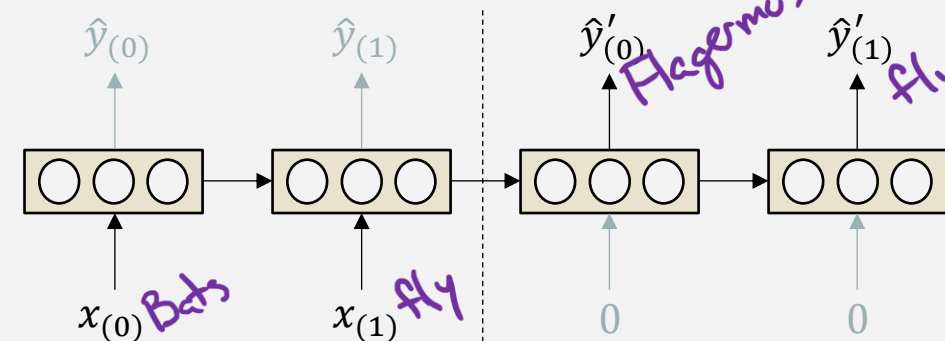


image captioning

encoder-decoder network



translation

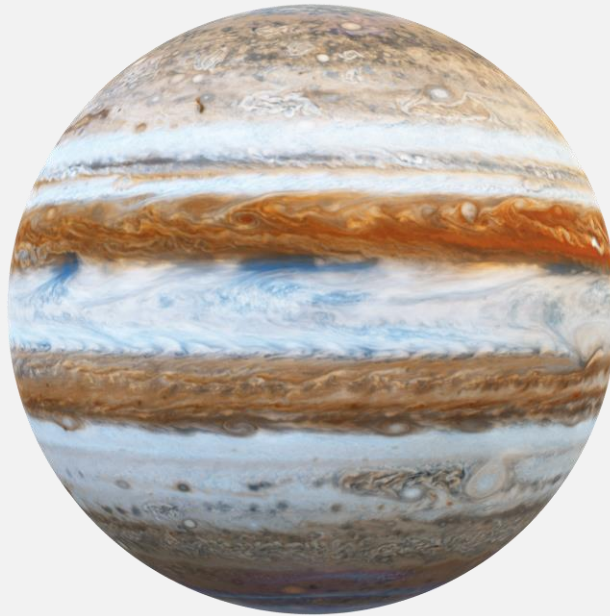
Flagermus  
flyer  
"recurrent"  
autoencoder



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LET'S DO IT



# LET'S DO IT

**Take the recurrent neural network  
we just made**



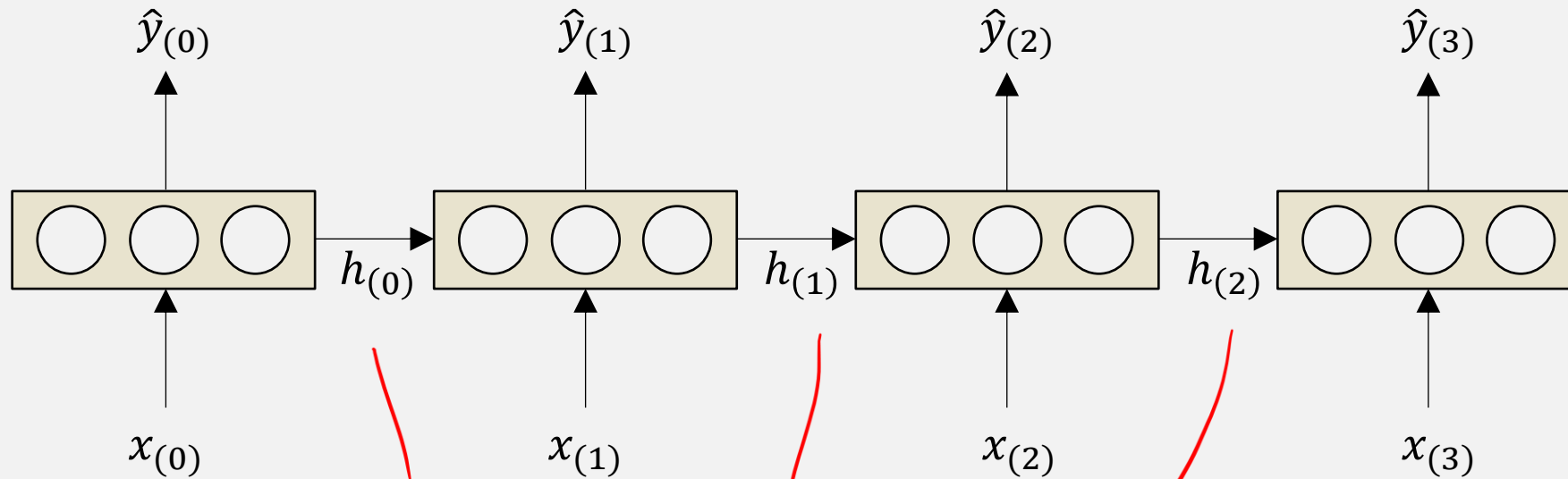
and experiment with it.  
*What happens if we change the number of  
recurrent layers?  
Or make it a deep RNN?  
If we try to predict March 2020?  
Something else?*

