

# Recurrent Neural Networks 101

# Recurrent Neural Networks

## Applications

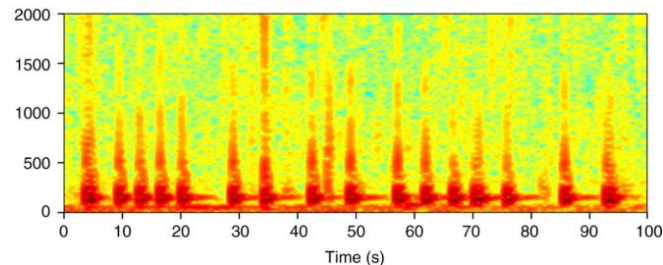
- RNNs are usually the best choice whenever the data is sequential!



Timeseries data



Natural Language Processing

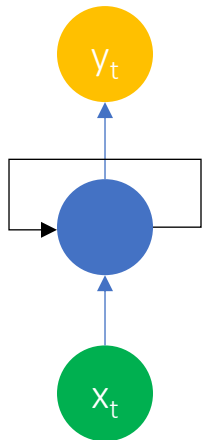


Speech Recognition

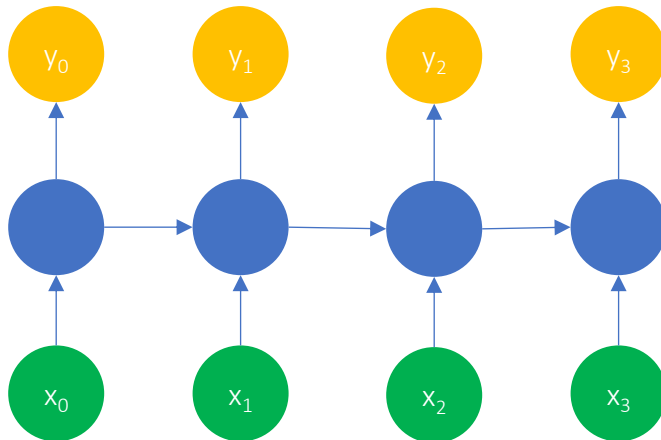
# Recurrent Neural Networks

## Rolled and Unrolled RNN

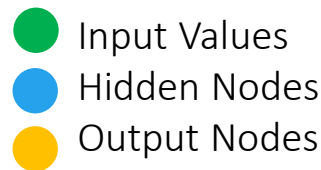
- Two ways to look at a RNN: rolled and unrolled.



