Algorithm

Counterfeit Banknotes

Data Analyst Course - Project 6
Michael Orange

Mission

Create an algorithm for detecting counterfeit banknotes

Algorithm based on banknotes characteristics:

- Length (in mm)
- Height measured in the left side (in mm)
- Height measured in the right side (in mm)
- Margin between superior side and the print (in mm)
- Margin between inferior side and the print (in mm)
- Diagonal (in mm)

Data Exploration 1

Principal Component Analysis 2

Modelisation 3

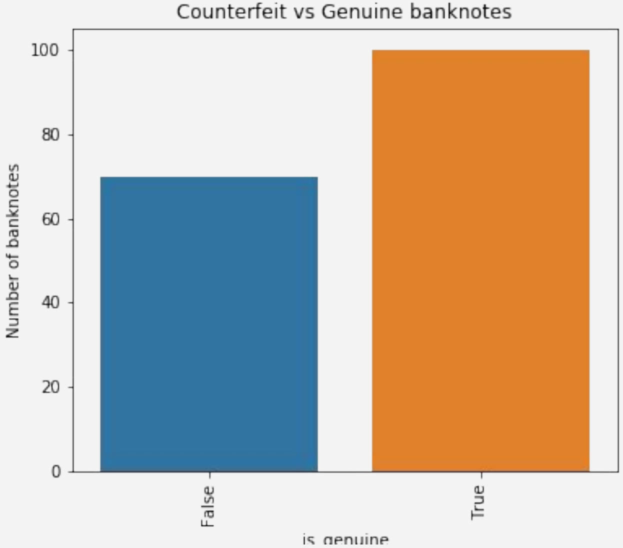
API 4

Data Exploration

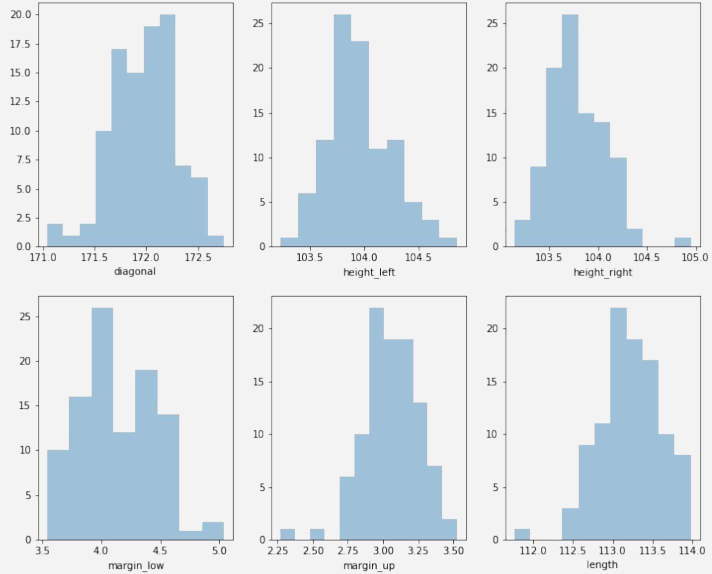
A dataset to train our model

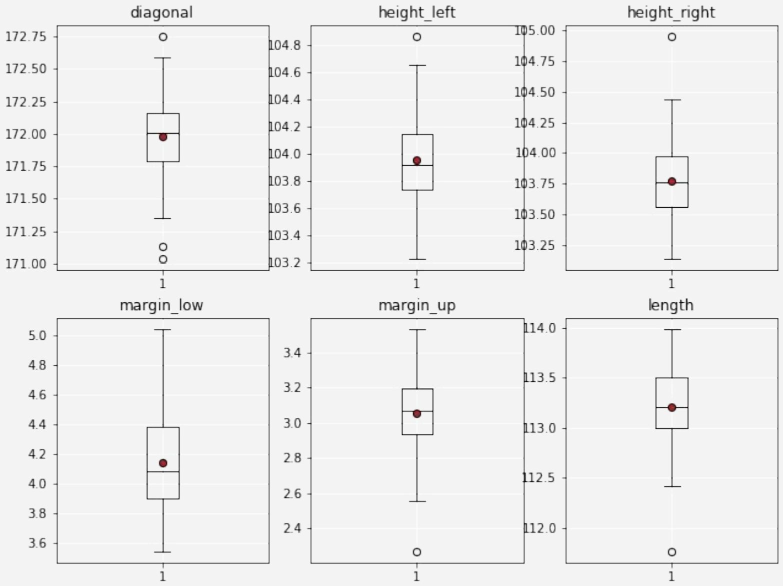
CSV file available to train our model with Genuine banknotes and Counterfeit (non Genuine) banknotes.

