```
from matplotlib.image import imread
import matplotlib.pyplot as plt
import numpy as np

# Załadowanie obrazu
A = imread('6.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()
```

```
# SVD - zgodnie z instrukcją laboratoryjną (Laboratorium 1)
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---------

[[ 0.03827056  0.00511923 -0.0681607  ...  0.00092128 -0.03146677
  -0.00479087]
```

```
 [ 0.03851838  0.00475479 -0.06961474 ... -0.003659    0.02378435
  -0.04076328]
 [ 0.03884374  0.00465102 -0.07172339 ...  0.00154476 -0.00568541
   0.07167896]
 ...
 [ 0.05110583  0.01388481 -0.00516815 ... -0.00159466  0.01254205
  -0.01705734]
 [ 0.05111351  0.015694   -0.00602961 ...  0.00723665 -0.00358644
  -0.00053993]
 [ 0.0508587   0.0088493  -0.00532903 ...  0.0083397   0.00078224
   0.00917267]]

---------S---------

[7.89030298e+04 1.71820889e+04 1.56964955e+04 1.43865937e+04
 1.16647225e+04 8.04332491e+03 6.63354022e+03 6.03094293e+03
 5.38041268e+03 4.91913259e+03 4.68628093e+03 4.27529212e+03
 3.99871404e+03 3.65209269e+03 3.56374875e+03 3.34836442e+03
 3.26315449e+03 2.91376590e+03 2.72338416e+03 2.67923040e+03
 2.59843823e+03 2.56305428e+03 2.42264547e+03 2.36745043e+03
 2.24328294e+03 2.20528682e+03 2.17341909e+03 2.12640952e+03
 2.04136592e+03 1.98718447e+03 1.96854600e+03 1.94831580e+03
 1.90530279e+03 1.84742799e+03 1.76484078e+03 1.72058682e+03
 1.67106281e+03 1.64594135e+03 1.62913267e+03 1.62161889e+03
 1.57990310e+03 1.56358438e+03 1.53301608e+03 1.47672234e+03
 1.44584341e+03 1.41279501e+03 1.40654465e+03 1.36841337e+03
 1.35999169e+03 1.31711759e+03 1.30842680e+03 1.26802653e+03
 1.25266365e+03 1.24007778e+03 1.22255292e+03 1.20999298e+03
 1.19010458e+03 1.17923439e+03 1.16316871e+03 1.15060341e+03
 1.14208345e+03 1.13011637e+03 1.12054861e+03 1.10324170e+03
 1.09343748e+03 1.08712984e+03 1.05875289e+03 1.05001972e+03
 1.02875765e+03 1.02366714e+03 1.01967027e+03 1.00471212e+03
 9.90662868e+02 9.65488732e+02 9.62329904e+02 9.48250928e+02
 9.46462158e+02 9.33592035e+02 9.27926684e+02 9.27154083e+02
 9.17204769e+02 9.03699677e+02 9.00475435e+02 8.85488910e+02
 8.73788644e+02 8.71530914e+02 8.65790941e+02 8.55051166e+02
 8.46225058e+02 8.43960579e+02 8.32734177e+02 8.28575734e+02
 8.16800901e+02 8.07603659e+02 7.98322542e+02 7.94776146e+02
 7.90823203e+02 7.79599851e+02 7.70011166e+02 7.68598068e+02
 7.60807406e+02 7.52842506e+02 7.48940144e+02 7.41156500e+02
 7.39581767e+02 7.35951105e+02 7.33000383e+02 7.23156728e+02
 7.16882132e+02 7.12766831e+02 7.06916087e+02 7.00560561e+02
