GENERAL ASSEMBLY

NEURAL NETWORKS

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LEARNING OBJECTIVES

- Understand various types of neural networks
- Applications of neural networks
- Apply a neural network model for regression
- Apply a neural network model for classification

PRE-WORK

PRE-WORK REVIEW

- Understand Logistic Regression and link functions
- Be familiar with training and testing classifiers and regressors

OPENING

ARTIFICIAL NEURAL NETWORKS

ARTIFICIAL NEURAL NETWORKS

- Neural networks were first studied in the 1940s (!) as a model of biological neural networks
- Many advances since then have improved the ability to train and apply neural networks
- Good for both classification and regression but difficult to interpret model behaviours
- Deep learning in the past few years has been highly successful for otherwise difficult problems

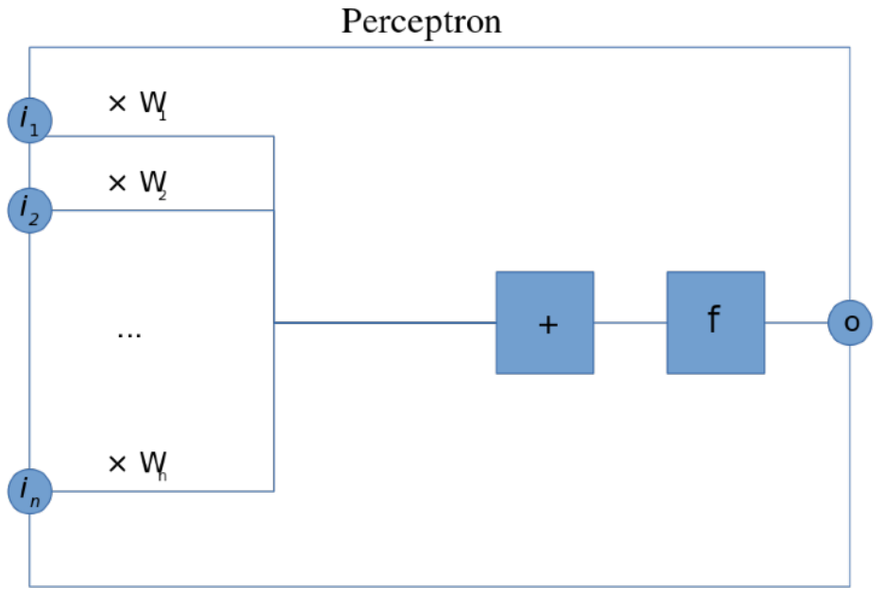
ARTIFICIAL NEURAL NETWORKS

- Today we will focus on types of neural networks and their applications and skip some of the more technical details
- Specifically we will skip training neural networks
  - There are many methods in various situations and the details can be tedious (but not particularly difficult)
- Methods include back propagation, gradient descent and Hessian-free learning

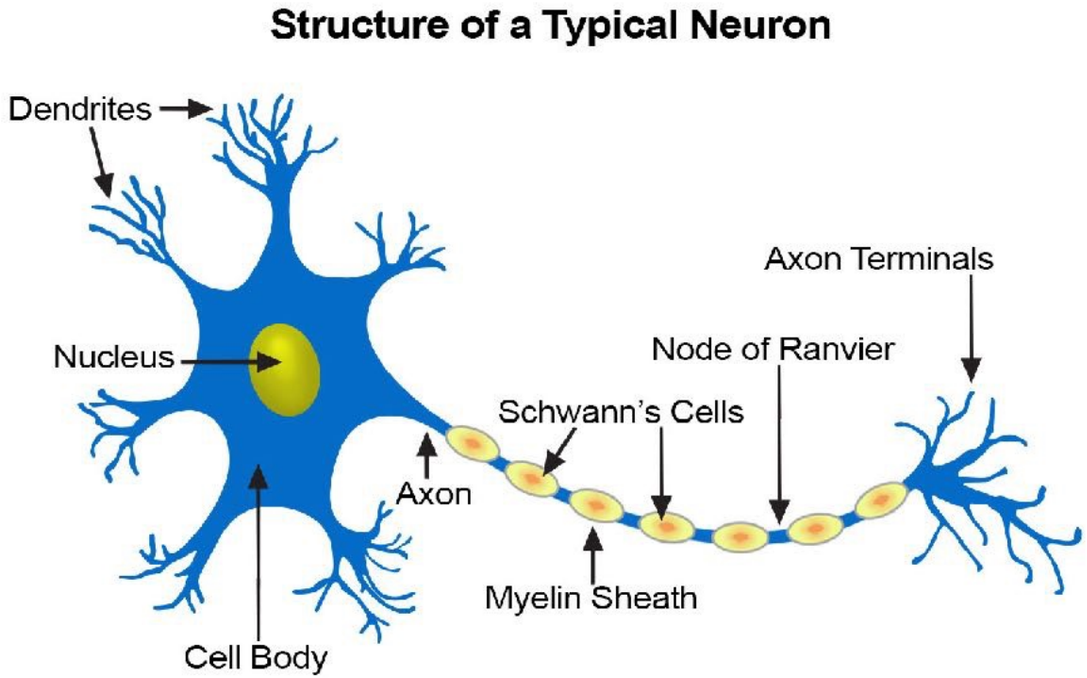
PERCEPTRON

PERCEPTRON

- Perceptrons are the simplest example of a neural network
- The idea is to emulate a single neuron

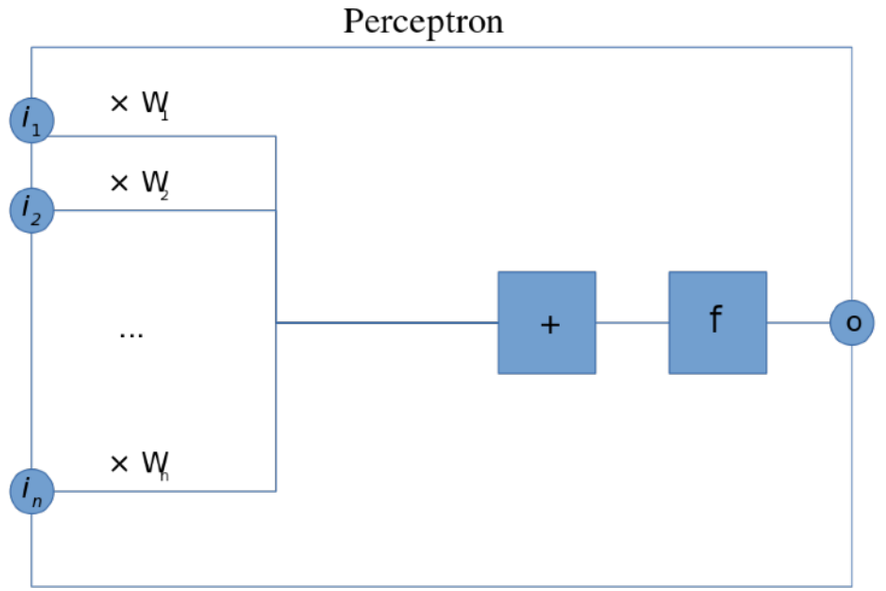


$$o = f\left(\sum_{k=1}^{n} i_k \cdot W_k\right)$$



PERCEPTRON

- Given n inputs and an activation or link function f
- The perceptron computes a linear separating curve



