sheet_01

April 26, 2017

1 Exercise sheet 1

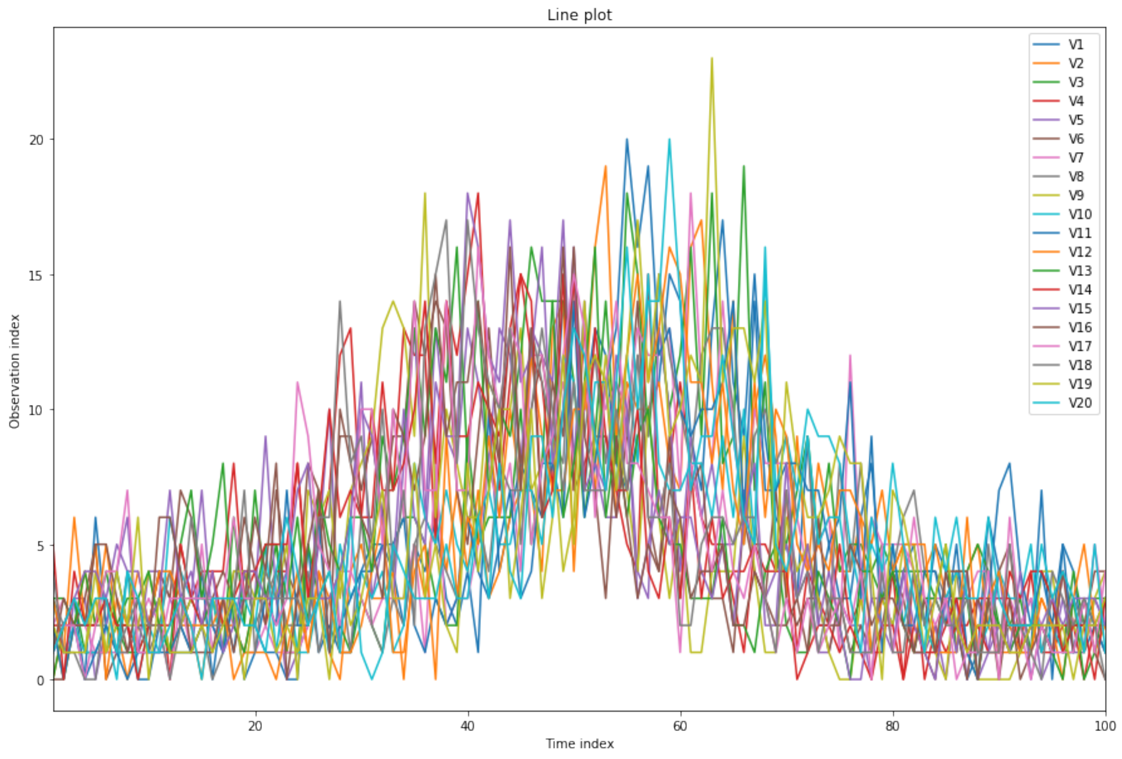
1.1 1.1 Scatter and Line Plots

1.1.1 (a) Importing libraries reading the data

```
In [61]: import numpy as np
         import matplotlib.pyplot as plt
         import pandas as pd

         # Reading the expDat.txt file using pandas.
         data = pd.read_csv("expDat.txt", sep=",", index_col=0)
```