 6.97924801e+02 6.97336159e+02 6.87863740e+02 6.78492334e+02
 6.76469256e+02 6.73350648e+02 6.68104806e+02 6.62280996e+02
 6.60207048e+02 6.57479700e+02 6.50801023e+02 6.49230188e+02
 6.42324721e+02 6.37531557e+02 6.33525357e+02 6.28818406e+02
 6.26217394e+02 6.21662792e+02 6.16208609e+02 6.15109558e+02
 6.08083292e+02 6.06370382e+02 6.02168476e+02 5.97559441e+02
 5.90523206e+02 5.86790834e+02 5.83452874e+02 5.81682678e+02
```

5.76626066e+02 5.74768899e+02 5.71564772e+02 5.69240375e+02
5.65089846e+02 5.64073929e+02 5.58785393e+02 5.57635007e+02
5.55593516e+02 5.50766275e+02 5.47382453e+02 5.41949796e+02
5.37589023e+02 5.35635485e+02 5.30744236e+02 5.27768317e+02
5.23385498e+02 5.22589404e+02 5.18273210e+02 5.15253065e+02
5.14754469e+02 5.09228978e+02 5.06882363e+02 5.02986254e+02
5.00115325e+02 4.98424395e+02 4.95939652e+02 4.91092370e+02
4.89515641e+02 4.88891585e+02 4.86675110e+02 4.84490634e+02
4.77144323e+02 4.75580345e+02 4.71844334e+02 4.69213642e+02
4.66893982e+02 4.65282139e+02 4.60968113e+02 4.59391711e+02
4.56144309e+02 4.54214381e+02 4.50962669e+02 4.50214532e+02
4.47740669e+02 4.44232318e+02 4.42107372e+02 4.41347294e+02
4.38650807e+02 4.34398853e+02 4.32371446e+02 4.29931751e+02
4.27166154e+02 4.26363635e+02 4.21431113e+02 4.18965236e+02
4.15489820e+02 4.14501126e+02 4.11551876e+02 4.10745765e+02
4.08804692e+02 4.05337671e+02 4.03748591e+02 4.02202873e+02
3.99900310e+02 3.99098610e+02 3.95642046e+02 3.92876959e+02
3.91909939e+02 3.88473176e+02 3.86531220e+02 3.84226035e+02
3.81181138e+02 3.77966025e+02 3.75587098e+02 3.74910034e+02
3.72787703e+02 3.70200242e+02 3.69134940e+02 3.66562990e+02
3.63534612e+02 3.61978751e+02 3.59472528e+02 3.56485758e+02
3.53507893e+02 3.51485871e+02 3.49478627e+02 3.46353928e+02
3.45011890e+02 3.42377022e+02 3.40709317e+02 3.40137875e+02
3.38937606e+02 3.37093544e+02 3.35951650e+02 3.31085989e+02
3.30003622e+02 3.28945081e+02 3.27491850e+02 3.26097176e+02
3.23719963e+02 3.21582376e+02 3.19963502e+02 3.18909825e+02
3.17566292e+02 3.14909087e+02 3.13146521e+02 3.10340450e+02
3.07189907e+02 3.06052807e+02 3.02138026e+02 2.98817709e+02
2.97594348e+02 2.95778187e+02 2.95393957e+02 2.93211746e+02
2.90796826e+02 2.89469585e+02 2.88070855e+02 2.86779281e+02
2.83530966e+02 2.83186696e+02 2.82093188e+02 2.81119174e+02
2.78838663e+02 2.76944359e+02 2.75738027e+02 2.73227352e+02
2.72301109e+02 2.71148716e+02 2.68324736e+02 2.67122602e+02
2.66064405e+02 2.62068792e+02 2.61615645e+02 2.61292229e+02
2.59888491e+02 2.58534183e+02 2.57217589e+02 2.53800940e+02
2.51300646e+02 2.49380939e+02 2.49017396e+02 2.46195379e+02
