Ecole Nationale d'ingénieurs de Carthage
Département de Génie Informatique

Rapport de

Mini Projet

Sujet :

Projet : Analyse ACP et classification K-means d'une base de données « Heart disease »

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Année Universitaire :2021-2022

Projet Analyse des données Heart disease

Introduction :

Dans le cadre d'un projet analyse des données de la deuxième année cycle ingénieur en génie informatique à l'école nationale d'ingénieur de Carthage et pour appliquer les connaissances acquises pendant le cours de "Analyse des données", nous sommes amenés à réaliser un projet basé sur les méthode de l'ACP et de la classification K-means.

Importation des données et bibliothèques

In [1]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.decomposition import PCA
from sklearn.preprocessing import StandardScaler
from pandas.plotting import scatter_matrix
import seaborn as sns
from sklearn.decomposition import PCA
import numpy
```

In [2]:

```
df=pd.read_csv("heart_cleveland_upload.csv") #lecture du dataset
#Référence dataset : https://www.kaggle.com/datasets/cherngs/heart-disease-cleveland-uci?resource=download
```

In [4]:

```
df
```

Out[4]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	condition
0	69	1	0	160	234	1	2	131	0	0.1	1	1	0	0
1	69	0	0	140	239	0	0	151	0	1.8	0	2	0	0
2	66	0	0	150	226	0	0	114	0	2.6	2	0	0	0
3	65	1	0	138	282	1	2	174	0	1.4	1	1	0	1
4	64	1	0	110	211	0	2	144	1	1.8	1	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
292	40	1	3	152	223	0	0	181	0	0.0	0	0	2	1
293	39	1	3	118	219	0	0	140	0	1.2	1	0	2	1
294	35	1	3	120	198	0	0	130	1	1.6	1	0	2	1
295	35	0	3	138	183	0	0	182	0	1.4	0	0	0	0
296	35	1	3	126	282	0	2	156	1	0.0	0	0	2	1

297 rows × 14 columns

In [5]:

```
df.shape
```

Out[5]:

```
(297, 14)
```

Elimination des valeurs nulles, incohérents inexploitables et colonnes dupliquées.

In [6]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 297 entries, 0 to 296
Data columns (total 14 columns):
 #   Column     Non-Null Count  Dtype
---  ------     --------------  -----
 0   age        297 non-null    int64
 1   sex        297 non-null    int64
 2   cp         297 non-null    int64
 3   trestbps   297 non-null    int64
 4   chol       297 non-null    int64
 5   fbs        297 non-null    int64
 6   restecg    297 non-null    int64
 7   thalach    297 non-null    int64
 8   exang      297 non-null    int64
 9   oldpeak    297 non-null    float64
 10  slope      297 non-null    int64
 11  ca         297 non-null    int64
 12  thal       297 non-null    int64
 13  condition  297 non-null    int64
dtypes: float64(1), int64(13)
memory usage: 32.6 KB
```

age: age in years

sex: sex (1 = male; 0 = female)

cp: chest pain type

Value 0: typical angina

Value 1: atypical angina

Value 2: non-anginal pain

Value 3: asymptomatic

trestbps: resting blood pressure (in mm Hg on admission to the hospital)

chol: serum cholestoral in mg/dl

fbs: (fasting blood sugar > 120 mg/dl) (1 = true; 0 = false)

restecg: resting electrocardiographic results

Value 0: normal

Value 1: having ST-T wave abnormality(T wave inversions and/or ST elevation or depression of > 0.05 mV)

Value 2: showing probable or definite left ventricular hypertrophy by Estes' criteria

thalach: maximum heart rate achieved

exang: exercise induced angina (1 = yes; 0 = no)

oldpeak = ST depression induced by exercise relative to rest

slope: the slope of the peak exercise ST segment

Value 0: upsloping Value 1: flat Value 2: downsloping ca: number of major vessels (0-3) colored by flourosopy

thal: A blood disorder called thalassemia

0 = normal; 1 = fixed defect; 2 = reversable defect Condition:

Value 0 = No Disease; Value 1 = Disease;

In [7]:

```
df.describe()
```

Out[7]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpe
count	297.000000	297.000000	297.000000	297.000000	297.000000	297.000000	297.000000	297.000000	297.000000	297.0000
mean	54.542088	0.676768	2.158249	131.693603	247.350168	0.144781	0.996633	149.599327	0.326599	1.0555
std	9.049736	0.468500	0.964859	17.762806	51.997583	0.352474	0.994914	22.941562	0.469761	1.1661
min	29.000000	0.000000	0.000000	94.000000	126.000000	0.000000	0.000000	71.000000	0.000000	0.0000
25%	48.000000	0.000000	2.000000	120.000000	211.000000	0.000000	0.000000	133.000000	0.000000	0.0000
50%	56.000000	1.000000	2.000000	130.000000	243.000000	0.000000	1.000000	153.000000	0.000000	0.8000
75%	61.000000	1.000000	3.000000	140.000000	276.000000	0.000000	2.000000	166.000000	1.000000	1.6000
max	77.000000	1.000000	3.000000	200.000000	564.000000	1.000000	2.000000	202.000000	1.000000	6.2000

In [8]:

```
df.rename(columns = {'condition':'target'}, inplace = True)
```

In [9]:

```
df
```

Out[9]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	target
0	69	1	0	160	234	1	2	131	0	0.1	1	1	0	0
1	69	0	0	140	239	0	0	151	0	1.8	0	2	0	0
2	66	0	0	150	226	0	0	114	0	2.6	2	0	0	0
3	65	1	0	138	282	1	2	174	0	1.4	1	1	0	1
4	64	1	0	110	211	0	2	144	1	1.8	1	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
292	40	1	3	152	223	0	0	181	0	0.0	0	0	2	1
293	39	1	3	118	219	0	0	140	0	1.2	1	0	2	1
294	35	1	3	120	198	0	0	130	1	1.6	1	0	2	1
295	35	0	3	138	183	0	0	182	0	1.4	0	0	0	0
296	35	1	3	126	282	0	2	156	1	0.0	0	0	2	1

