Machine Learning: An Introduction

Joseph Bullock

Institute of Particle Physics Phenomenology

CERN Collaboration

Bad Press

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Technology

The 'creepy Facebook AI' story that captivated the media

By Chris Baraniuk
Technology reporter

Deal or No Deal? End-to-End Learning for Negotiation Dialogues

Mike Lewis[1], **Denis Yarats**[1], **Yann N. Dauphin**[1], **Devi Parikh**[2,1] and **Dhruv Batra**[2,1]
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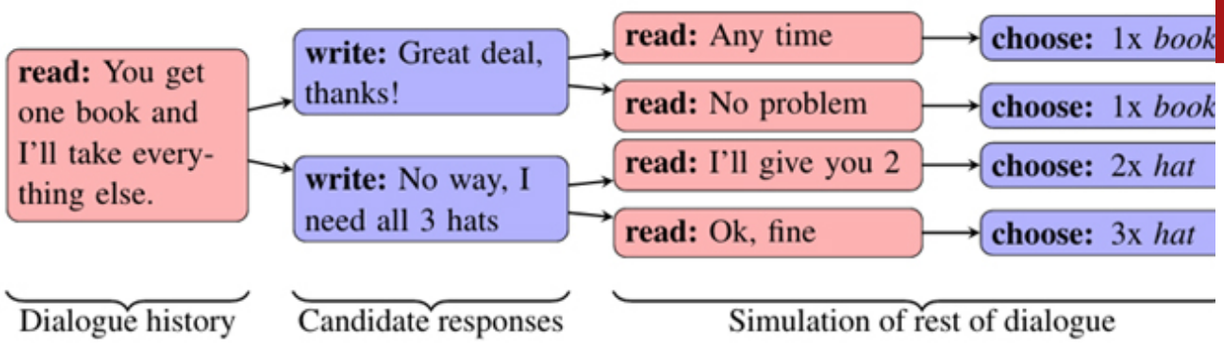

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Technology

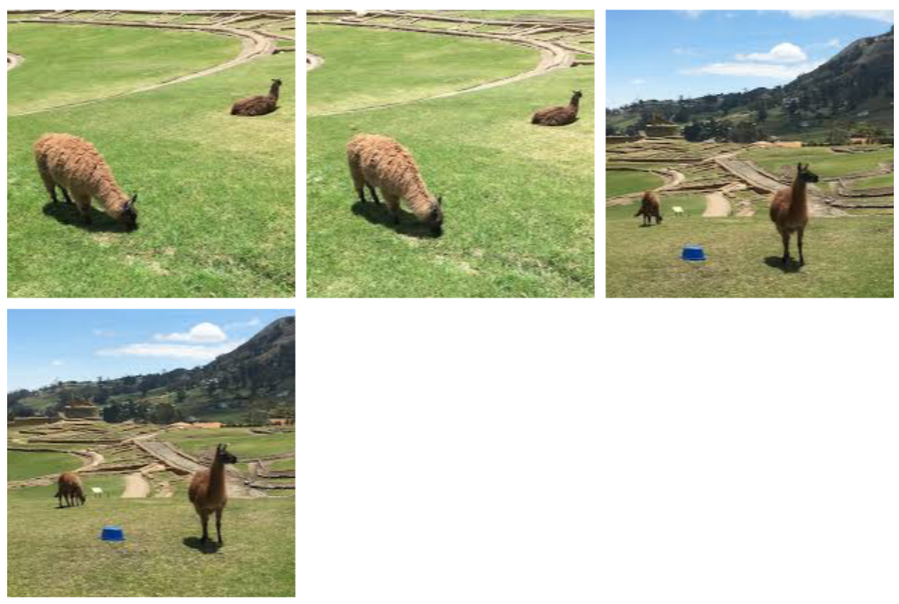
Stephen Hawking warns artificial intelligence could end mankind

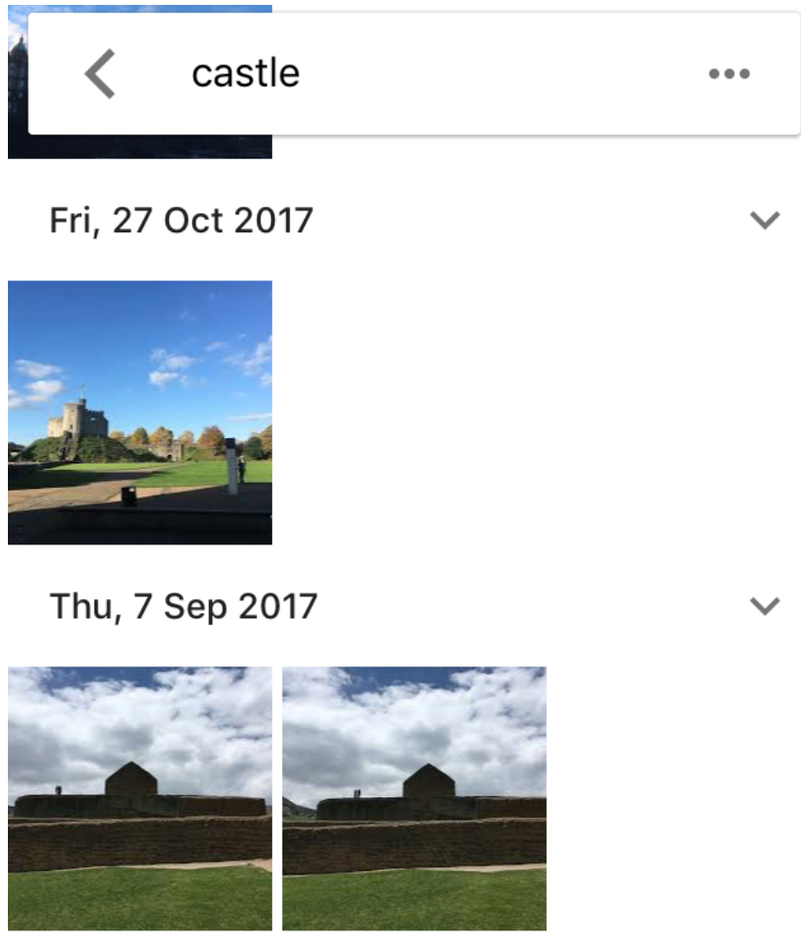
By Rory Cellan-Jones
Technology correspondent

"…such articles are actually rather impressive, because they succinctly summarise the scenario that AI researchers don't worry about. That scenario combines as many as three misconceptions: concern about *consciousness, evil and robots*"

Max Tegmark, Future of Life Institute

Google Photos





Industry and Political view

Supercomputer

P ntists and
aticians

MIRACLE!!!

Collect data

Collect data

Collect data

[Top image: Inside HPC; Middle image: Numeric Analytics]

Types of Machine Learning

Supervised Learning

- Training sets with labelled samples

Unsupervised Learning

- No labels
- Model has to find features
- Can pre-classify before supervised learning

