

## lab2

December 4, 2023

```
[1]: from matplotlib.image import imread
import matplotlib.pyplot as plt
import numpy as np

# Załadowanie obrazu
A = imread('4.webp')
X = np.mean(A,-1) # convert RGB to grayscale

# Pokazanie obrazu
img = plt.imshow(X)
img.set_cmap('gray')
plt.axis('off')
plt.show()
```



```
[2]: #SVD
U, S, VT = np.linalg.svd(X,full_matrices=False)

print("\n-----U-----\n")
print(U)
print("\n-----S-----\n")
print(S)
print("\n-----VT-----\n")
print(VT)
```

-----U-----

```
[[ 0.04246486  0.02647037  0.04576652 ... -0.10266961 -0.06829512
   -0.00959719]
 [ 0.04243974  0.02667179  0.0454259 ...  0.27718388  0.13059501
    0.0240936 ]
 [ 0.04241393  0.02687153  0.04511802 ... -0.25479413 -0.14123793
   -0.0436979 ]
 ...
 [ 0.04351011 -0.05806945  0.05096096 ... -0.00837429  0.02615645
   -0.04054143]
 [ 0.04358968 -0.05665683  0.05146187 ...  0.01558429 -0.02829799
    0.023056 ]
 [ 0.04363001 -0.05551785  0.0511997 ... -0.00629902  0.00917076
   -0.00324952]]
```

-----S-----

```
[1.04323662e+05 2.50347772e+04 1.09069272e+04 1.01497355e+04
 8.25480048e+03 7.88605980e+03 6.46145486e+03 5.36585612e+03
 5.14717467e+03 4.71949019e+03 4.23146680e+03 3.59774677e+03
 3.48220597e+03 3.30570844e+03 3.24266867e+03 3.18083310e+03
 3.04157032e+03 2.79010695e+03 2.63700923e+03 2.40783305e+03
 2.35777406e+03 2.18741870e+03 2.08792870e+03 2.02539496e+03
 1.86515164e+03 1.81151231e+03 1.72281158e+03 1.63002883e+03
 1.56185077e+03 1.49596560e+03 1.44930693e+03 1.36076823e+03
 1.27035923e+03 1.23253190e+03 1.18899591e+03 1.15916246e+03
 1.08671955e+03 1.07691014e+03 1.04232738e+03 9.84758026e+02
 9.39109214e+02 8.88129256e+02 8.76139646e+02 8.73614487e+02
 8.49734124e+02 8.19575687e+02 7.98530151e+02 7.82343718e+02
 7.48959612e+02 7.17495732e+02 6.98939199e+02 6.96494195e+02
 6.69038031e+02 6.50939951e+02 6.31318423e+02 6.13826968e+02
 6.03415889e+02 5.85277748e+02 5.58321685e+02 5.41268231e+02
 5.26841656e+02 5.24282599e+02 5.10897335e+02 5.00927417e+02
 4.88756008e+02 4.71417625e+02 4.67364279e+02 4.55295829e+02
 4.37250166e+02 4.32510092e+02 4.30019988e+02 4.16598324e+02
 4.13717021e+02 4.05773095e+02 4.00245672e+02 3.79061021e+02]
```

