# Introduction to Machine Learning in Python

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# Overview

1. An introduction to Machine Learning
2. Scikit-Learn
3. Practical 1 – Decision Trees/K-Means
4. More Theory
5. Practical 2 – TBD

# Assumptions

- Solid understanding of Python.
- No/Little understanding of Machine Learning.
- Exposure to Pandas and NumPy beneficial.
- Knowledge of the Jupyter Notebook and a Python IDE like Spyder will be beneficial.

# Machine Learning – What is it?

- A subset of Computer Science and derived from Artificial Intelligence (AI)
- At it's heart a probability generator, with strong ties to statistics/ mathematical optimisation.
- Improving the probability score taken as 'learning'. Uses this learnt data to 'predict' on new data.
- Examples of use: *Spam Filtering, Character Recognition, Computer Vision, Search Engines, Social Media*

# Machine Learning – What is it?

$$F(\boldsymbol{X}) = \boldsymbol{y}$$

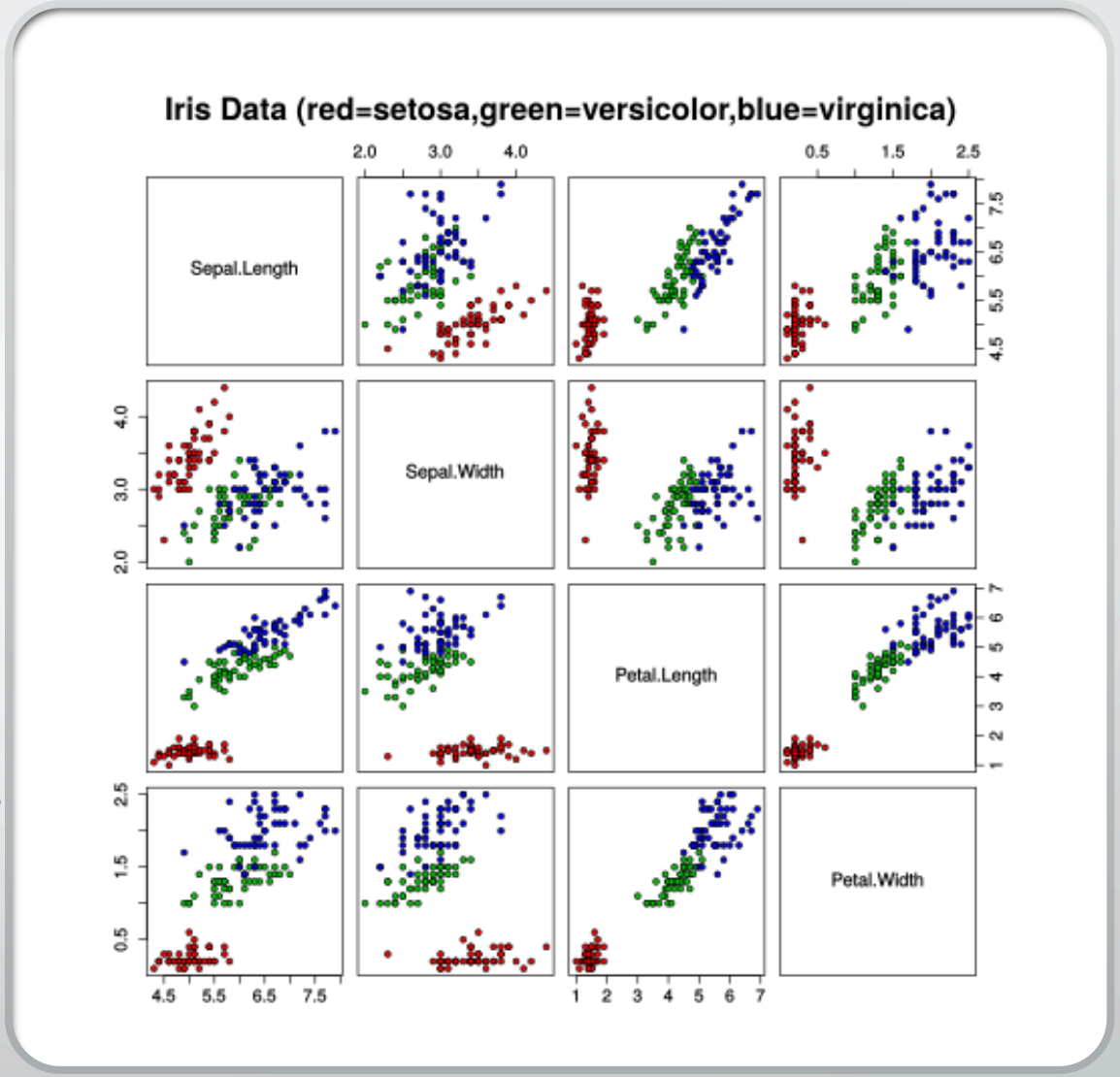
where ***X*** is a **matrix** of input, independent variables, and *y* is a **vector** of output, dependent variables *that classify* ***X***.