297 rows × 14 columns

In [10]:

```
df.describe()
```

Out[10]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpe
count	297.000000	297.000000	297.000000	297.000000	297.000000	297.000000	297.000000	297.000000	297.000000	297.0000
mean	54.542088	0.676768	2.158249	131.693603	247.350168	0.144781	0.996633	149.599327	0.326599	1.0555

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpe
std	9.049736	0.468500	0.964859	17.762806	51.97583	0.352474	0.994914	22.941562	0.469761	1.1661
min	29.000000	0.000000	0.000000	94.000000	126.000000	0.000000	0.000000	71.000000	0.000000	0.0000
25%	48.000000	0.000000	2.000000	120.000000	211.000000	0.000000	0.000000	133.000000	0.000000	0.0000
50%	56.000000	1.000000	2.000000	130.000000	243.000000	0.000000	1.000000	153.000000	0.000000	0.8000
75%	61.000000	1.000000	3.000000	140.000000	276.000000	0.000000	2.000000	166.000000	1.000000	1.6000
max	77.000000	1.000000	3.000000	200.000000	564.000000	1.000000	2.000000	202.000000	1.000000	6.2000

In [11]:

```
df["target"].unique() #returns all unique values
```

Out[11]:

```
array([0, 1], dtype=int64)
```

In [12]:

```
scatter_matrix(df,figsize=(10,10))
```

Out[12]:

```
array([[<AxesSubplot:xlabel='age', ylabel='age'>,
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```

```
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```
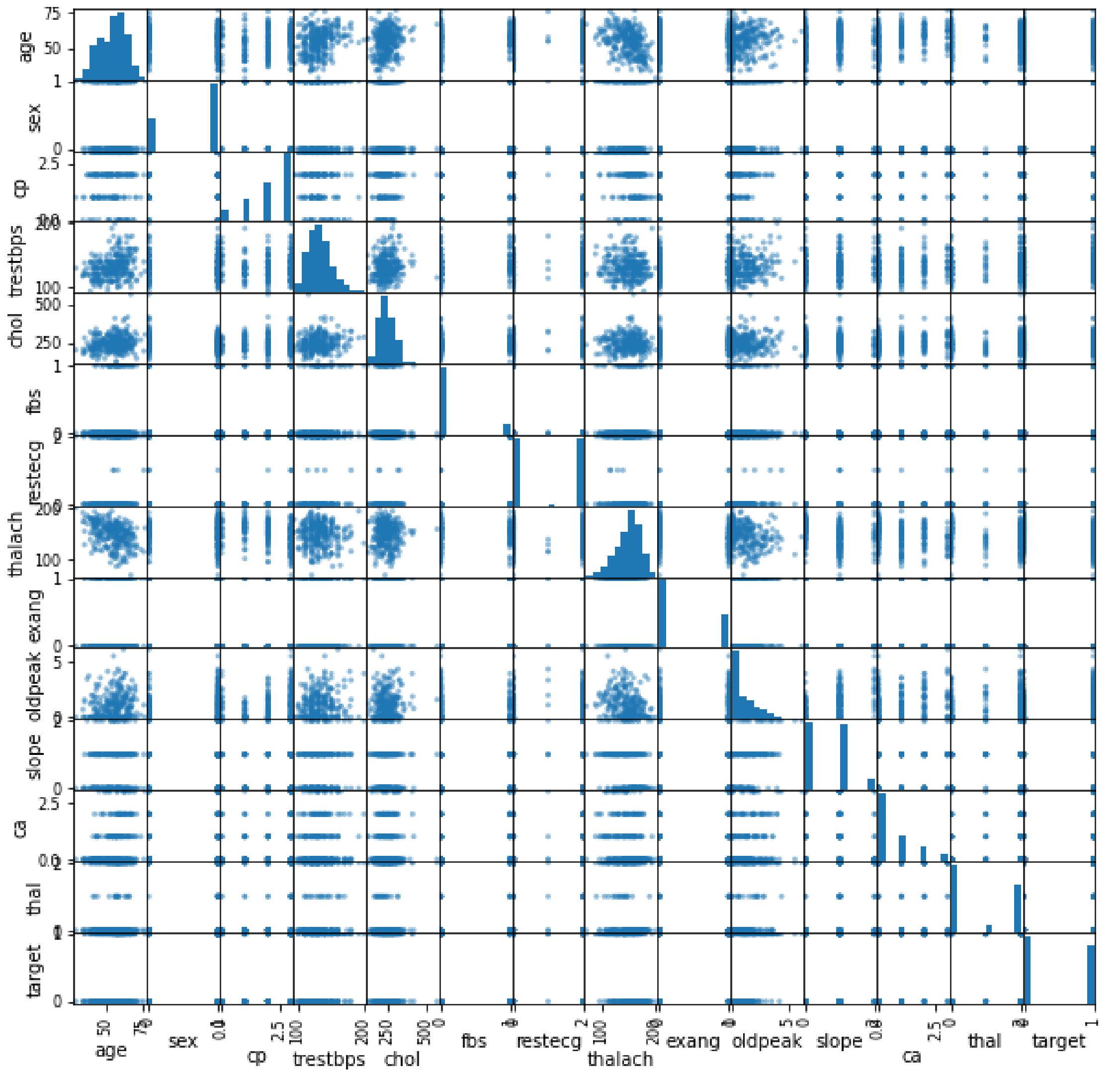



