Decision Trees

July 2, 2019

Introduction

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- They can be used for **classification** and for **regression**.

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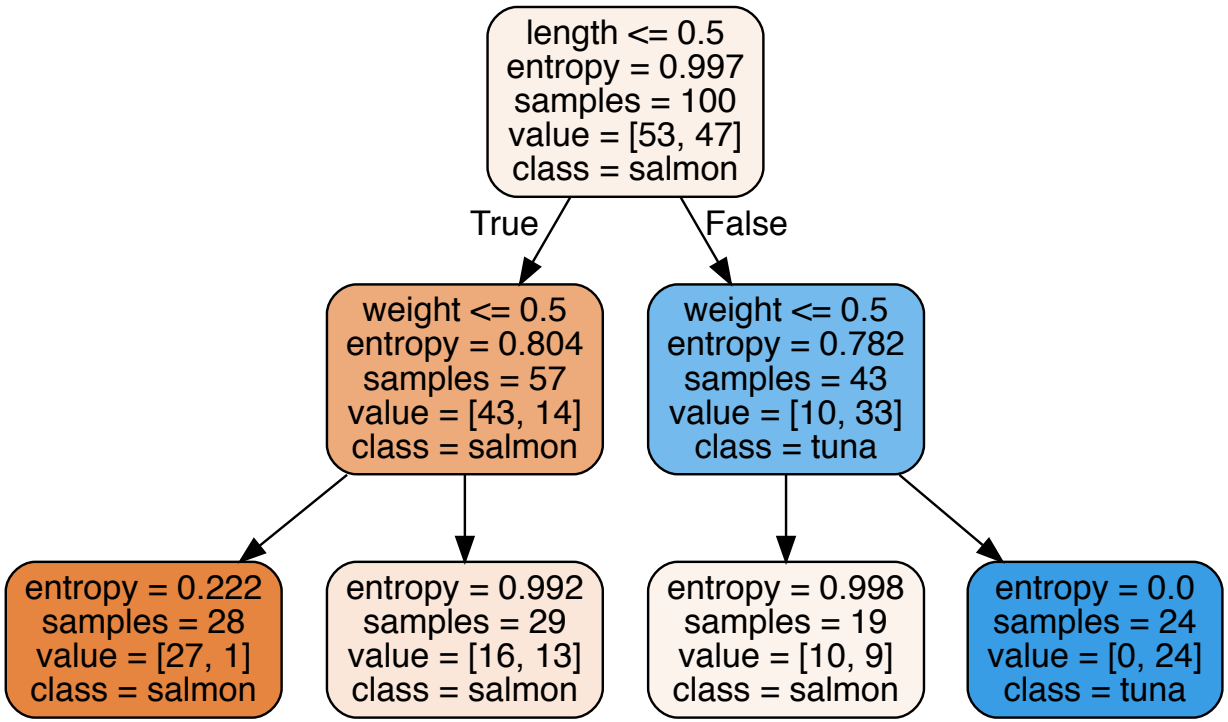
- For instance we study two types of fishs : the possible classes are **tuna** and **salmon**.
- Each fish has two features : its weight and its length.
- The question is : are we able to **predict the class by looking at the features ?**

Problem statement

- The **Decision Tree** is a classifier that we will build from the data that will help us to **predict the class of a new datapoint**.

Problem statement

- When the tree is built, is will look like this. Let us analyze what this means :



Building a tree

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- Let us try to design such a method.

Segmentation variable

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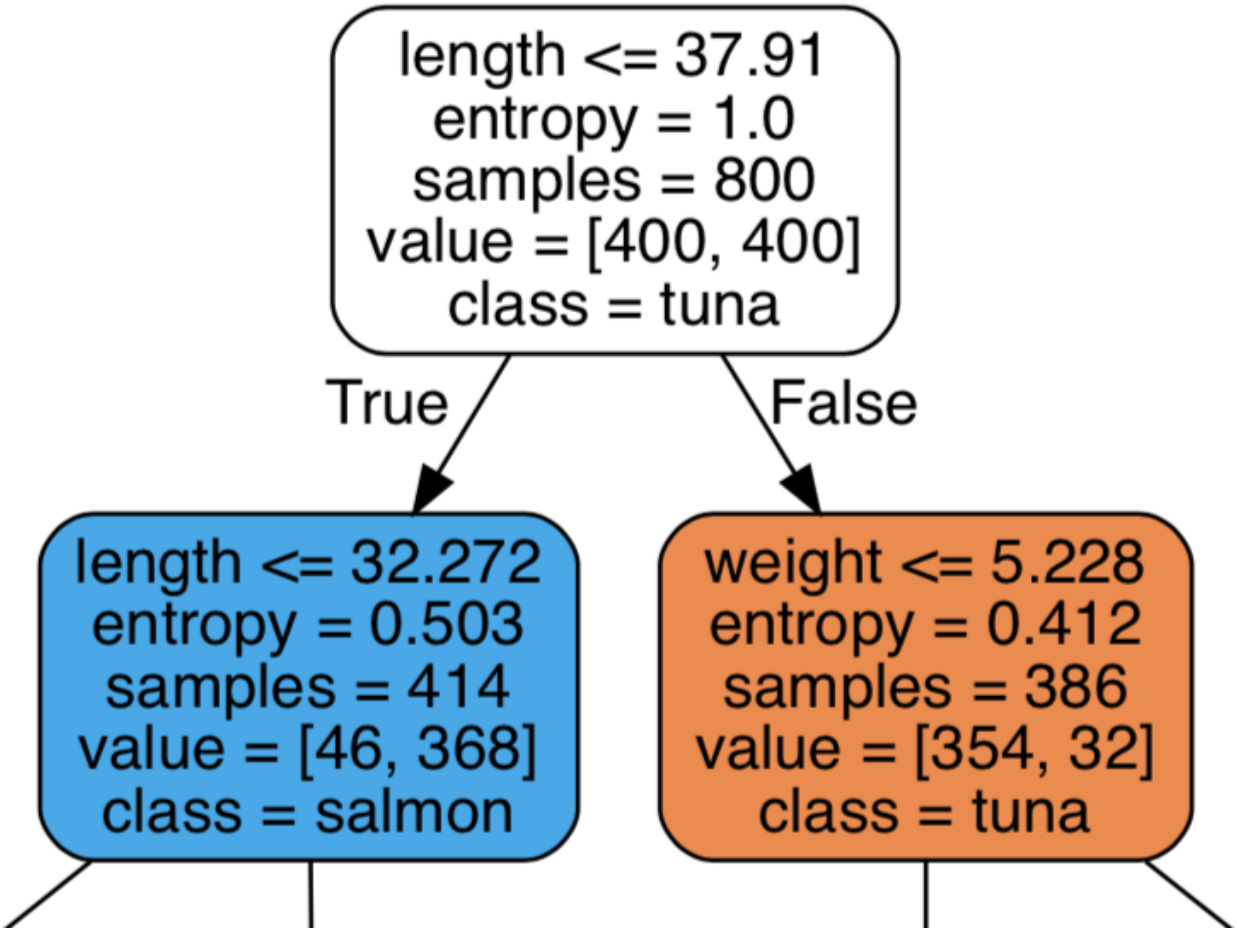

Figure: segmentation

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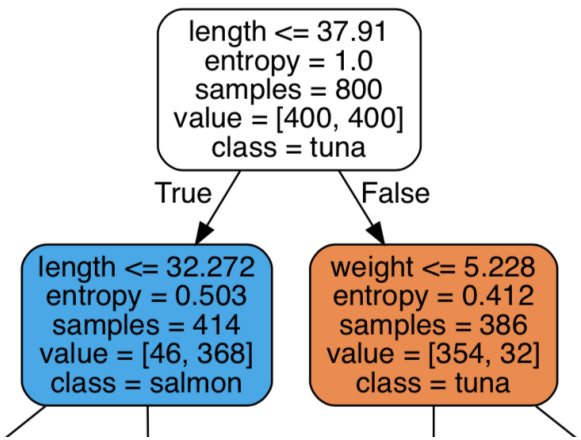

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- We want to find the feature that helps us to predict the class of the fish with most certainty.
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- There are several possible measures :
  - Gini factor
  - Information gain
  - Misclassification probability

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- Its entopy is then

$$H = -\sum_{i=1}^{n} p_k \log p_k \tag{1}$$

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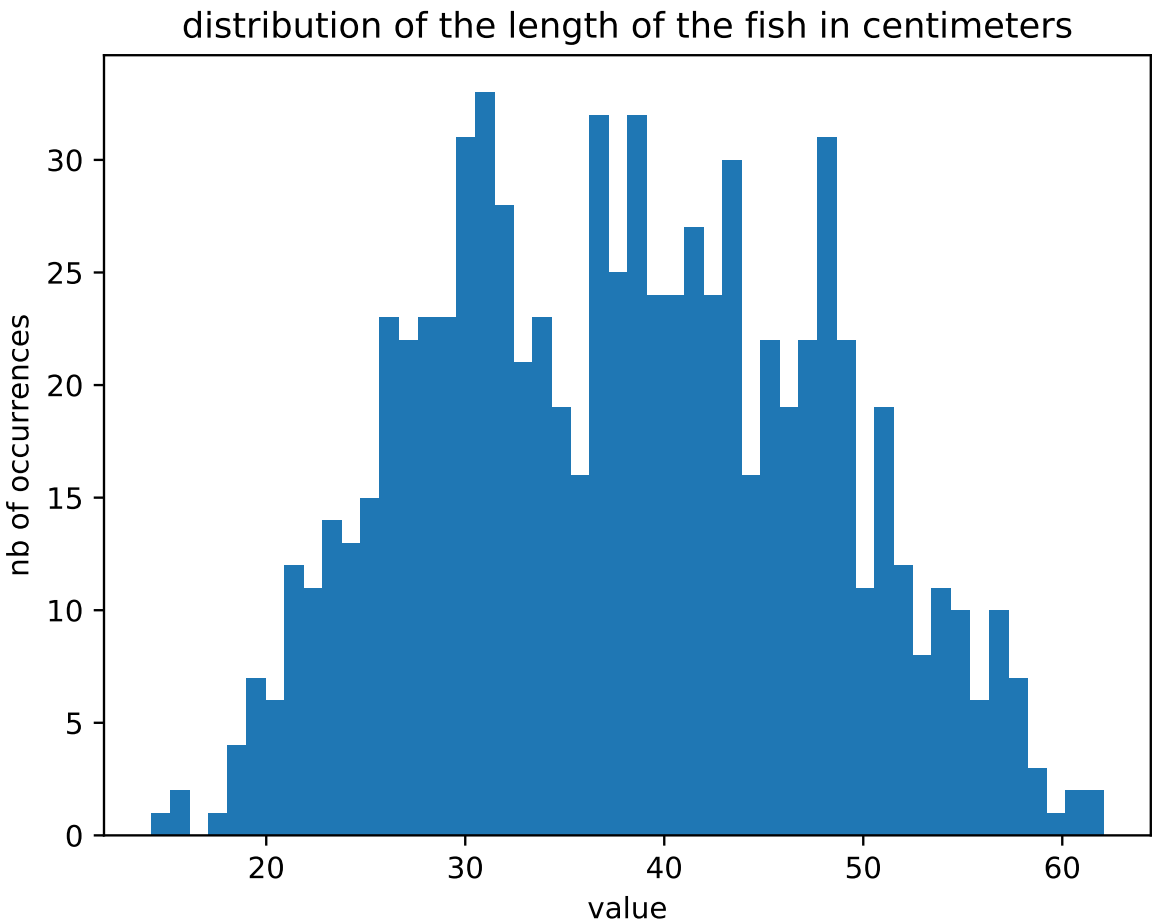
- the features of the fishes are stored in **numpy arrays**.

Dataset : ipython demo

```
In [44]: np.load("fish_features.npy")
Out[44]:
array([[53.75892579,  0.27022806],
       [43.5530757 ,  5.39964379],
       [48.71780521,  0.57694348],
       ...,
       [27.63229236,  4.86565666],
       [24.64053512,  5.5411517 ],
       [35.20792985,  4.22064417]])

In [45]:
```