Rolled RNN



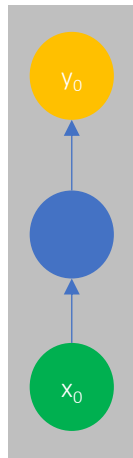
Unrolled RNN



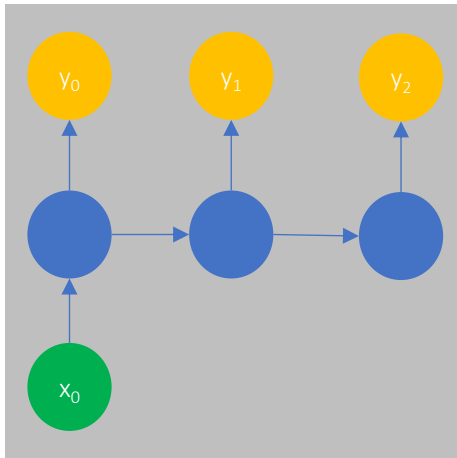
# Recurrent Neural Networks

Sequences Input, Hidden State, and Output

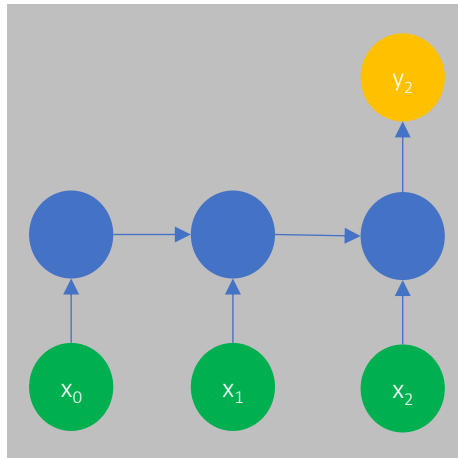
One to One



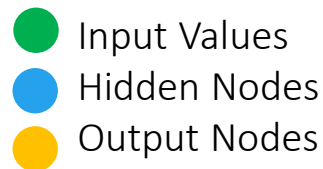
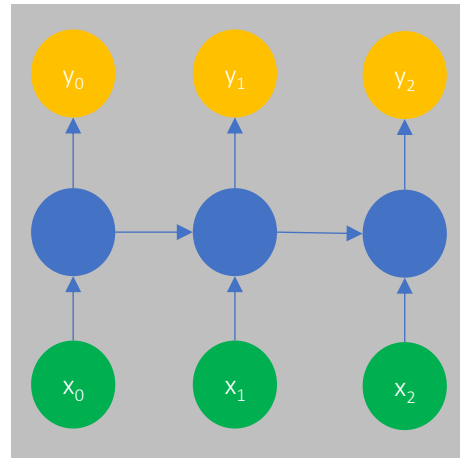
One to Many