| Sepal Length | Sepal Width | Petal Length | Petal Width | Species |
|---|---|---|---|---|
| 5.1 | 3.5 | 1.4 | 0.2 | I. setosa |
| 4.9 | 3.0 | 1.4 | 0.2 | I. setosa |
| 4.7 | 3.2 | 1.3 | 0.2 | I. setosa |
| 7.0 | 3.2 | 4.7 | 1.4 | I. versicolor |
| 6.4 | 3.2 | 4.5 | 1.5 | I. versicolor |
| 6.3 | 3.3 | 6.0 | 2.5 | I. virginica |

Taken from Fisher's *Iris* data set

# Iris Dataset

- Each species is shaded a different colour
- Clear distinct patterns emerge
- ML trained to learn these patterns
- Applies it to new information when available

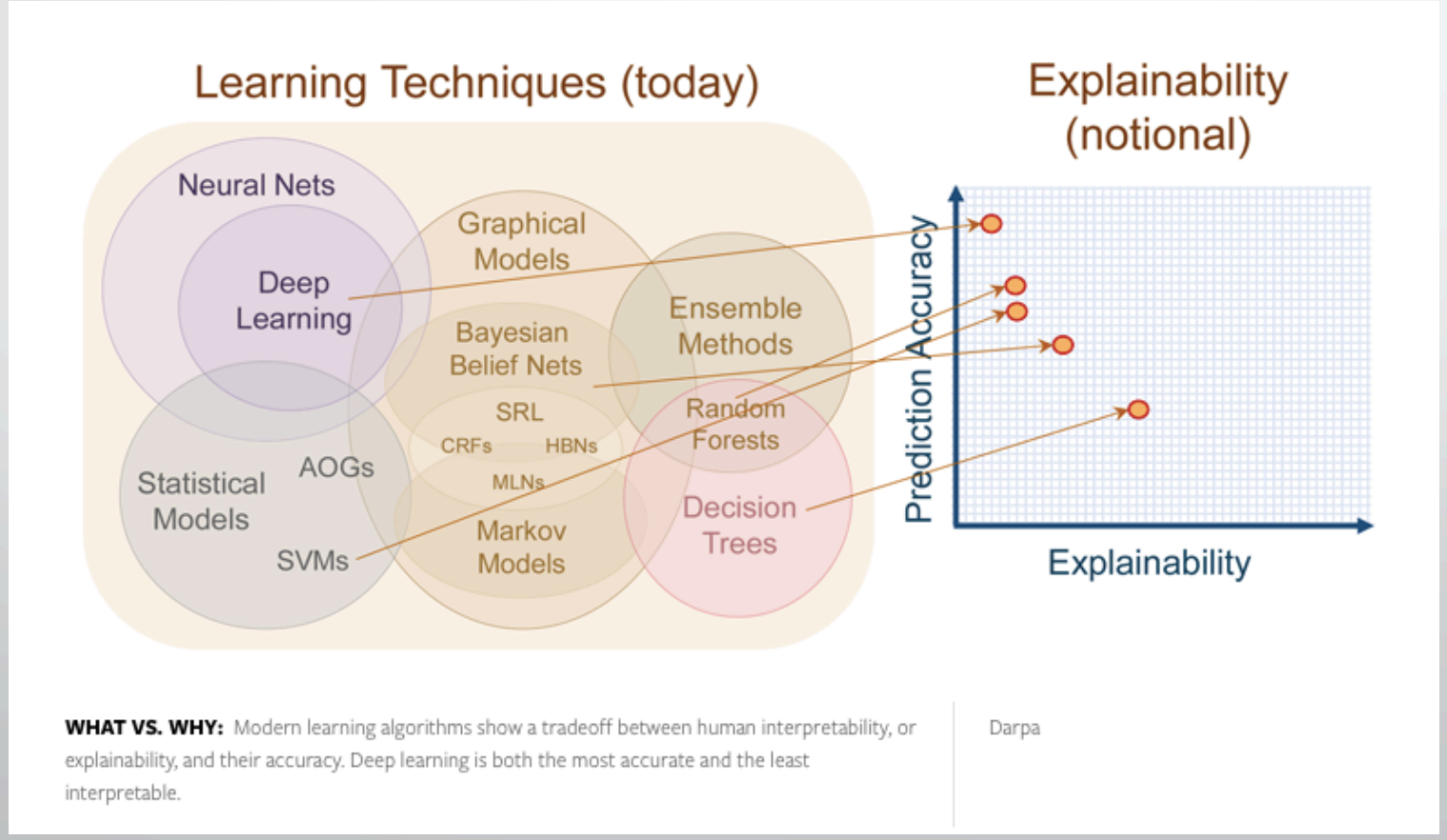


# Machine Learning – Going slightly deeper

Three broad categories:

1. **Supervised Learning** – Presented with example inputs and corresponding outputs, given by a 'teacher'.
2. **Unsupervised Learning/Data Mining** – No labels given to inputs, computer infers features.
3. **Reinforcement Learning** – Interacts with a dynamic environment where it must perform a certain goal, feedback via rewards/punishments.

# Understandability of Machine Learning




**WHAT VS. WHY:** Modern learning algorithms show a tradeoff between human interpretability, or explainability, and their accuracy. Deep learning is both the most accurate and the least interpretable.

Darpa

Taken from Nautil.us

# Scikit-Learn

- A package in Python programming language. Part of the Anaconda Distribution.
- Built on NumPy, SciPy and MatPlotLib libraries.
- Open source, commercially usable.
