

Artificial Intelligence

ACTL3143 & ACTL5111 Deep Learning for Actuaries
Patrick Laub



Lecture Outline

- **Artificial Intelligence**
- Neural Networks



Lecture Outline

- Artificial Intelligence
- **Neural Networks**

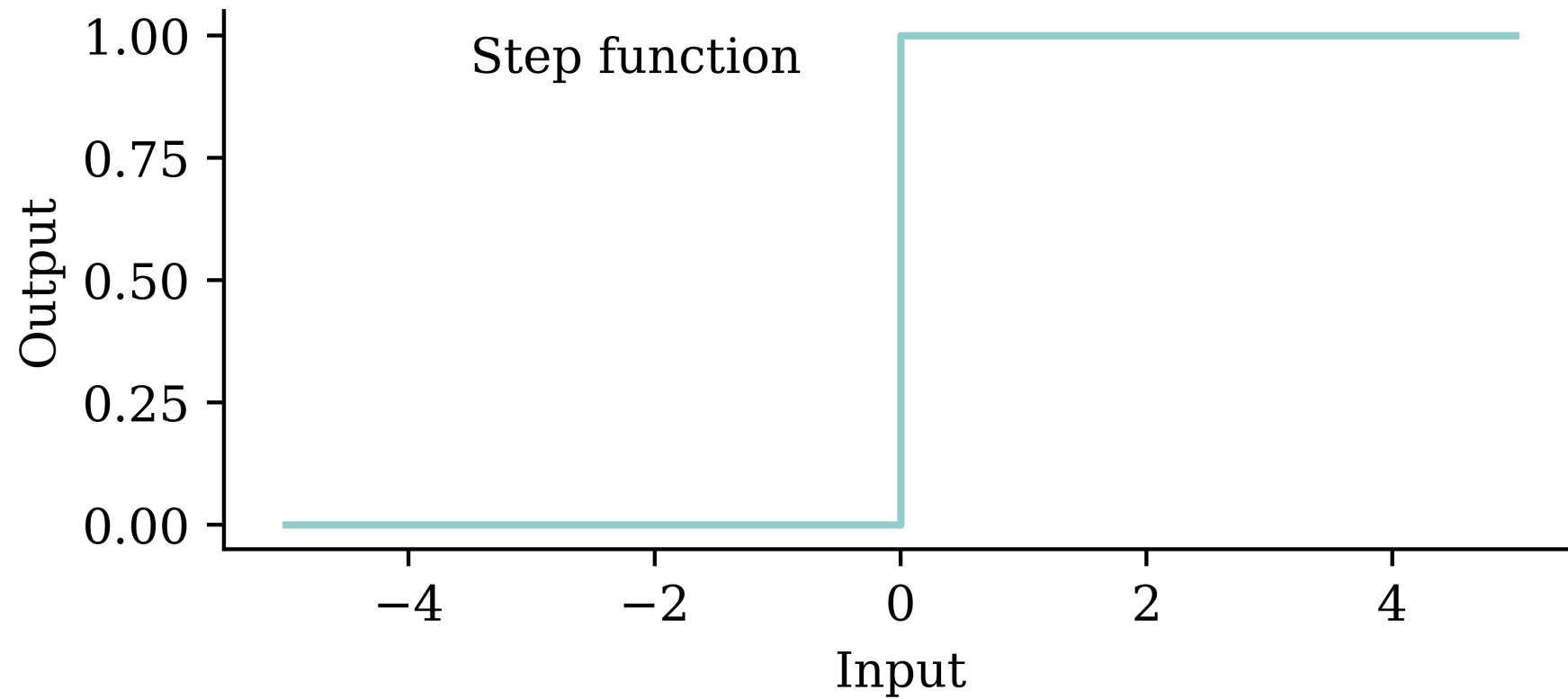


How do real neurons work?