3.71145407e+02 3.70020767e+02 3.65562497e+02 3.57089540e+02  
 3.50910626e+02 3.38238644e+02 3.32453721e+02 3.29622357e+02  
 3.25906894e+02 3.17440612e+02 3.06450475e+02 2.98559914e+02  
 2.97081650e+02 2.88792147e+02 2.86693500e+02 2.82666783e+02  
 2.77180148e+02 2.73696231e+02 2.72619269e+02 2.68832226e+02  
 2.65038075e+02 2.59028358e+02 2.52527996e+02 2.49373259e+02  
 2.47225064e+02 2.43295650e+02 2.42025029e+02 2.41214171e+02  
 2.31964415e+02 2.29749251e+02 2.27550241e+02 2.24979849e+02  
 2.19569288e+02 2.17152868e+02 2.11017340e+02 2.08658009e+02  
 2.06691949e+02 2.02155071e+02 1.98342372e+02 1.96957032e+02  
 1.92616631e+02 1.91909291e+02 1.85527392e+02 1.84183318e+02  
 1.83455658e+02 1.79884929e+02 1.78110858e+02 1.76623816e+02  
 1.69218850e+02 1.68334026e+02 1.64662076e+02 1.59485367e+02  
 1.58617154e+02 1.57687147e+02 1.56299688e+02 1.55689148e+02  
 1.51929283e+02 1.48819417e+02 1.48072509e+02 1.46494975e+02  
 1.45086181e+02 1.39174050e+02 1.36988471e+02 1.35637775e+02  
 1.33961728e+02 1.33100701e+02 1.29739865e+02 1.27937704e+02  
 1.26197227e+02 1.25823921e+02 1.22818335e+02 1.21980015e+02  
 1.2022232e+02 1.18510416e+02 1.16880364e+02 1.14650799e+02  
 1.14359696e+02 1.13291180e+02 1.12526383e+02 1.09734820e+02  
 1.09456838e+02 1.07485911e+02 1.06952062e+02 1.05581865e+02  
 1.04101622e+02 1.03162956e+02 1.01606399e+02 1.00052154e+02  
 9.91131842e+01 9.82854844e+01 9.57754811e+01 9.54790396e+01  
 9.49423247e+01 9.44658512e+01 9.29184713e+01 9.16911141e+01  
 9.09519144e+01 8.90143205e+01 8.84380480e+01 8.79553197e+01  
 8.65307054e+01 8.50321796e+01 8.40232368e+01 8.38749562e+01  
 8.19661397e+01 8.17603697e+01 8.13182641e+01 8.04206257e+01  
 7.89930350e+01 7.84486549e+01 7.71461416e+01 7.66748804e+01  
 7.55063366e+01 7.51938353e+01 7.35204192e+01 7.31116458e+01  
 7.22342575e+01 7.18507060e+01 7.13424377e+01 7.08105097e+01  
 6.97433087e+01 6.94656040e+01 6.86090385e+01 6.81974588e+01  
 6.71058188e+01 6.60620529e+01 6.54416010e+01 6.51459451e+01  
 6.46777819e+01 6.42374633e+01 6.38396281e+01 6.30620725e+01  
 6.22054087e+01 6.16311995e+01 6.08358244e+01 6.01880386e+01  
 5.98951685e+01 5.91940707e+01 5.87348837e+01 5.84183356e+01  
 5.75459512e+01 5.65698178e+01 5.61617905e+01 5.55376190e+01  
 5.51113905e+01 5.48496655e+01 5.46157099e+01 5.41706390e+01  
 5.38208872e+01 5.31009190e+01 5.24030892e+01 5.20918502e+01  
 5.17594839e+01 5.10068417e+01 5.08710254e+01 5.07168119e+01  
 5.05296219e+01 5.00929864e+01 4.93014674e+01 4.90456664e+01  
 4.85975846e+01 4.85262200e+01 4.81565276e+01 4.78663017e+01  
 4.75102236e+01 4.71517165e+01 4.66680113e+01 4.61209232e+01  
 4.60515845e+01 4.54290281e+01 4.50206667e+01 4.49638741e+01  
 4.44668212e+01 4.42973178e+01 4.36754526e+01 4.34003123e+01  
 4.30178580e+01 4.26026295e+01 4.23731076e+01 4.19388666e+01  
 4.17695930e+01 4.13743199e+01 4.10034416e+01 4.07872932e+01  
 4.07492057e+01 4.02620946e+01 3.99656206e+01 3.97742162e+01  
 3.94642639e+01 3.92061729e+01 3.91195733e+01 3.88530210e+01