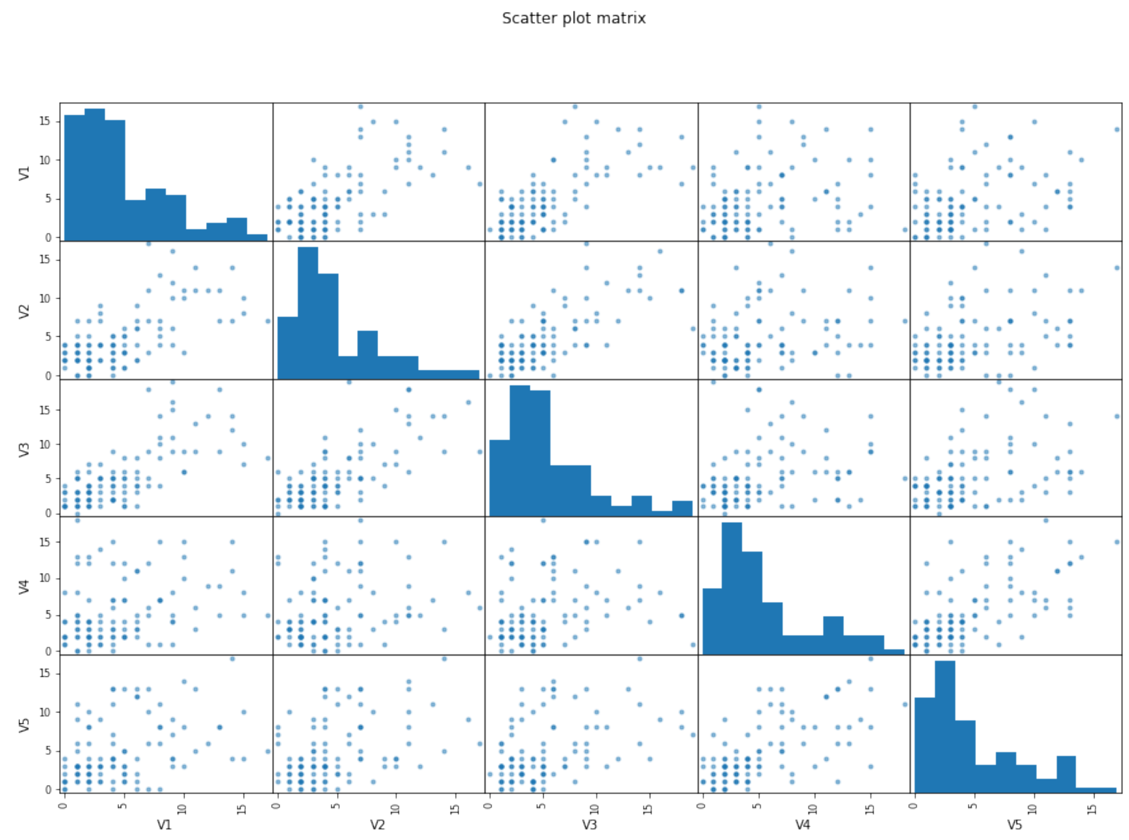
1.1.2 (b) Creating the line plot

```
In [62]: # Creating the line plot with the built-in DataFrame.plot function.
         data.plot(figsize=(15,10))
         plt.title("Line plot")
         plt.xlabel("Time index")
         plt.ylabel("Observation index")
         plt.show()
```