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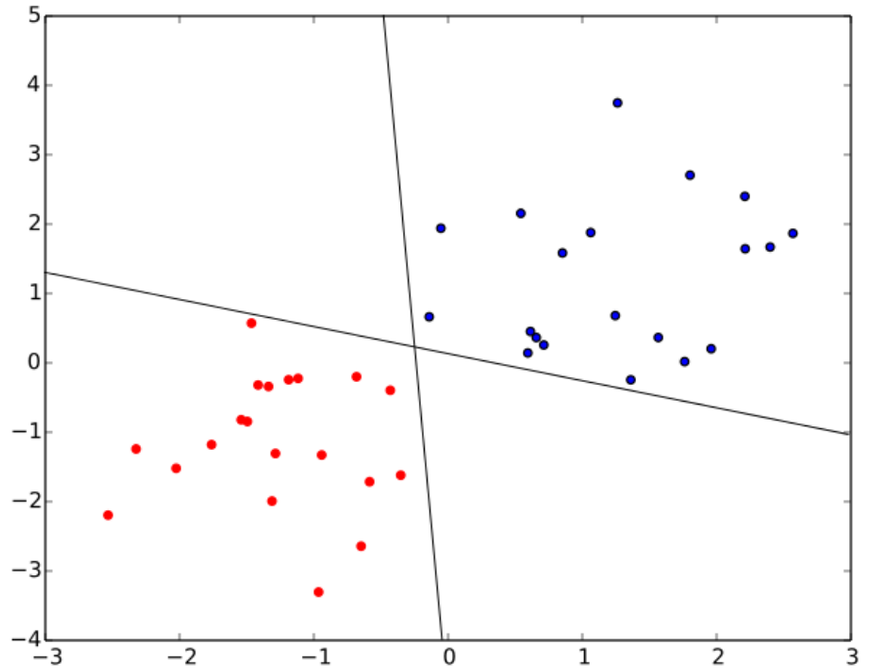
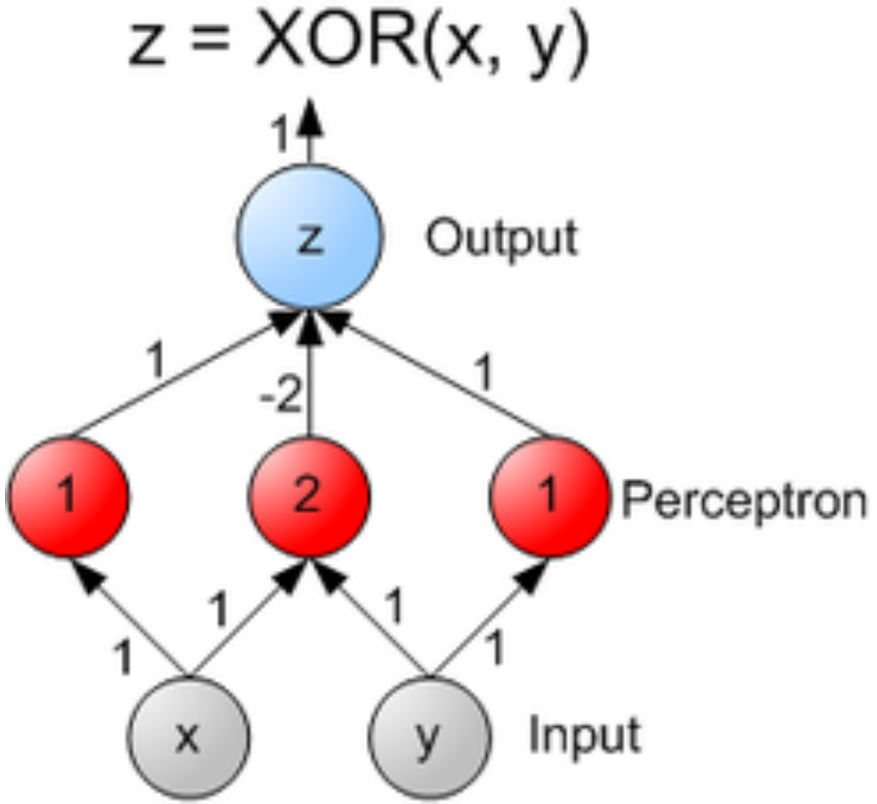
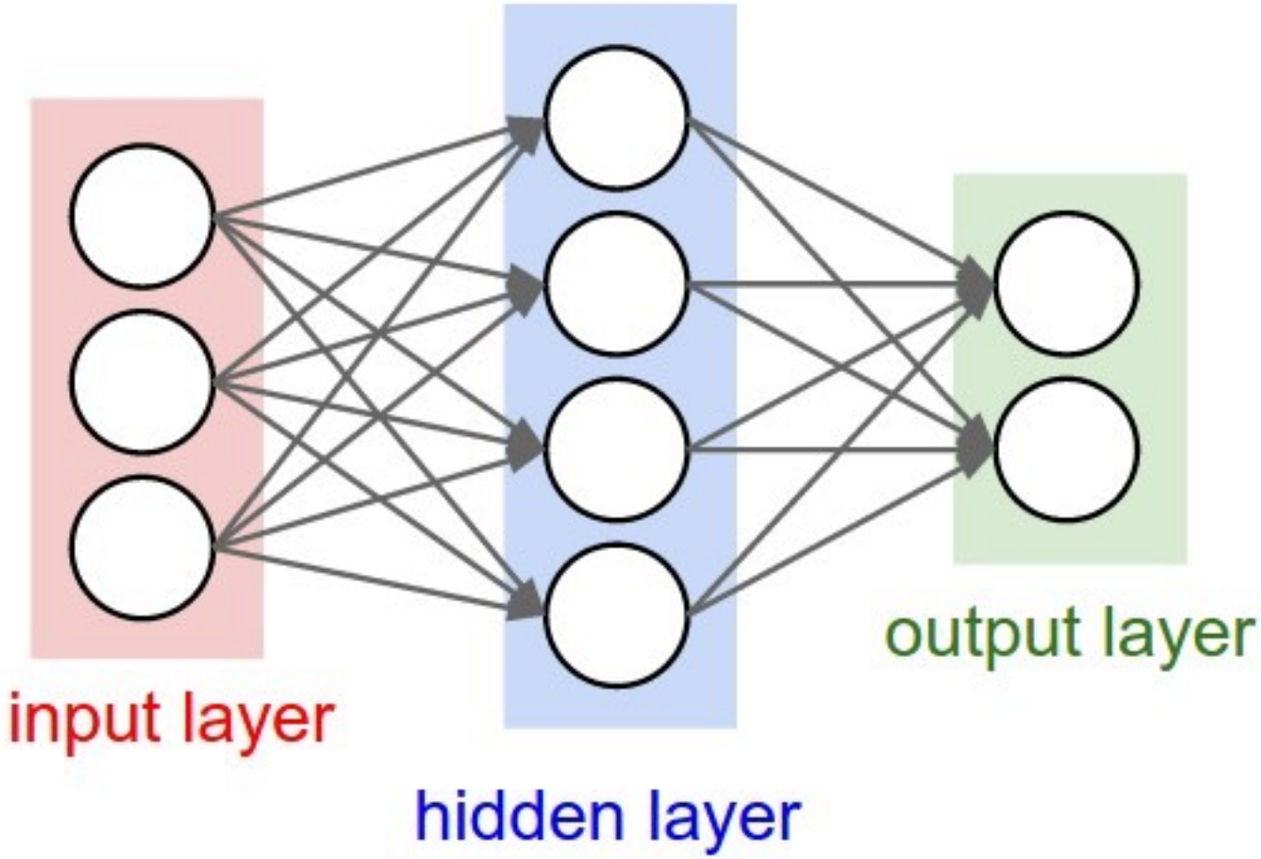


PERCEPTRON

- Common activation functions are linear, logistic, tanh and softmax
- We will see shortly that some are better for classification, some for regression
- Perceptrons can be combined into multilayer perceptrons or feed-forward network



FEED FORWARD NEURAL NETWORKS



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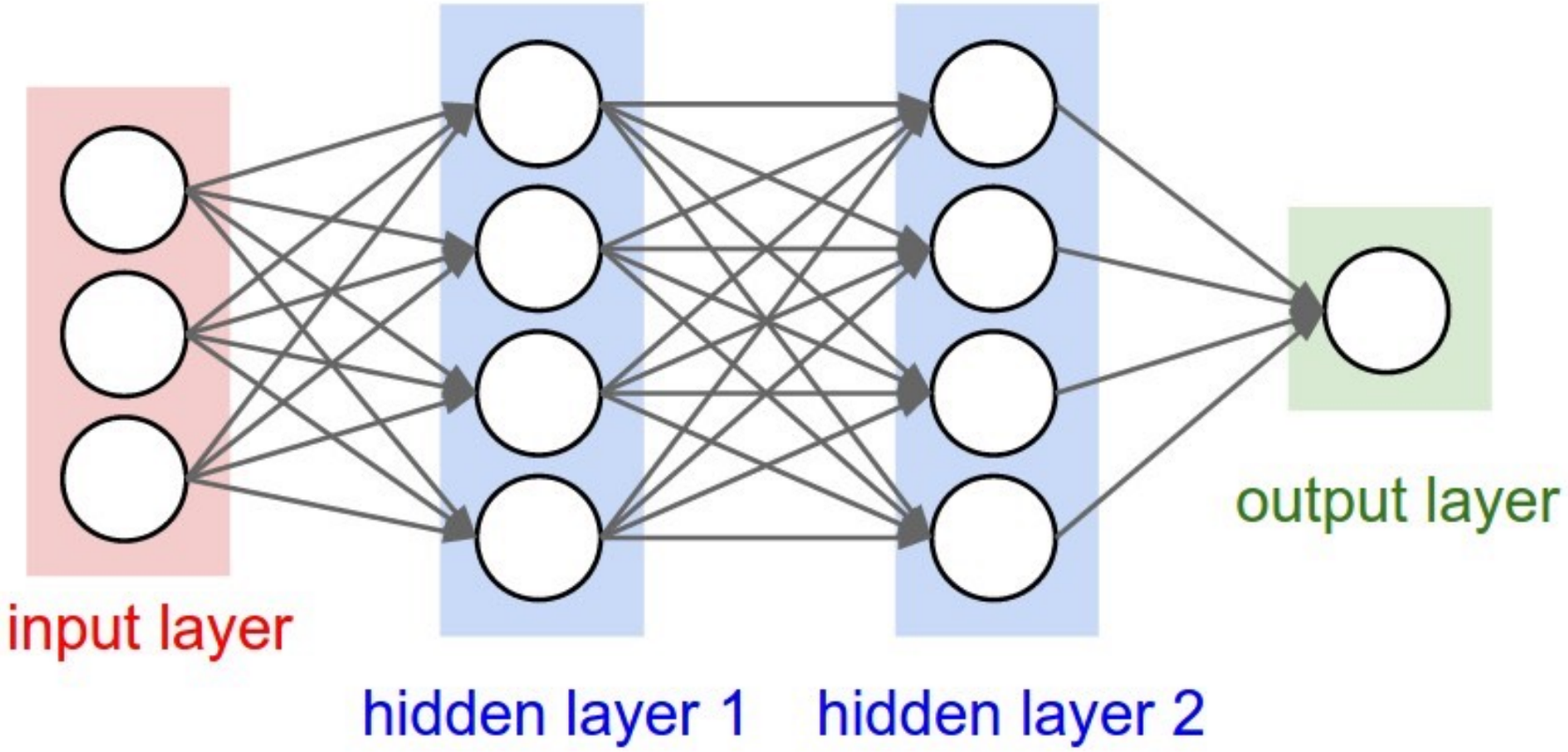