Matrice de **Covariance**

In [13]:

```
cov=df.cov()
cov
```

Out[13]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slo
age	81.897716	-	0.964601	46.693682	95.356834	0.421251	1.349804	-81.917201	0.410194	2.080255	0.8917
sex	-0.391755	0.219492	0.004027	-0.552075	-4.825621	0.006416	0.015800	-0.650218	0.031600	0.058221	0.0096
cp	0.964601	0.004027	0.930954	-0.633782	3.616696	-0.019611	0.061345	-7.510704	0.171114	0.228679	0.0901
trestbps	46.693682	-0.552075	-0.633782	315.517290	121.489410	1.132348	2.637478	-20.011694	0.556488	3.961336	1.3305
chol	95.356834	-4.825621	3.616696	121.489410	2703.748589	0.232915	8.538345	-0.088953	1.449438	2.340278	0.2962
fbs	0.421251	0.006416	-0.019611	1.132348	0.232915	0.124238	0.024138	-0.063416	-0.000148	0.003416	0.0104
restecg	1.349804	0.015800	0.061345	2.637478	8.538345	0.024138	0.989853	-1.650002	0.038266	0.131944	0.0831
thalach	-81.917201	-0.650218	-7.510704	-20.011694	-0.088953	-0.063416	-1.650002	526.315270	-4.142347	-9.300300	-5.5212

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slo
exang	0.410194	0.031600	0.171114	0.556488	1.449438	-0.000148	0.038266	-4.142347	0.220675	0.158483	0.0727
oldpeak	2.080255	0.058221	0.228679	3.961336	2.340278	0.003416	0.131944	-9.300300	0.158483	1.359842	0.4174
slope	0.891778	0.009657	0.090113	1.330558	-0.296217	0.010420	0.083117	-5.521214	0.072766	0.417417	0.3821
ca	3.077839	0.040438	0.213486	1.633736	5.660865	0.050334	0.120530	-5.788732	0.065384	0.322410	0.0637
thal	1.045819	0.166087	0.245791	2.219549	1.166075	0.017210	0.012956	-5.671057	0.145282	0.375751	0.1538
target	1.026128	0.065145	0.197027	1.361407	2.084550	0.000557	0.082639	-4.855094	0.098837	0.246922	0.1028

Centrer et réduire les données

In [14]:

```
from sklearn import preprocessing
df_cr = preprocessing.scale(df)
```

Matrice de **corrélation**

In [15]:

```
corr=df.corr()
```

In [16]:

```
corr
```

Out[16]:

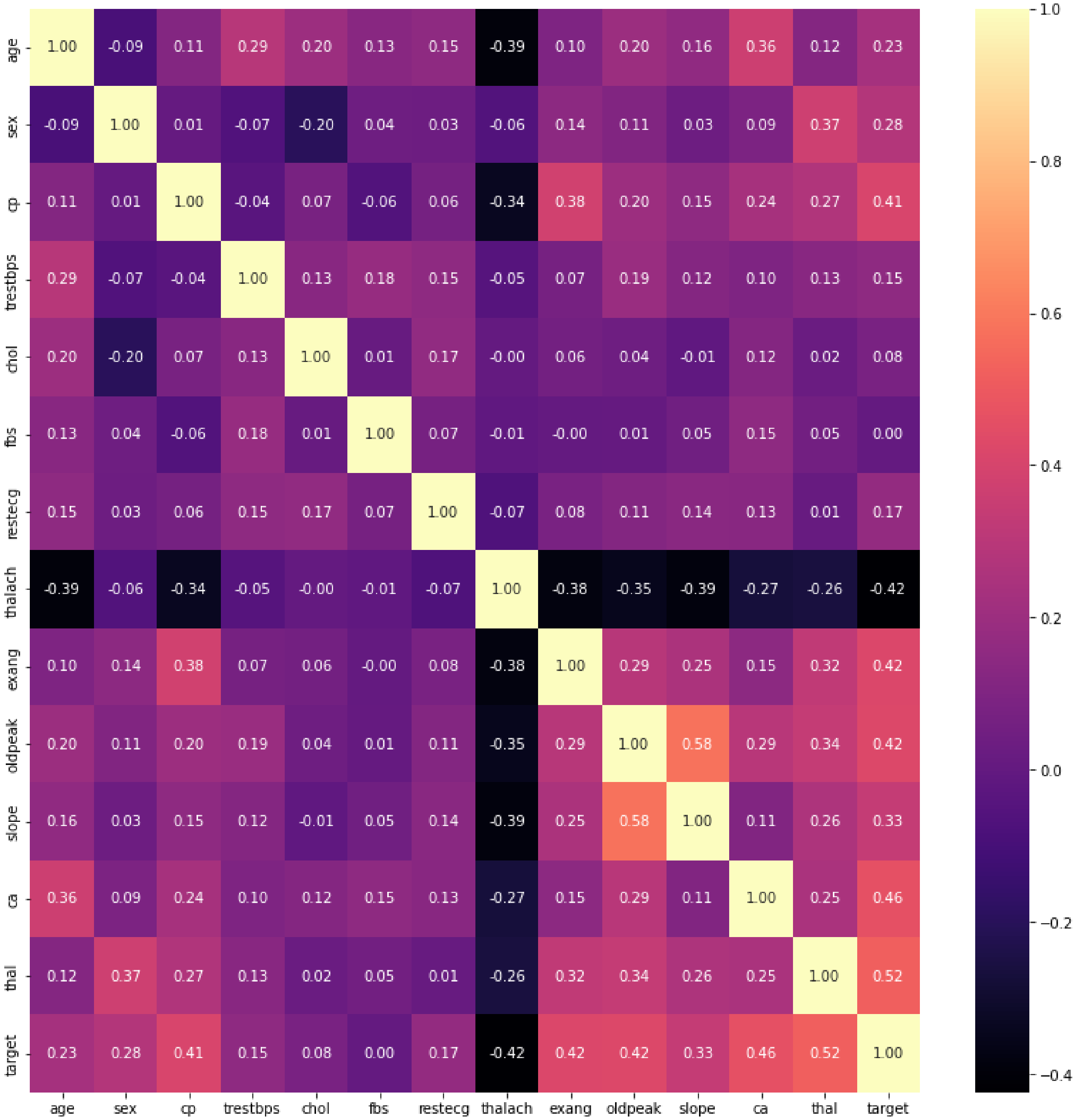
	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	
age	1.000000	-0.092399	0.110471	0.290476	0.202644	0.132062	0.149917	-0.394563	0.096489	0.197123	0.159405	0.362
sex	-0.092399	1.000000	0.008908	-0.066340	-0.198089	0.038850	0.033897	-0.060496	0.143581	0.106567	0.033345	0.091
cp	0.110471	0.008908	1.000000	-0.036980	0.072088	-0.057663	0.063905	-0.339308	0.377525	0.203244	0.151079	0.235
trestbps	0.290476	-0.066340	-0.036980	1.000000	0.131536	0.180860	0.149242	-0.049108	0.066691	0.191243	0.121172	0.097
chol	0.202644	-0.198089	0.072088	0.131536	1.000000	0.012708	0.165046	-0.000075	0.059339	0.038596	-0.009215	0.115
fbs	0.132062	0.038850	-0.057663	0.180860	0.012708	1.000000	0.068831	-0.007842	-0.000893	0.008311	0.047819	0.152
restecg	0.149917	0.033897	0.063905	0.149242	0.165046	0.068831	1.000000	-0.072290	0.081874	0.113726	0.135141	0.129
thalach	-0.394563	-0.060496	-0.339308	-0.049108	-0.000075	-0.007842	-0.072290	1.000000	-0.384368	-0.347640	-0.389307	0.268
exang	0.096489	0.143581	0.377525	0.066691	0.059339	-0.000893	0.081874	-0.384368	1.000000	0.289310	0.250572	0.148
oldpeak	0.197123	0.106567	0.203244	0.191243	0.038596	0.008311	0.113726	-0.347640	0.289310	1.000000	0.579037	0.294
slope	0.159405	0.033345	0.151079	0.121172	-0.009215	0.047819	0.135141	-0.389307	0.250572	0.579037	1.000000	0.109
ca	0.362210	0.091925	0.235644	0.097954	0.115945	0.152086	0.129021	-0.268727	0.148232	0.294452	0.109761	1.000
thal	0.120795	0.370556	0.266275	0.130612	0.023441	0.051038	0.013612	-0.258386	0.323268	0.336809	0.260096	0.248
target	0.227075	0.278467	0.408945	0.153490	0.080285	0.003167	0.166343	-0.423817	0.421355	0.424052	0.333049	0.463