- Simple to set up for most applications, very powerful functionality.
- Highly accessible.

# Scikit-Learn

| Name of Method | Example use | Algorithm |
|---|---|---|
| Classification | Spam Detection, Image Recognition | SVM, random forest, nearest neighbours |
| Regression | Drug response, stock prices | SVR, Ridge regression, LASSO |
| Clustering | Customer segmentation, grouping experiment outcomes | K-Means, Spectral Clustering, mean-shift |
| Dimensionality Reduction | Visualization, increased efficiency | PCA, Feature Selection, non-negative matrix factorisation |
| Model Selection | Improved accuracy via parameter tuning | Grid search, cross validation, metrics |
| Preprocessing | Transforming data (i.e text) for use in ML algorithms | Feature Extraction |

Taken from scikit-learn.org

# Practical 1.1 – Decision Trees

1. Enter the folder ‘Practical_1’
2. Open ‘apples.py’, run the example, and make changes to the features, labels, and trying your own pieces of fruit. Try and understand what is happening.
3. A ’tree.dot’ file will be created from running ’apples.py’. Use $ bash apples.sh $ to create a .png to visualise the decision tree.

# Practical 1.2 – Classification & Iris Dataset

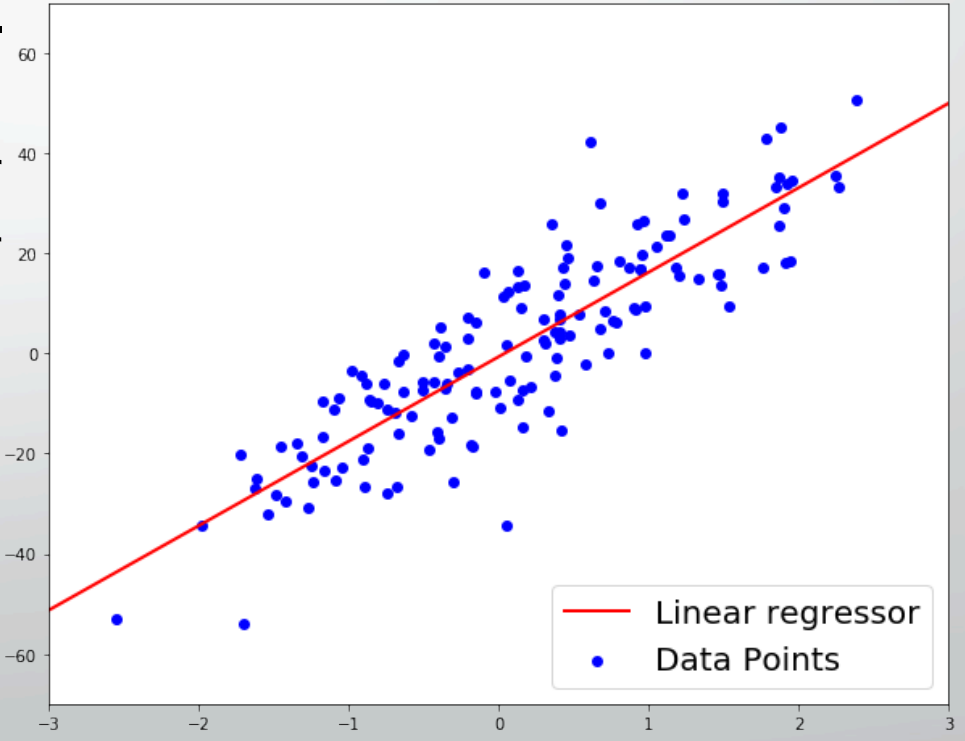
1. Enter the folder 'Practical_1'
2. Open 'iris.py', run the example, and make changes to the code, such as features, labels etc.
3. Complete Tasks 1 and 2 by implementing iris_dataset_2 and 3.
4. For a challenge, complete Task 3 by using another dataset.