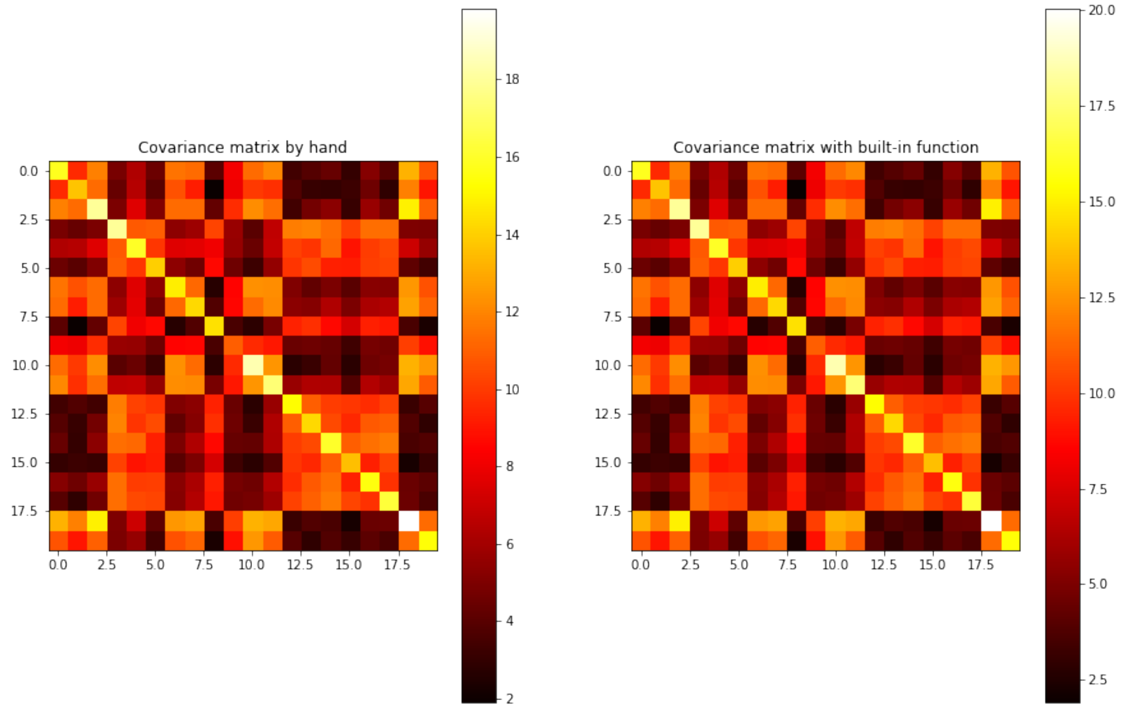
1.1.3 (c) Creating the scatter plot matrix

```
In [63]: from pandas.tools.plotting import scatter_matrix

         # Creating the scatter plot matrix from the first 5 observations.
         scatter_matrix(data.ix[:, 0:5], alpha=0.5,figsize=(15,10))
         plt.suptitle("Scatter plot matrix")
         plt.show()
```



1.1.4 (d) Computing of the covariance matrix and creating a heatplot

```
In [64]: # Computing the mean vector.
         meanVector = np.mean(data.values, 0)

         # Centering the data.
         centeredData = data.values - meanVector
         length = centeredData.shape[0]

         # Computing the covariance matrix by hand (using matrix multiplication).
         covarianceMatrix = np.dot(centeredData.T, centeredData) / length
         #print(covarianceMatrix)

         # Computing the covariance matrix with the built-in cov() function.
         covarianceMatrixBuiltIn = np.cov(centeredData.T)
         #print(covarianceMatrixBuiltIn)

         # Plotting the results on a heatplot.
         plt.figure(figsize=(15,10))
         plt.subplot(121)
         plt.imshow(covarianceMatrix, cmap='hot')
         plt.colorbar()
         plt.title("Covariance matrix by hand")

         plt.subplot(122)
         plt.imshow(covarianceMatrixBuiltIn, cmap='hot')
         plt.colorbar()
         plt.title("Covariance matrix with built-in function")

         plt.show()
```