You have 15 minutes

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# SHORT-TERM MEMORY



Some information is lost  
at every time step  $\Rightarrow$  virtually  
all info gone after 10 steps

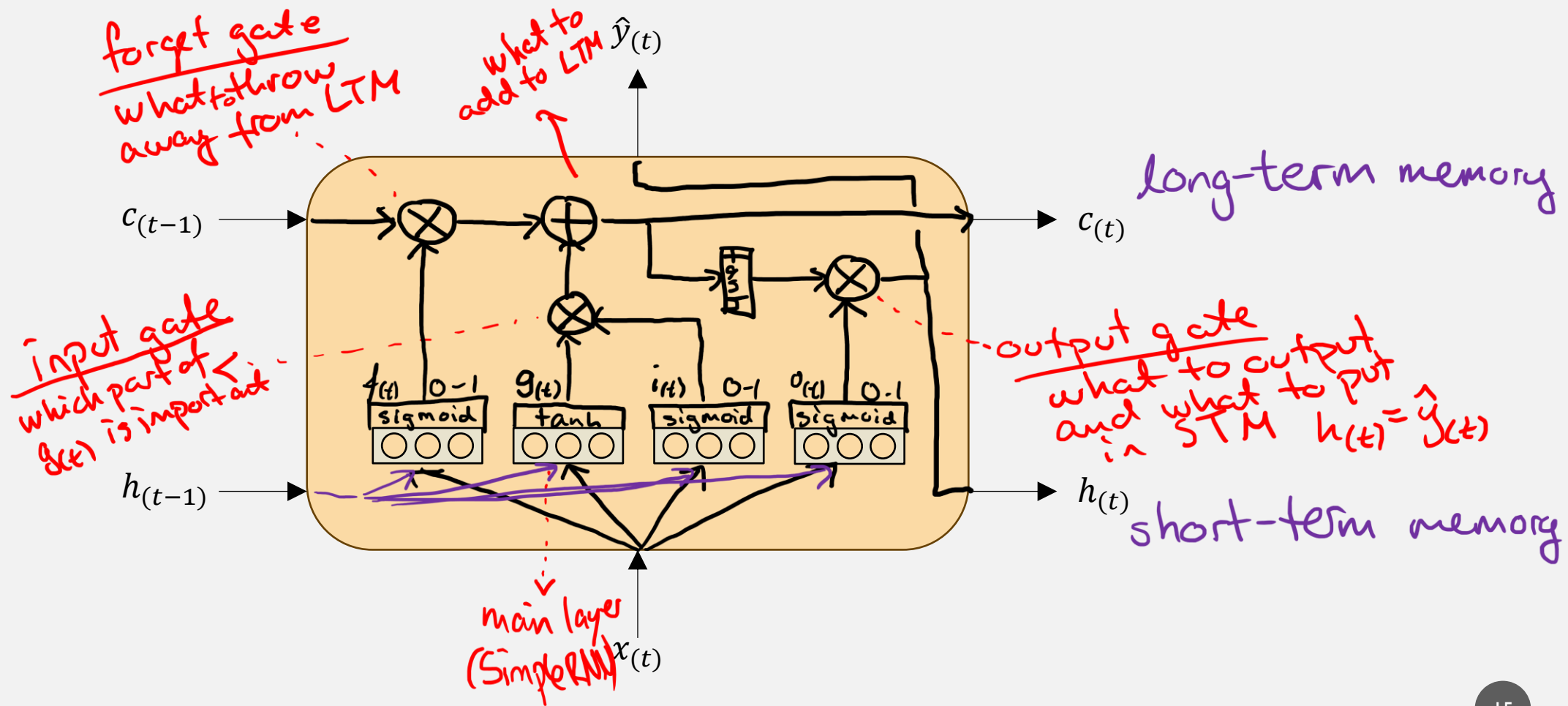
# SHORT-TERM MEMORY



Simple RNN  
in disguise

"long short-term memory"