Attempt all of the tasks before looking at the solutions-iris.py file.

# Classification Summary

# Regression

- Regression is a measure of the relationship between some input values (features) and an output value (target).
- Regression can be used for prediction of a target variable, the modeling of relationships, and the testing of hypotheses.
- There are many different regression techniques.
- Ski-Kit learn contains useful modules for regression.

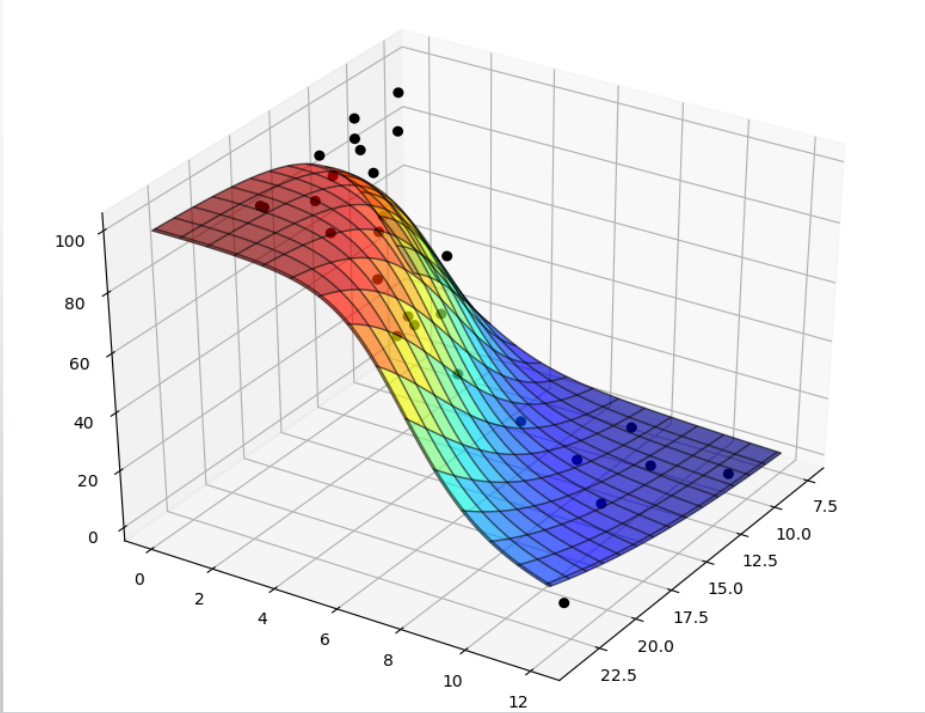


# Regression

- Regression becomes very useful when the dataset being dealt with is large or there are many features to it.
- In a linear regression model, n variables satisfy a linear relationship,

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n + \varepsilon_i$$

- where the coefficients β are unknown and $\varepsilon_i$ are random error terms.
- By fitting a dataset, the β coefficients can be found and a model made.