2.45581912e+02 2.44127341e+02 2.42803967e+02 2.42602952e+02
2.37234364e+02 2.37111621e+02 2.36758715e+02 2.34828127e+02
2.34780840e+02 2.30065585e+02 2.29935867e+02 2.28019188e+02
2.27771733e+02 2.25783999e+02 2.23666946e+02 2.23478026e+02
2.22389209e+02 2.21304245e+02 2.20451621e+02 2.18921936e+02
2.17155542e+02 2.16216390e+02 2.14170218e+02 2.13155003e+02
2.10615974e+02 2.09750402e+02 2.08457900e+02 2.06247096e+02
2.05383272e+02 2.03783961e+02 2.03207302e+02 2.02481667e+02
2.01796500e+02 2.00525776e+02 1.98571084e+02 1.97377850e+02
1.94408396e+02 1.93682746e+02 1.91066578e+02 1.90341932e+02
1.89879847e+02 1.88548296e+02 1.86487824e+02 1.85077026e+02
1.84591283e+02 1.82811163e+02 1.81864780e+02 1.81603133e+02
1.80802004e+02 1.77495089e+02 1.76288511e+02 1.74824202e+02

1.74732911e+02 1.73622098e+02 1.72053712e+02 1.70761317e+02
1.68042742e+02 1.66975585e+02 1.65845850e+02 1.64488424e+02
1.64020980e+02 1.61122039e+02 1.60599154e+02 1.59879094e+02
1.58335102e+02 1.57941327e+02 1.56912978e+02 1.56313468e+02
1.54288102e+02 1.53932080e+02 1.52419050e+02 1.51246032e+02
1.50222780e+02 1.48898713e+02 1.48417932e+02 1.46769013e+02
1.46304138e+02 1.44684446e+02 1.43746228e+02 1.42451171e+02
1.41398810e+02 1.40521160e+02 1.39014791e+02 1.37294788e+02
1.36095648e+02 1.34779132e+02 1.33689970e+02 1.33485485e+02
1.32493288e+02 1.30564900e+02 1.29751508e+02 1.28241856e+02
1.27482269e+02 1.27092934e+02 1.26522547e+02 1.24761154e+02
1.23051638e+02 1.22756307e+02 1.20605298e+02 1.19611546e+02
1.18223620e+02 1.18060461e+02 1.17663274e+02 1.16996687e+02
1.16069853e+02 1.15942462e+02 1.13398574e+02 1.12864344e+02
1.12454929e+02 1.11877239e+02 1.08944095e+02 1.08370913e+02
1.08119735e+02 1.07619609e+02 1.06915423e+02 1.05232048e+02
1.04872285e+02 1.03562700e+02 1.03286723e+02 1.02726788e+02
1.01467006e+02 1.00127875e+02 9.91181054e+01 9.87914550e+01
9.75519319e+01 9.67392151e+01 9.56554362e+01 9.53834566e+01
9.45121880e+01 9.42608105e+01 9.28466327e+01 9.17830429e+01
9.10024868e+01 9.00531854e+01 8.92567362e+01 8.82151132e+01
8.78787264e+01 8.70119099e+01 8.60647796e+01 8.51219959e+01
8.43137064e+01 8.38913644e+01 8.26826729e+01 8.14992180e+01
8.06778077e+01 7.99833329e+01 7.92519741e+01 7.87356590e+01
7.82613480e+01 7.72436473e+01 7.70573862e+01 7.63187659e+01
7.54911865e+01 7.51074945e+01 7.43708950e+01 7.41952516e+01
7.30569747e+01 7.14970720e+01 7.08235500e+01 7.04755045e+01
6.96781495e+01 6.92419034e+01 6.89397918e+01 6.81743750e+01
6.66580811e+01 6.61968624e+01 6.59080261e+01 6.55080118e+01
6.41644224e+01 6.37548671e+01 6.28562095e+01 6.24151642e+01
