

Practical Machine Learning

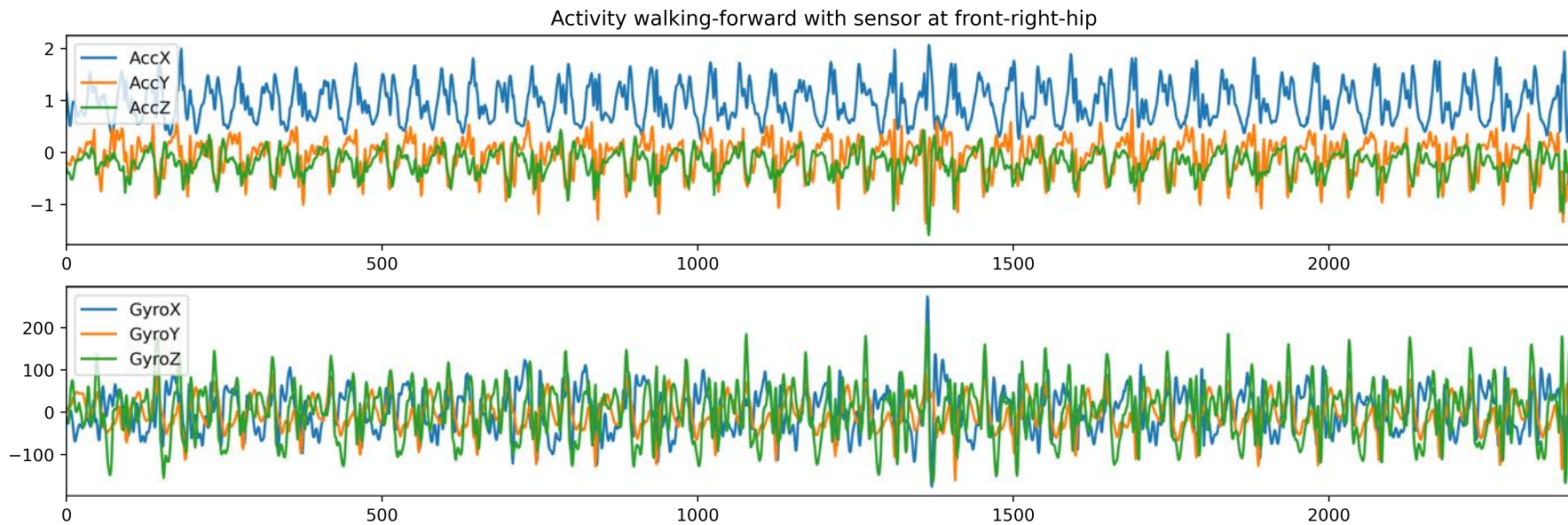
Recurrent Neural Network and Long Short-Term Memory

Model Layers

- Dense Layer
 - No specific relationship between inputs
- CNN Layer
 - Building an understanding by looking at neighboring inputs in an n-dimensional input

Sequence Data

- Time Series Data
- Natural Language

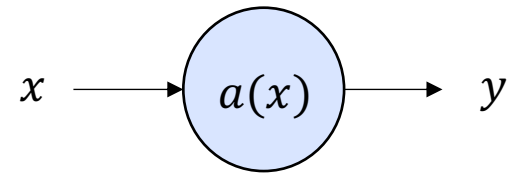


Data Source: <https://dl.acm.org/doi/10.1145/2370216.2370438>

Recurrent Neural Network (RNN)

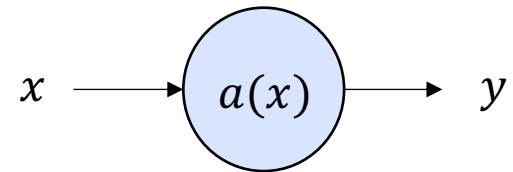
Recap Perceptron

Perceptron

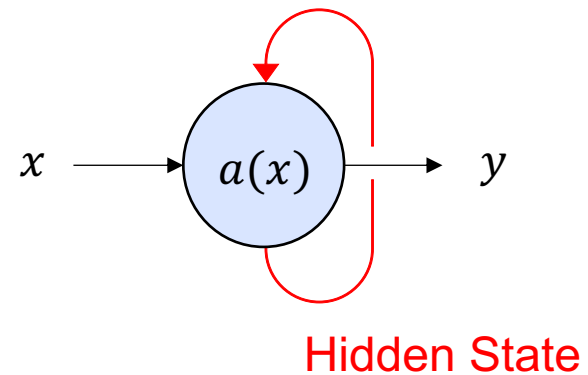


Recurrent Neural Network (RNN)