	diagonal	height_left	height_right	margin_low	margin_up	length
count	100.000000	100.000000	100.000000	100.000000	100.000000	100.000000
mean	171.976100	103.951500	103.775900	4.143500	3.055500	113.207200
std	0.307981	0.296251	0.292406	0.314509	0.197726	0.380476
min	171.040000	103.230000	103.140000	3.540000	2.270000	111.760000
25%	171.790000	103.740000	103.557500	3.900000	2.937500	112.995000
50%	172.005000	103.915000	103.760000	4.080000	3.070000	113.210000
75%	172.162500	104.145000	103.972500	4.382500	3.192500	113.505000
max	172.750000	104.860000	104.950000	5.040000	3.530000	113.980000



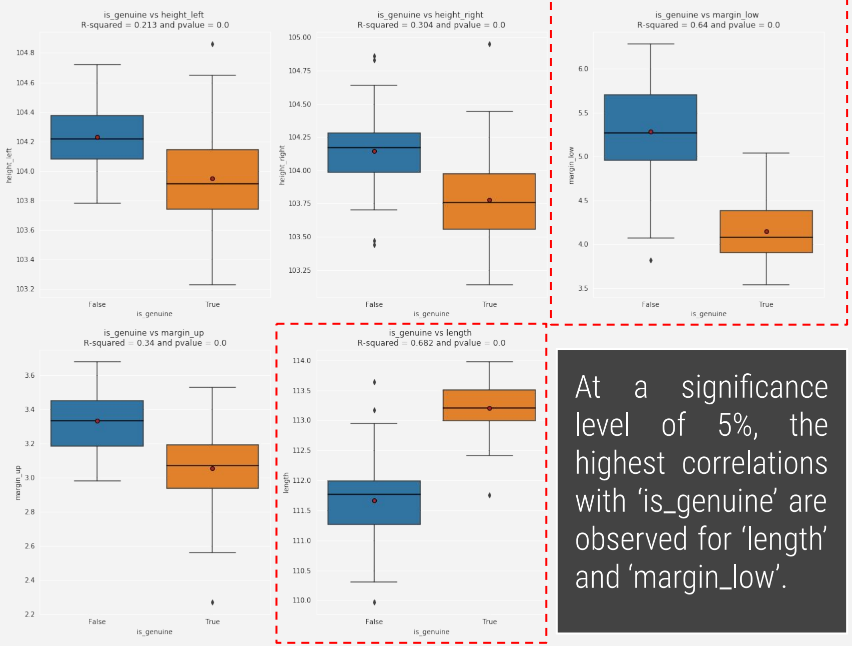
No significant outliers





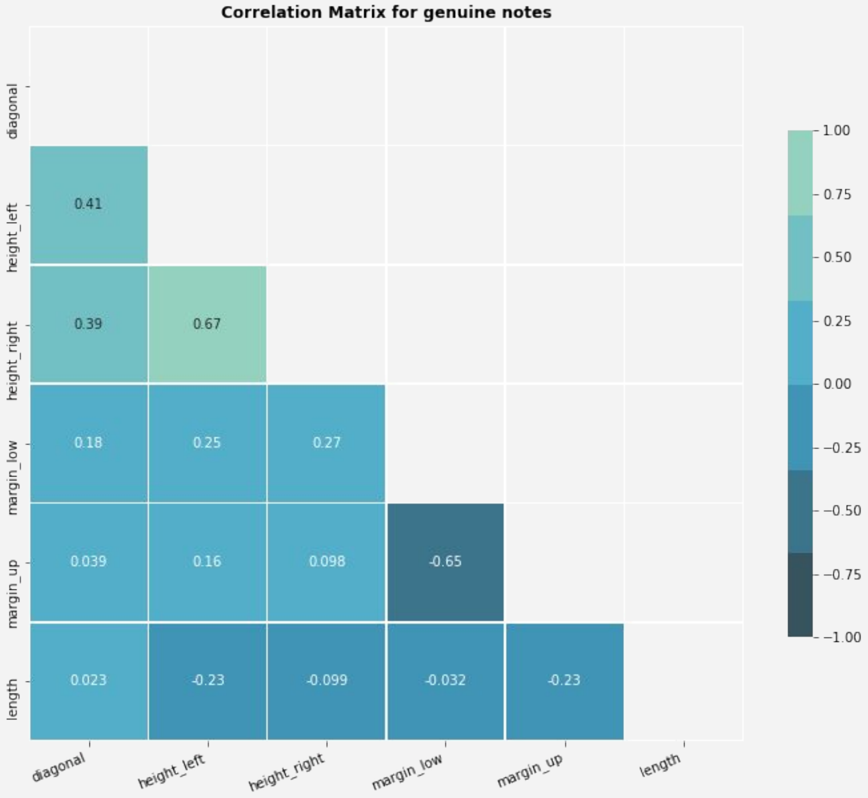
exploration

Significance of margin_low and length



At a significance level of 5%, the highest correlations with 'is_genuine' are observed for 'length' and 'margin_low'.

No numerical variables highly correlated



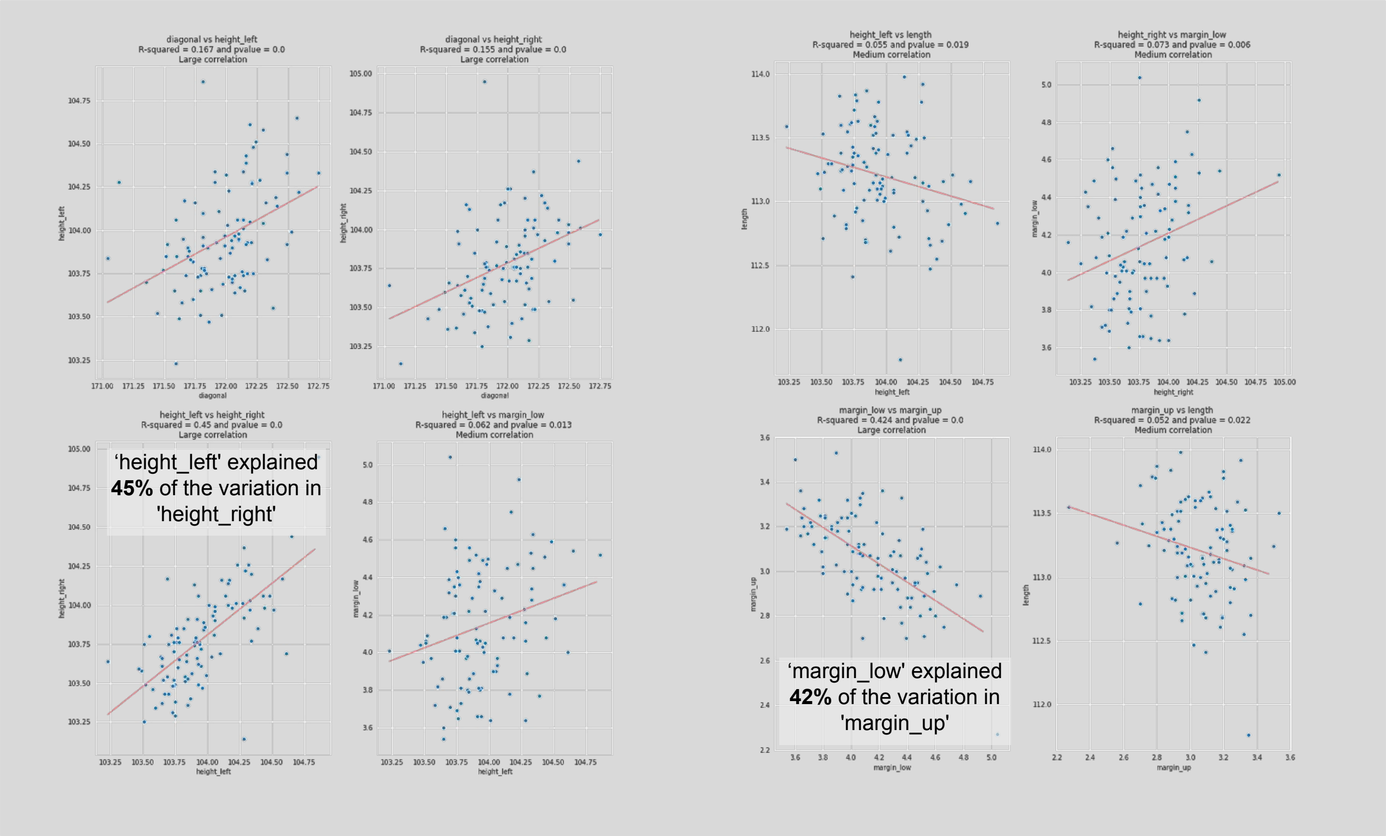
‘height_right’ and **‘height_left’** have a significant correlation (0.67).