In [17]:

```
plt.figure(figsize=(14,14))
sns.heatmap(corr,annot=True,cmap="magma",fmt='.2f')
```

Out[17]:

```
&lt;AxesSubplot:&gt;
```



In [18]:

```
eig_vals, eig_vecs = np.linalg.eig(corr)
```

Les valeurs et les vecteurs propres

In [19]:

```
eig_vals
```

Out[19]:

```
array([3.60824442, 1.62477356, 1.24279546, 1.14396226, 0.33018872,
       0.36787669, 0.43369218, 0.46465627, 0.56815364, 1.00165783,
       0.69627709, 0.77991321, 0.85726734, 0.88054134])
```

In [20]:

```
eig_vecs
```

Out[20]:

```
array([[ 0.24053549, -0.44322858,  0.01590806, -0.0741482 , -0.18610381,
         0.28517679,  0.48703716, -0.05519485,  0.14096228,  0.34875917,
         0.278374  ,  0.33506525,  0.21103358,  0.0890432 ],
       [ 0.1308981 ,  0.42802017, -0.49694338, -0.18694807,  0.13624242,
         0.07845948, -0.00207369, -0.55990004, -0.0125279 , -0.15053874,
         0.31516329,  0.15831411,  0.13298534,  0.12106471],
       [ 0.27378965,  0.13821378,  0.39789082, -0.290084  ,  0.10135065,
         0.03437627,  0.15210894, -0.39909199,  0.45044502,  0.03629891,
        -0.40503255, -0.04041831, -0.3137967 , -0.03512005],
       [ 0.14100437, -0.40381088, -0.30705922,  0.15706847,  0.18841602,
        -0.04806602, -0.21575188, -0.17109722, -0.03776823, -0.13025715,
        -0.3685335 ,  0.44205594, -0.01710464, -0.48430184],
       [ 0.07194476, -0.41319209,  0.2421796 , -0.28332722,  0.05886525,
        -0.03436179, -0.15520753, -0.19739628,  0.01576559, -0.39128305,
         0.45344171, -0.38467918,  0.11729685, -0.31108435],
       [ 0.05329646, -0.2526208 , -0.51315072, -0.05307562, -0.14813721,
        -0.0371158 , -0.033591  , -0.02035814,  0.08412007,  0.2754091 ,
         0.09947589, -0.37429105, -0.63928579,  0.02710342],
       [ 0.12980794, -0.26954322, -0.07889399, -0.0538794 ,  0.01037296,
        -0.12746657,  0.07508644,  0.16499134,  0.09208818, -0.62155422,
        -0.07816095,  0.19141162, -0.17265118,  0.62031266],
       [-0.35044615, -0.00688387, -0.23558664, -0.11135087, -0.09971641,
         0.45894129,  0.489587  , -0.00064329, -0.08455421, -0.32913401,
        -0.34180522, -0.27404459,  0.08917915, -0.18333285],
       [ 0.31004575,  0.1784161 ,  0.19630072, -0.06704487,  0.08099023,
         0.09999471,  0.26386412,  0.12567729, -0.62872779, -0.11829656,
         0.1641371 ,  0.18404435, -0.46368647, -0.20474805],
       [ 0.35426644,  0.01165261, -0.02174672,  0.4317407 , -0.35376447,
        -0.45755952,  0.30934834, -0.27759188, -0.16782489, -0.08153079,
        -0.14226281, -0.29226711,  0.19879453, -0.01524413],
       [ 0.30531715,  0.01528699,  0.03750405,  0.61465013,  0.37890029,
         0.51851505, -0.08610981,  0.02324582,  0.15585185, -0.07168975,
         0.094237  , -0.24452961, -0.0245327 ,  0.09089249],
       [ 0.29279267, -0.1616287 , -0.11186481, -0.35947467,  0.44051808,
        -0.0279748 , -0.03602805,  0.07608814, -0.3695096 ,  0.26644248,
        -0.3075966 , -0.29120856,  0.30642656,  0.2522744 ],
       [ 0.32774835,  0.24230132, -0.24875965, -0.13829209,  0.15403102,
        -0.22711695,  0.23272462,  0.55418818,  0.40849276, -0.10170505,
         0.1001274 , -0.04154491,  0.12604021, -0.33380266],
       [ 0.41771765,  0.11789585, -0.04102758, -0.18789179, -0.61033944,
         0.37284162, -0.44086169,  0.14835147, -0.03916411, -0.08180995,
        -0.15545243, -0.01394969,  0.11791075, -0.01561952]])
```