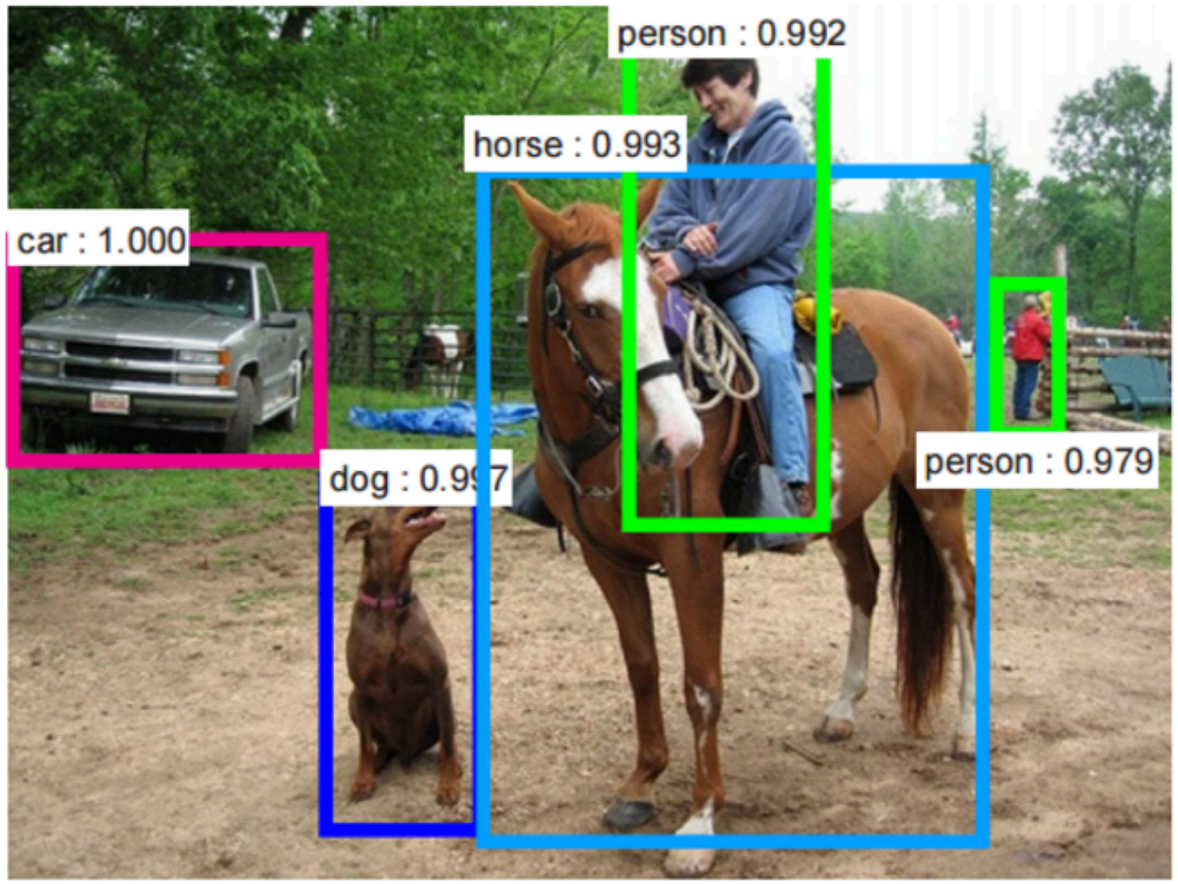
Deep Learning

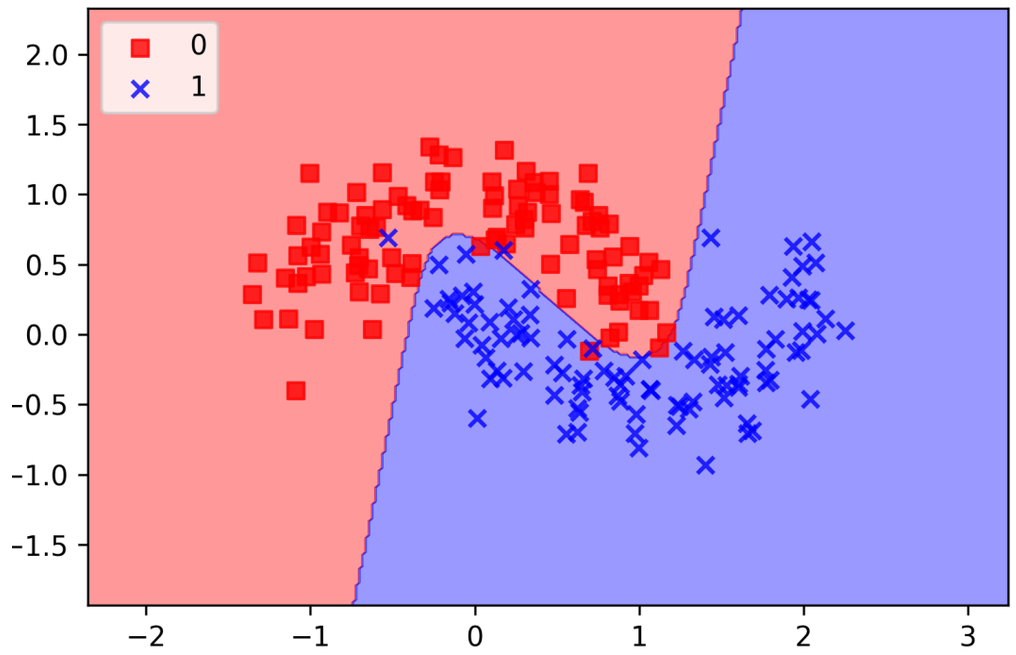
- Any system which layers the above styles of learning
- Neural Networks

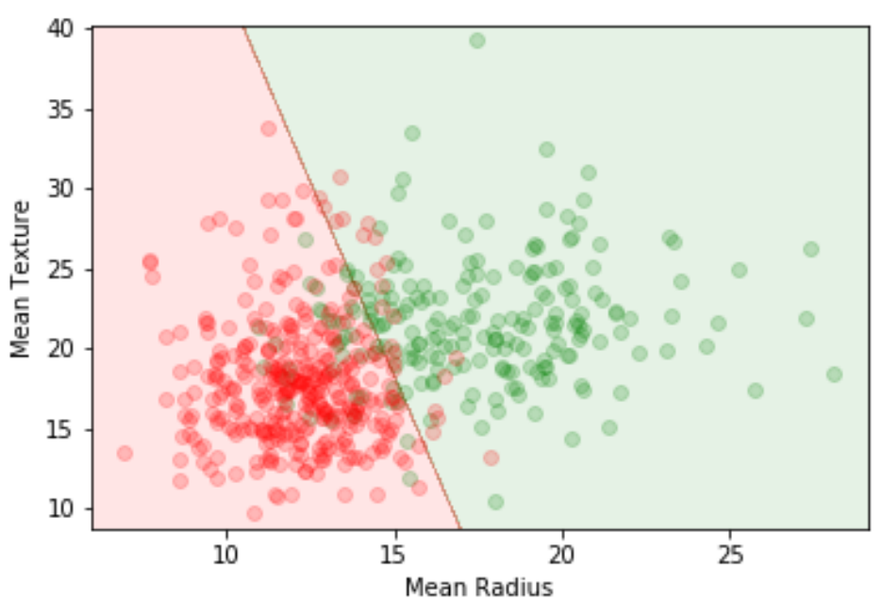
[Maitre ‘18]

What Really is Machine Learning?

Classification problem







Left top: Data Science Blog; Left bottom: adapted from Maitre '18

Supervised Learning - K-Means Clustering

Application of the k-means clustering algorithm to predict load shedding of the Southern Electrical Grid of Libya