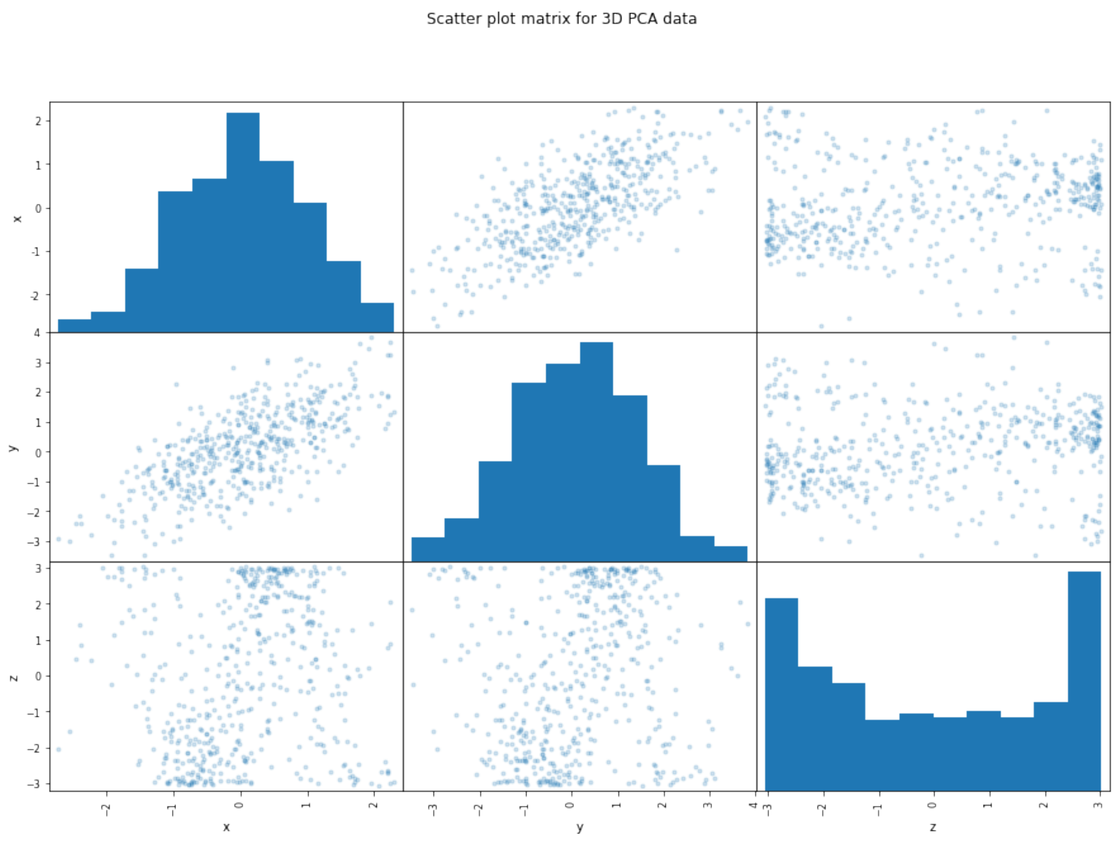
1.2 1.2 Plotting 3d

1.2.1 (a) Reading the data

```
In [65]: pcaData = pd.read_csv("pca-data-3d.txt", sep=",")
         #print(pcaData)
```

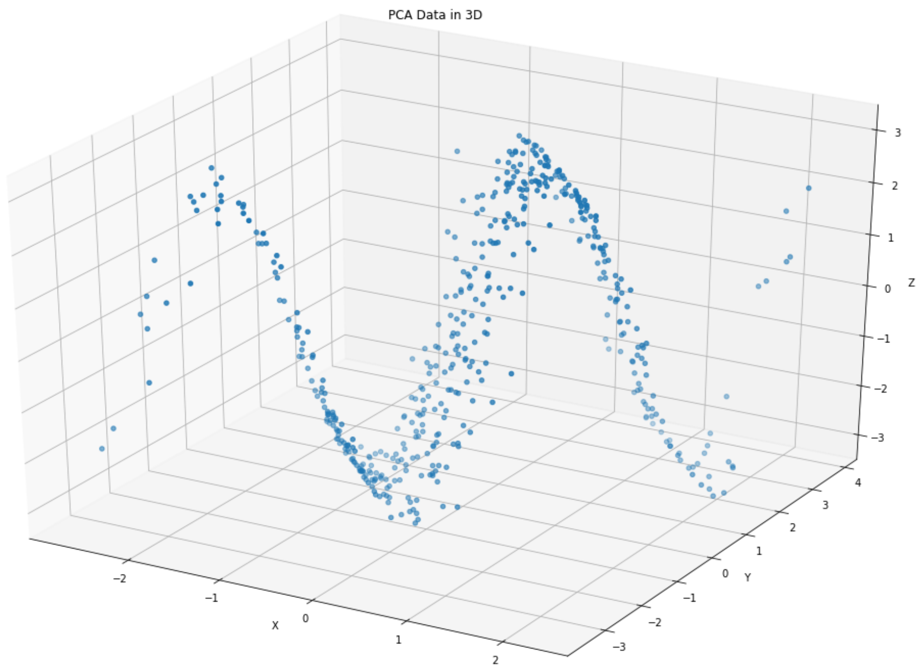
1.2.2 (b) Creating the scatter plot matrix

```
In [66]: # Same as exercise 1 but without any projection of the data.
         scatter_matrix(pcaData, alpha=0.2, figsize=(15,10))
         plt.suptitle("Scatter plot matrix for 3D PCA data")
         plt.show()
```