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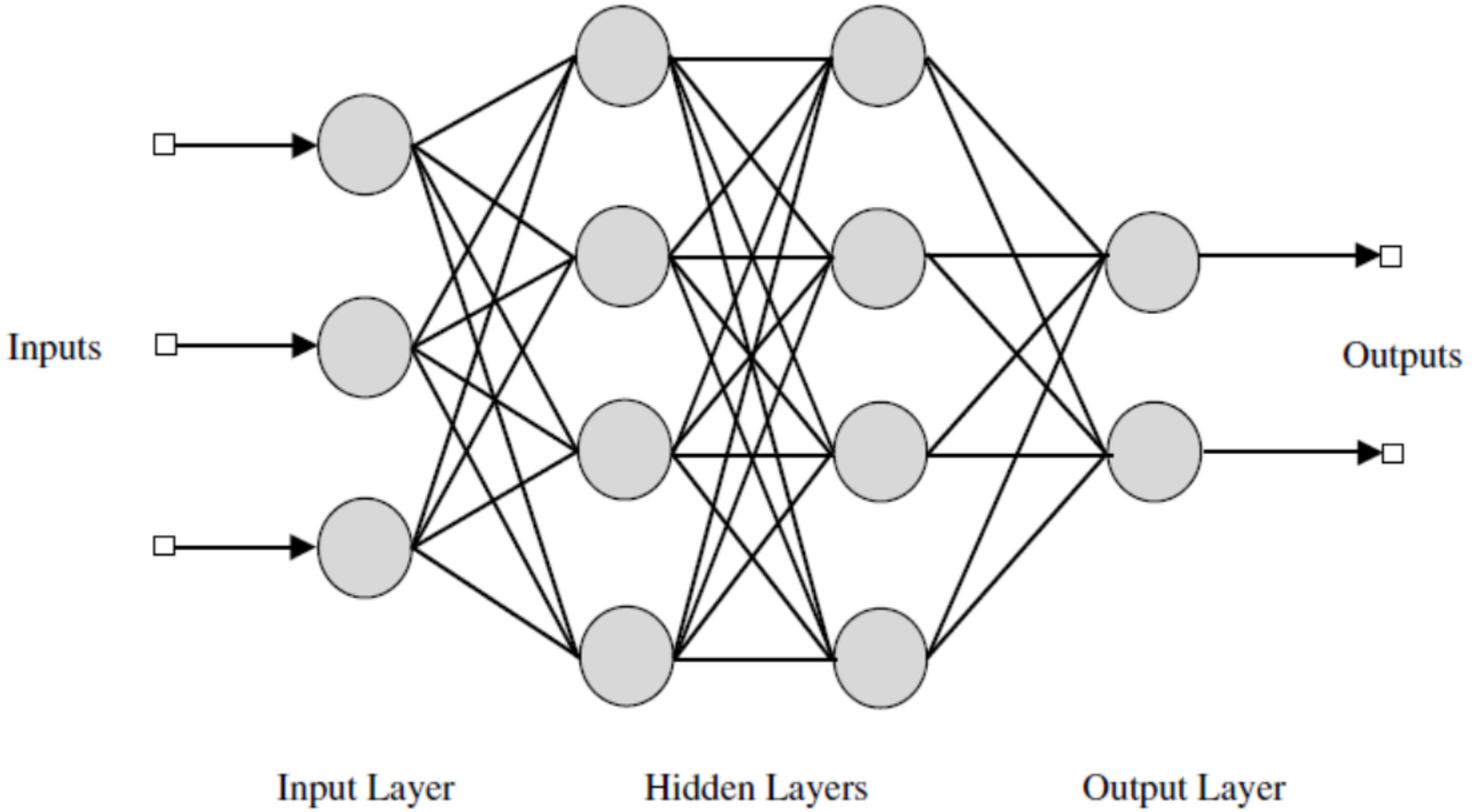

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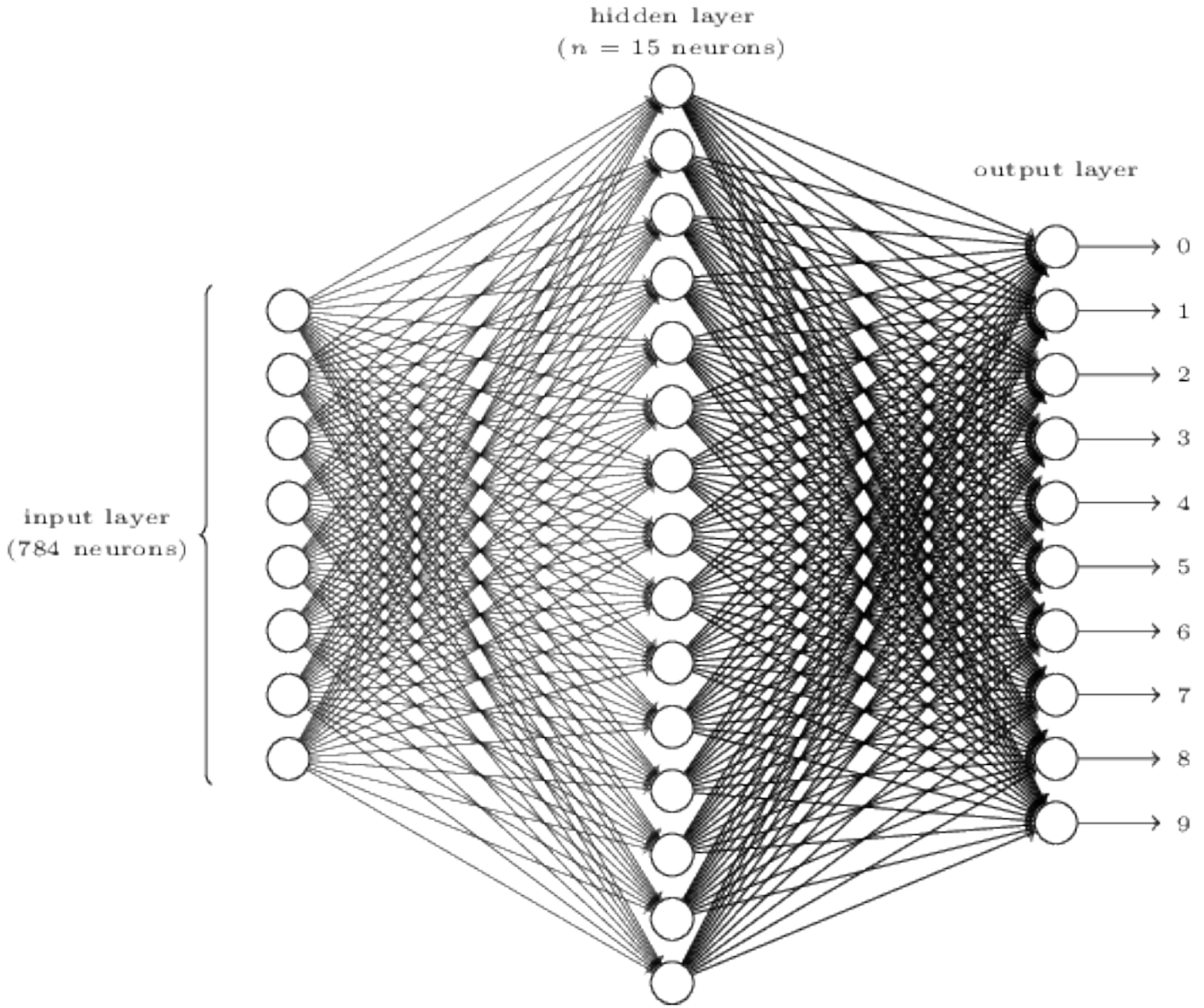

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FEED FORWARD NEURAL NETWORKS