3.86714049e+01	3.78502692e+01	3.74738193e+01	3.73718106e+01
3.67551183e+01	3.65558375e+01	3.63334853e+01	3.62256531e+01
3.60596192e+01	3.59012439e+01	3.55755106e+01	3.54511004e+01
3.49373593e+01	3.48492344e+01	3.46072873e+01	3.43509177e+01
3.41917188e+01	3.41288455e+01	3.37993439e+01	3.31954041e+01
3.31468175e+01	3.29618159e+01	3.28748700e+01	3.26636909e+01
3.25706933e+01	3.21991404e+01	3.19593602e+01	3.18037998e+01
3.15554560e+01	3.13381350e+01	3.12500958e+01	3.10411018e+01
3.08930178e+01	3.05402330e+01	3.02180392e+01	2.99886839e+01
2.99203794e+01	2.93535685e+01	2.92236817e+01	2.91684229e+01
2.88132037e+01	2.86459212e+01	2.85288055e+01	2.83699499e+01
2.81824263e+01	2.77828226e+01	2.76437639e+01	2.73925240e+01
2.73015725e+01	2.71707216e+01	2.70541349e+01	2.67465461e+01
2.65689289e+01	2.63905180e+01	2.62413653e+01	2.60998649e+01
2.60367434e+01	2.59484748e+01	2.56427396e+01	2.55395494e+01
2.54788369e+01	2.51024647e+01	2.50511583e+01	2.48615558e+01
2.45901925e+01	2.42689257e+01	2.42230790e+01	2.40861107e+01
2.39019366e+01	2.37424490e+01	2.36967408e+01	2.35201297e+01
2.33805762e+01	2.31002826e+01	2.30201483e+01	2.27913010e+01
2.26686089e+01	2.25400664e+01	2.22371427e+01	2.20604871e+01
2.19134361e+01	2.17819234e+01	2.15533449e+01	2.14243311e+01
2.13746133e+01	2.12352529e+01	2.11337803e+01	2.10159246e+01
2.07057527e+01	2.06402758e+01	2.05157275e+01	2.03204992e+01
2.02602995e+01	2.01393035e+01	1.99864028e+01	1.99247150e+01
1.97649255e+01	1.96582035e+01	1.95494121e+01	1.95003395e+01
1.92237879e+01	1.91260321e+01	1.90350155e+01	1.88502291e+01
1.86970060e+01	1.85338196e+01	1.84653711e+01	1.83474316e+01
1.82047285e+01	1.80231785e+01	1.78223905e+01	1.77247262e+01
1.76362472e+01	1.75562948e+01	1.75171393e+01	1.73582474e+01
1.72321265e+01	1.70952957e+01	1.70096485e+01	1.69199498e+01
1.66399838e+01	1.65112194e+01	1.64748707e+01	1.62552095e+01
1.61897661e+01	1.61014298e+01	1.59493630e+01	1.57206958e+01
1.56829153e+01	1.56410269e+01	1.56012141e+01	1.55410576e+01
1.53614585e+01	1.52755703e+01	1.51195137e+01	1.50609684e+01
1.49252149e+01	1.47608116e+01	1.47174854e+01	1.46678478e+01
1.45472819e+01	1.44785749e+01	1.43311352e+01	1.41512311e+01
1.40426290e+01	1.39829565e+01	1.39202803e+01	1.38147175e+01
1.34904576e+01	1.33748075e+01	1.33502034e+01	1.32451574e+01
1.31828994e+01	1.29963799e+01	1.29286526e+01	1.28085279e+01
1.27504196e+01	1.26724209e+01	1.25779414e+01	1.24202813e+01
1.23171863e+01	1.22034570e+01	1.20987894e+01	1.20638507e+01
1.18902256e+01	1.18453975e+01	1.17611657e+01	1.16067153e+01
1.15436017e+01	1.15097586e+01	1.14290572e+01	1.13709869e+01
1.12592153e+01	1.11556226e+01	1.10195426e+01	1.09852245e+01
1.09085682e+01	1.07996631e+01	1.07323571e+01	1.06600089e+01
1.05881828e+01	1.05245824e+01	1.03747318e+01	1.02799140e+01
1.02492388e+01	1.01755995e+01	1.01317078e+01	9.99736861e+00
9.97947669e+00	9.88222132e+00	9.82520231e+00	9.79707159e+00

```

9.73563057e+00 9.59288405e+00 9.45214452e+00 9.42619546e+00
9.38342032e+00 9.21203701e+00 9.15710828e+00 9.13662637e+00
8.95947917e+00 8.85154034e+00 8.77946621e+00 8.74502820e+00
8.65545834e+00 8.62614726e+00 8.54222870e+00 8.50101878e+00
8.38170936e+00 8.34242116e+00 8.25625148e+00 8.22812666e+00
8.19681826e+00 7.97319119e+00 7.92984824e+00 7.90379966e+00
7.88115532e+00 7.74276349e+00 7.66510852e+00 7.55043874e+00
7.42655739e+00 7.42152260e+00 7.28543436e+00 7.18712650e+00
7.16797229e+00 7.10835064e+00 7.03225430e+00 7.01842415e+00
6.93313235e+00 6.83339151e+00 6.79000166e+00 6.66714546e+00
6.60026320e+00 6.58185257e+00 6.49987437e+00 6.43648512e+00
6.42121734e+00 6.29210549e+00 6.24070720e+00 6.19551137e+00
6.15347096e+00 6.08049013e+00 6.04776099e+00 5.98501025e+00
5.97107763e+00 5.91921155e+00 5.77310745e+00 5.75277107e+00
5.70647759e+00 5.63246087e+00 5.62112665e+00 5.52842943e+00
5.46194794e+00 5.42776097e+00 5.37441530e+00 5.29023227e+00
5.26982682e+00 5.19745206e+00 5.15893796e+00 5.11609277e+00
5.07007055e+00 5.00334251e+00 4.96267725e+00 4.93010812e+00
4.84647476e+00 4.80171750e+00 4.74670017e+00 4.72661214e+00
4.70623889e+00 4.66640319e+00 4.56115668e+00 4.54094187e+00
4.50180619e+00 4.43484083e+00 4.36048744e+00 4.33542370e+00
4.23113508e+00 4.19836562e+00 4.19092867e+00 4.14694364e+00
4.04714850e+00 3.98513425e+00 3.89989135e+00 3.89027858e+00
3.87212816e+00 3.83776355e+00 3.80724587e+00 3.76146168e+00
3.67296415e+00 3.58172018e+00 3.57032175e+00 3.54909209e+00
3.52003059e+00 3.46514048e+00 3.39842509e+00 3.34872913e+00
3.32572708e+00 3.31564337e+00 3.26456904e+00 3.24782119e+00
3.20130793e+00 3.15132072e+00 3.10776199e+00 3.07289026e+00
3.00278981e+00 2.96546813e+00 2.90704536e+00 2.87917855e+00
2.78592178e+00 2.75548734e+00 2.70786903e+00 2.68674226e+00
2.65965229e+00 2.60828727e+00 2.55570857e+00 2.48580793e+00
2.41590390e+00 2.37155862e+00 2.33833751e+00 2.30166445e+00
2.27936476e+00 2.21325674e+00 2.16847745e+00 2.11864867e+00
2.04744270e+00 1.99771246e+00 1.97650597e+00 1.91287885e+00
1.85437113e+00 1.72950281e+00 1.70160155e+00 1.63199262e+00]