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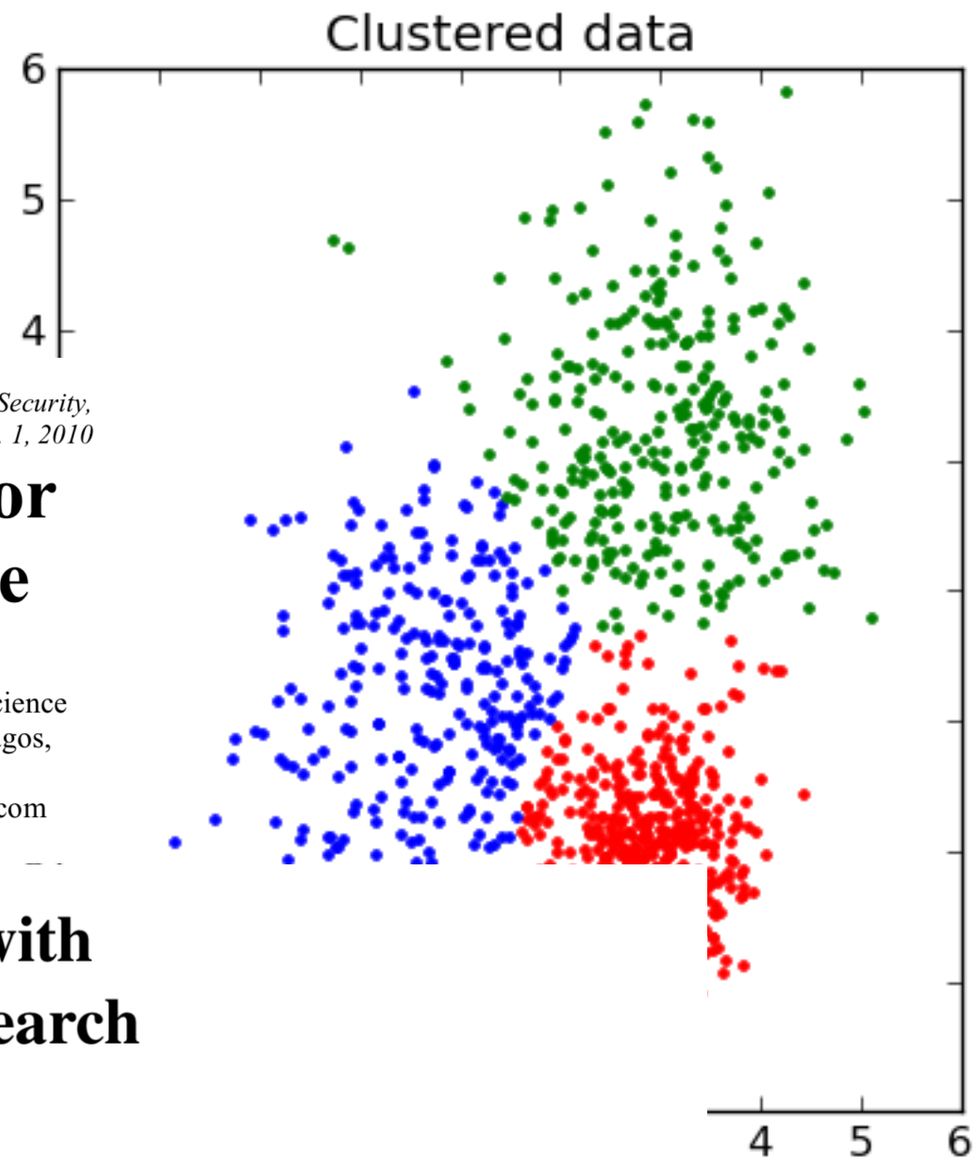

(IJCSIS) International Journal of Computer Science and Information Security,
Vol. 7, No. 1, 2010

Application of k-Means Clustering algorithm for prediction of Students' Academic Performance

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Clustering Billions of Images with Large Scale Nearest Neighbor Search

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Charles Rosenberg
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Henry A. Rowley
har@google.com

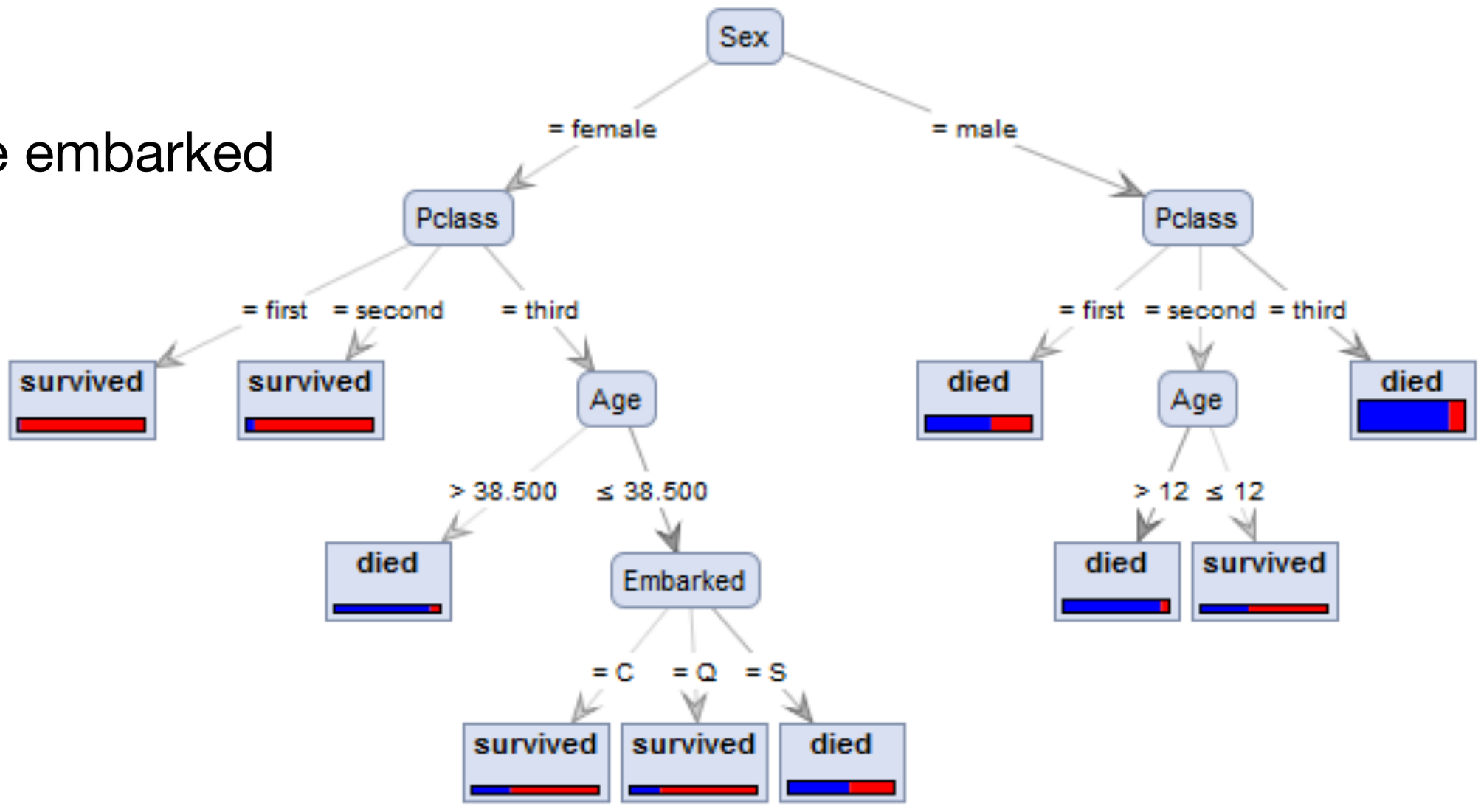
Google Inc., Mountain View, CA, USA

[Graph: Mubaris '17]