‘margin_up’ and **‘margin_low’** have a significant inverse correlation (-0.65).

>> However no variables are redundant due to a very level of correlation.

exploration

Explanation of the variation are all under 50%



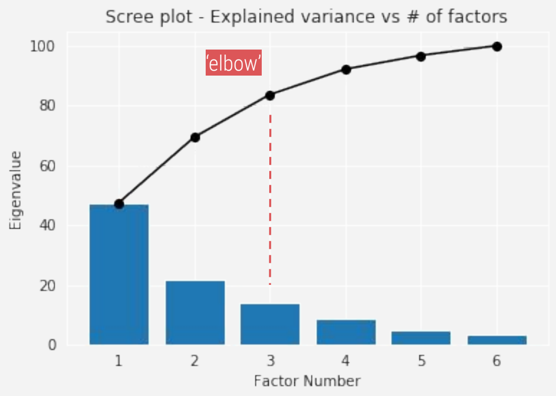
Principal Component Analysis

Preparation for PCA

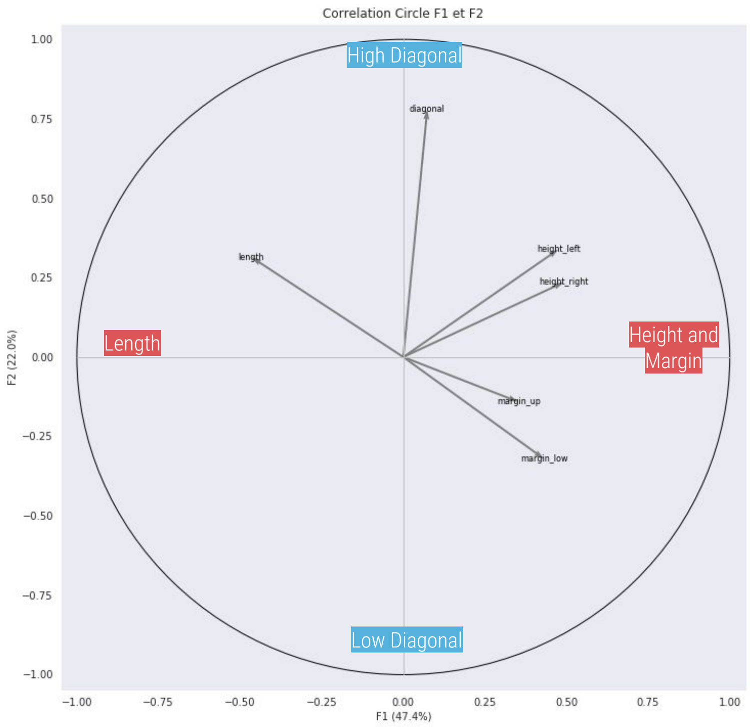
Mean centering - subtracting variable measured mean from each data value so that its empirical mean (average) is zero