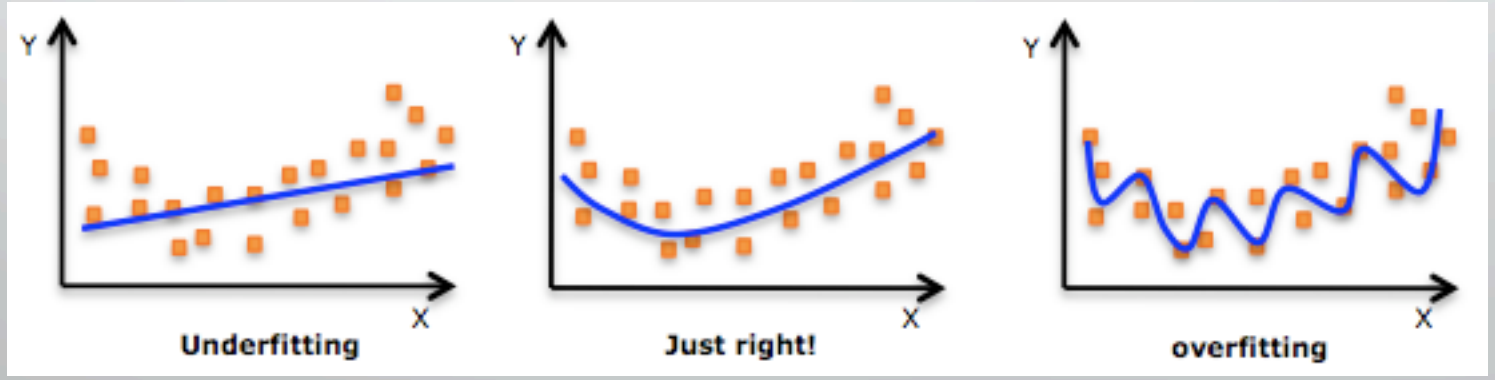


# Preprocessing

- Preprocessing is the processing of data before modeling or analysis such that it is gotten into a ready state to be worked on.
- An example of preprocessing was seen earlier in the first classification exercise, where the texture of the fruit was given as a string and had to be converted to a binary number.
- Other preprocessing includes the splitting of data into training and testing sets and normalisation of the data.
- More about preprocessing can be found on the scikit-learn website: http://scikit-learn.org/stable/modules/preprocessing.html#preprocessing

# Underfiitting and Overfitting

- If underfitted a model will not be good at making predictions.
- If overfitted a model has been trained too much on one dataset and while it will good accuracy for that set, for other sets it will not have good accuracy.
- One way to reduce overfitting is to only include features in a dataset that are believed to have a significant impact on the target.




https://stats.stackexchange.com/questions/192007/what-measures-you-look-at-the-determine-over-fitting-in-linear-regression/192021

# Scikit-Learn and Regression

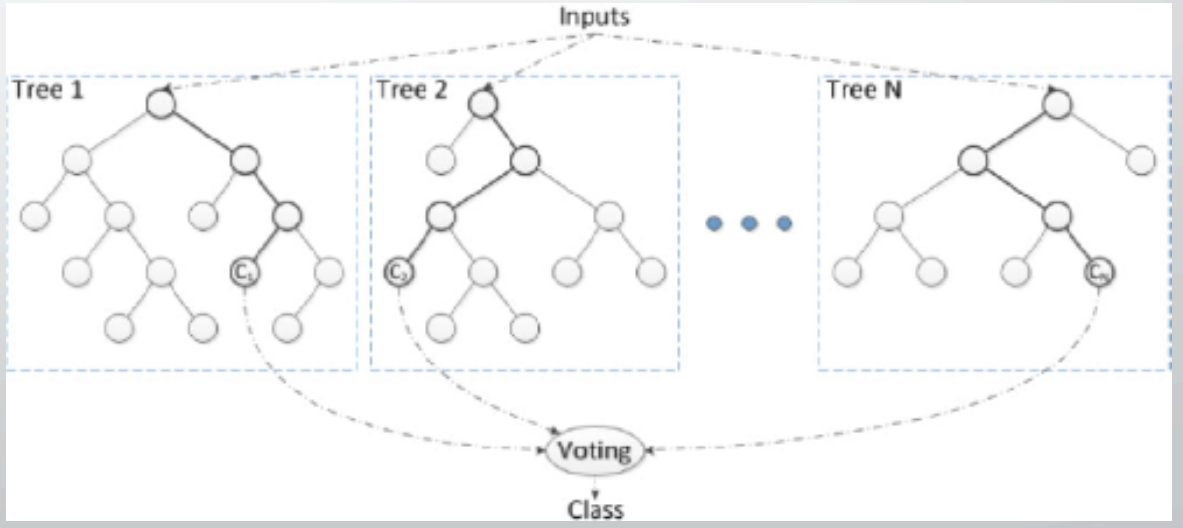
- Scikit-learn makes linear regression very simple.
- Import the linear_model module from sklearn, choose which linear model to use, fit the data to it, analyse and test the results.
- In scikit-learn there are a number of regression techniques available, including linear, lasso, and ridge regression.
- The linear regression techniques can be found under sklearn.linear_model
- Scikit-learn comes with some built in dataset which can be found under sklearn.datasets