Supervised Learning - Decision Tree

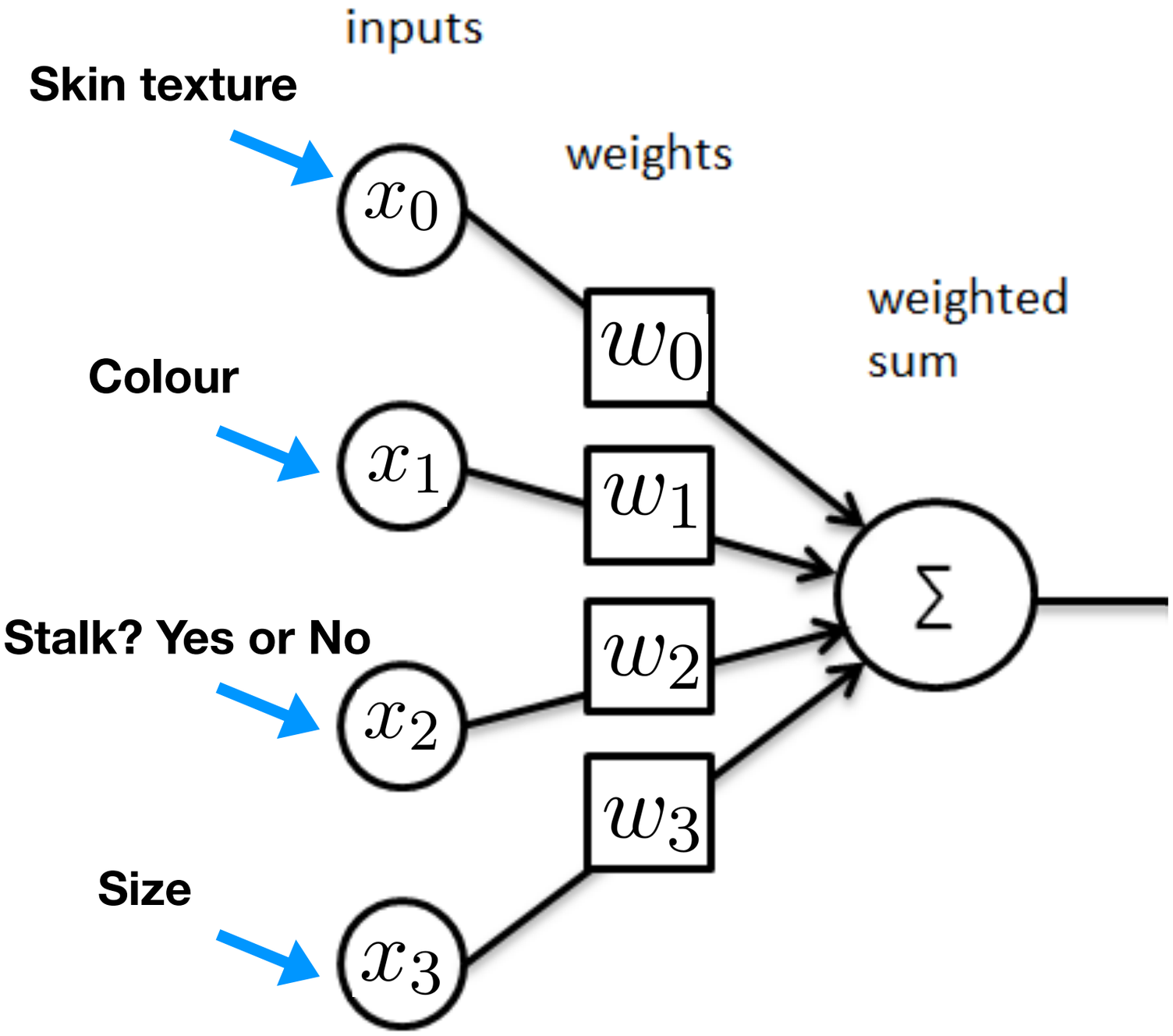
Input parameters:

- Sex
- Age
- Class
- Where embarked



[Image: Data Mining]

Supervised Learning - Perceptron



[Image: Taspinar '16]

The Iris Dataset

sepal length (cm)	sepal width (cm)	petal length (cm)	petal width (cm)
5.9	3.0	4.2	1.5
5.8	2.6	4.0	1.2
6.8	3.0	5.5	2.1
4.7	3.2	1.3	0.2
6.9	3.1	5.1	2.3
5.0	3.5	1.6	0.6
5.4	3.7	1.5	0.2
5.0	2.0	3.5	1.0
6.5	3.0	5.5	1.8
6.7	3.3	5.7	2.5

Setosa

0

Versicolor

Virginica

2

1

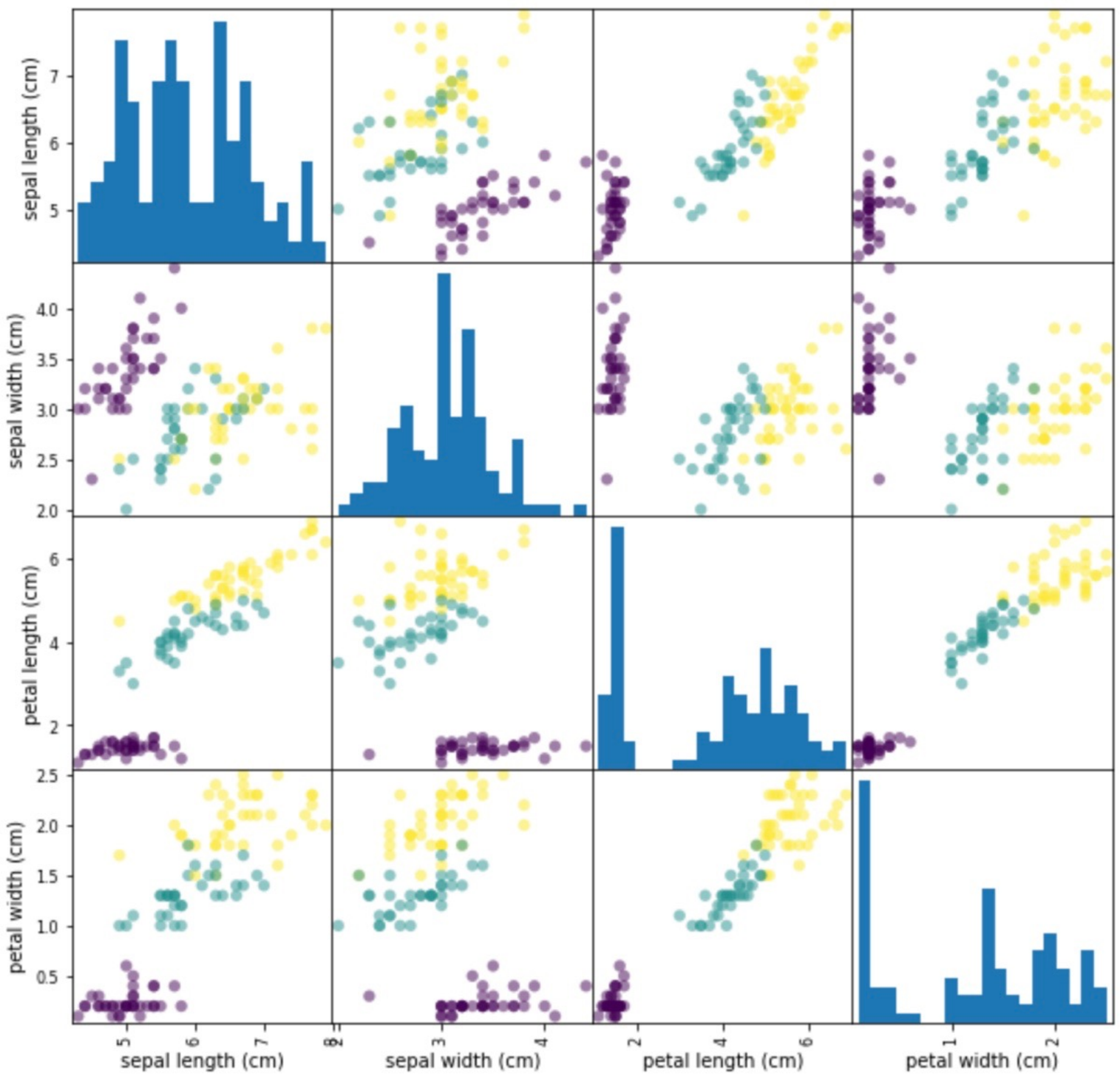
[Fisher '36]

The Machine Learning Process?