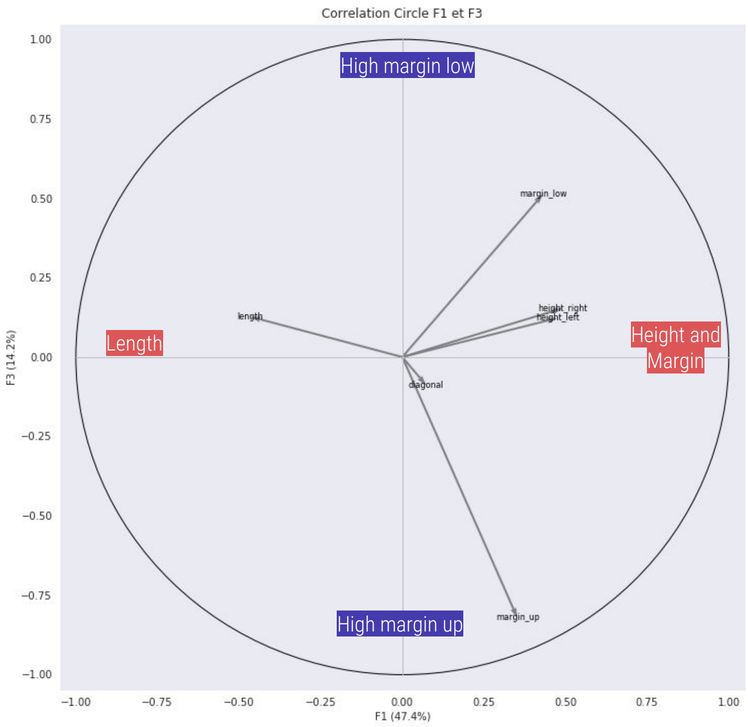
Variance standardization to 1 - after the mean centering, dividing 'centered' data by standard deviation.

3 components are selected
(capturing approx. 80% of the variance)