6.17744923e+01 6.12254487e+01 6.05428758e+01 5.99026602e+01
5.89967039e+01 5.83332762e+01 5.76569110e+01 5.71170687e+01
5.63793144e+01 5.59277120e+01 5.54970023e+01 5.45224584e+01
5.39128330e+01 5.31805044e+01 5.24266947e+01 5.19298347e+01
5.15445701e+01 5.10263733e+01 5.04235022e+01 4.98036662e+01
4.93489060e+01 4.92976056e+01 4.82582392e+01 4.73266587e+01
4.67400346e+01 4.65911636e+01 4.57373074e+01 4.54744031e+01
4.45499508e+01 4.38098543e+01 4.34762764e+01 4.30529299e+01
4.24157634e+01 4.21451216e+01 4.18778595e+01 4.13769053e+01
4.12849303e+01 4.07372889e+01 4.05706025e+01 3.98636365e+01
3.89532977e+01 3.83146376e+01 3.75438902e+01 3.72591371e+01
3.68087862e+01 3.63272728e+01 3.60245117e+01 3.55359008e+01
3.50325618e+01 3.41492746e+01 3.39663577e+01 3.38062712e+01
3.28445207e+01 3.24569004e+01 3.17841254e+01 3.12650805e+01
3.10014901e+01 3.00587765e+01 2.98920646e+01 2.97987463e+01
2.91865291e+01 2.88492387e+01 2.82625761e+01 2.73599589e+01
2.70197711e+01 2.67063770e+01 2.59120528e+01 2.53091868e+01
2.42447133e+01 2.38254962e+01 2.31886688e+01 2.29148846e+01
2.20808819e+01 2.15009483e+01 2.08975791e+01 2.02230244e+01

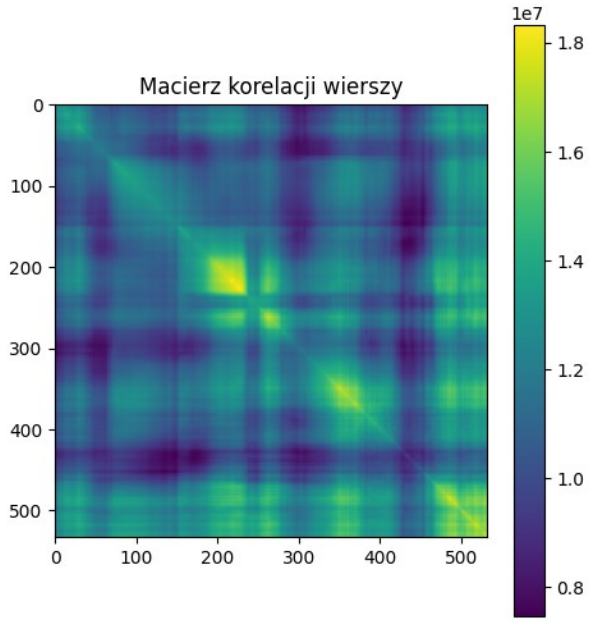
```
 1.96999328e+01]

---------VT---------

[[ 0.03732282  0.03739623  0.03762693 ...  0.0262997   0.0261801
   0.02572548]
 [ 0.00829946  0.00776736  0.00704683 ...  0.00514369  0.00572971
   0.0070719 ]
 [-0.00792226 -0.00741178 -0.00713816 ...  0.02335572  0.02440289
   0.0245425 ]
 ...
 [-0.01423511  0.02552233 -0.02041694 ...  0.03255586 -0.11515421
   0.07701148]
 [-0.06239599 -0.068784    0.04043476 ...  0.02009449 -0.03247172
   0.01153084]
 [ 0.00440375 -0.00023017  0.01717382 ... -0.02976363  0.04305937
  -0.08384458]]
```

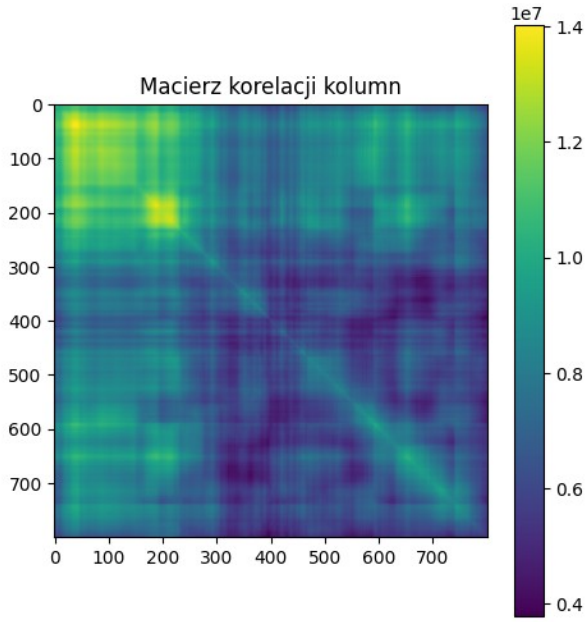
```python
from numpy import diag

# Macierze korelacji

# X^T X
column_corr = X.T@X
column_corr2 = VT.T@diag(S)@diag(S)@VT

print("\n---------X^T X---------\n")
print(column_corr)
print("\n---------X^T X v2---------\n")
print(column_corr2)

# X X^T
row_corr = X.dot(X.T)
row_corr2 = U@diag(S)@diag(S)@U.T

print("\n---------X X^T---------\n")
print(row_corr)
print("\n---------X X^T v2---------\n")
print(row_corr2)

# Sprawdźmy, czy uzyskaliśmy to samo w obu przypadkach
print("\n\n")
print("Czy w przypadku kolumn mamy to samo: " +
str(np.allclose(column_corr, column_corr2)))
print("Czy w przypadku wierszy mamy to samo: " +
str(np.allclose(row_corr, row_corr2)))

# Wyświetlenie macierzy
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^T X---------

[[ 9957525.44444445  9949192.          9968678.44444445 ...