Many to One



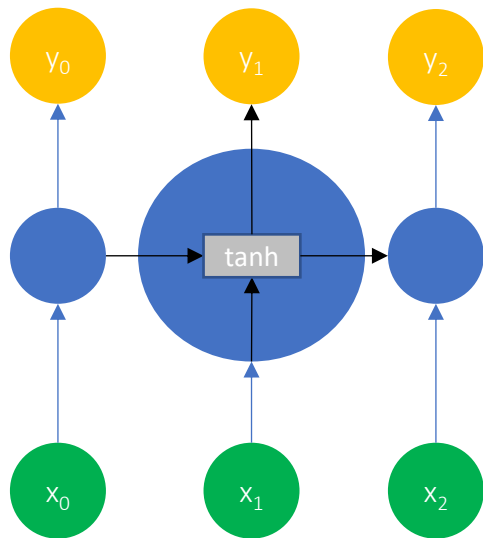
Many to Many



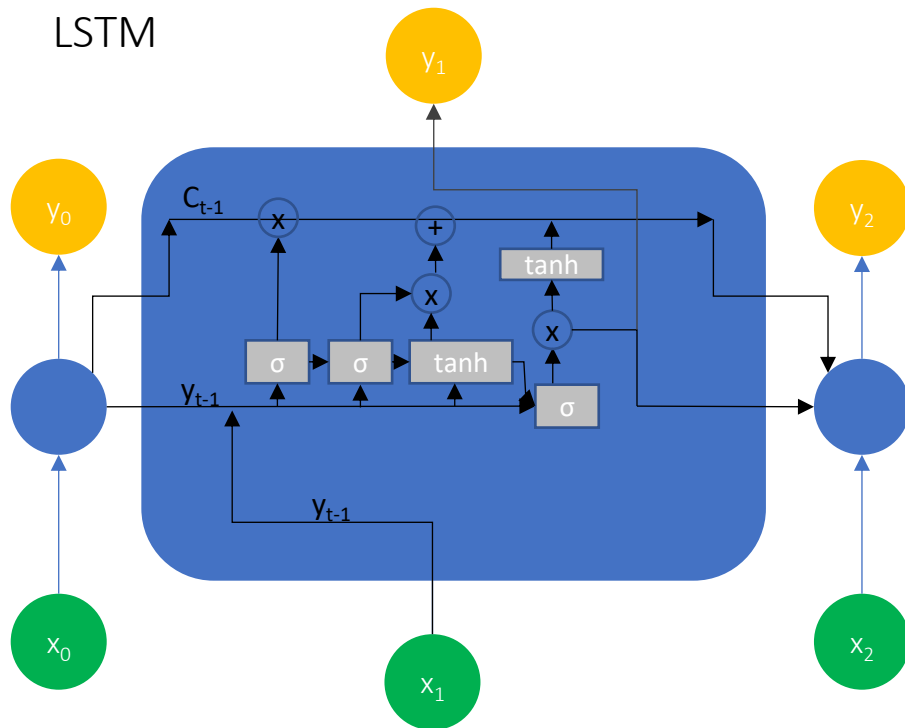
# Recurrent Neural Networks

## Difference of Basic RNN and LSTM

Basic RNN Cell



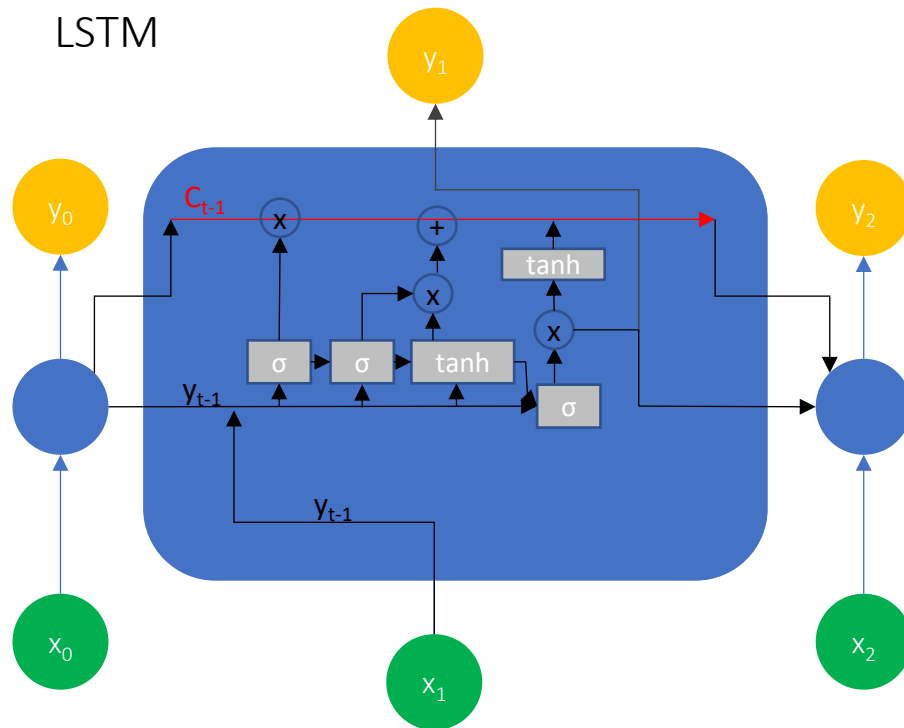
LSTM



# Recurrent Neural Networks

## LSTM-Cell Details

Cell State

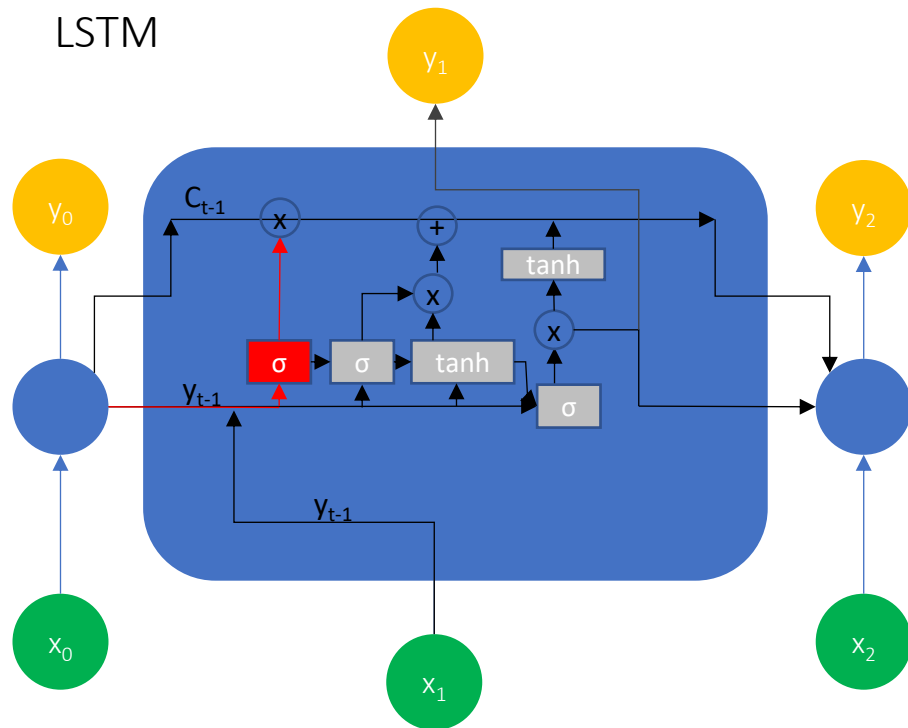


own graph, inspired by <https://colah.github.io/posts/2015-08-Understanding-LSTMs/>