Perceptron

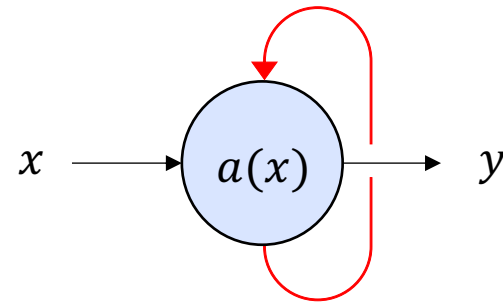
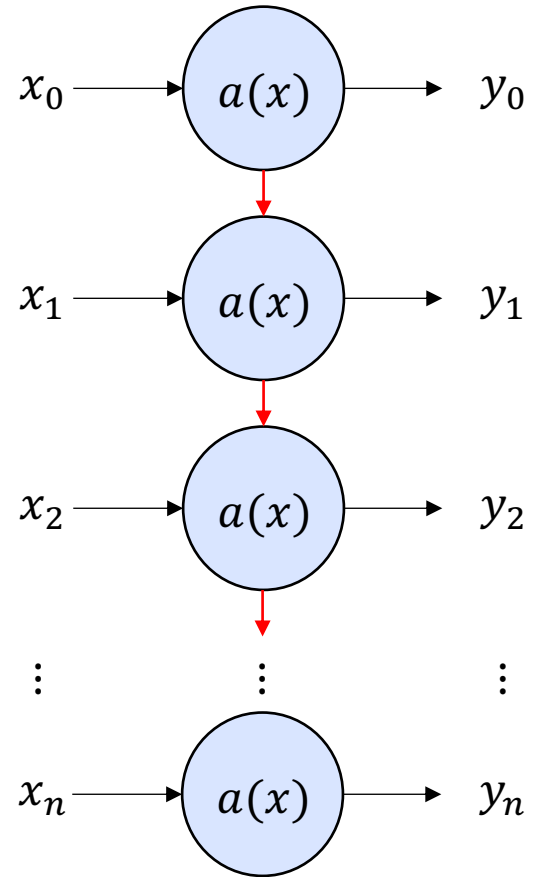