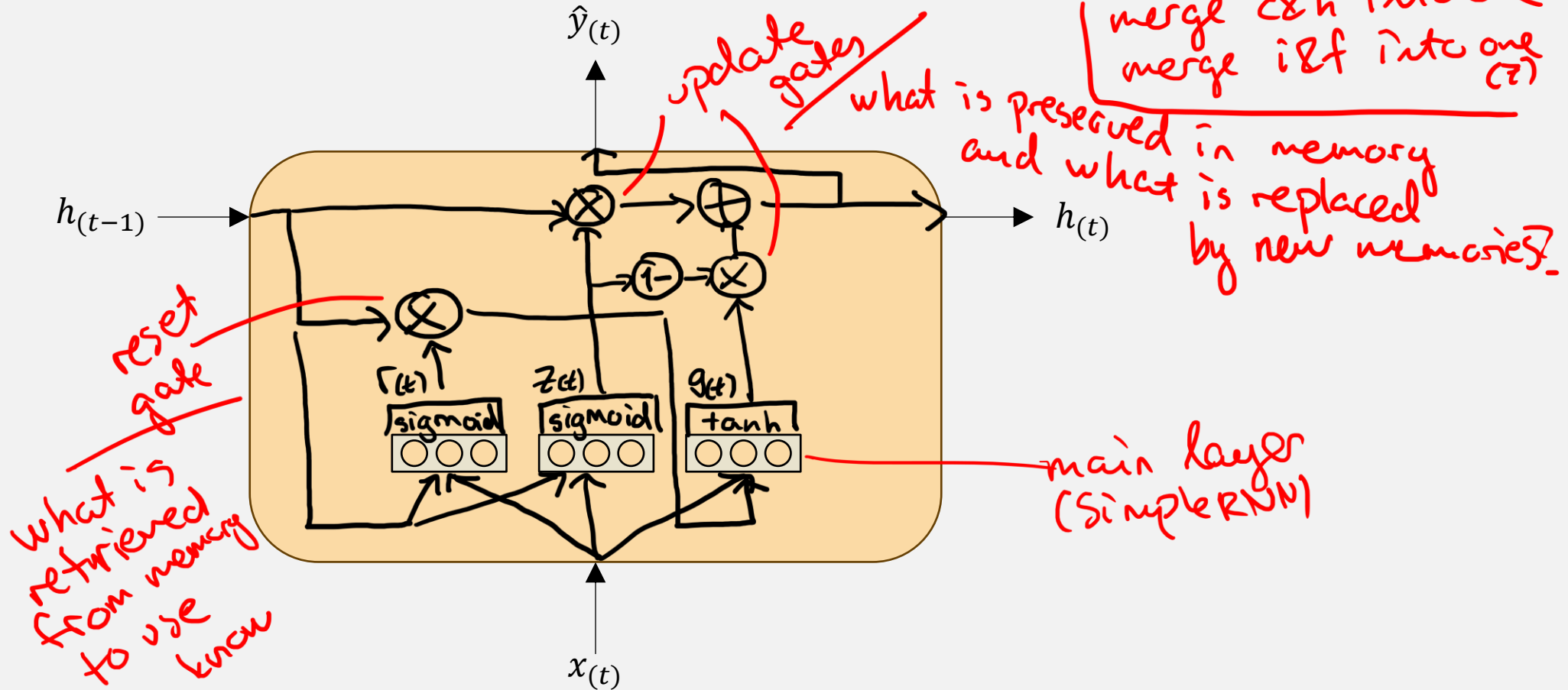
## LSTM CELLS



"gated recurrent units"

## GRU CELLS

simpler version  
of LSTM





## IT'S A PIECE OF CAKE TO USE

```
tf.keras.layers.SimpleRNN(...)
```

```
tf.keras.layers.LSTM(...)
```

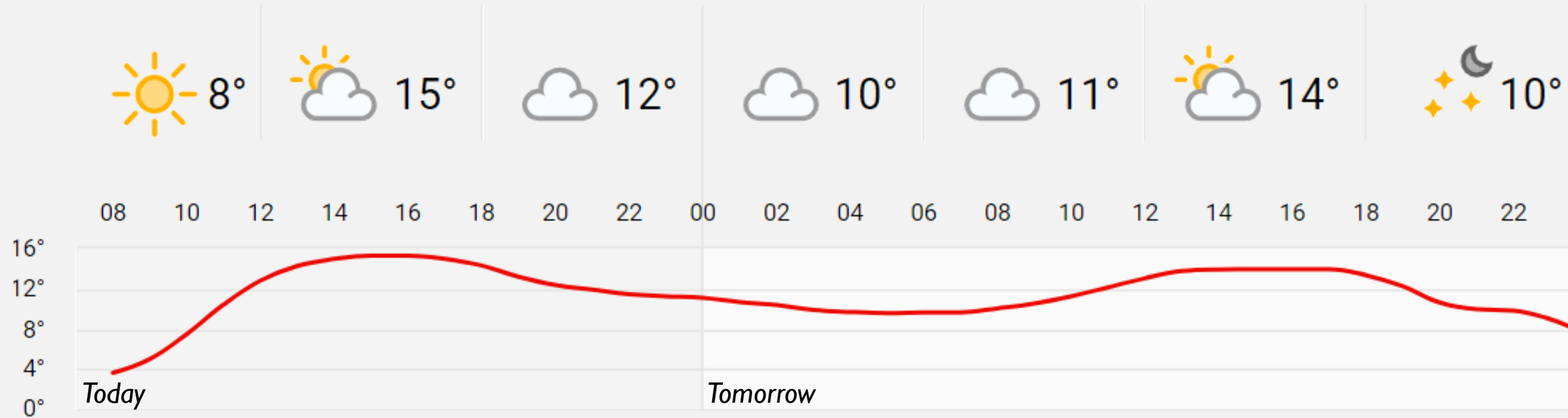
```
tf.keras.layers.GRU(...)
```

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Great idea for a final project!

## WEATHER FORECASTS (AGAIN)



dmi.dk

Use a recurrent neural network  
to predict tomorrow's weather!

# YOUR TICKET OUT THE DOOR

**Scan this QR code**



and tell me about something  
you are still unsure about