# Recurrent Neural Networks

## LSTM-Cell Details

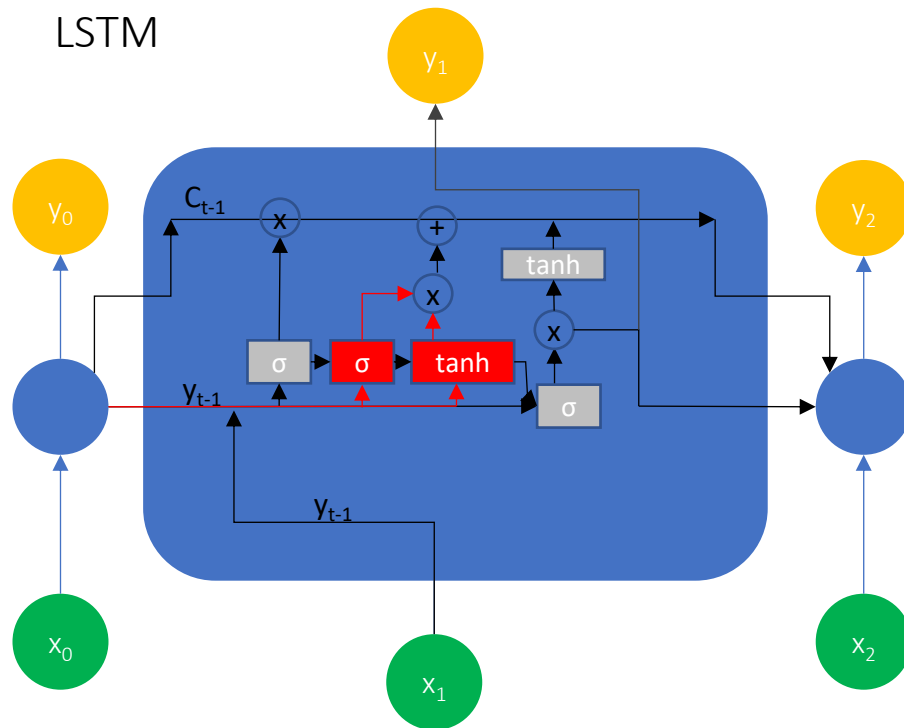
Forget Gate



# Recurrent Neural Networks

## LSTM-Cell Details

Input Gate Layer &  
State Update

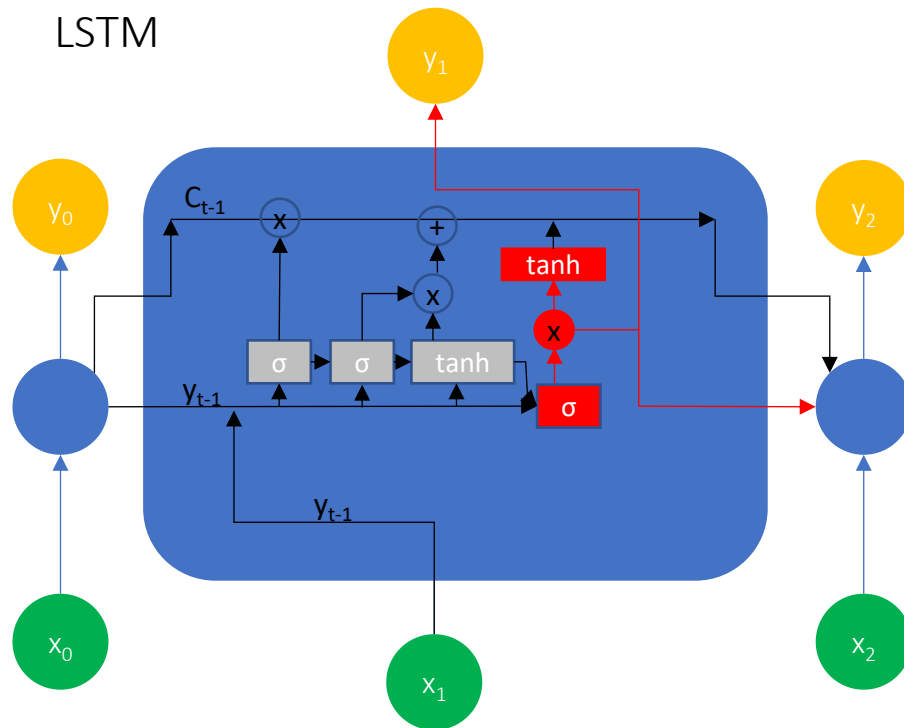




# Recurrent Neural Networks

## LSTM-Cell Details

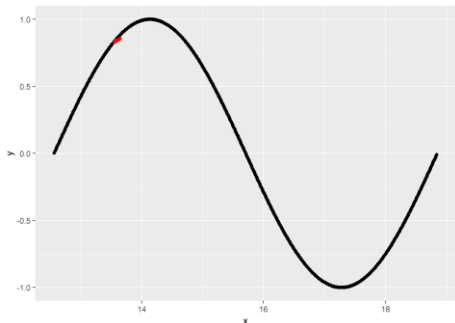
Output



# Recurrent Neural Networks

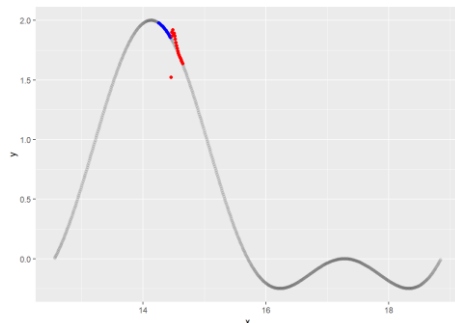
## Our Lab Lectures

- RNNs are usually the best choice whenever the data is sequential!



### Timeseries data

- univariate
- multi-step regression



### Timeseries data

- multivariate
- multi-step regression

ham What you doing?how are you?  