RNN Unit

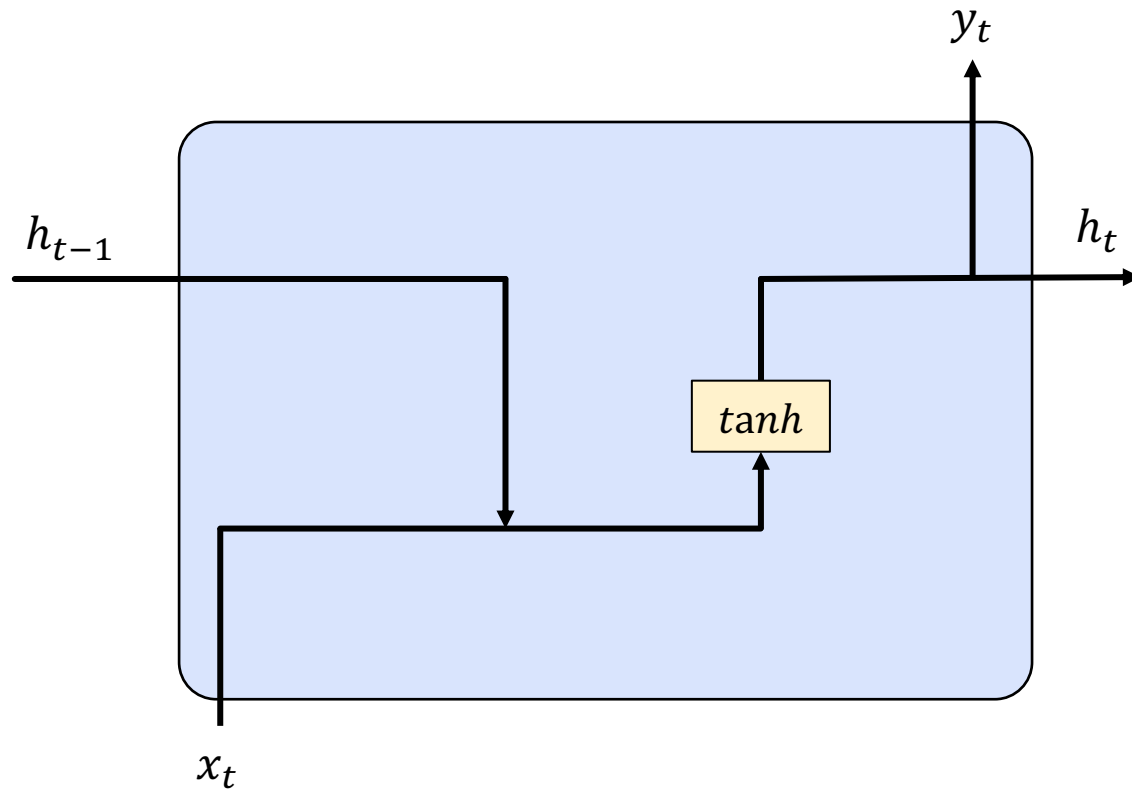


Recurrent Neural Network

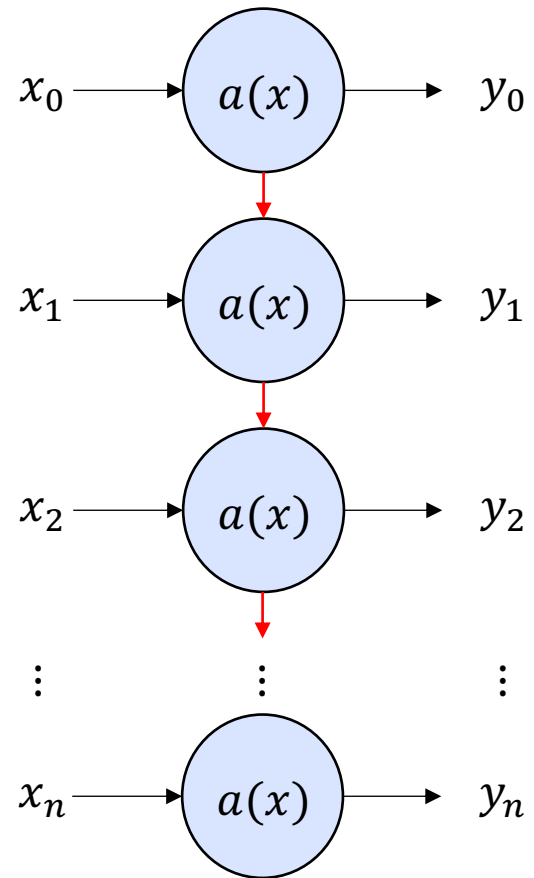
Unrolled Recurrent Neural Network



Recurrent Neural Network



Recurrent Neural Network



- Each state gets the “recent” information
- Long-term dependencies gets lost

RNN in TensorFlow

Two RNN layer using a fixed window length

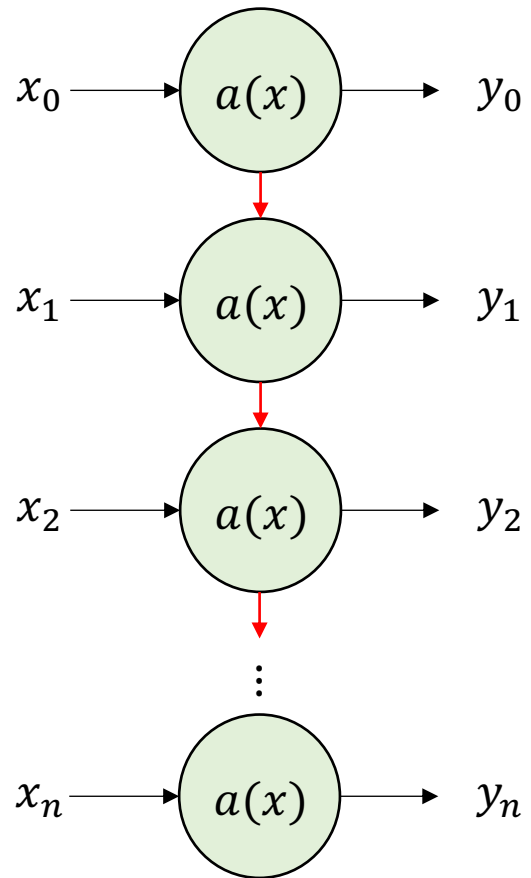
```
inputs = Input(shape=(WINDOW_LENGTH, 3), name="Input")
x = SimpleRNN(32, name="RNN_1", return_sequences=True)(inputs)
x = SimpleRNN(32, name="RNN_2")(x)
prediction = Dense(len(classes), activation="softmax", name="Output")(x)
model_functional = tf.keras.Model(inputs = inputs, outputs = prediction)
model_functional.summary()
```