1.2.3 (c) Visualizing the data in 3D

```
In [67]: from mpl_toolkits.mplot3d import Axes3D

         # Creating a 3D scatter plot
         fig = plt.figure(figsize=(15,10));
         plot3D = Axes3D(fig)
         plot3D.scatter(pcaData["x"], pcaData["y"], pcaData["z"])
         plot3D.set_xlabel("X")
         plot3D.set_ylabel("Y")
         plot3D.set_zlabel("Z")
         plot3D.set_title("PCA Data in 3D")
         plt.show()
```

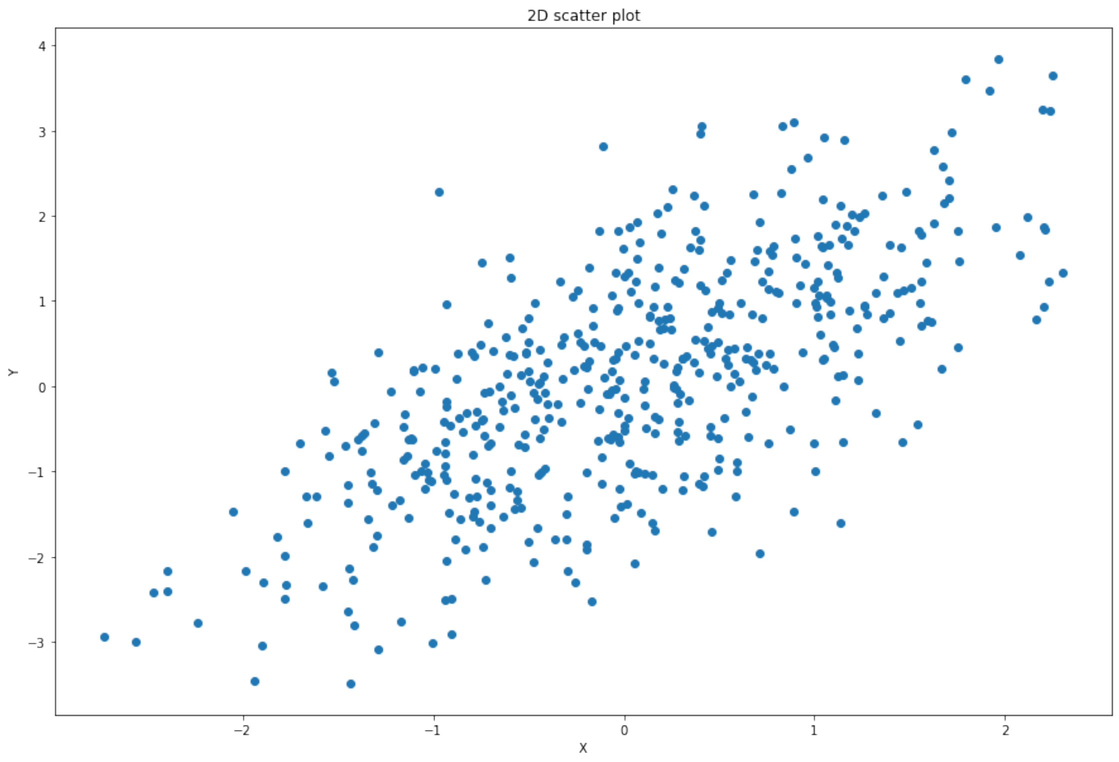


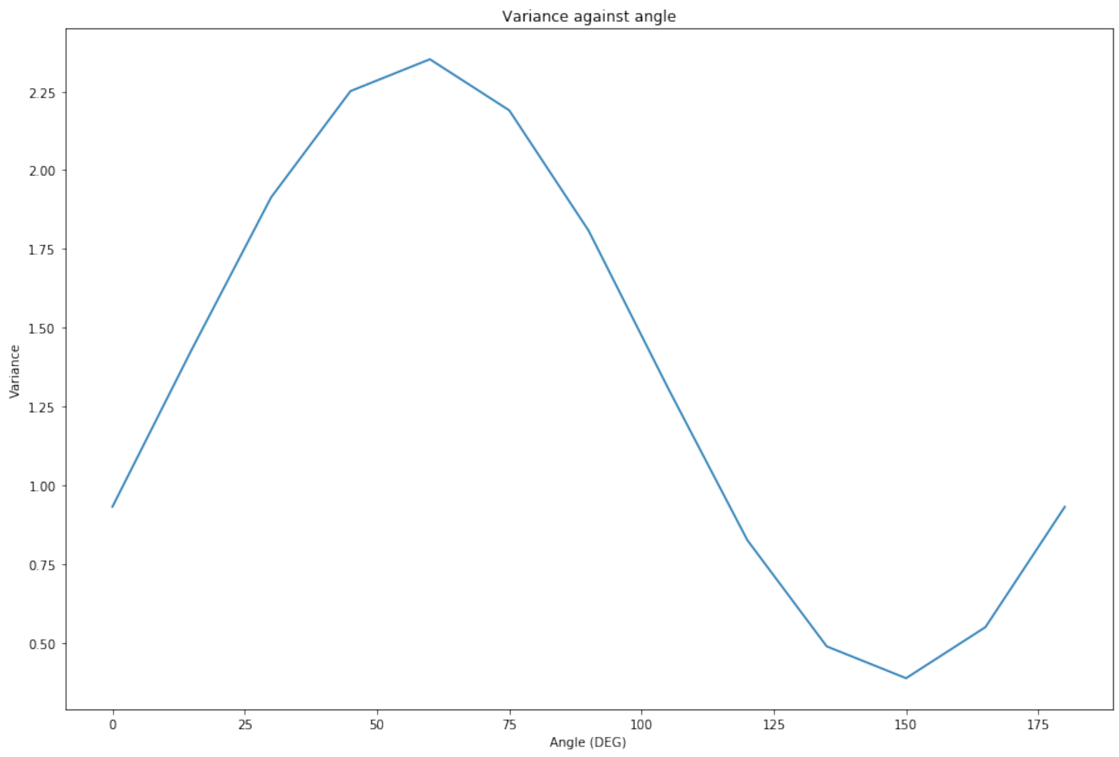
1.2.4 Interpretation: The given data describes a plane wave in the 3D space.

1.2.5 (d) Converting the data to 2D, projecting it to unit vector (0, 15 ... 180), variances against angles

```
In [68]: # Selecting the required dimensions.
         pcaData2D = pcaData.ix[:, 'x':'y']
         #print(pcaData2D)

         # Creating the scatter plot.
         plt.figure(figsize=(15,10))
         plt.scatter(pcaData2D['x'], pcaData2D['y'])
         plt.title("2D scatter plot")
         plt.xlabel("X")
         plt.ylabel("Y")
         plt.show()

         # Creating the angles (DEG only for later use). Linear sequence from 0, 15 ... 180 (1
         anglesCount = 13
         anglesDeg = np.linspace(0, 180, anglesCount)
         anglesRad = np.deg2rad(anglesDeg)
         #print(angles)
```

```
# Creating the vectors.
uv = np.zeros((13,2));
uv[:, 0] = np.cos(anglesRad)
uv[:, 1] = np.sin(anglesRad)

# Number of records.
count = pcaData2D.shape[0]

# Creating projections.
projections = np.zeros((count, anglesCount))
for i in range(0,anglesCount):
    # Multiplying the data with the vectors.
    projections[:,i] = np.dot(pcaData2D, uv[i])

# Calculating variances.
variances = np.var(projections, 0)

# Plotting the results.
plt.figure(figsize=(15,10))
plt.plot(anglesDeg, variances)
plt.title("Variance against angle")
plt.xlabel("Angle (DEG)")
plt.ylabel("Variance")
plt.show()
```