ham Ok lar... Joking wif u oni...  
ham dun say so early hor... U c already then say...  
ham MY NO. IN LUTON 0125698789 RING ME IF UR AROUND! H\*  
ham Siva is in hostel aha:-.  
ham Cos i was out shopping wif darren jus now n i called him 2 ask wat present he wan lor. Th  
spam FreeMsg: Txt: CALL to No: 86888 & claim your reward of 3 hours talk time to use from y  
spam Sunshine Quiz! Win a super Sony DVD recorder if you canname the capital of Australia?  
spam URGENT! Your Mobile No 07808726822 was awarded a L2,000 Bonus Caller Prize on C

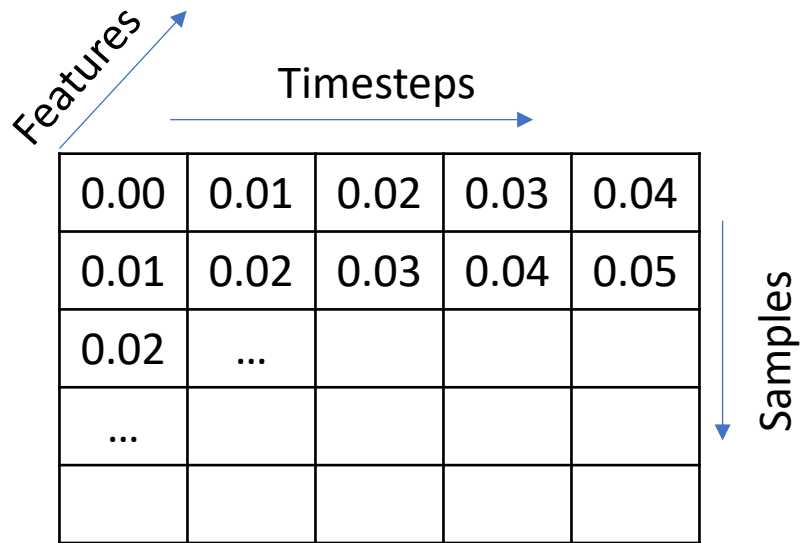
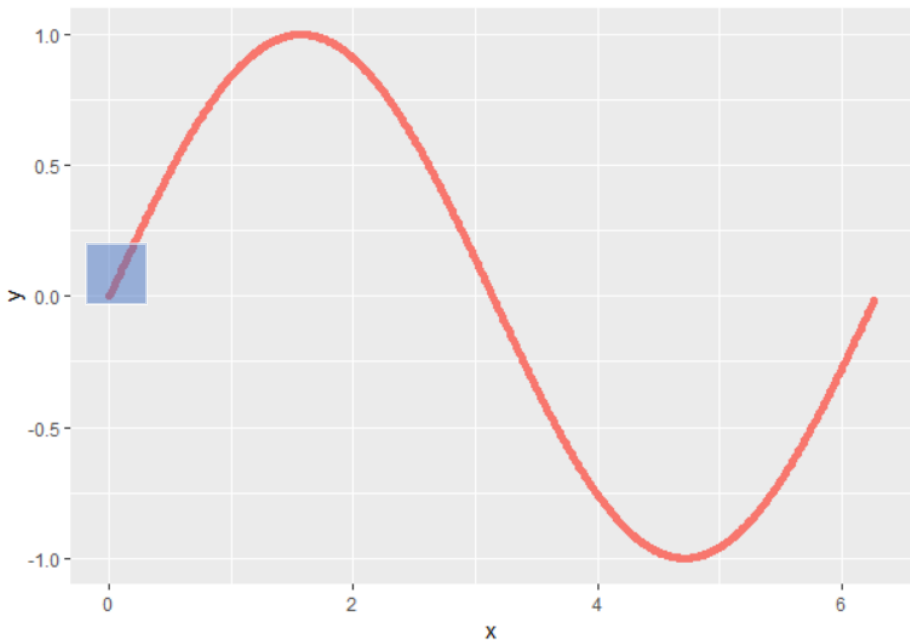
### Natural Language Processing