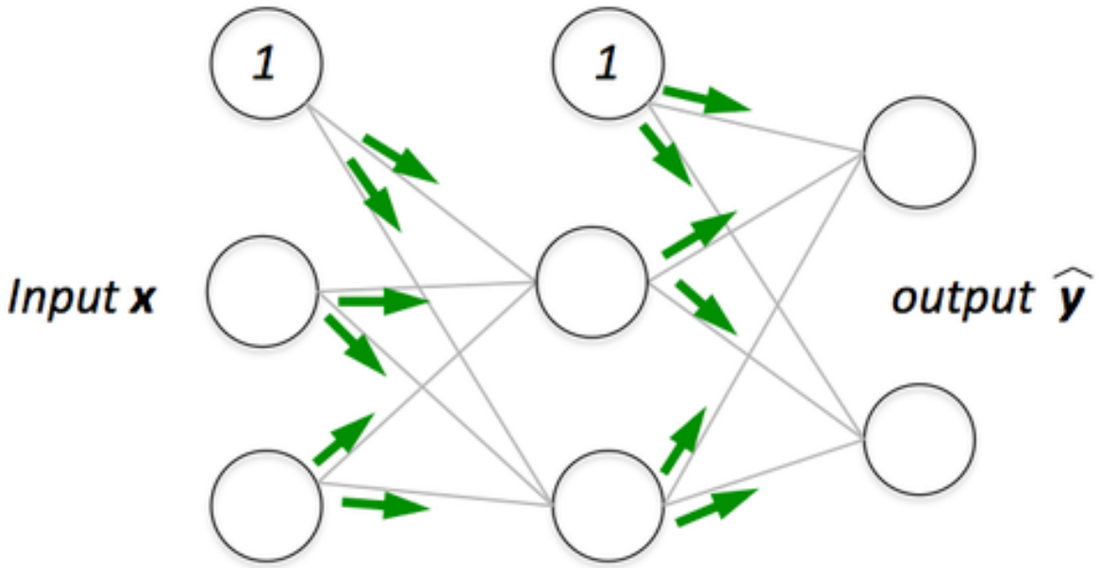
- Typically we use
  - Tanh or logistic layers for input
  - Linear layers for regression output
  - Logistic or Tanh for binary output
  - Softmax for n-class output (yields probabilities)

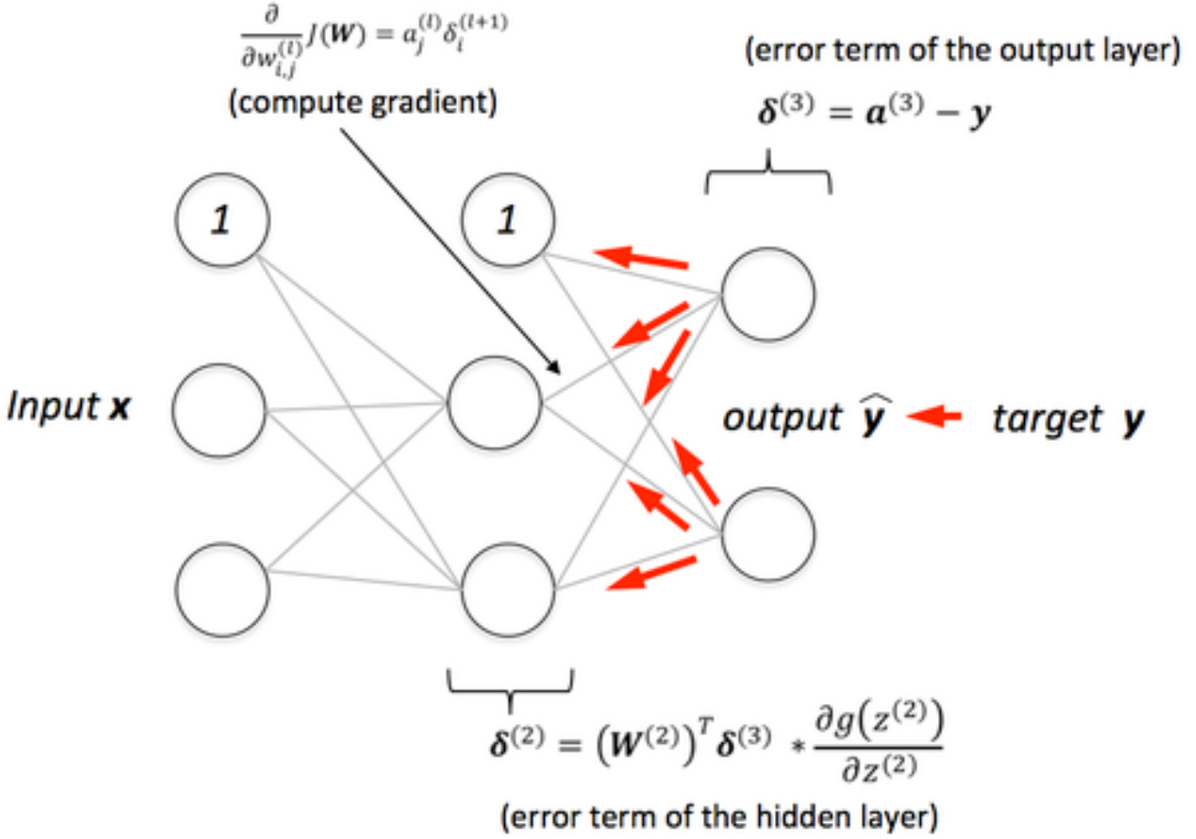
GUIDED PRACTICE

TRAINING

TRAINING

- Feed forward neural networks can be trained with back propagation





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TRAINING

- Key Parameters
  - Learning Rate (gradient descent for training)
  - Epochs: number of back propagation passes (over entire data set)
  - Batch size: how many training points used at a time to update weights

- Model others behaves as usual with
  - model.predict
  - model.predict_classes

TRAINING

- Tips
  - If the error jumps around per epoch, decrease the learning rate
  - Taking too long to train: use higher learning rate or batch_size
  - High error after convergence?
    - More hidden layers / neurons
    - Normalise data or use PCA

UNIVERSAL APPROXIMATION THEOREM

UNIVERSAL APPROXIMATION THEOREM

- One major reason that neural networks are useful is the Universal Approximation Theorem

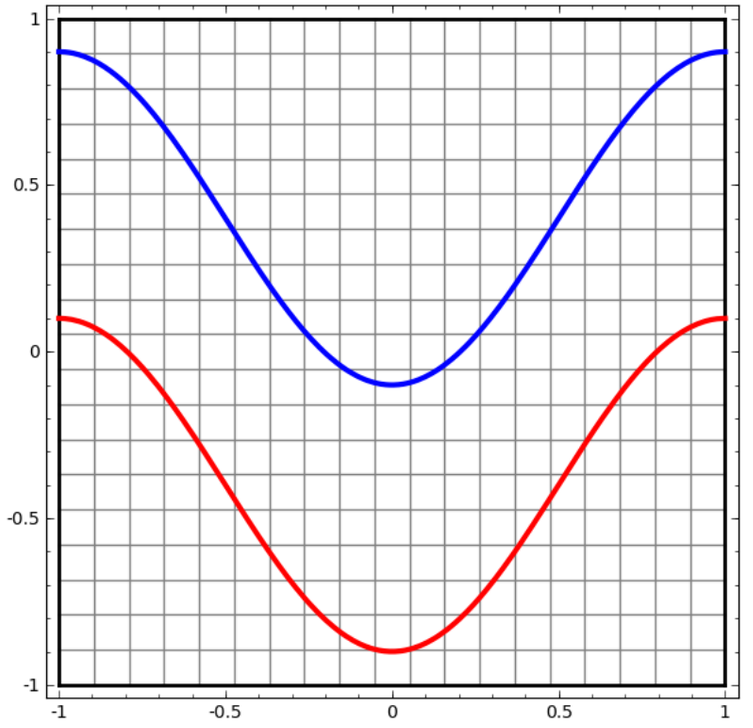
- The result basically says that many real vector-valued functions can be approximated arbitrarily well with some feed-forward neural network

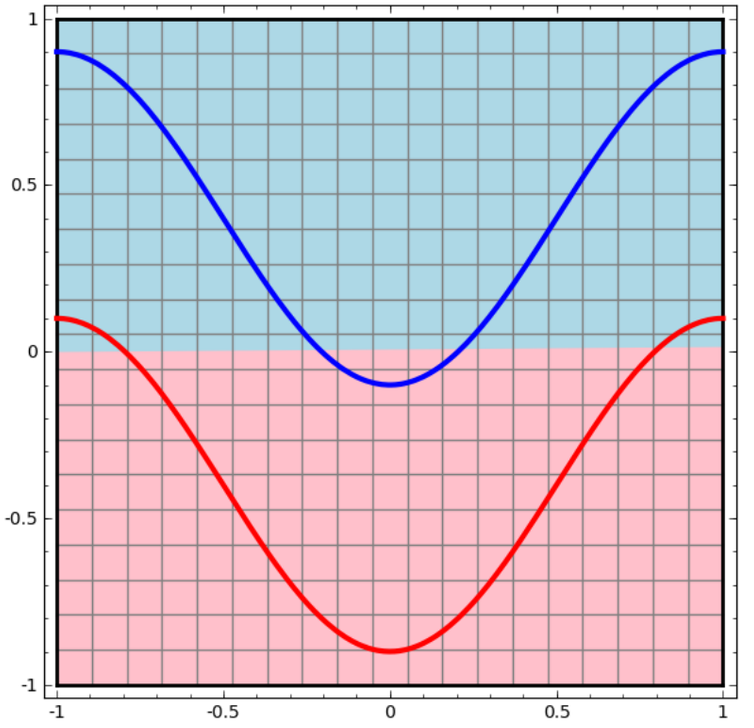
- This is why neural networks are useful for regression - given enough data and the right network structure they can fit many common data sets

CLASSIFICATION WITH NEURAL NETWORKS

CLASSIFICATION

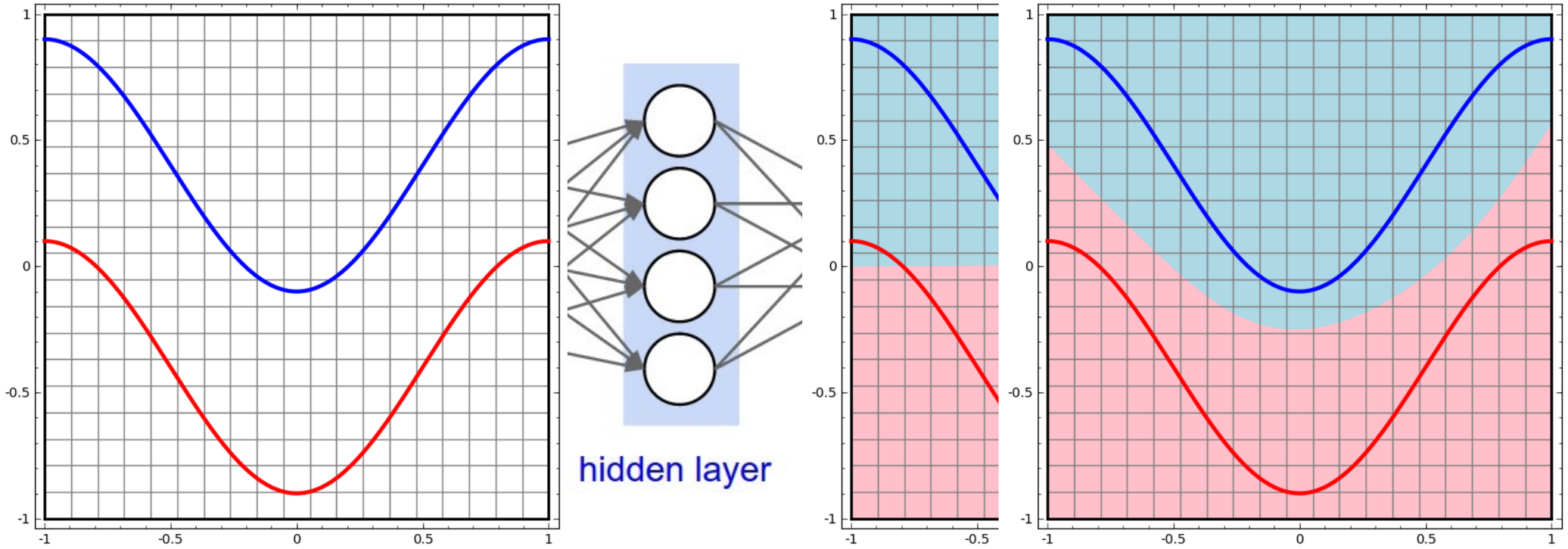
- Neural Networks are also extremely useful for classification
- **No** hidden layers
- Source





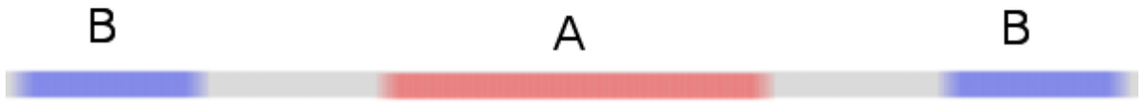
CLASSIFICATION

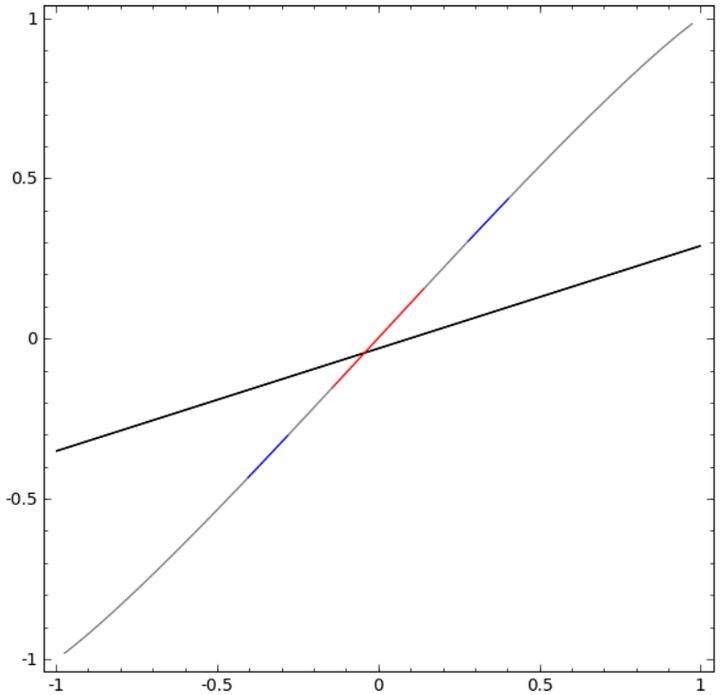
- Neural Networks are also extremely useful for classification
- **One** hidden layers