Data

sepal length (cm)	sepal width (cm)	petal length (cm)	petal width (cm)
5.9	3.0	4.2	1.5
5.8	2.6	4.0	1.2
6.8	3.0	5.5	2.1
4.7	3.2	1.3	0.2
6.9	3.1	5.1	2.3
5.0	3.5	1.6	0.6
5.4	3.7	1.5	0.2
5.0	2.0	3.5	1.0
6.5	3.0	5.5	1.8
6.7	3.3	5.7	2.5

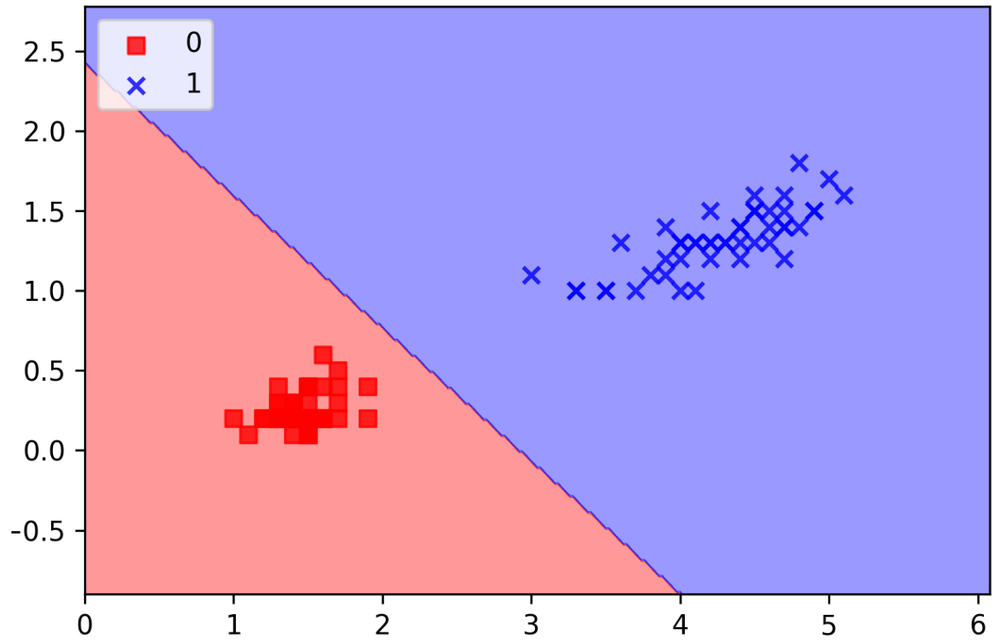
Understand correlation



Supervised Learning

Linear Models

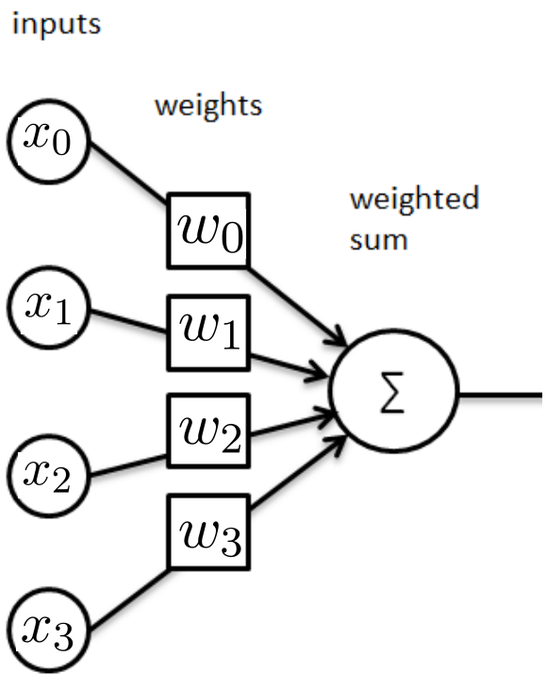
Linear / logistic regression



1. **Data**

sepal length (cm)	sepal width (cm)	petal length (cm)	petal width (cm)
5.9	3.0	4.2	1.5
5.8	2.6	4.0	1.2
6.8	3.0	5.5	2.1
4.7	3.2	1.3	0.2

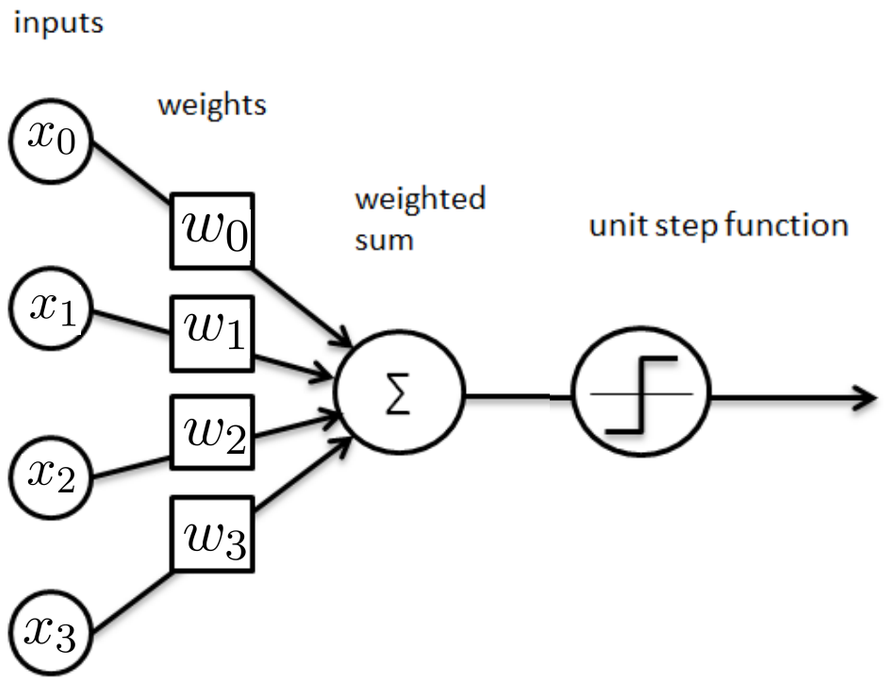
$$x_{ij} = \begin{pmatrix} x_{00} & x_{01} \\ x_{10} & x_{11} \\ x_{20} & x_{21} \\ x_{30} & x_{31} \end{pmatrix} \quad \begin{matrix} 0 \\ 1 \\ 0 \\ 1 \end{matrix} \qquad y_i = \begin{pmatrix} y_0 \\ y_1 \\ y_2 \\ y_3 \end{pmatrix}$$