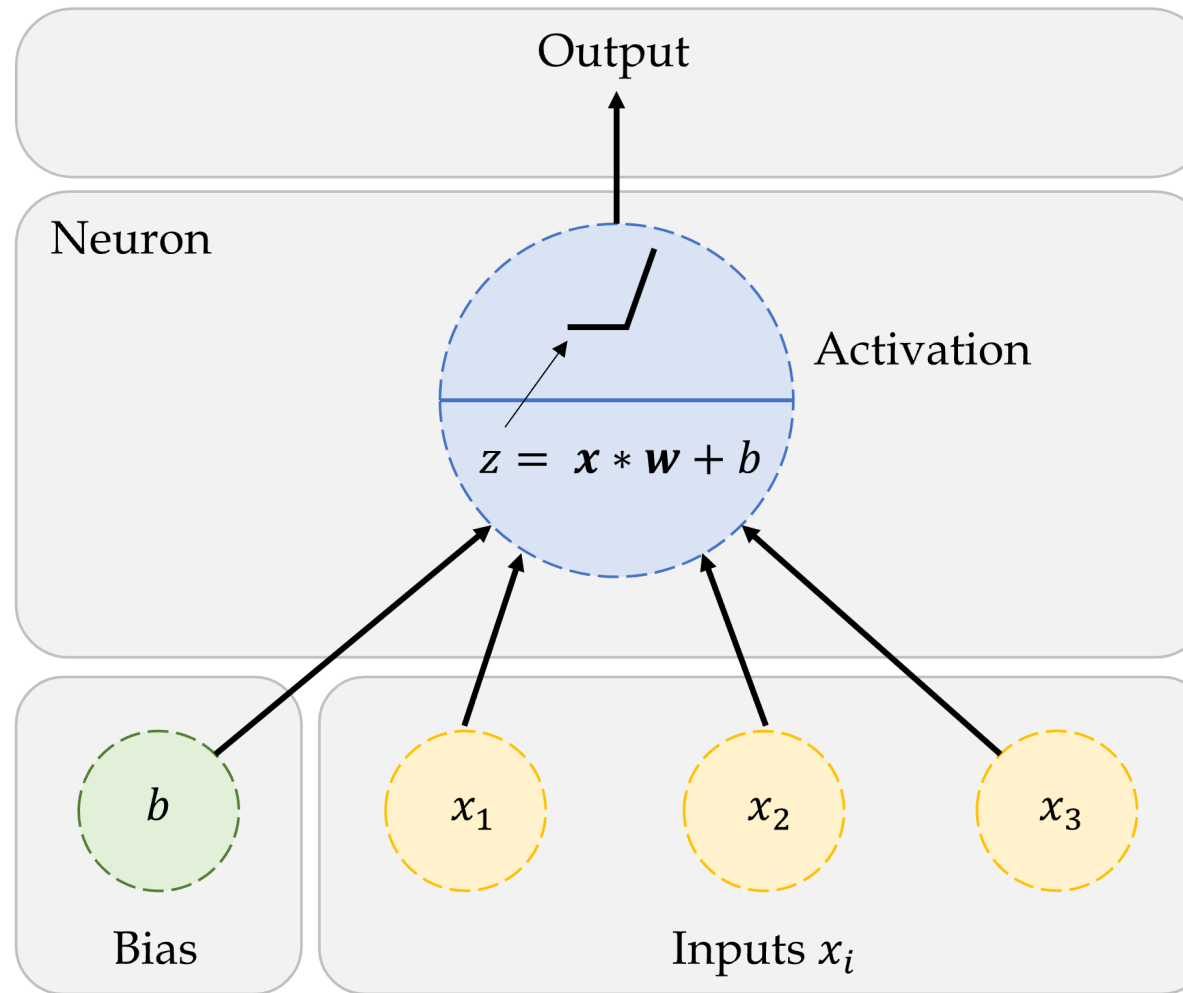
2-Minute Neuroscience: The Neuron



A neuron 'firing'



An artificial neuron



A neuron in a neural network with a ReLU activation.

Source: Marcus Lautier (2022).