```

-----VT-----

```

[[ 0.0243567  0.02437704 0.0244675 ... 0.0121046  0.01227022
   0.01242115]
 [-0.02884   -0.02866131 -0.02862609 ... -0.00411263 -0.0041195
  -0.00404142]
 [-0.02258857 -0.02319923 -0.02368514 ... 0.01281092  0.01132435
   0.00994165]
 ...
 [ 0.02838069  0.00927155 -0.00485208 ... 0.06073681 -0.01954413
  -0.00793317]
 [ 0.0028956  -0.07129952 -0.02868691 ... -0.0165202  0.08281594

```

```
-0.04815052]
[-0.01776116 -0.00352748  0.01518767 ...  0.00690174  0.03251321
-0.03355821]]
```

```
[3]: from numpy import diag

# Macierze korelacji

column_corr = X.T@X
column_corr2 = VT.T@diag(S)@diag(S)@VT
print("\nXT X\n")
print(column_corr)
print("\nXT X v2\n")
print(column_corr2)
row_corr = X.dot(X.T)
row_corr2 = U@diag(S)@diag(S)@U.T
print("\nX XT\n")
print(row_corr)
print("\nX XT v2\n")
print(row_corr2)

# Check
print("\n\n")
print("Same in case of columns: " + str(np.allclose(column_corr, column_corr2)))
print("Same in case of rows: " + str(np.allclose(row_corr, row_corr2)))

# draw
plt.figure(figsize=(12, 6))
plt.subplot(1, 2, 1)
plt.imshow(row_corr, cmap='viridis')
plt.title('Macierz korelacji wierszy')
plt.colorbar()

plt.subplot(1, 2, 2)
plt.imshow(column_corr, cmap='viridis')
plt.title('Macierz korelacji kolumn')
plt.colorbar()

plt.show()
```

-X<sup>T</sup> X

```
[[7374441.11111112 7375612.88888889 7394842.22222222 ... 3308839.77777778
 3359188.55555556 3403905.11111111]
 [7375612.88888889 7378118.22222222 7398104.11111111 ... 3311311.11111111
 3362088.77777778 3407225.11111111]
 [7394842.22222222 7398104.11111111 7419611.66666667 ... 3324295.11111111
```

3375619.77777778 3421243.88888889]

...

[3308839.77777778 3311311.11111111 3324295.11111111 ... 1690652.