Dataset : histograms



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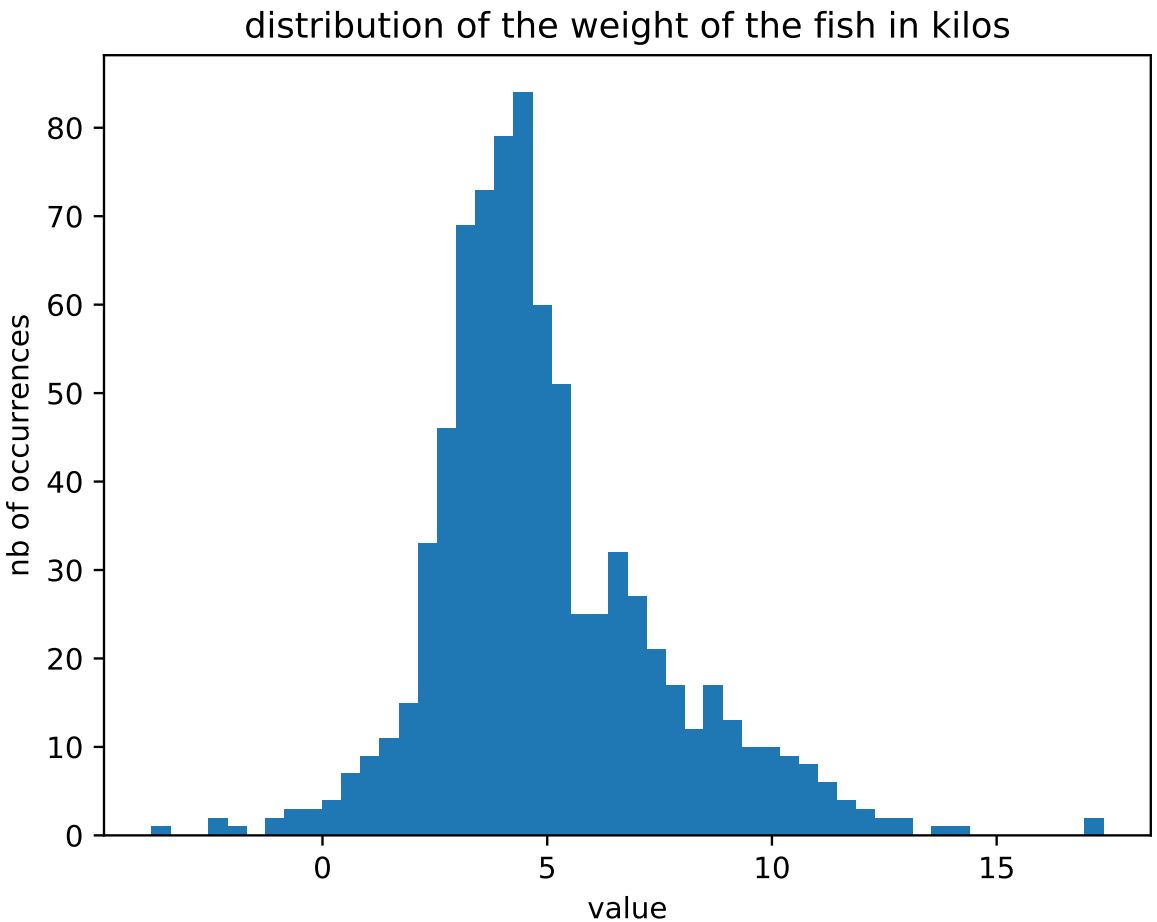

Exercise 1

- Given the number n of datapoints, what is the maximal number of nodes in the tree ?

Implementation

- We will use **sklearn** to build decision trees.
- `https://scikit-learn.org/stable/modules/generated/sklearn.tree.DecisionTreeClassifier.html`
- `https://scikit-learn.org/stable/modules/tree.html`

Implementation

- **pip install sklearn**
- We will also need
  - **numpy**
  - **matploblib**

Exercise 2

- Use the file **fish_tree.py** in order to build your decision tree and plot it.
- Try to use different depths !

Exercise 3

- Uncomment the end of the file **fish_tree.py** in order to predict the class for new fishes.

Exercise 4

- Modify the file **fish_dataset.py** in order to modify the dataset by **adding a new feature to the fishes**.

Exercise 5

- Use the files **fish_tree_blurred.py** and **fish_dataset_blurred.py** so that the obtained tree has a smaller number of nodes.
- You can use the documentation `https://scikit-learn.org/stable/modules/generated/sklearn.tree.DecisionTreeClassifier.html`
- You can modify :
  - the distributions
  - the value of the parameters **min_samles_split** and **min_impurity_decrease**

Exercise 6

- We can apply what we learned to a famous dataset, the **iris dataset**.
- please use the file **iris.py** in order to build several decision trees with different number of nodes, by changing the specifications given to sklearn.

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- When the variable to predict is continuous, we build a **regression** tree.
- Sometimes the rule used to predict the variable at a leaf node is not the **majority rule**.
- The χ^2 test can also be used to choose to split a node or not.

Overfitting

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- To handle it, **pruning** is often performed. It consists in **removing nodes from the tree** :
  - **pre pruning :** while building the tree, we choose not to split some nodes
  - **post pruning :** after building the tree, we remove some nodes.
  - in **Exercise 5** we used prepruning.