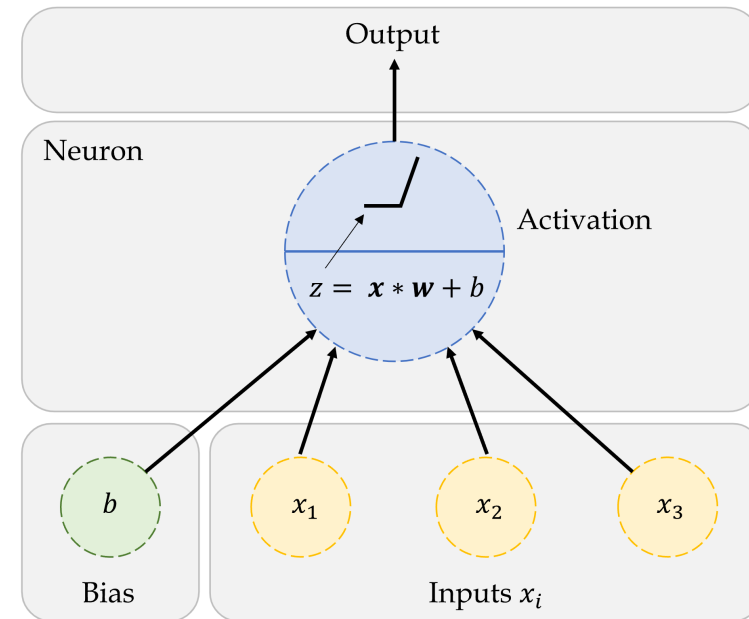
One neuron

$$z = x_1 \times w_1 + x_2 \times w_2 + x_3 \times w_3.$$

$$a = \begin{cases} z & \text{if } z > 0 \\ 0 & \text{if } z \leq 0 \end{cases}$$

Here, x_1, x_2, x_3 is just some fixed data.

The weights w_1, w_2, w_3 should be ‘learned’.



A neuron in a neural network with a ReLU activation.

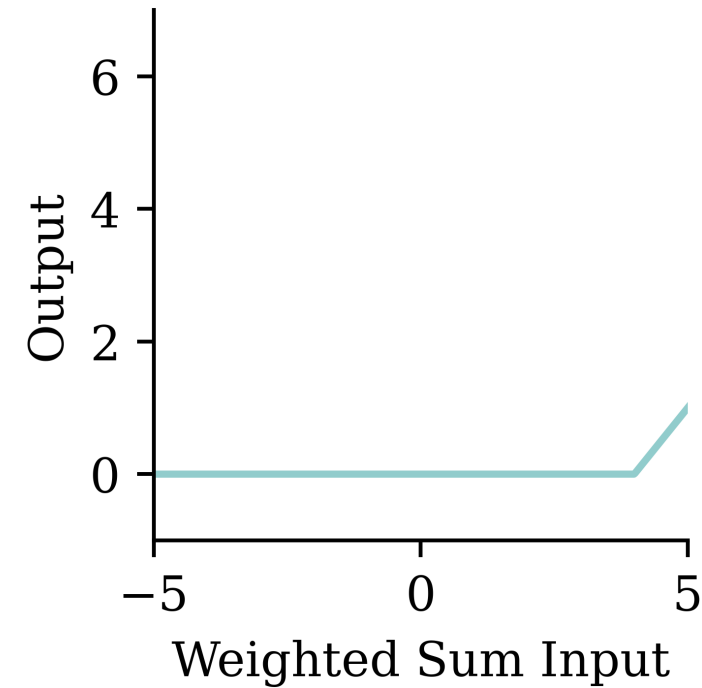
One neuron with bias

$$z = x_1 \times w_1 + x_2 \times w_2 + x_3 \times w_3 + b.$$

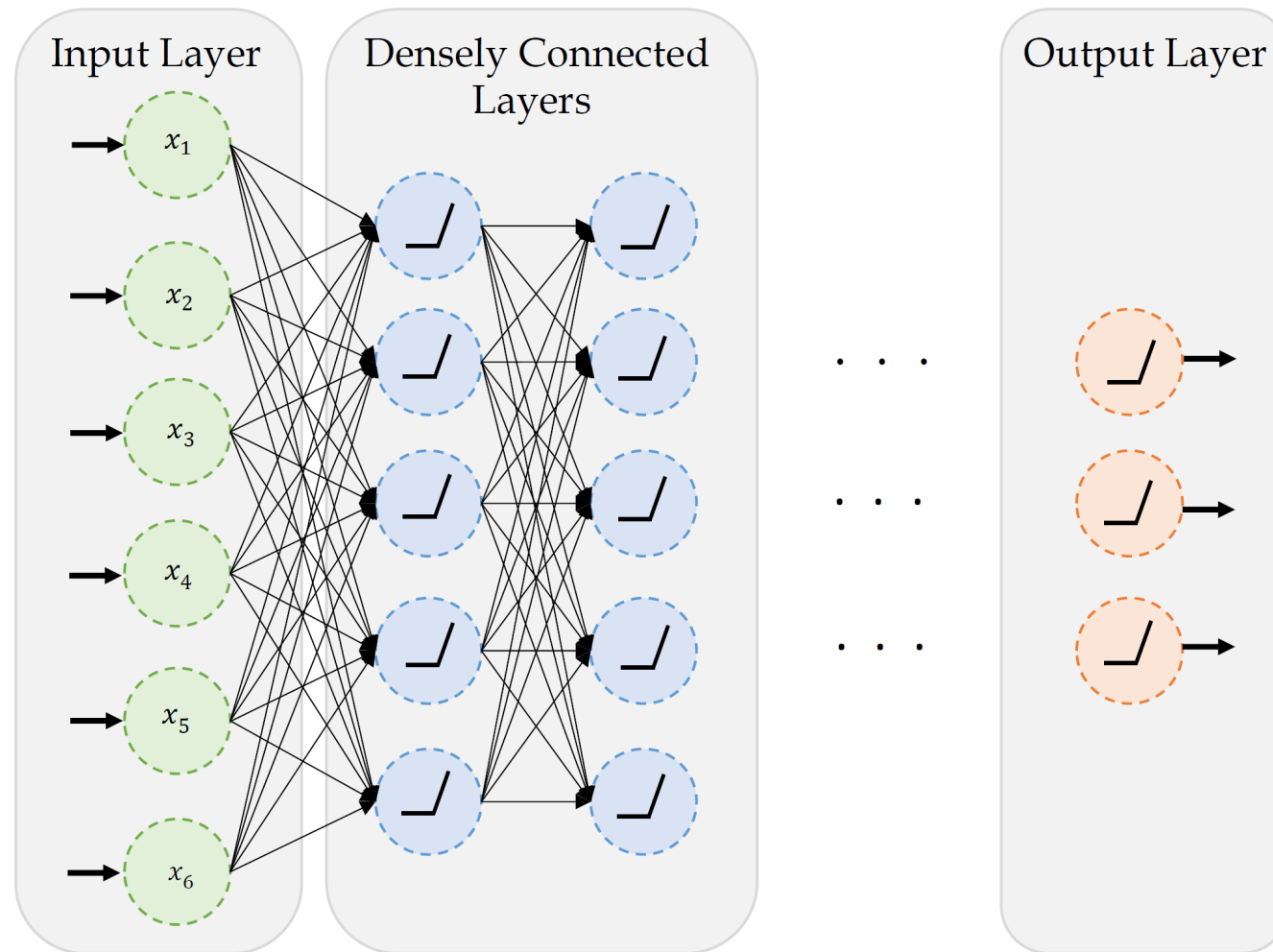
$$a = \begin{cases} z & \text{if } z > 0 \\ 0 & \text{if } z \leq 0 \end{cases}$$

The weights w_1 , w_2 , w_3 and bias b should be ‘learned’.

Bias = -4 0 4



A basic neural network



A basic fully-connected/dense network.