- univariate
- binary classification

# Recurrent Neural Networks

## Practical Considerations: Input Shape

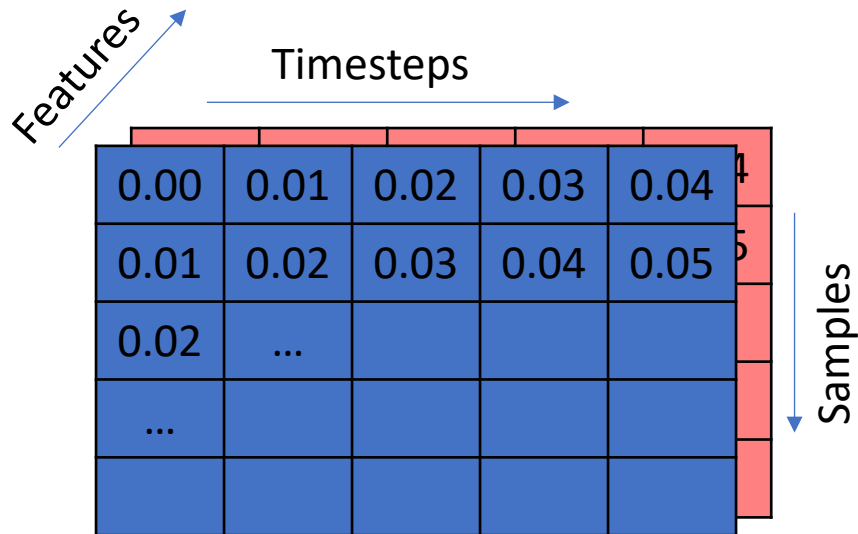
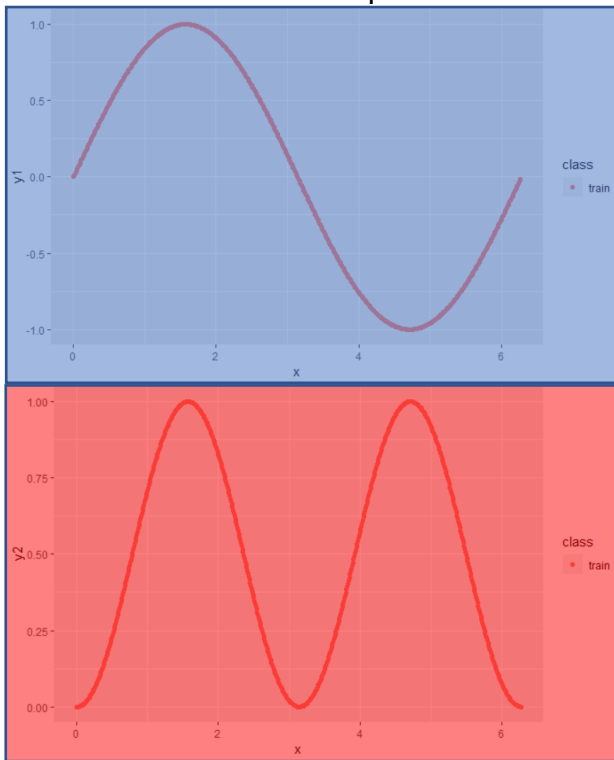
- Data needs have have 3D shape!
- (samples, nr. of timesteps, nr. of features)



# Recurrent Neural Networks

## Practical Considerations: Input Shape

### ■ Multi-variate prediction



# Recurrent Neural Networks

Practical Considerations: Natural Language Processing with LSTMs

## Word Embeddings

- Add more content here
- Input Shape: 2D (samples, sequence length)
- Output Shape: 3D (samples, sequence length, output dimension)

# Recurrent Neural Networks

Advantages / Disadvantages



- Most powerful technique for sequential data
- LSTMs keep long-term memory



- Basic RNNs typically too simple
- Numerically expensive