les valeurs propres superieurs a 1 sont 4: 3.60824442, 1.62477356, 1.24279546, 1.14396226 donc on va choisir 4 axes

Analyse ACP

In [21]:

```
pca = PCA(4)
acp = pca.fit_transform(df_cr)
```

In [22]:

```
pd.DataFrame(acp)
```

Out[22]:

	0	1	2	3
	0	1	2	3
0	-0.268497	2.642831	2.775324	0.891532
1	-1.084386	2.067849	0.143596	0.499909
2	0.071588	1.631391	-0.343179	3.919528
3	0.092195	2.091091	2.726380	0.363654
4	-0.315354	-0.208030	0.194892	1.573849
...	...	...	...	...
292	-0.757877	-1.616296	0.939875	-1.084579
293	0.426856	-2.520544	-0.088533	0.284633
294	1.243018	-3.225847	-0.462855	0.503797
295	-2.451173	-0.853468	-0.736412	0.631335
296	0.289072	-1.829236	-0.293664	-1.725770

297 rows × 4 columns

In [23]:

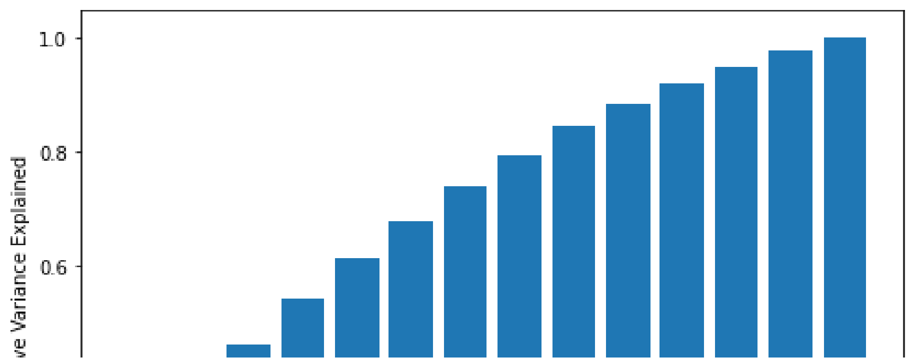
```
pca.components_
```

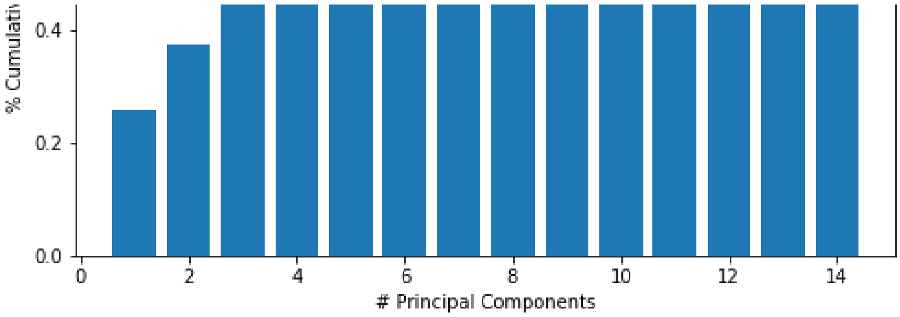
Out[23]:

```
array([[ 0.24053549,  0.1308981 ,  0.27378965,  0.14100437,  0.07194476,
         0.05329646,  0.12980794, -0.35044615,  0.31004575,  0.35426644,
         0.30531715,  0.29279267,  0.32774835,  0.41771765],
       [ 0.44322858, -0.42802017, -0.13821378,  0.40381088,  0.41319209,
         0.2526208 ,  0.26954322,  0.00688387, -0.1784161 , -0.01165261,
        -0.01528699,  0.1616287 , -0.24230132, -0.11789585],
       [-0.01590806,  0.49694338, -0.39789082,  0.30705922, -0.2421796 ,
         0.51315072,  0.07889399,  0.23558664, -0.19630072,  0.02174672,
        -0.03750405,  0.11186481,  0.24875965,  0.04102758],
       [-0.0741482 , -0.18694807, -0.290084  ,  0.15706847, -0.28332722,
        -0.05307562, -0.0538794 , -0.11135087, -0.06704487,  0.4317407 ,
         0.61465013, -0.35947467, -0.13829209, -0.18789179]])
```