Source: Marcus Lautier (2022).



Step-function activation

Perceptrons

Brains and computers are binary, so make a perceptron with binary data. Seemed reasonable, impossible to train.

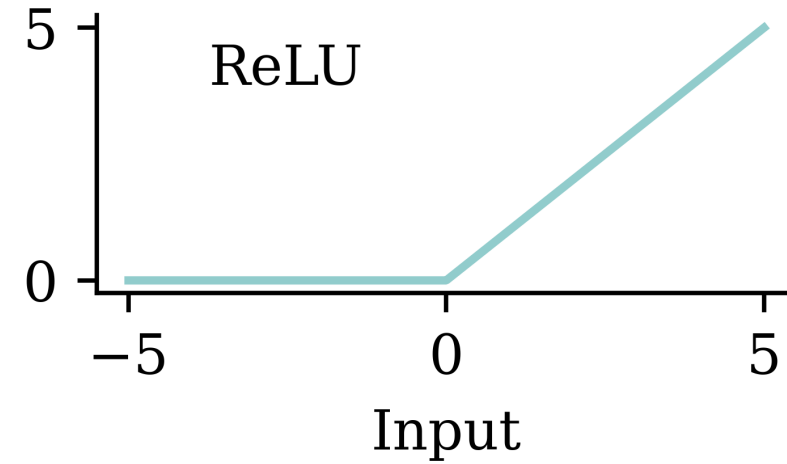
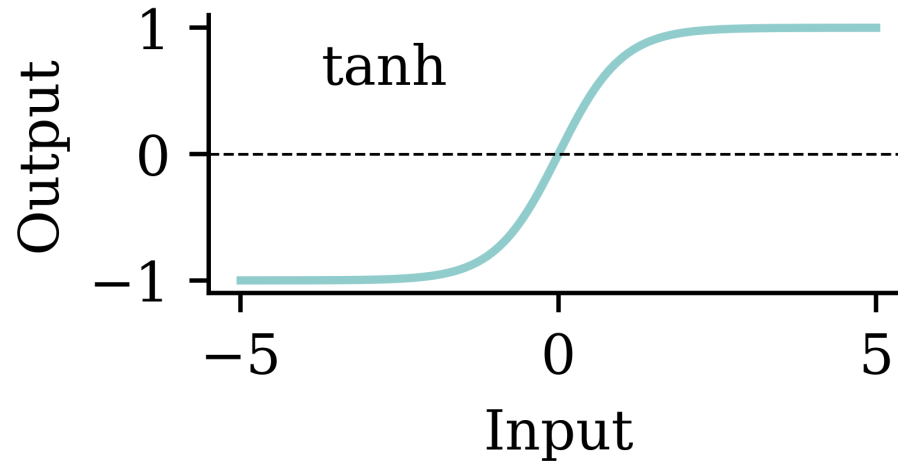
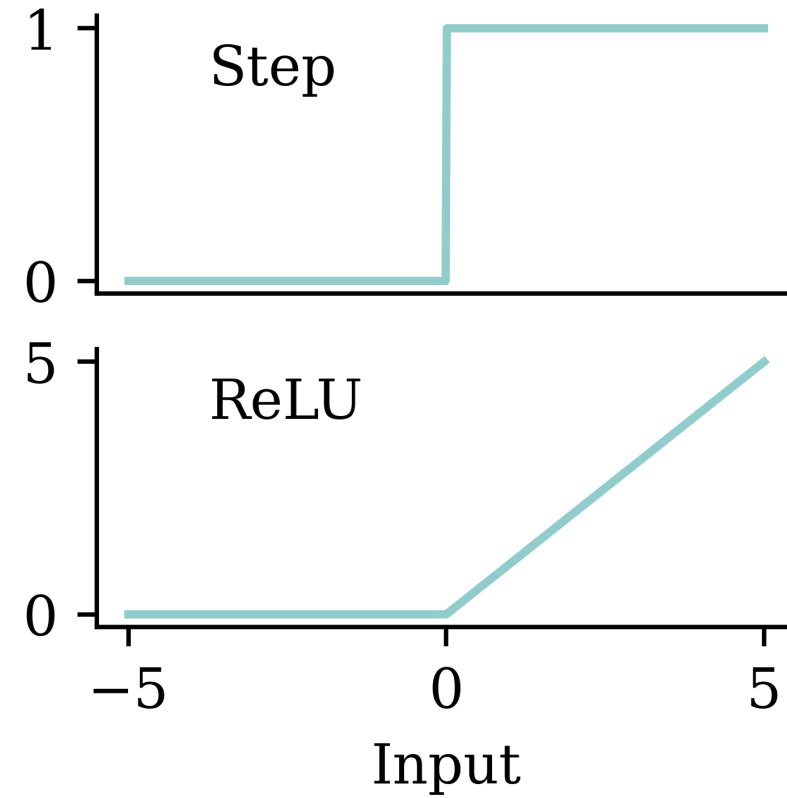
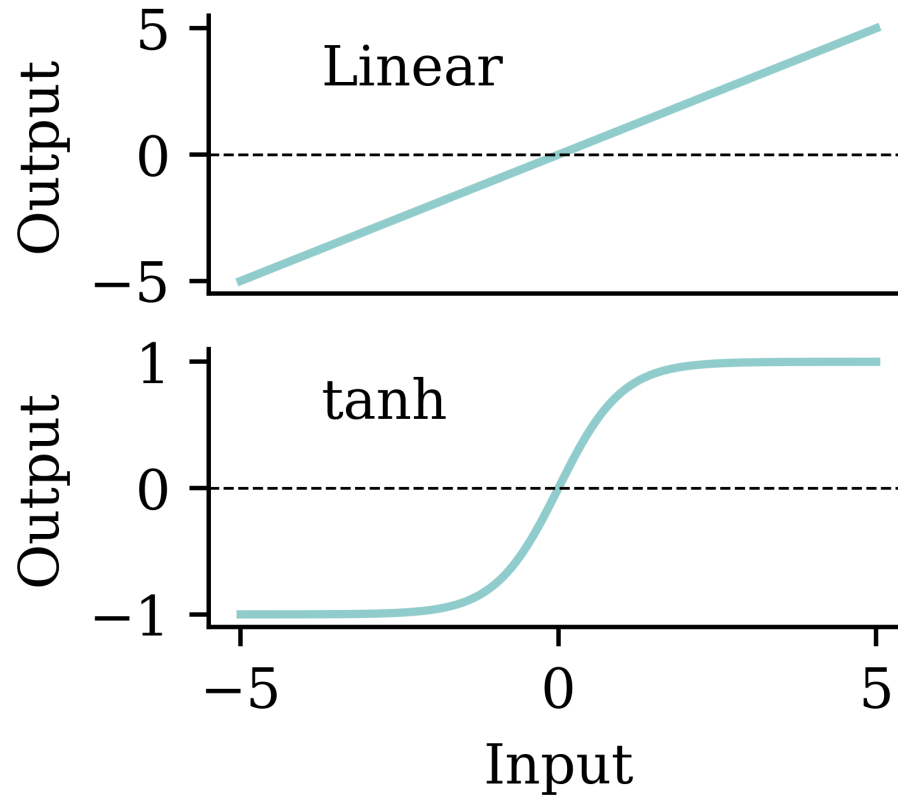
Modern neural network