# Regression and Decision Trees

- When the target in a dataset is discrete the problem is one of classification.
- When the target in a dataset is continuous then the problem is one of prediction.
- It was seen how decision trees were used to classify the type of iris species.
- Decision trees can be used continuous targets to predict values and the importance of each feature.

# Extra Tree Regressor

- To help improve accuracy for decision trees with regression and extra tree regressor can be used.
- An extra tree regressor fits a number of randomised trees on different subsamples of the dataset and averages them to improve the accuracy and to control overfitting.
- When an optimal selection of features is chosen the Extra Tree performs as well as the Random Forest, though in general is computationally faster.




https://wwrchgate.net/301243118_fig4_Figure-6-Random-Forest-Modelw.resea

# Feature Importance and Metrics

- Extra Trees are hard to visualise as there's typically a large number of trees.
- Instead, useful information such as feature importance can be extracted.
- Feature importance gives a score to each feature that is a measure of how much they affect the target.
- To gauge the accuracy metrics such as the R-squared value can be used.
- Feature importance and the R-squared values are easy to extract in scikit-learn.

# Regression Practical

- An example of linear regression analysis using scikit-learn and Python can be found in the "RegressionPractical" Jupyter Notebook, located in the "Practical_2" directory.
- Follow through the regression analysis in this Notebook and perform the same regression analysis for the Boston dataset found in scikit-learn.

# Regression Summary

- Regression can be used to find the relationship between a target variable and feature variables.
- It can also be used to predict values of the target variable for given feature values.
- Decision trees can be used to make a regression model.
- Feature importances can be found for a given model.

# Image Classifier With TensorFlow

Overview

1. Basic Introduction to Deep-learning
2. TensorFlow for Poets
3. Practical 1
4. Practical 2

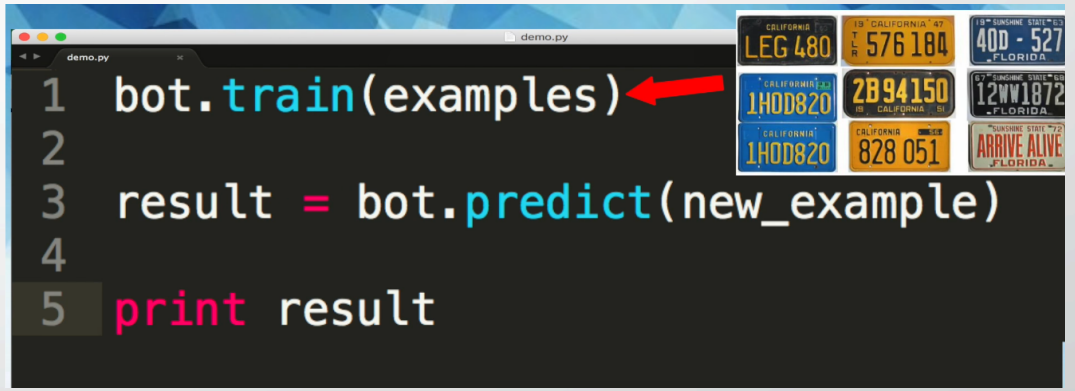
# Deep-Learning

Hard Coding

```
1  def detect_letters
2
3  def detect_shapes
4
5  def detect_colors
6
7  def detect_state
```