2. Initialise **weights** and **bias**

$$w_j = (w_0, w_1) \qquad b$$

Supervised Learning



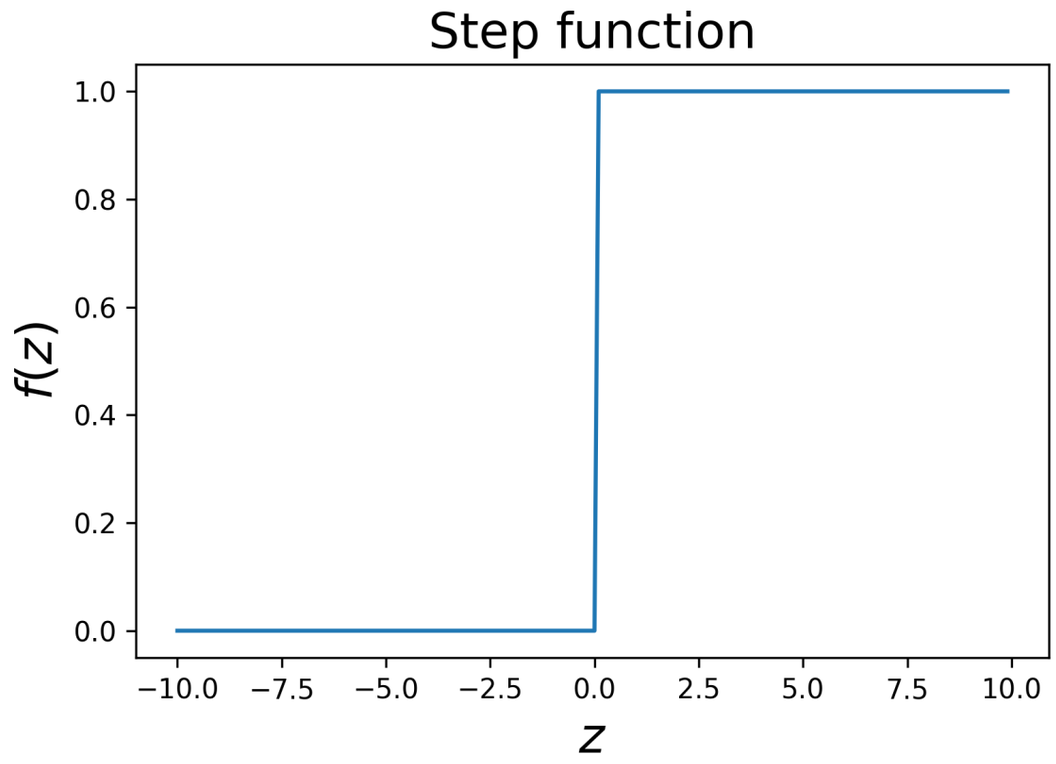
3. Calculate the **input**

$$z^{(i)} = w \cdot x^{(i)} + b$$

$$= w_0 x_{i0} + w_1 x_{i1} + b$$

4. Pass the input through an **activation function**

$$f(z^{(i)}) = \begin{cases} 0, & \text{if } z^{(i)} < 0 \\ 1, & \text{otherwise} \end{cases}$$



Supervised Learning

Training

1. **Best fit** the line / **Minimise** the **cost function**

$$J(z^{(i)}) = \frac{1}{2}|f(z^{(i)}) - y^{(i)}|^2$$

Prediction **Target**

2. **Update** the weights

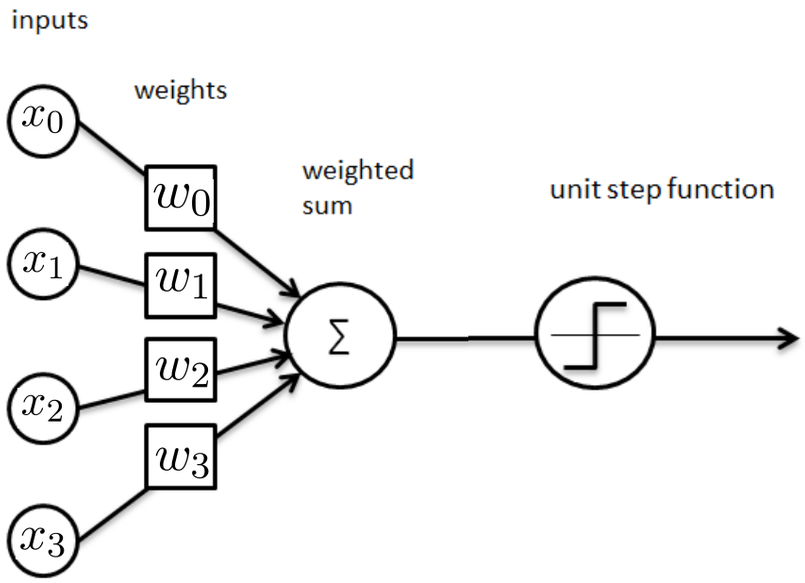
$$\vec{w} = \vec{w} - \eta \nabla_{\vec{w}} J(\vec{w}, \vec{b})$$