Replace binary state with continuous state. Still rather slow to train.

Note

It's a **neural** network made of **neurons**, not a “neuron network”.

Try different activation functions

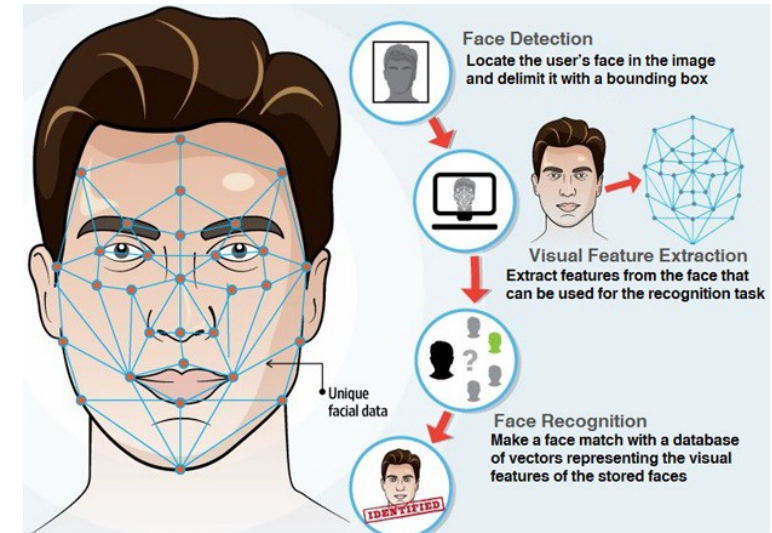
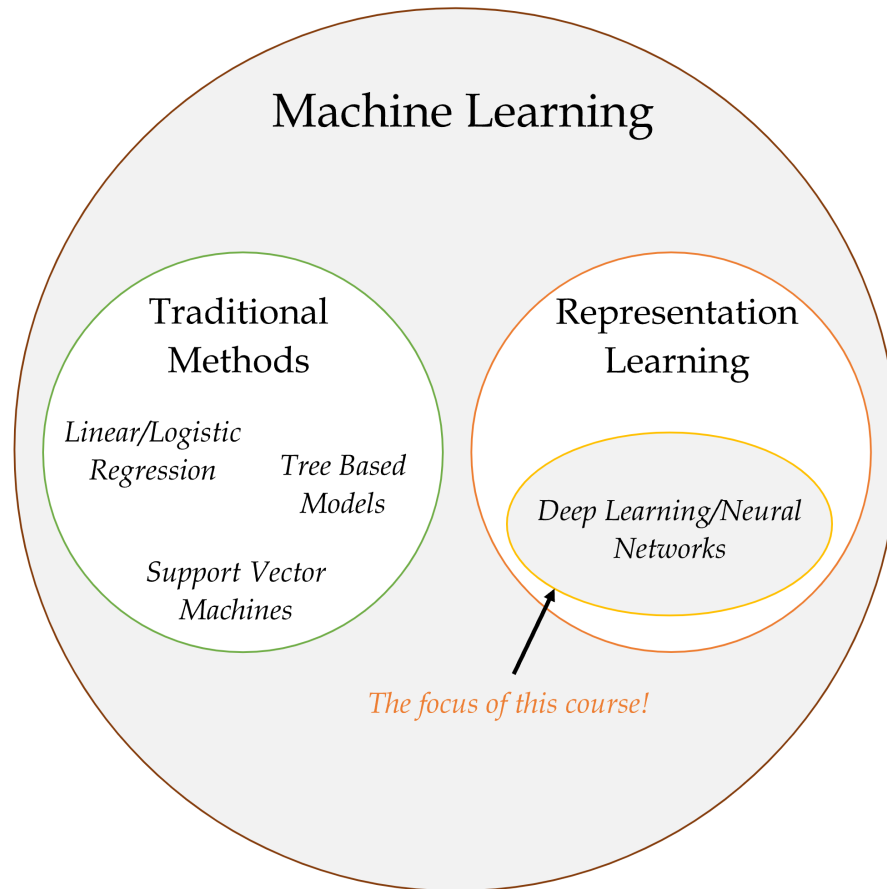


Flexible

One can show that an MLP is a **universal approximator**, meaning it can model any suitably smooth function, given enough hidden units, to any desired level of accuracy (Hornik 1991). One can either make the model be “wide” or “deep”; the latter has some advantages...



Feature engineering



Traditional ML

Feature Engineering

Modelling

Deep Learning

Feature Engineering

Modelling

Sources: Marcus Lautier (2022) & Fenjiro (2019), *Face Id: Deep Learning for Face Recognition*, Medium.