In [24]:

```
pca = PCA(n_components=14)
pca.fit(df_cr)
X_pca = pca.transform(df_cr)
# Calculate cumulative explained variance across all PCs

cum_exp_var = []
var_exp = 0
for i in pca.explained_variance_ratio_:
    var_exp += i
    cum_exp_var.append(var_exp)

# Plot cumulative explained variance for all PCs

fig, ax = plt.subplots(figsize=(8,6))
ax.bar(list(range(1,15)), cum_exp_var)
ax.set_xlabel('# Principal Components')
ax.set_ylabel('% Cumulative Variance Explained');
```





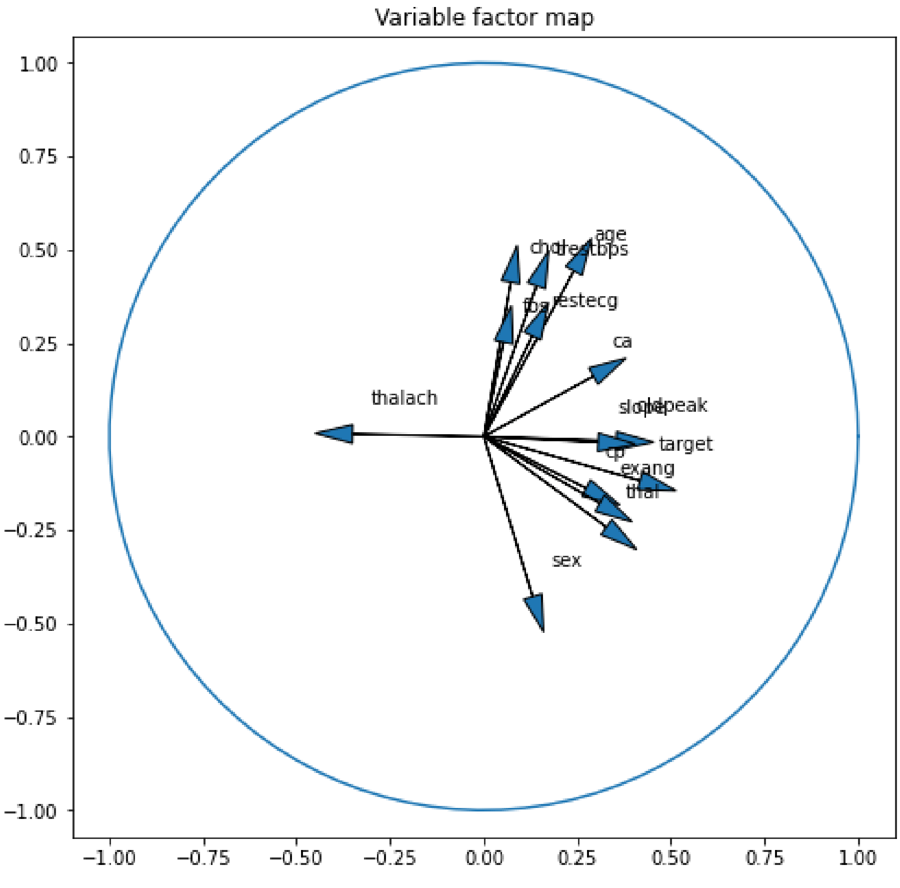
La contribtion commutative des 14 axes

In [25]:

```
def plot_circle(df,axe1,axe2):
  # Plot a variable factor map for the first two dimensions.
  (fig, ax) = plt.subplots(figsize=(8, 8))
  for i in range(0, pca.components_.shape[1]):
      ax.arrow(0,
              0,  # Start the arrow at the origin
              pca.components_[axe1, i],   #0 for PC1
              pca.components_[axe2, i],   #1 for PC2
              head_width=0.05,
              head_length=0.1)

      plt.text(pca.components_[axe1, i] + 0.05,
              pca.components_[axe2, i] + 0.08,
              df.columns.values[i])


  an = np.linspace(0, 2 * np.pi, 100)
  plt.plot(np.cos(an), np.sin(an))   # Add a unit circle for scale
  plt.axis('equal')
  ax.set_title('Variable factor map')
  plt.show()
```