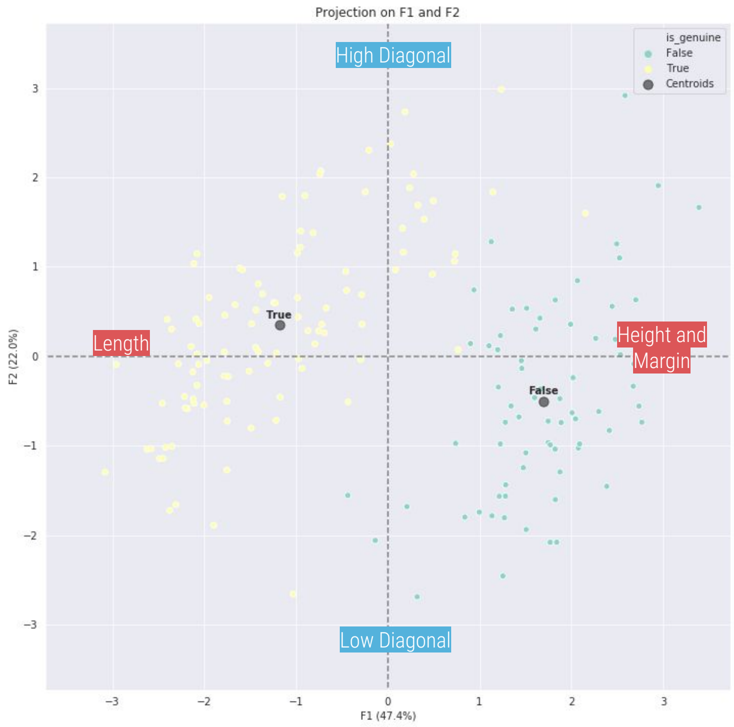


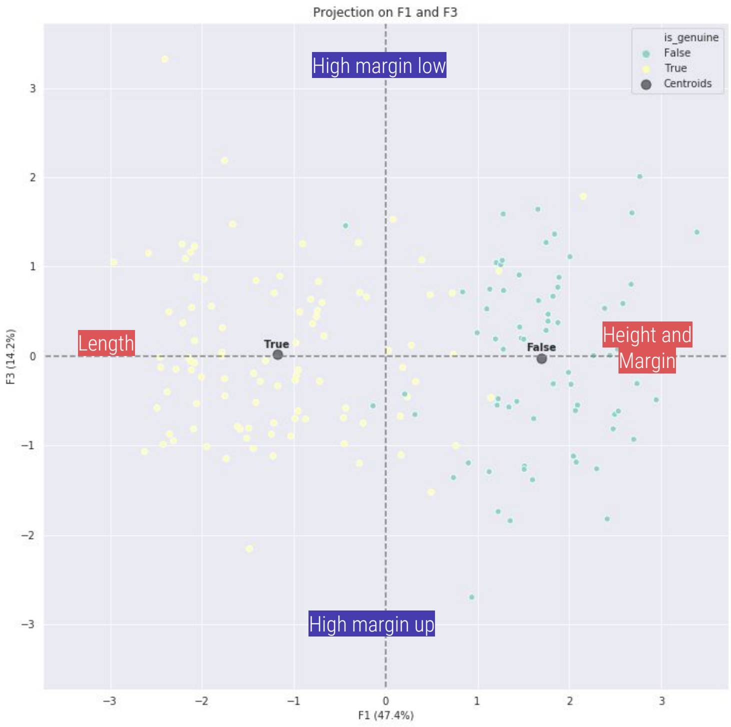
Correlation Circles



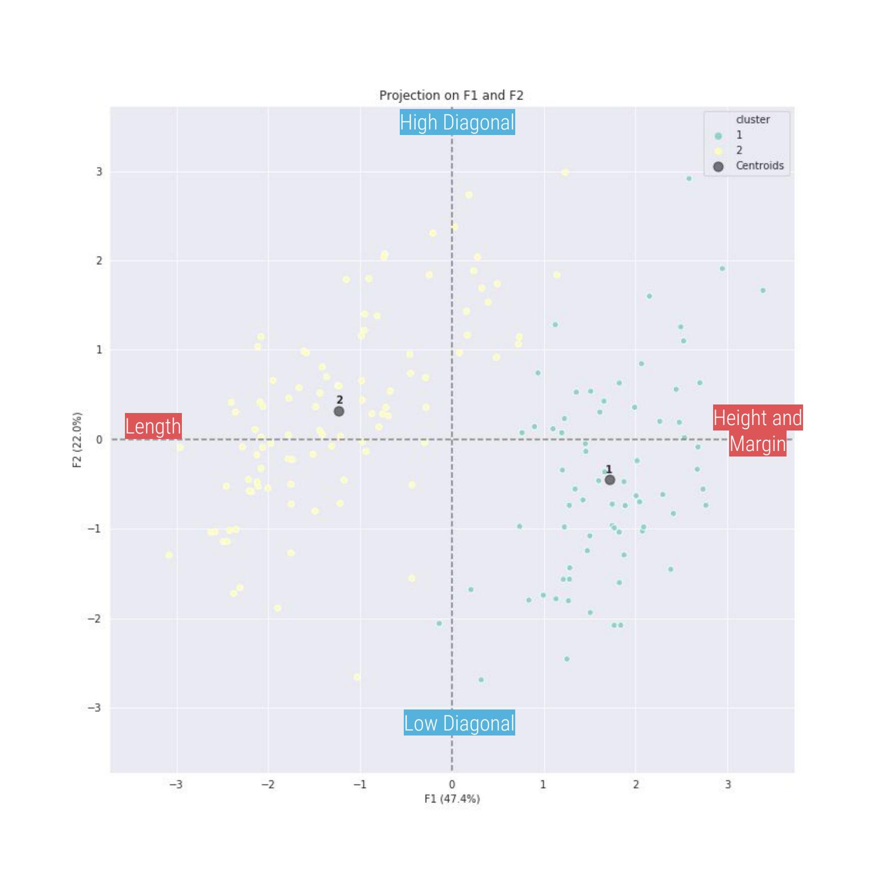


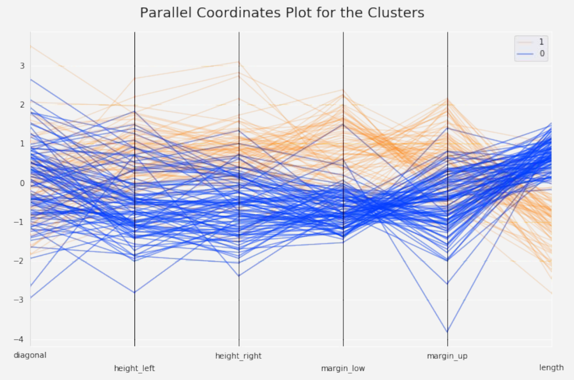
Projection on F1 and F2

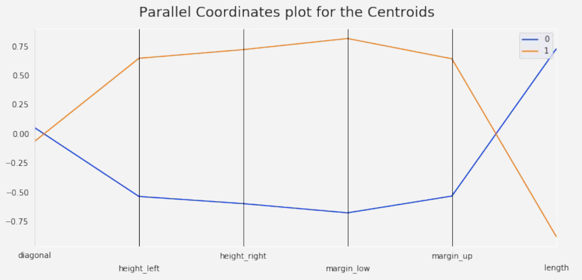




K-means Clustering







Modelisation

Logistic Regression

Methodology

- Statsmodel: Logit regression on scaled values
- Statsmodel: Logit regression on projected values (ACP)