Layer (type)	Output Shape	Param #
Input (InputLayer)	[(None, 200, 3)]	0
RNN_1 (SimpleRNN)	(None, 200, 32)	1152
RNN_2 (SimpleRNN)	(None, 32)	2080
Output (Dense)	(None, 12)	396

=====
Total params: 3,628
Trainable params: 3,628
Non-trainable params: 0

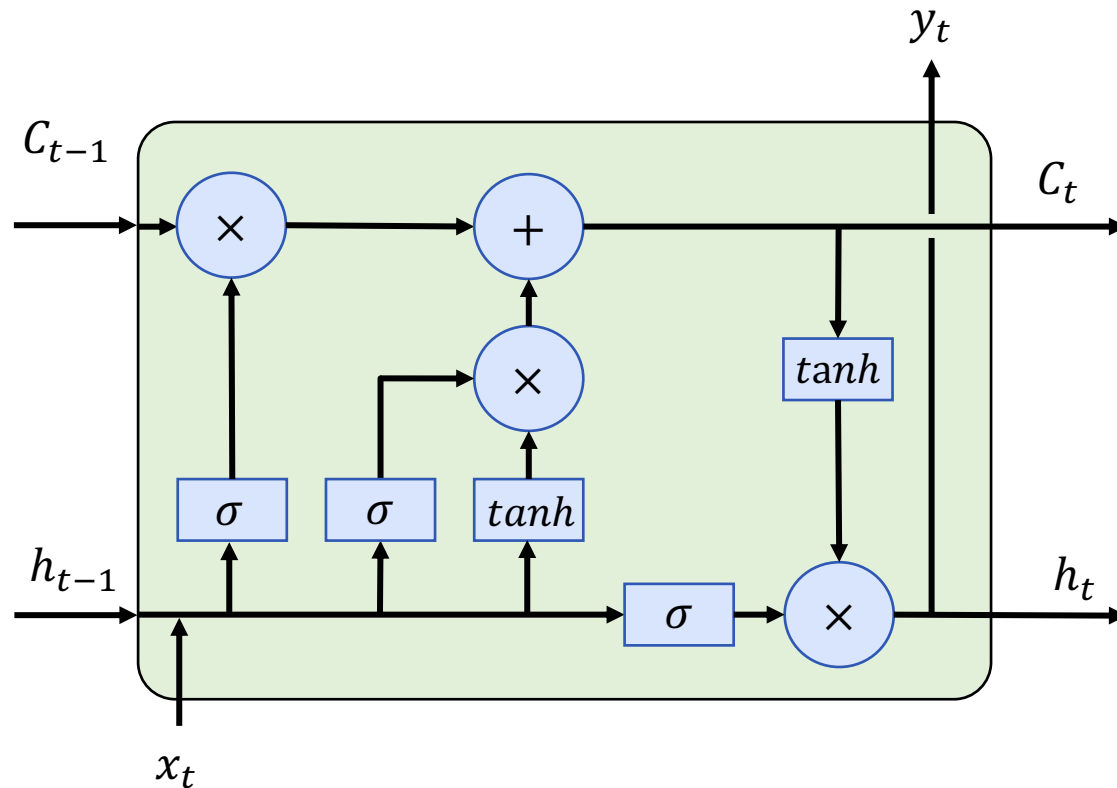
Long Short-Term Memory (LSTM)

Long Short-Term Memory (LSTM)