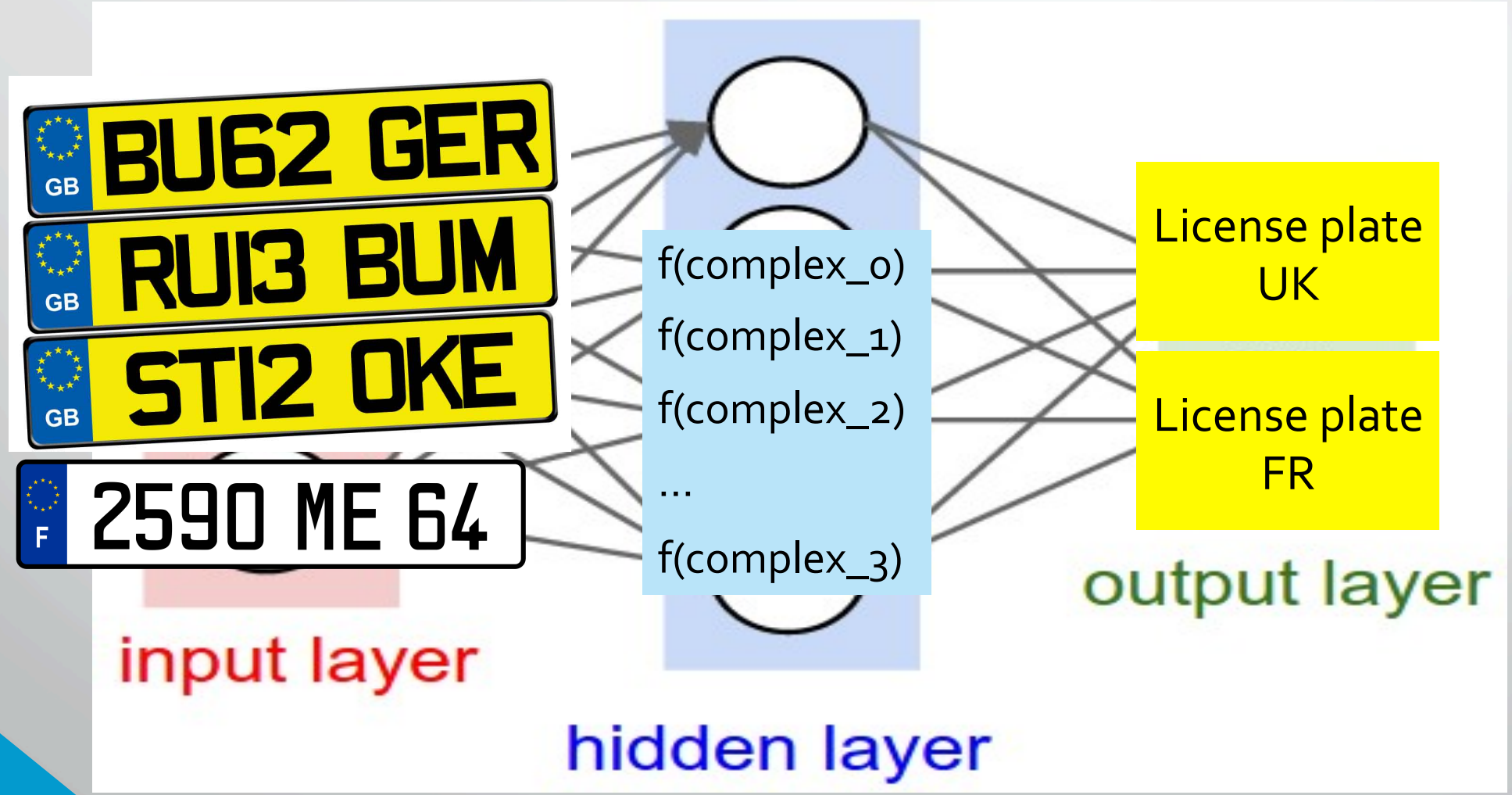

E.G License plate

Machine-Learning



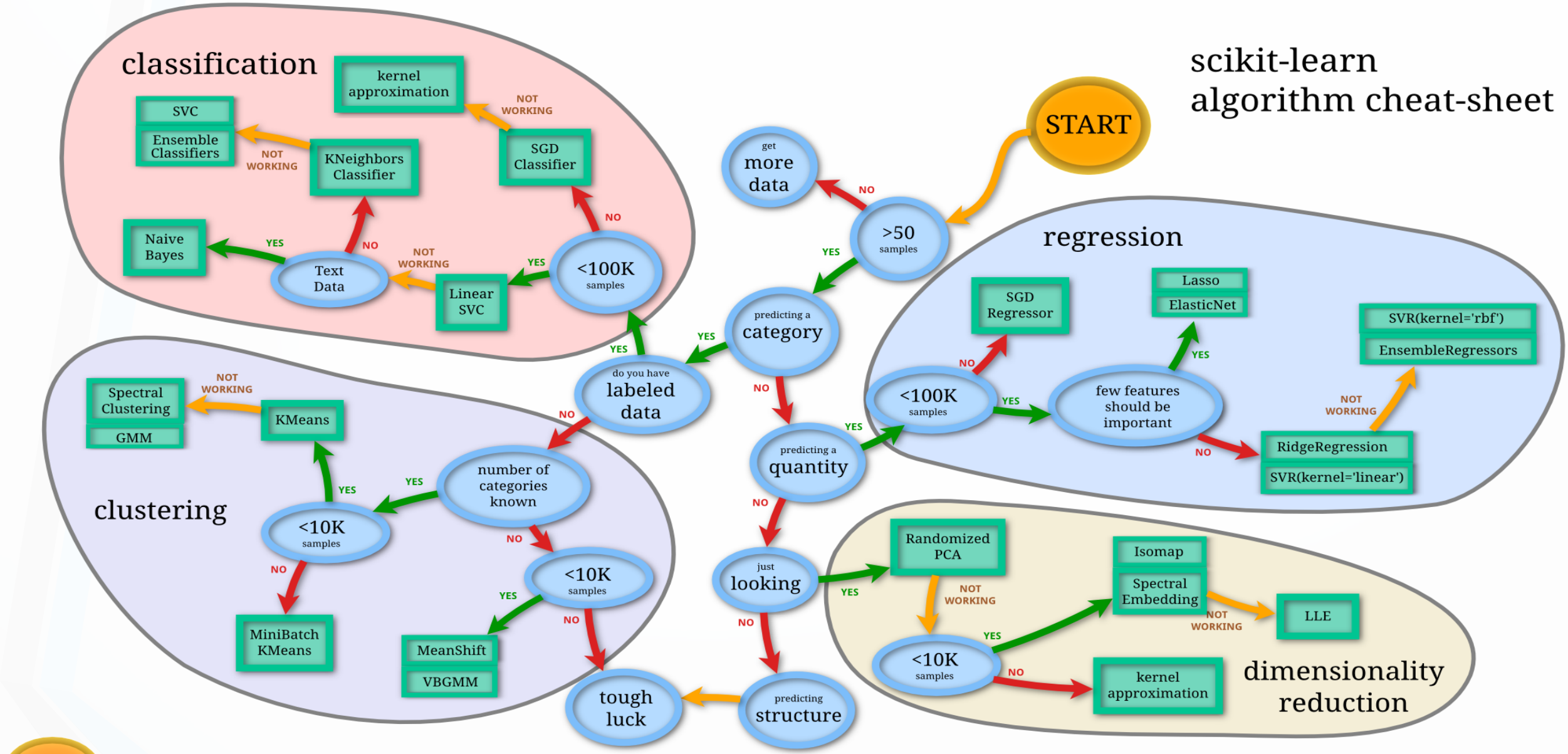

Recap:
Supervised: Feedback every time- (Practical 1)
Unsupervised: No feedback, learns by itself
Reinforced learning: Feedback if positive(trial and error)- Practical 2

# Neural Network




http://playground.tensorflow.org/

# scikit-learn algorithm cheat-sheet




Back

scikit learn

# What is TensorFlow?

- TensorFlow is a deep learning library recently open-sourced by Google.
- But what does it actually do?

TensorFlow provides primitives for defining functions on tensors and automatically computing their derivatives.


http://playground.tensorflow.org/

# Practical 1 - Supervised

https://codelabs.developers.google.com/codelabs/tensorflow-for-poets/?utm_campaign=chrome_series_machinelearning_063016&utm_source=gdev&utm_medium=yt-desc#0

# Practical 2

What about a game using reinforcement learning?

Input

Raw Pixel

Output

Maximise the score

https://github.com/HackerHouseYT/OpenAI-NEAT

# Deep-Learning Summary

# Summary

- Machine learning is a wide ranging topic that focuses on learning from large datasets.
- Data from discrete types of input can be classified using decision trees.
- Regression can be used to find relationships in datasets and to make predictions.
- TensorFlow can be used for image classification.

This work was supported by an EPSRC Doctoral Training Centre grant (EP/L015382/1)

# Further Resources

- The scikit-learn website: www.scikit-learn.org
- The tensorflow website: www.tensorflow.org
- A YouTube series on making a basic neural network: https://goo.gl/uvhELR