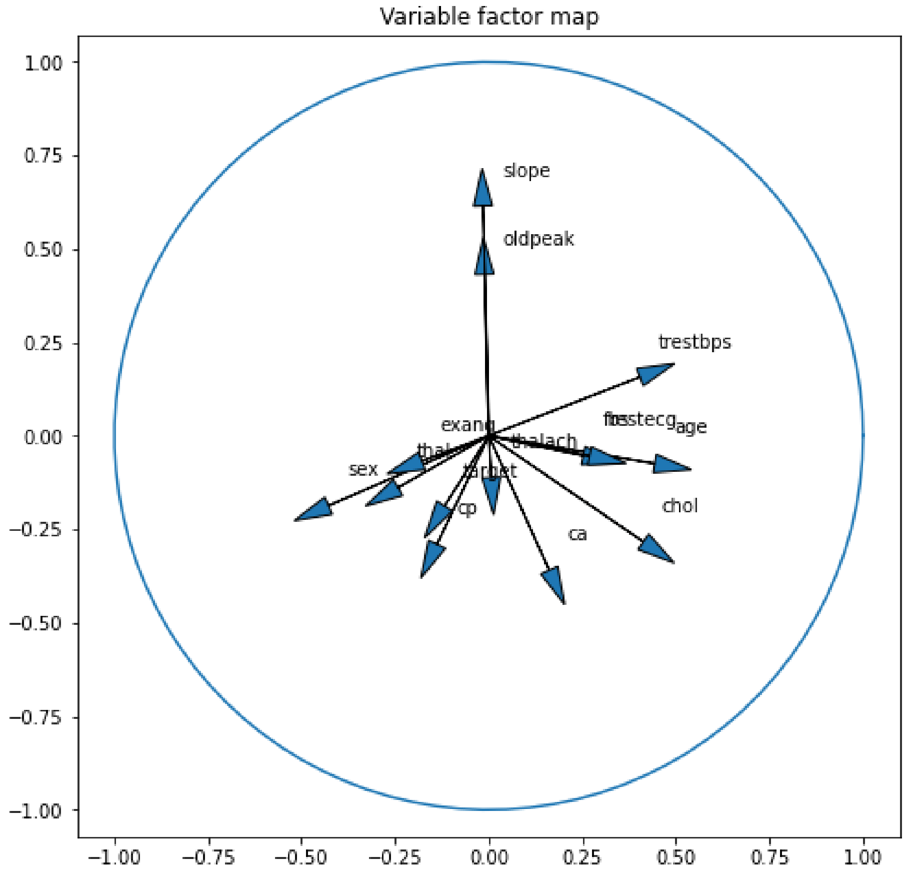
In [26]:

```
plot_circle(df,0,1)
```



In [27]:

```python
plot_circle(df,1,3)
```



In [28]:

```python
def plot_scatter(df,axe1,axe2,hue):
  return sns.scatterplot(data=df, x=axe1, y=axe2, hue=hue)
```

In [29]:

```python
acp =  pd.DataFrame(acp , columns=['axe1','axe2','axe3','axe4'])
```

In [30]:

```python
acp
```

Out[30]:

	axe1	axe2	axe3	axe4
0	-0.268497	2.642831	2.775324	0.891532
1	-1.084386	2.067849	0.143596	0.499909
2	0.071588	1.631391	-0.343179	3.919528
3	0.092195	2.091091	2.726380	0.363654
4	-0.315354	-0.208030	0.194892	1.573849
...	...	...	...	...
292	-0.757877	-1.616296	0.939875	-1.084579
293	0.426856	-2.520544	-0.088533	0.284633
294	1.243018	-3.225847	-0.462855	0.503797
295	-2.451173	-0.853468	-0.736412	0.631335
296	0.289072	-1.829236	-0.293664	-1.725770

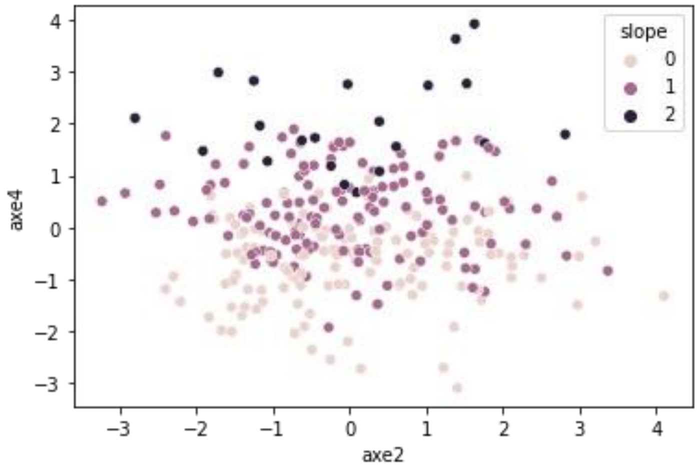
297 rows × 4 columns

In [31]:

```
plot_scatter(acp,"axe2","axe4",df["slope"])
```

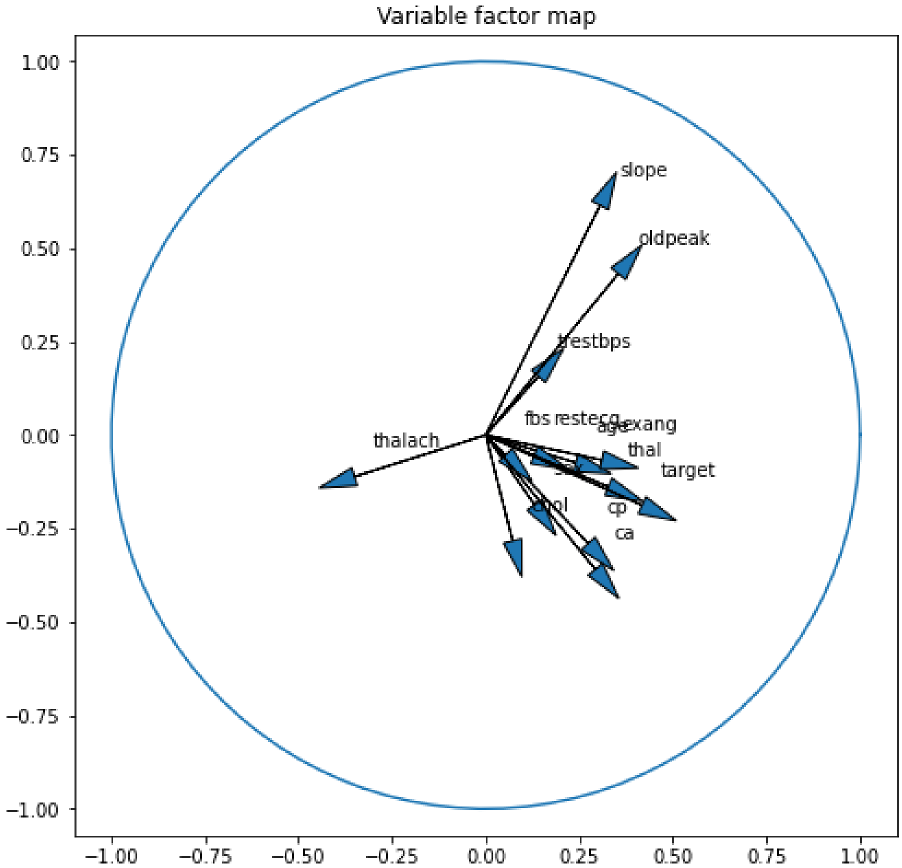
Out[31]:

```
<AxesSubplot:xlabel='axe2', ylabel='axe4'>
```