1722830.88888889 1752838.44444444]

[3359188.55555556 3362088.77777778 3375619.77777778 ... 1722830.88888889

1764448. 1803344.55555556]

[3403905.11111111 3407225.11111111 3421243.88888889 ... 1752838.44444444

1803344.55555556 1851460.11111111]]

$X^T X$  v2

[7374441.11111135 7375612.888889 7394842.22222232 ... 3308839.77777783

3359188.55555561 3403905.11111117]

[7375612.888889 7378118.22222219 7398104.11111108 ... 3311311.11111109

3362088.77777776 3407225.11111109]

[7394842.22222232 7398104.11111108 7419611.66666662 ... 3324295.11111109

3375619.77777776 3421243.88888887]

...

[3308839.77777783 3311311.11111109 3324295.11111109 ... 1690652.

1722830.88888889 1752838.44444444]

[3359188.55555561 3362088.77777776 3375619.77777776 ... 1722830.88888889

1764448. 1803344.55555555]

[3403905.11111117 3407225.11111109 3421243.88888887 ... 1752838.44444444

1803344.55555555 1851460.11111111]]

$X X^T$

[20798723.66666668 20785178.44444445 20773207.66666667 ...

19452180.77777778 19533815.11111111 19586756.44444444]

[20785178.44444445 20772720.77777778 20761127.66666668 ...

19424126.33333334 19505532.55555555 19558306. ]

[20773207.66666667 20761127.66666668 20750038.77777778 ...

19396862. 19478067. 19530692.77777778]

...

[19452180.77777778 19424126.33333334 19396862. ...

24730156.77777778 24765105.33333334 24733205.44444445]

[19533815.11111111 19505532.55555555 19478067. ...

24765105.33333334 24863987.77777778 24870472.55555555]

[19586756.44444444 19558306. 19530692.77777778 ...

24733205.44444445 24870472.55555555 24918899.88888888]]

$X X^T$  v2

[20798723.66666665 20785178.44444438 20773207.66666666 ...

19452180.77777774 19533815.11111109 19586756.44444441]

[20785178.44444438 20772720.77777771 20761127.66666664 ...

19424126.33333326 19505532.55555548 19558305.99999991]

[20773207.66666666 20761127.66666663 20750038.77777778 ...

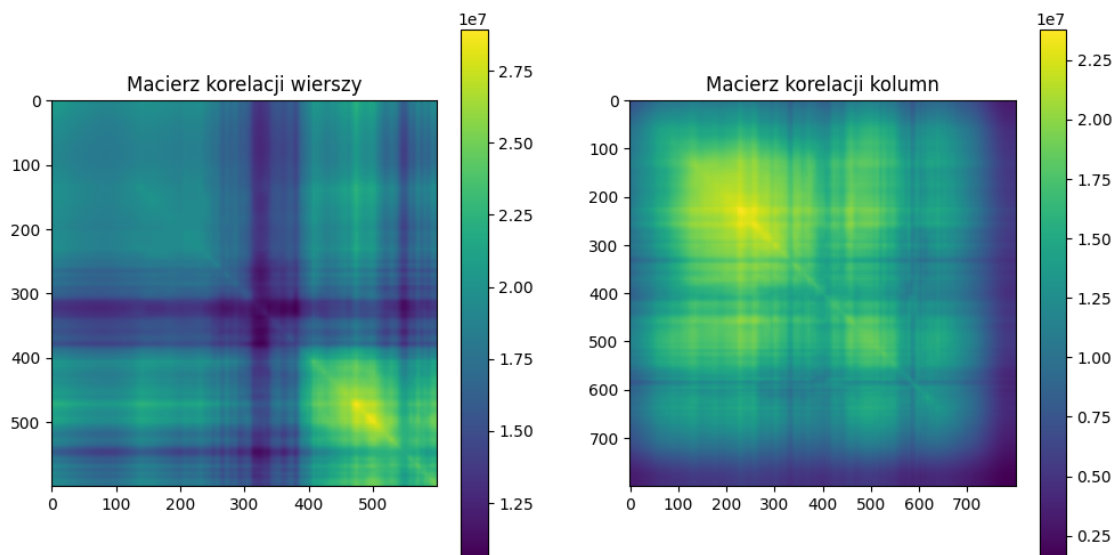
```

19396861.99999995 19478066.99999995 19530692.77777774]
...
[19452180.77777774 19424126.33333326 19396861.99999995 ...
 24730156.77777771 24765105.33333328 24733205.44444435]
[19533815.11111109 19505532.55555548 19478066.99999995 ...
 24765105.33333327 24863987.77777768 24870472.55555546]
[19586756.44444444 19558305.99999991 19530692.77777775 ...
 24733205.44444435 24870472.55555546 24918899.88888879]]

```

Same in case of columns: True

Same in case of rows: True



[ ]: