```python
import numpy as np
import scipy.io as io
import pandas as pd
import matplotlib.pyplot as plt

# DMD
def DMD(X,Xprime,r):
    U,Sigma,VT = np.linalg.svd(X,full_matrices=0) # Step 1
    Ur = U[:,:r]
    Sigmar = np.diag(Sigma[:r])
    VTr = VT[:r,:]
    Atilde = np.linalg.solve(Sigmar.T,(Ur.T @ Xprime @ VTr.T).T).T #
Step 2
    Lambda, W = np.linalg.eig(Atilde) # Step 3
    Lambda = np.diag(Lambda)

    Phi = Xprime @ np.linalg.solve(Sigmar.T,VTr).T @ W # Step 4
    alpha1 = Sigmar @ VTr[:,0]
    b = np.linalg.solve(W @ Lambda,alpha1)
    return Phi, Lambda, b

# Wczytanie danych z plików CSV
X = pd.read_table("War6_X.csv", delimiter=";", decimal=",")
Xprime = pd.read_table("War6_Xprime.csv", delimiter=";", decimal=",")

print(X)
```

```
     1  141,4006404  1585,896647  19329,12522  234533,5856
2850856,755  \
0    2   121.324479  1399.588645  16821.18305  204082.2508
2480136.321
1    3   126.958778  1659.448024  20099.95888  244546.9901
2971939.160
2    4   155.350214  1913.608991  23482.25446  284884.2838
3462338.507
3    5   144.444707  1956.567518  23511.63852  285655.4429
3470651.449
4    6   154.373523  1934.551838  23306.17053  283151.3239
3440725.238
5    7   133.863412  1759.765910  21453.04378  260750.9660
3168954.728
6    8   154.589049  1888.467817  23178.98281  281365.6415
3419513.605
7    9   110.448798  1459.212740  17731.03699  215473.8321
2618723.037
8   10   135.314272  1590.641515  19102.67259  232098.8343
2820932.911
9   11   153.898943  1790.554459  21855.75170  265848.9241
3231181.276
10  12   130.278526  1878.377536  22856.75663  277840.2310
```

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3138421.813
12  14   166.036149  1892.333410  22872.76961  278119.0941
3379983.575
13  15   154.396428  1836.356525  22478.03940  273384.0629
3322346.514
14  16   179.940650  2134.509977  26017.37798  316119.8715
3841917.083
15  17   166.816387  1897.122102  22981.31844  279462.6577
3396746.335
16  18   172.162580  2042.155658  24966.00858  303415.7978
3687133.865
17  19   142.463824  1535.628466  18791.08902  228642.7877
2778980.288
18  20   130.429452  1558.588524  19228.87223  233569.2974
2838632.342
19  21   128.496475  1552.269177  19024.13842  231697.6599
2815532.690
20  22   144.901744  1852.777816  22521.30885  273806.2114
3327313.385
21  23   142.666221  1771.934913  21256.97231  258499.6074
3141269.611

    34645425,02  421042366,3  5116871155  62184675831  ...
1,7109E+29  \
0   30140926.21  366299219.4  4451586321  54099552272  ...
1.488450e+29
1   36118019.65  438936913.5  5334344039  64827591083  ...
1.783610e+29
2   42077300.27  511361394.7  6214507661  75524107648  ...
2.077910e+29
3   42178750.49  512592368.7  6229470653  75705948254  ...
2.082910e+29
4   41815519.02  508177971.0  6175822400  75053967148  ...
2.064970e+29
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2.052170e+29
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1.571610e+29
8   34282698.87  416633257.2  5063288719  61533493073  ...
1.692980e+29
9   39268098.59  477220111.3  5799593458  70481708183  ...
1.939180e+29
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1.996890e+29
21  38176026.48  463947591.1  5638296398  68521484542  ...
1.885240e+29

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4,53543E+34  \
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3.945740e+34
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4.728190e+34
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5.508340e+34
3   2.531340e+30  3.076300e+31  3.738590e+32  4.543460e+33
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5.474050e+34
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5.041610e+34
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5.440110e+34
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4.166200e+34
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5.370780e+34
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4.515970e+34
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5.293570e+34
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4.997600e+34

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21  6.073520e+35  7.381080e+36  8.970130e+37  1.090130e+39

[22 rows x 36 columns]