In [32]:

```
plot_circle(df,0,3)
```



Interpretation :

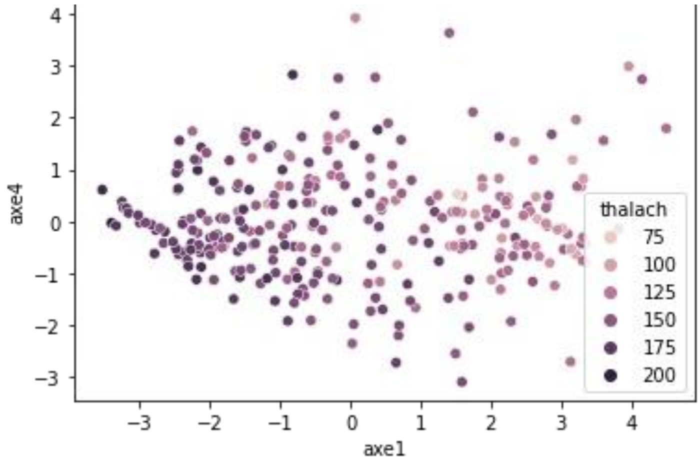
slope et old peak sont les plus représentés sur l'axe 4 sachant que le sens positive de l'axe 4 est vers le haut.

In [33]:

```
plot_scatter(acp,"axe1","axe4",df["thalach"])
```

Out[33]:

```
<AxesSubplot:xlabel='axe1', ylabel='axe4'>
```



Interpretation:

thalach est bien représenté sur l'axe1 et le sens positive de l'axe 1 est dirigé vers la gauche

Clustering K-means

In [34]:

```
from sklearn.cluster import KMeans
kmeans = KMeans(n_clusters=3, random_state=0).fit(acp)
```

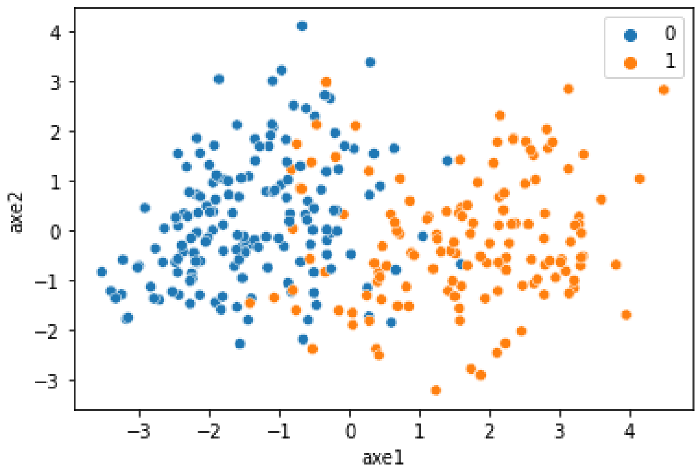
In [35]:

```
from sklearn.metrics import accuracy_score
```

In [36]:

```
print(plot_scatter(acp,'axe1','axe2',list(df['target'])))
```

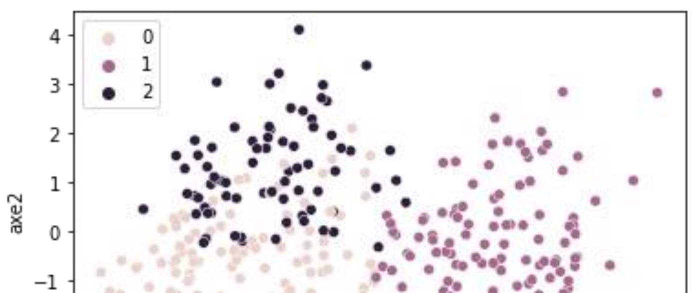
```
AxesSubplot(0.125,0.125;0.775x0.755)
```

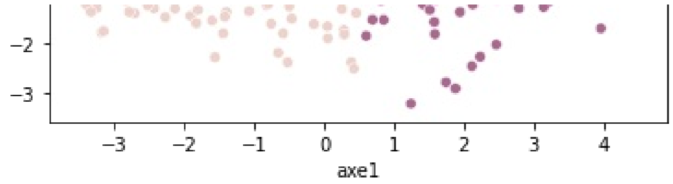


In [37]:

```
print(plot_scatter(acp,'axe1','axe2',kmeans.labels_))
```

```
AxesSubplot(0.125,0.125;0.775x0.755)
```





Conclusion :

En conclusion, ce projet nous a permis de nous servir de nos connaissances théoriques en analyse de données, de maîtriser l'aspect technique (programmation python) et de les mettre dans le cadre pratique. Ça nous a permis d'approfondir nos connaissances en Python et d'assimiler sa puissance qui est d'une syntaxe claire. Enfin, ce projet était le résultat d'une analyse d'une base de données Heart_Diseases et un partage des connaissances entre tous les membres de notre ce qui nous a permis d'absorber la pression et de constituer un noyau solide.

Réalisé par: Oumayma SAIDI Chaima MEZGAR Emna OUERGHI Oumayma REDISSI