   5861274.22222222  5836128.66666667  5743130.11111111]
 [ 9949192.          9975491.22222222  9999360.22222222 ...
   5886091.77777778  5861496.88888889  5767974.88888889]
 [ 9968678.44444445  9999360.22222222 10051039.44444445 ...
   5934464.66666667  5910389.88888889  5819107.        ]
 ...
 [ 5861274.22222222  5886091.77777778  5934464.66666667 ...
   5479527.44444444  5424996.44444444  5316523.88888889]
 [ 5836128.66666667  5861496.88888889  5910389.88888889 ...
   5424996.44444444  5423806.33333333  5310786.44444444]
 [ 5743130.11111111  5767974.88888889  5819107.         ...
   5316523.88888889  5310786.44444444  5256277.11111111]]

---------X^T X v2---------

[[ 9957525.44444415  9949191.99999988  9968678.44444429 ...
   5861274.22222209  5836128.66666654  5743130.11111099]
 [ 9949191.99999988  9975491.22222229  9999360.22222225 ...
   5886091.77777779  5861496.8888889   5767974.8888889 ]
 [ 9968678.44444429  9999360.22222225 10051039.44444444 ...
   5934464.66666665  5910389.88888888  5819106.99999999]
 ...
 [ 5861274.22222209  5886091.77777779  5934464.66666665 ...
   5479527.44444442  5424996.44444442  5316523.88888887]
 [ 5836128.66666654  5861496.8888889   5910389.88888888 ...
   5424996.44444442  5423806.33333331  5310786.44444442]
 [ 5743130.11111099  5767974.8888889   5819106.99999999 ...
   5316523.88888887  5310786.44444442  5256277.1111111 ]]

---------X X^T---------

[[12213272.66666667 12221834.22222222 12272492.55555555 ...
  12151929.77777778 12163371.33333334 12035921.33333334]
 [12221834.22222222 12279051.55555555 12329301.11111111 ...
```

```
  12246773.33333334 12251188.11111111 12131350.33333333]
 [12272492.55555555 12329301.11111111 12440822.88888889 ...
  12368542.55555556 12375023.11111111 12256537.44444444]
 ...
 [12151929.77777778 12246773.33333334 12368542.55555556 ...
  17636963.11111112 17381964.44444444 17183298.88888889]
 [12163371.33333334 12251188.11111111 12375023.11111111 ...
  17381964.44444444 17588782.00000001 17293751.44444444]
 [12035921.33333334 12131350.33333333 12256537.44444444 ...
  17183298.88888889 17293751.44444444 17456441.77777778]]

---------X X^T v2---------

[[12213272.6666667  12221834.22222231 12272492.55555557 ...
  12151929.7777778  12163371.33333336 12035921.33333335]
 [12221834.22222231 12279051.5555557  12329301.11111118 ...
  12246773.33333342 12251188.11111122 12131350.33333343]
 [12272492.55555557 12329301.11111118 12440822.88888889 ...
  12368542.55555556 12375023.11111112 12256537.44444445]
 ...
 [12151929.7777778  12246773.33333343 12368542.55555556 ...
  17636963.1111111  17381964.44444444 17183298.88888888]
 [12163371.33333336 12251188.11111122 12375023.11111112 ...
  17381964.44444444 17588782.00000002 17293751.44444445]
 [12035921.33333335 12131350.33333343 12256537.44444445 ...
  17183298.88888888 17293751.44444445 17456441.77777778]]



Czy w przypadku kolumn mamy to samo: True
Czy w przypadku wierszy mamy to samo: True
```


Macierz korelacji wierszy
1e7
1.8
1.6
1.4
1.2
1.0
0.8
0
100
200
300
400
500


Macierz korelacji kolumn
1e7
1.4
1.2
1.0
0.8
0.6
0.4
0
100
200
300
400
500
600
700