Sklearn: LogisticRegression

Train, Test split : 80% to train the model, 20% to test the model

Selection

Logit on Scaled values

```
                    Results: Logit
==================================================================
Model:            Logit          Pseudo R-squared: 0.954
Dependent Variable: is_genuine      AIC:            12.5605
Date:             2020-07-08 12:11 BIC:            18.3858
No. Observations:   136           Log-Likelihood:   -4.2802
Df Model:           1             LL-Null:         -92.139
Df Residuals:       134           LLR p-value:     4.1727e-40
Converged:          1.0000        Scale:           1.0000
No. Iterations:     14.0000
------------------------------------------------------------------
             Coef.  Std.Err.    z    P>|z|   [0.025   0.975]
------------------------------------------------------------------
margin_low  -9.0096   3.6243 -2.4859 0.0129 -16.1131 -1.9061
length       7.5277   3.0038  2.5061 0.0122   1.6404 13.4151
==================================================================
```

Prob = logistic(x) = 1 / (1 + $e^{(-x)}$)
with x = -9.0096 * margin_low + 7.5277 * length

Accuracy of the model: 98.82% **Selected**

Logit on ACP (F1, F2, F3)

```
                    Results: Logit
==================================================================
Model:            Logit          Pseudo R-squared: 0.848
Dependent Variable: is_genuine      AIC:            32.0556
Date:             2020-07-08 12:26 BIC:            37.8809
No. Observations:   136           Log-Likelihood:  -14.028
Df Model:           1             LL-Null:         -92.139
Df Residuals:       134           LLR p-value:     7.5678e-36
Converged:          1.0000        Scale:           1.0000
No. Iterations:     10.0000
------------------------------------------------------------------
      Coef.    Std.Err.    z      P>|z|    [0.025    0.975]
------------------------------------------------------------------
F1  -3.1539    0.6725   -4.6902  0.0000   -4.4719   -1.8360
F2   2.2678    0.6089    3.7247  0.0002    1.0745    3.4611
==================================================================
```

Prob = logistic(x) = 1 / (1 + $e^{(-x)}$)
with x = -3.1539 * F1 + 2.2678 * F2

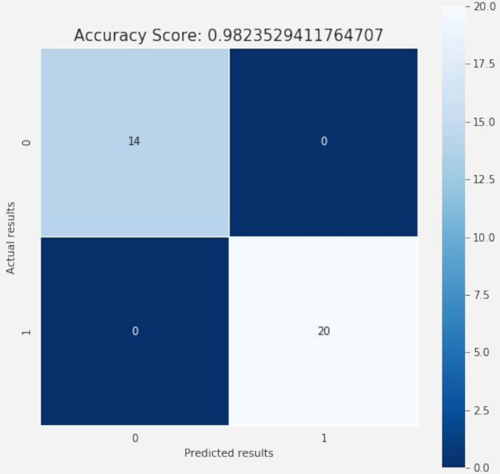
Accuracy of the model: 98.23% **Rejected**

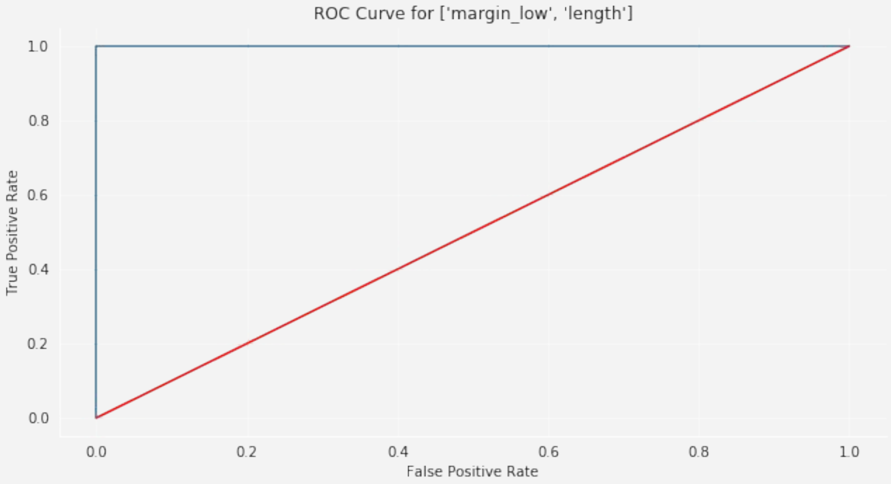
Sklearn LogisticRegression

- Features: **length** and **margin low**

- **Cross-validation (kfold with 5 splits):**
  [0.94117647 1. 1. 0.97058824 1.]
  Accuracy of the model: **98.24 %**