CLASSIFICATION

- Neural Networks are also extremely useful for classification





CLASSIFICATION

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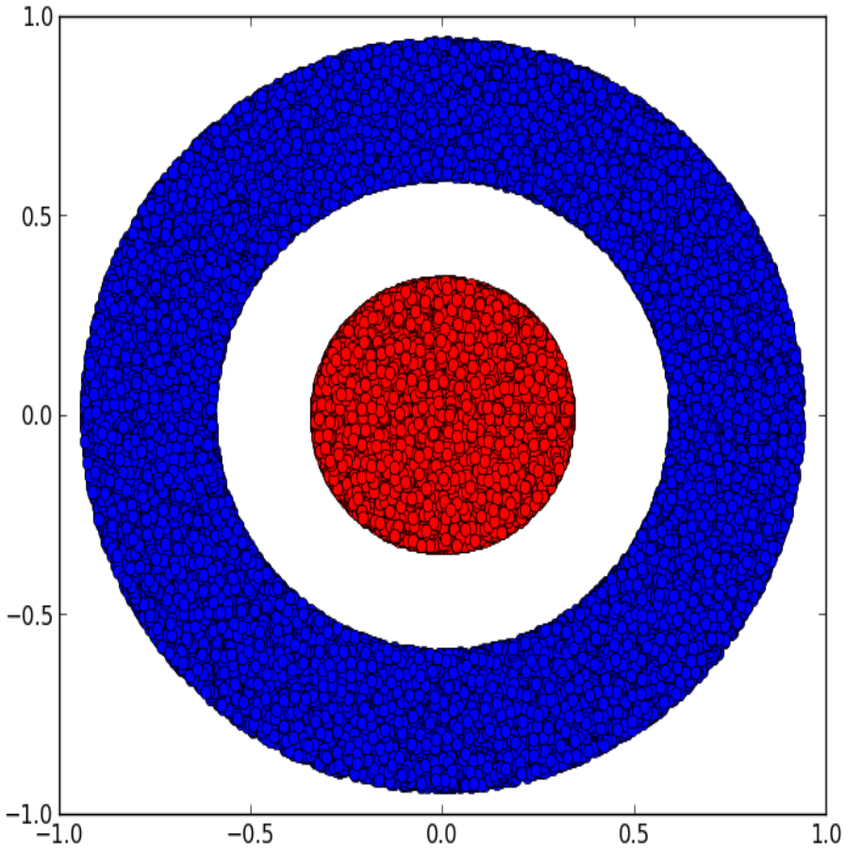
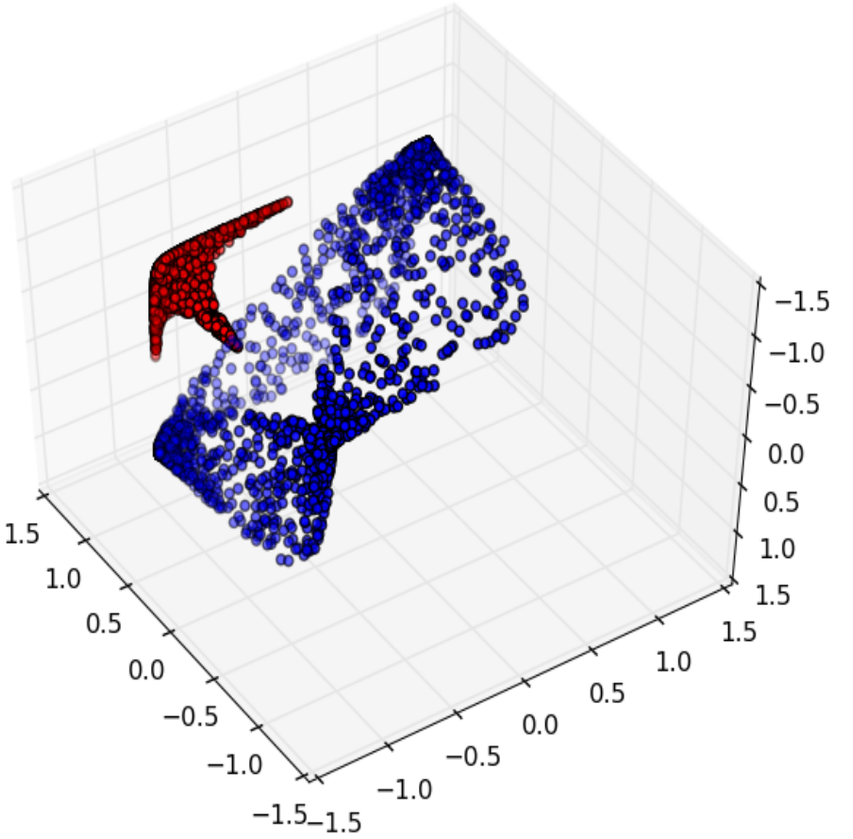




CLASSIFICATION

- The neural network transforms the data topologically (no tears or breaks) and then separates the data with a hyperplane

- NNs are capable of handling difficult data sets, including
  - Image processing: recognising hand-written characters
  - Image compression
  - Financial forecasting
  - Many others

ACTIVITY: KNOWLEDGE CHECK

EXERCISE

DIRECTIONS: ANSWER THE FOLLOWING QUESTIONS

1. Let's practice using neural networks for classification
2. For each of the four data sets for classification, experiment with the number of layers and neurons to find the best model
3. Also take a look at this visualisation

GUIDED PRACTICE

NEURAL NETWORKS IN PYTHON

NEURAL NETWORK IN PYTHON

- There are many NN libraries for python and other languages
- Python
  - Theano
  - Keras
  - Lasagne
  - TensorFlow
  - Scikit Learn support for NN coming in 0.18
- Lua
  - Torch
- Some of these libraries utilise GPUs for (much) faster training