The deep learning hammer

Deep learning is not always the answer!



The map of data science.

Source: Serge Masis (2022), [LinkedIn post](#).

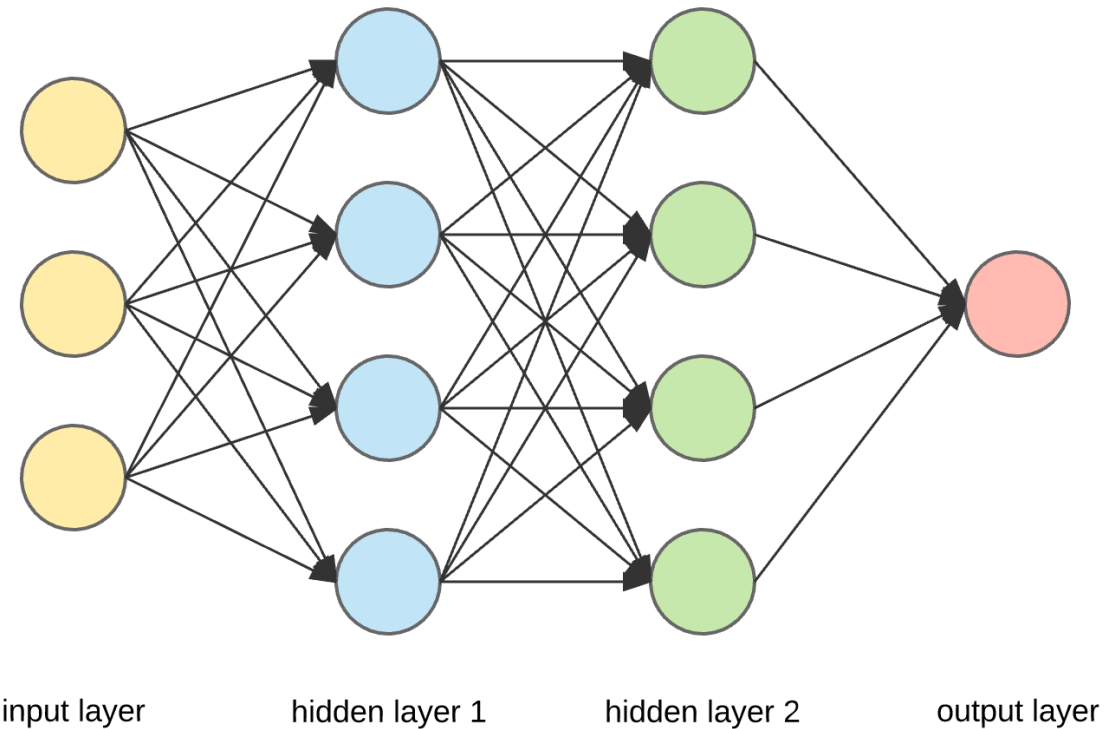


Quiz

In this ANN, how many of the following are there:

- features,
- targets,
- weights,
- biases, and
- parameters?

What is the depth?



An artificial neural network.

Package Versions

```
1 from watermark import watermark  
2 print(watermark(python=True, packages="keras,matplotlib,numpy,pandas,seaborn,scipy,torch
```

Python implementation: CPython
Python version : 3.11.8
IPython version : 8.23.0

keras : 3.2.0
matplotlib: 3.8.4
numpy : 1.26.4
pandas : 2.2.1
seaborn : 0.13.2
scipy : 1.11.0
torch : 2.2.2
tensorflow: 2.16.1
tf_keras : 2.16.0



Glossary

- activations, activation function
- artificial neural network
- biases (in neurons)
- classification problem
- deep network, network depth
- dense or fully-connected layer
- feed-forward neural network
- labelled/unlabelled data
- machine learning
- neural network architecture
- perceptron
- ReLU
- representation learning
- sigmoid activation function
- targets
- training/test split
- weights (in a neuron)