With a AUC of 1, the model is excellent





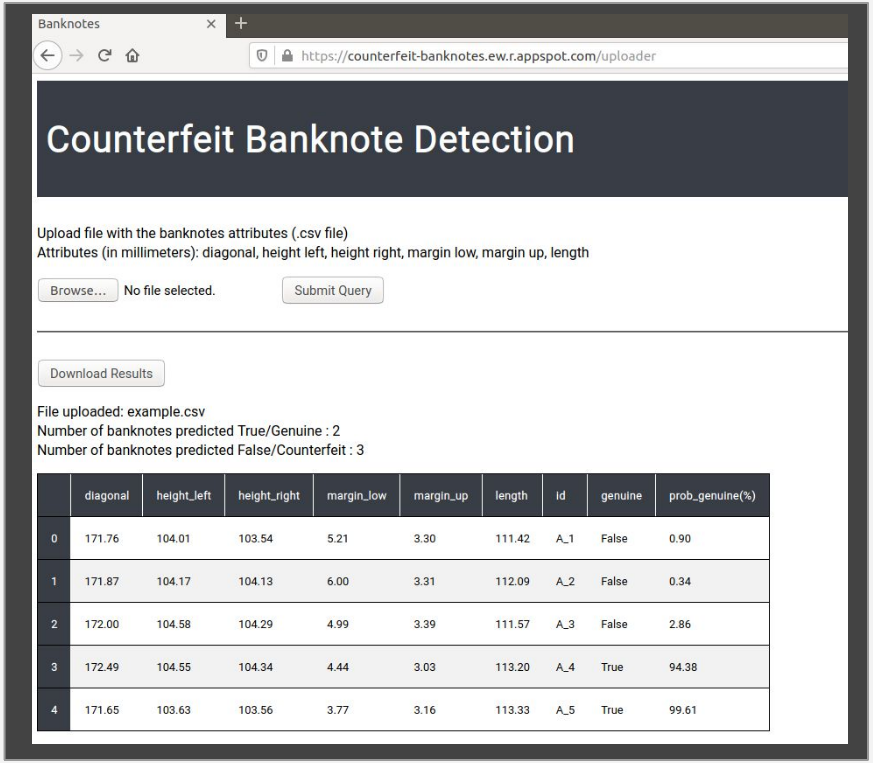
API

API - Google Cloud Platform

Python API hosted with Google App Engine

https://counterfeit-banknotes.ew.r.appspot.com

- Upload SKLearn LogisticRegression and StandardScaler trained models
- Request CSV file with 6 attributes (in mm)
- Scale values of the CSV file (mean centering and variance standardization)
- Perform a SKLearn LogisticRegression on scaled values of 'length' and 'margin_low'
- Return a table with prediction and probability of the prediction.



Banknotes

https://counterfeit-banknotes.ew.r.appspot.com/uploader

Counterfeit Banknote Detection

Upload file with the banknotes attributes (.csv file)
Attributes (in millimeters): diagonal, height left, height right, margin low, margin up, length

Browse... No file selected. Submit Query

Download Results

File uploaded: example.csv
Number of banknotes predicted True/Genuine : 2
Number of banknotes predicted False/Counterfeit : 3

	diagonal	height_left	height_right	margin_low	margin_up	length	id	genuine	prob_genuine(%)
0	171.76	104.01	103.54	5.21	3.30	111.42	A_1	False	0.90
1	171.87	104.17	104.13	6.00	3.31	112.09	A_2	False	0.34
2	172.00	104.58	104.29	4.99	3.39	111.57	A_3	False	2.86
3	172.49	104.55	104.34	4.44	3.03	113.20	A_4	True	94.38
4	171.65	103.63	103.56	3.77	3.16	113.33	A_5	True	99.61

THANK YOU!

Do you have any questions?

Code available on
https://github.com/Michael-Orange/algorithm_banknotes

CREDITS: This presentation template was inspired from **Slidesgo**, including icons by **Flaticon**, and infographics & images by **Pixabay**