NEURAL NETWORK IN PYTHON

- Let’s look at some examples in Keras
  - Regression
  - Classification

GUIDED PRACTICE

DESIGNING NEURAL NETWORKS

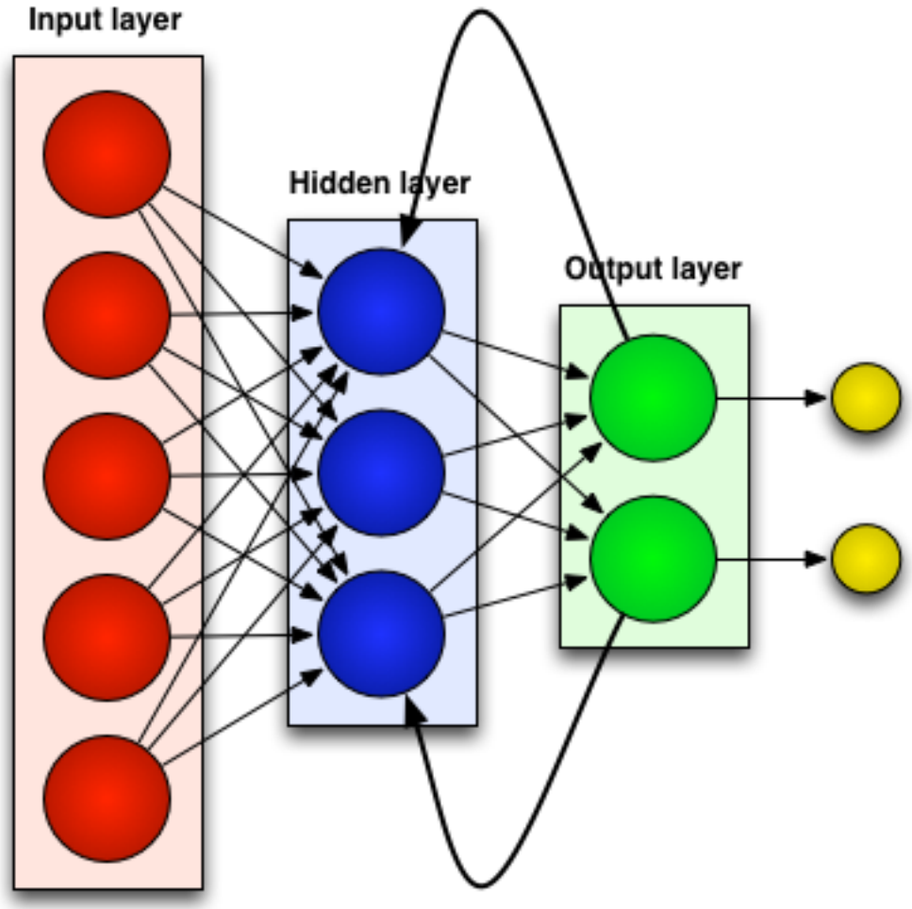
DESIGNING NEURAL NETWORK

- Network design is a hard problem
  - Experience helps
  - Evolutionary algorithms are useful for design
  - Nice (free) book available

RECURRENT NEURAL NETWORKS

RECURRENT NEURAL NETWORKS

- Recurrent Neural Networks contain loops (source)



RECURRENT NEURAL NETWORKS

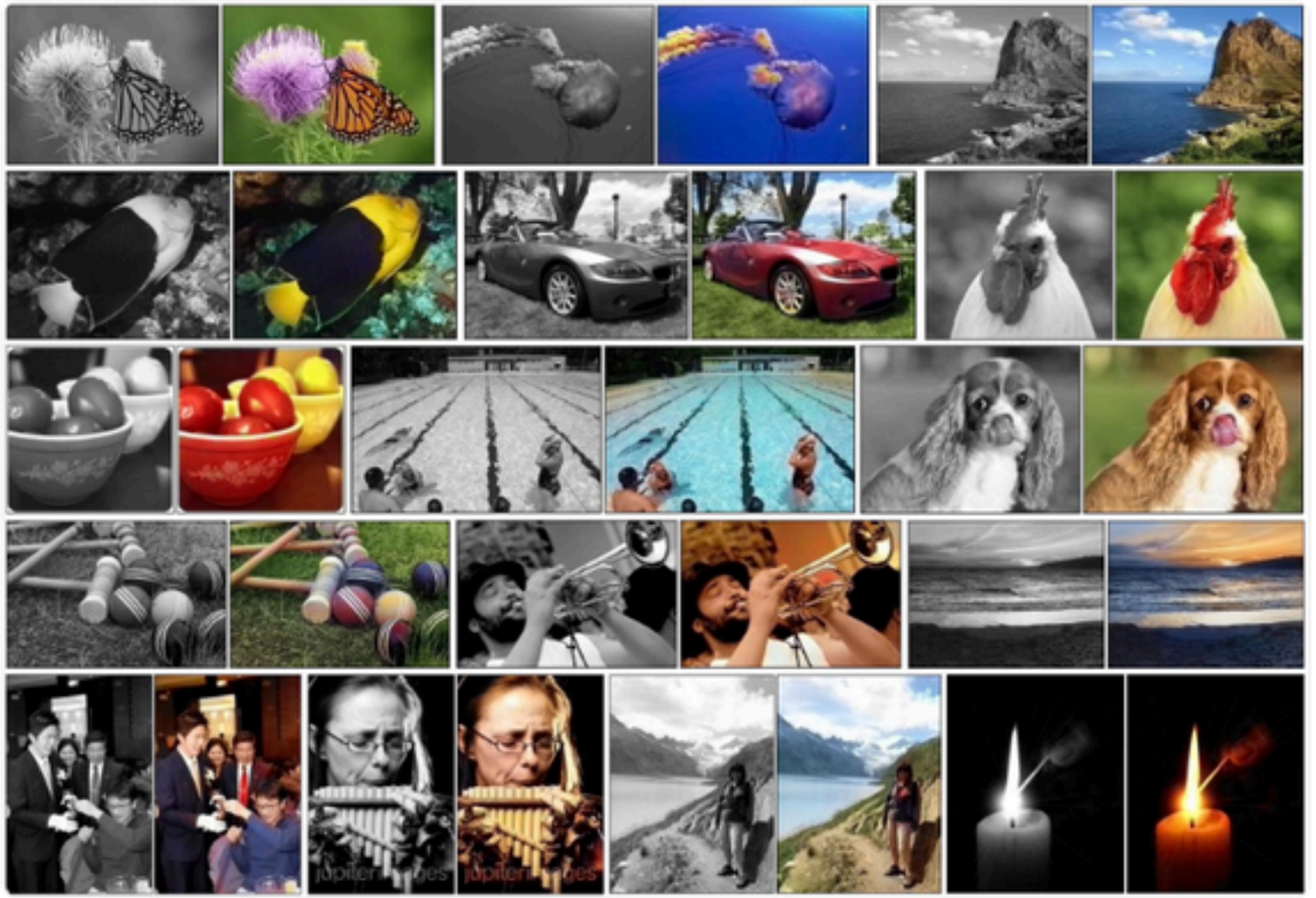
- Recurrent Neural Networks contain loops
- This implements feedback and gives neural networks “memory” or context
- Particularly good for predicting sequences, translating text, recognising objects in images, speech translation
- Commonly referred to as deep learning, involving both feature extraction and modelling
- Nice intro here

RECURRENT NEURAL NETWORKS

- RNN font analysis

RECURRENT NEURAL NETWORKS

- Automatic Colorization with CNN



RECURRENT NEURAL NETWORKS

- RNN font analysis
- Automatic Colorisation with CNN
- Automatic translation
- Deep Learning Applications

TOPIC REVIEW

TOPIC REVIEW

Pros	Cons
Flexible	Can require a lot of data
Good for a variety of tasks	Training may be slow
Good for many types of data	Many parameters to tune
	Many layer types and activations
	Black Box model

TOPIC REVIEW

- Many more examples for Keras available
- Recommended articles: Convolutional Neural Networks
- Advanced machine learning methods you should explore include Bayesian methods and deep learning

BEFORE NEXT CLASS

BEFORE NEXT CLASS

DUE DATE

- Project
  - Final Project, part 5

Q & A