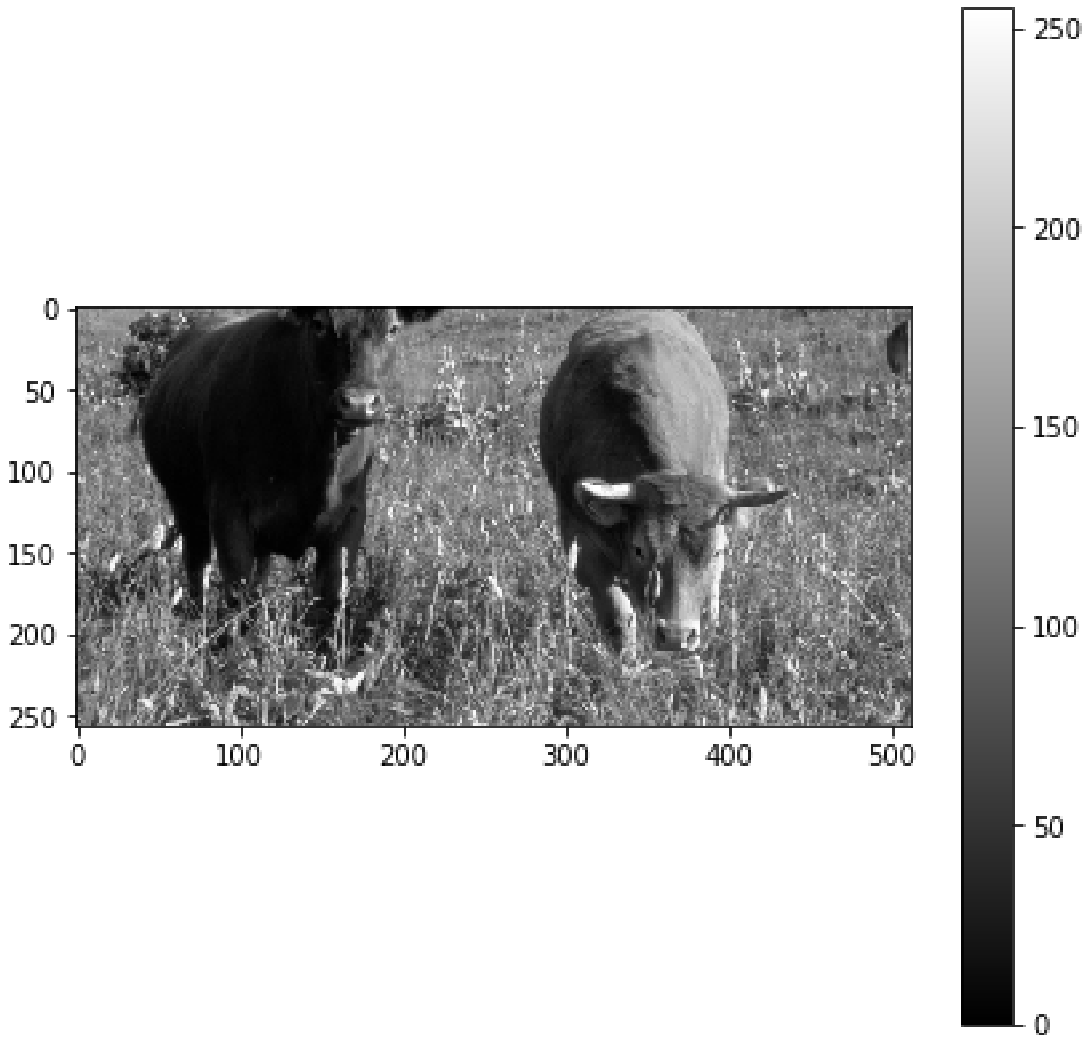
1.3 1.3 Data Processing: Image data

1.3.1 (a) Reading the image data

```
In [69]: from PIL import Image
         img = Image.open("natIMG.jpg")
         #print(img.getim())
```

1.3.2 (b) Plotting the image on a heatplot

```
In [70]: plt.figure(figsize=(7,7))
         plt.imshow(img, cmap='gray')
         plt.colorbar()
         plt.show()
```