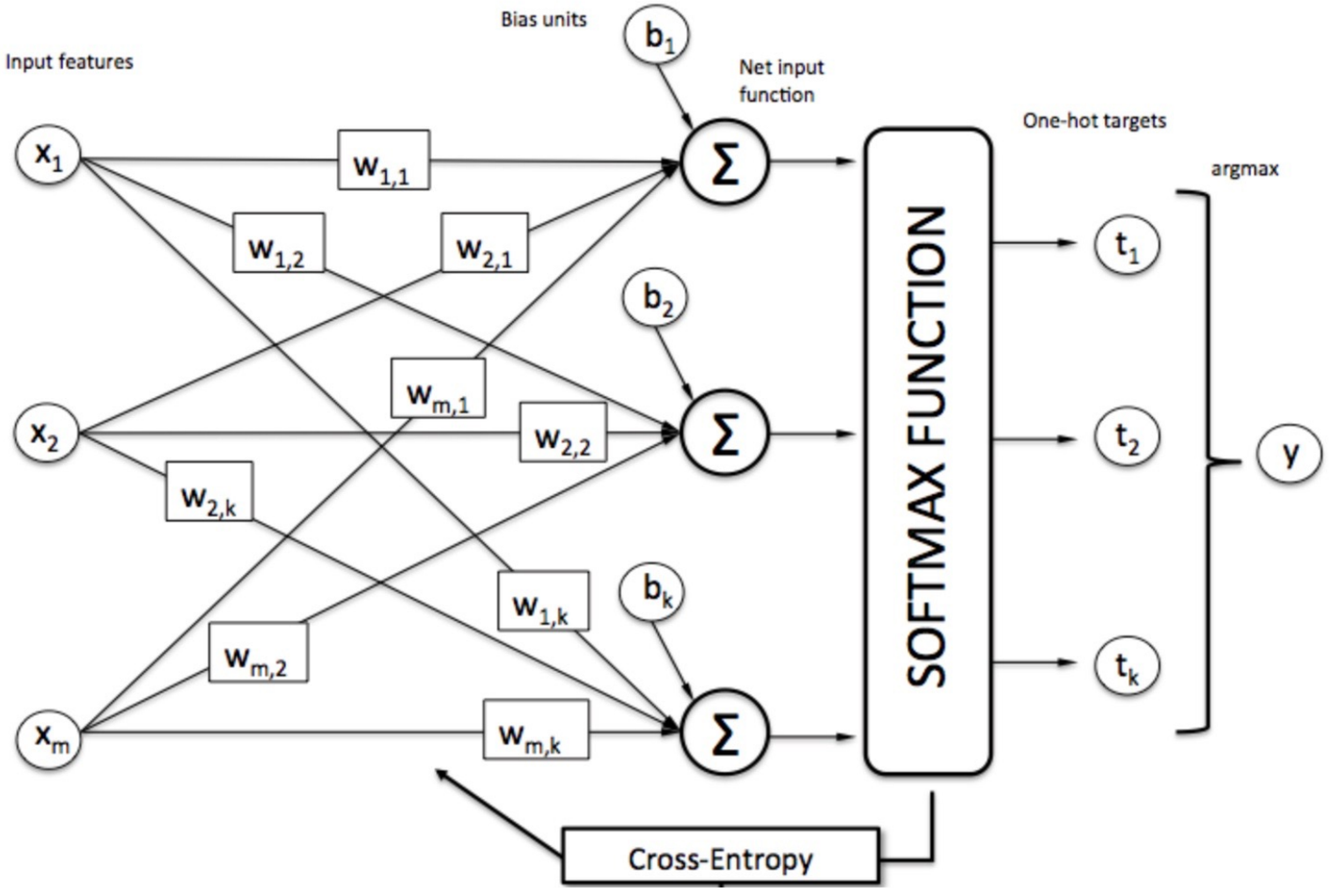
3. **Repeat** over all data points

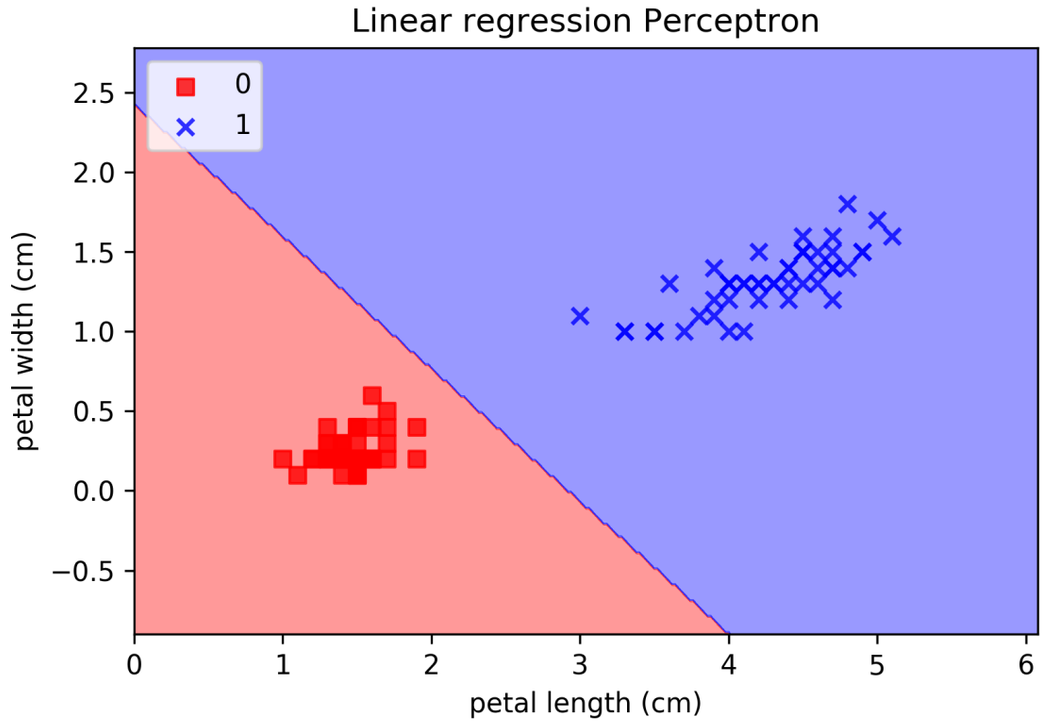
4. **Repeat** over a given number of epochs

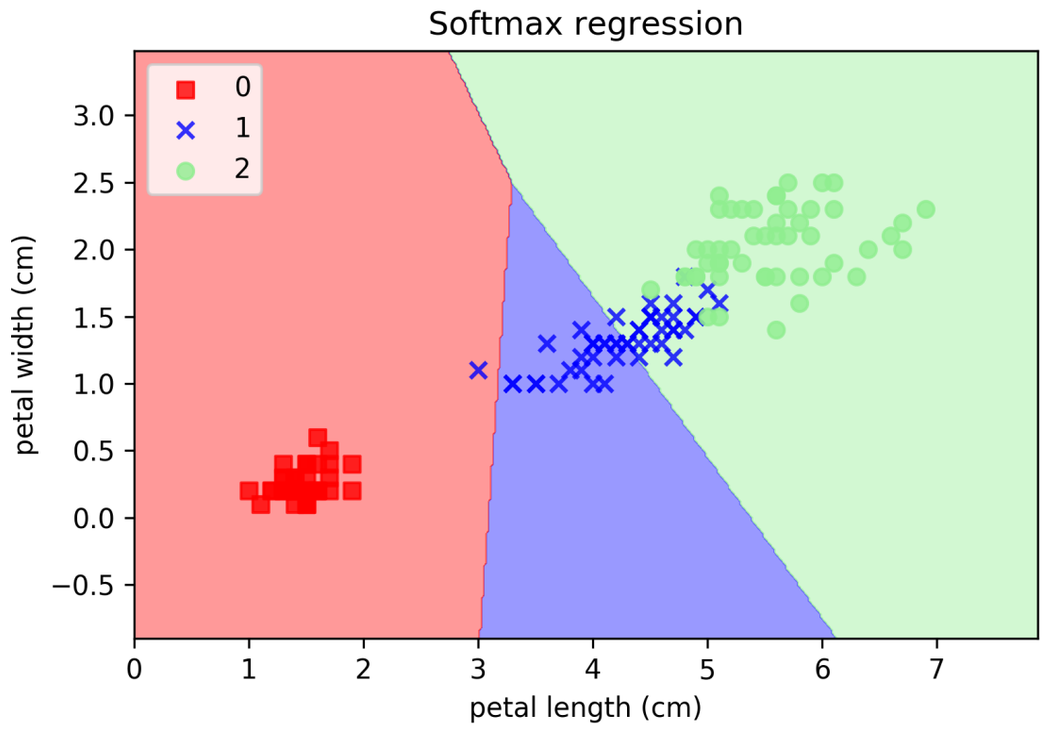
[Bottom left image: Raschka '16]