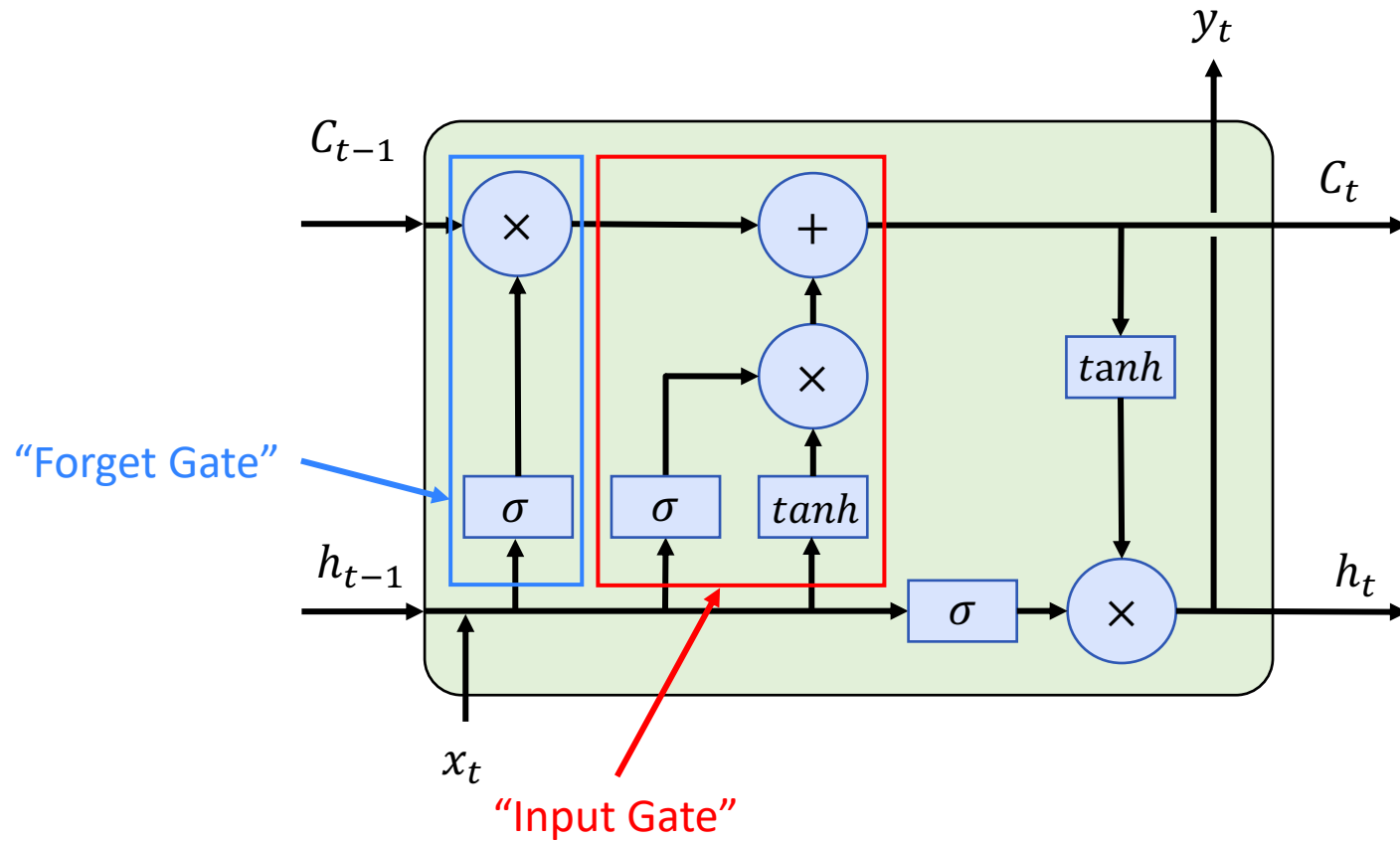
Sepp Hochreiter, and Schmidhuber Jürgen. "Long short-term memory." *Neural computation* (1997).

Long Short-Term Memory (LSTM)



Credit: <http://colah.github.io/posts/2015-08-Understanding-LSTMs/>

Long Short-Term Memory (LSTM)



LSTM in TensorFlow

Two RNN layer using a fixed window length

```
inputs = Input(shape=(WINDOW_LENGTH, 3), name="Input")
x = LSTM(32, name="LSTM_1", return_sequences=True)(inputs)
x = LSTM(32, name="LSTM_2")(x)
prediction = Dense(len(classes), activation="softmax", name="Output")(x)
model_functional = tf.keras.Model(inputs = inputs, outputs = prediction)
model_functional.summary()
```

Layer (type)	Output Shape	Param #
Input (InputLayer)	[(None, 200, 3)]	0
LSTM_1 (LSTM)	(None, 200, 32)	4608
LSTM_2 (LSTM)	(None, 32)	8320
Output (Dense)	(None, 12)	396

=====
Total params: 13,324
Trainable params: 13,324
Non-trainable params: 0

Conclusion

Recurrent Neural Network and Long Short-Term Memory

- Processing sequence data using neuronal networks
- Recurrent Neural Network (RNN)
- Long Short-Term Memory (LSTM)

- Variations
 - Gated Recurrent Unit (GRU) [1]

[1] Cho, Kyunghyun, et al. "Learning phrase representations using RNN encoder-decoder for statistical machine translation." *arXiv preprint arXiv:1406.1078* (2014).

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