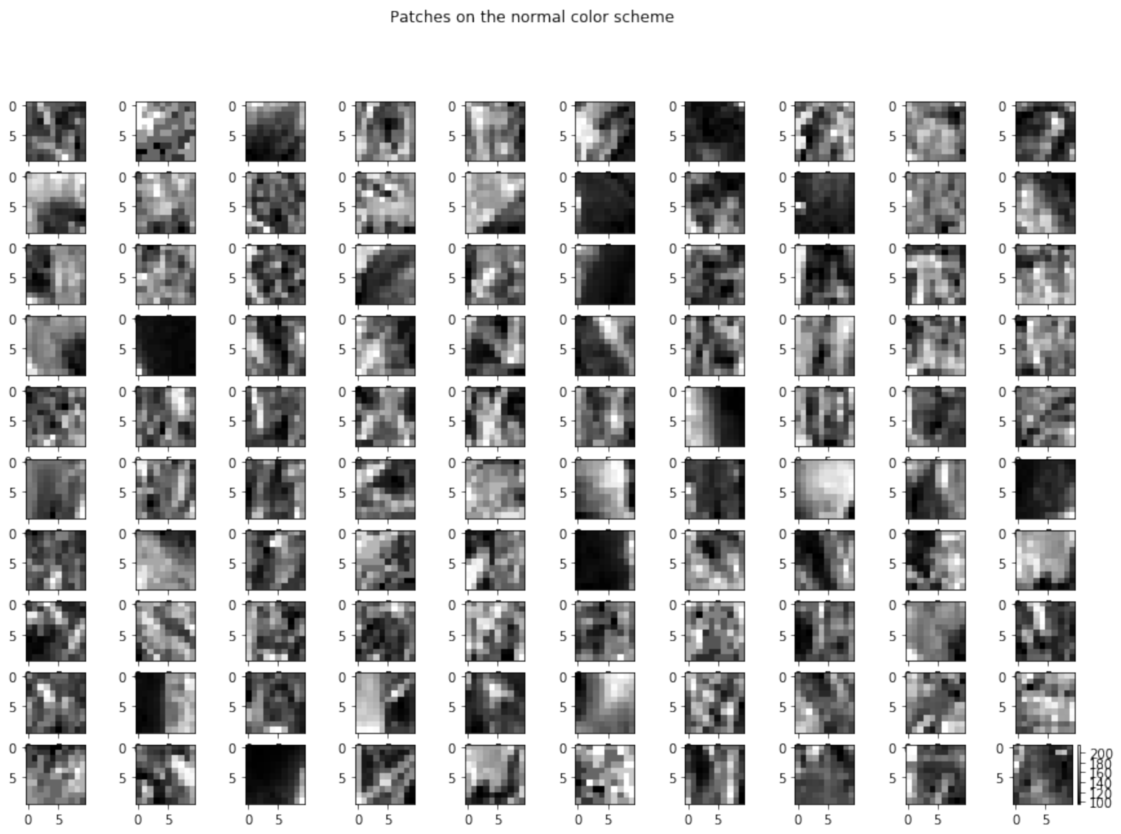
1.3.3 (c) Sampling image patches

```
In [71]: from sklearn.feature_extraction import image

         #Extracting 2D patches with the imported library. The loaded image must be converted
         imgArray = np.array(img)
         sampledPatches = image.extract_patches_2d(np.array(imgArray), (10,10), max_patches=10
         #print(samples)
```

1.3.4 (d)-(e) Plotting the patches on the same and on the inverted color scheme

```
In [72]: plt.figure(figsize=(15,10))
         # Patches on the same color scheme.
         # Subplot requires a number larger than 0 mind the indexes!
```

```
for i in range(1, 101):
    plt.subplot(10,10,i)
    plt.imshow(sampledPatches[i-1,:,:], cmap="gray")
plt.suptitle("Patches on the normal color scheme")
plt.colorbar()
plt.show()

plt.figure(figsize=(15,10))
# Patches on the inverted color scheme.
for i in range(1, 101):
    plt.subplot(10,10,i)
    plt.imshow(sampledPatches[i-1,:,:], cmap="Greys")
plt.suptitle("Patches on the inverted color scheme")
plt.colorbar()
plt.show()
```



Patches on the inverted color scheme

200
180
160
140
120
100