Supervised Learning





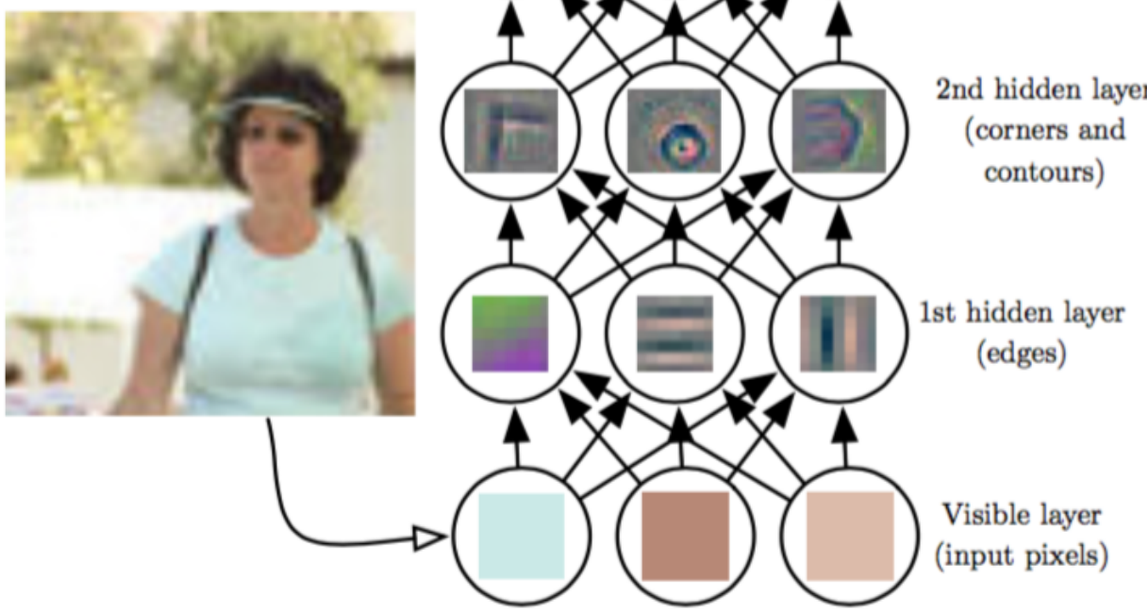


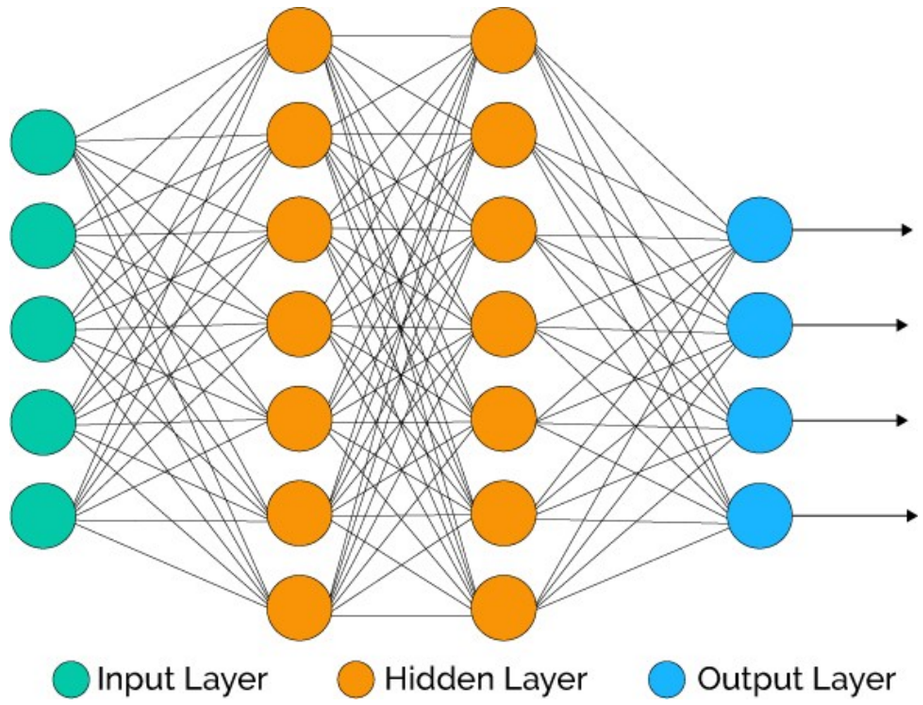


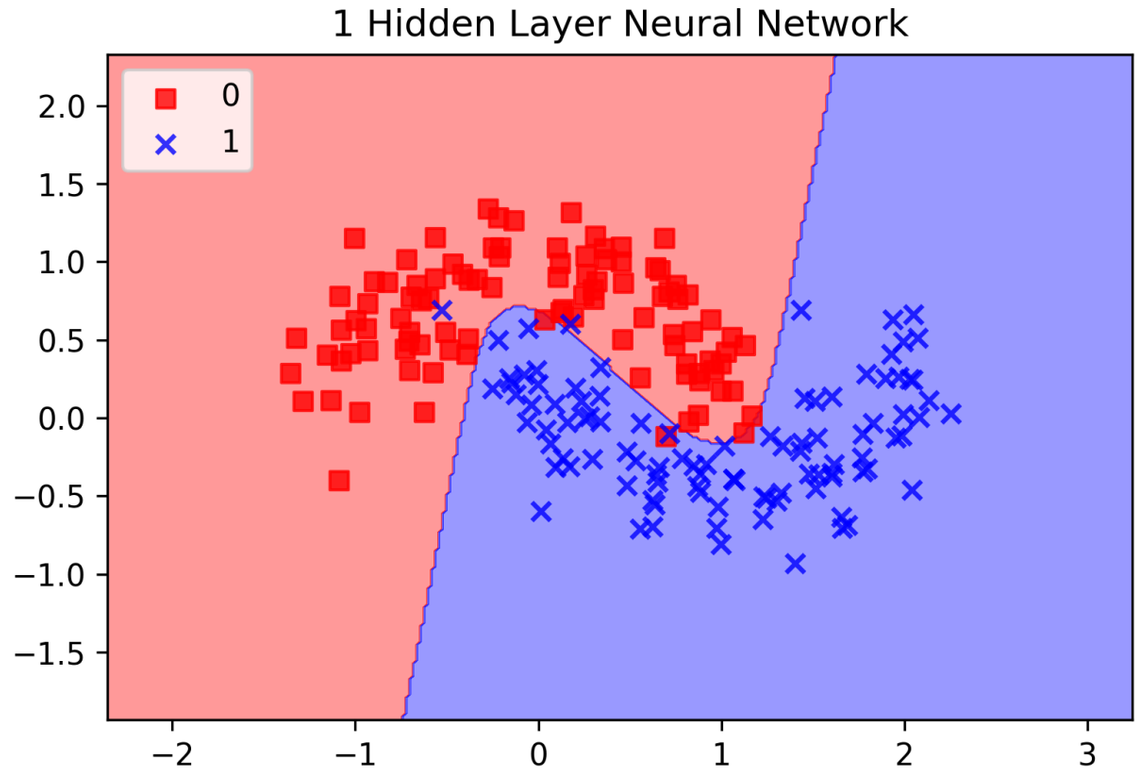
[Left image: Goodfellow et al '16; Top right image: Medium; Bottom right image: Reppel '17]

Deep Learning

Neural Networks







DeepMind

DeepMind AI Reduces Google Data Centre Cooling Bill by 40%

Examples and code

Supervised Learning:

- My GitHub repository

Neural Networks:

- TensorFlow Playground
- ConvNetJS

Other code sources:

Overview: “Getting started with machine learning”
Python Machine Learning book repository

Summary

- Machine Learning is a classification problem
- The problem revolves around determining how important different input parameters are in order to get an accurate classification
- It is not a ‘black box’ where we cannot get information about what’s going on inside the algorithms
- Machine Learning is not the answer to all problems, the techniques should be applied intelligently and appropriately, and there may well be other more classical statistical techniques that are more appropriate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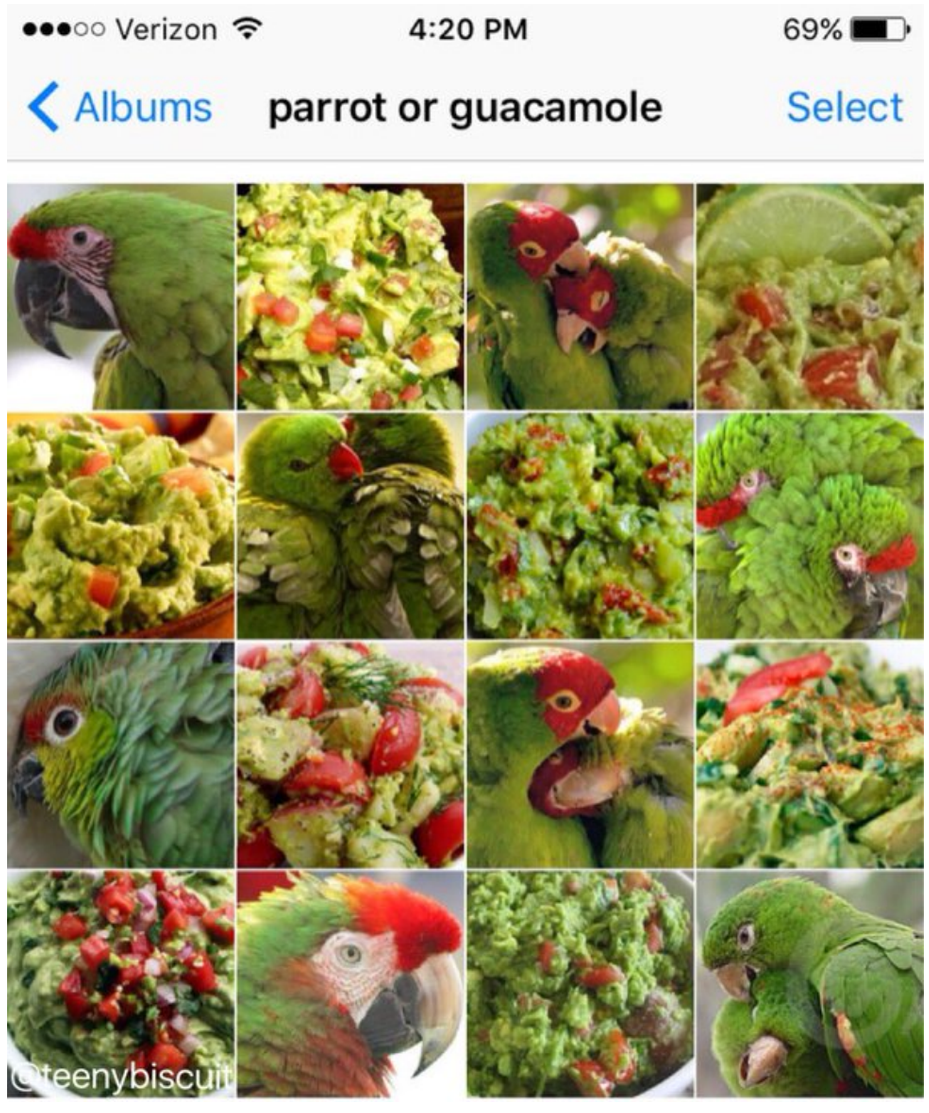
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