# Convert to matrix
X = np.matrix(X)
Xprime = np.matrix(Xprime)
```

```
print(X)
```

```
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  4.45158632e+09 5.40995523e+10 6.57465000e+11 7.99009000e+12
  9.71025000e+13 1.18007000e+15 1.43413000e+16 1.74288000e+17
  2.11810000e+18 2.57410000e+19 3.12826000e+20 3.80174000e+21
  4.62021000e+22 5.61488000e+23 6.82369000e+24 8.29274000e+25
  1.00781000e+27 1.22477000e+28 1.48845000e+29 1.80889000e+30
  2.19833000e+31 2.67160000e+32 3.24676000e+33 3.94574000e+34
  4.79521000e+35 5.82756000e+36 7.08216000e+37 8.60685000e+38]
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  5.33434404e+09 6.48275911e+10 7.87841000e+11 9.57453000e+12
  1.16358000e+14 1.41408000e+15 1.71852000e+16 2.08849000e+17
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  5.53640000e+22 6.72832000e+23 8.17683000e+24 9.93720000e+25
  1.20766000e+27 1.46765000e+28 1.78361000e+29 2.16760000e+30
  2.63426000e+31 3.20138000e+32 3.89060000e+33 4.72819000e+34
  5.74611000e+35 6.98317000e+36 8.48656000e+37 1.03136000e+39]
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  3.06891000e+31 3.72961000e+32 4.53254000e+33 5.50834000e+34
  6.69421000e+35 8.13539000e+36 9.88684000e+37 1.20153000e+39]
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  6.46543000e+22 7.85736000e+23 9.54894000e+24 1.16047000e+26
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 1.28771000e+27 1.56493000e+28 1.90184000e+29 2.31129000e+30
 2.80888000e+31 3.41359000e+32 4.14849000e+33 5.04161000e+34
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 6.29647000e+22 7.65201000e+23 9.29939000e+24 1.13014000e+26
 1.37345000e+27 1.66913000e+28 2.02848000e+29 2.46518000e+30
 2.99590000e+31 3.64088000e+32 4.42472000e+33 5.37730000e+34
 6.53497000e+35 7.94186000e+36 9.65164000e+37 1.17295000e+39]
[1.50000000e+01 1.54396428e+02 1.83635652e+03 2.24780394e+04
 2.73384063e+05 3.32234651e+06 4.03754939e+07 4.90678383e+08
 5.96315101e+09 7.24694027e+10 8.80711000e+11 1.07032000e+13
 1.30074000e+14 1.58078000e+15 1.92110000e+16 2.33468000e+17
 2.83731000e+18 3.44815000e+19 4.19049000e+20 5.09264000e+21
 6.18903000e+22 7.52144000e+23 9.14071000e+24 1.11086000e+26
 1.35001000e+27 1.64065000e+28 1.99386000e+29 2.42312000e+30
 2.94478000e+31 3.57876000e+32 4.34922000e+33 5.28555000e+34
 6.42346000e+35 7.80634000e+36 9.48695000e+37 1.15294000e+39]
[1.60000000e+01 1.79940650e+02 2.13450998e+03 2.60173780e+04
 3.16119872e+05 3.84191708e+06 4.66900663e+07 5.67418585e+08
 6.89576400e+09 8.38033279e+10 1.01845000e+12 1.23771000e+13
 1.50417000e+14 1.82800000e+15 2.22155000e+16 2.69982000e+17
 3.28105000e+18 3.98742000e+19 4.84586000e+20 5.88911000e+21
 7.15696000e+22 8.69777000e+23 1.05703000e+25 1.28459000e+26
 1.56115000e+27 1.89724000e+28 2.30570000e+29 2.80208000e+30
 3.40533000e+31 4.13846000e+32 5.02942000e+33 6.11218000e+34
 7.42806000e+35 9.02722000e+36 1.09707000e+38 1.33325000e+39]
[1.70000000e+01 1.66816387e+02 1.89712210e+03 2.29813184e+04
 2.79462658e+05 3.39674633e+06 4.12798825e+07 5.01668823e+08
 6.09671623e+09 7.40926045e+10 9.00438000e+11 1.09429000e+13
 1.32988000e+14 1.61618000e+15 1.96413000e+16 2.38698000e+17
 2.90086000e+18 3.52538000e+19 4.28435000e+20 5.20671000e+21
 6.32765000e+22 7.68991000e+23 9.34545000e+24 1.13574000e+26
 1.38025000e+27 1.67740000e+28 2.03852000e+29 2.47739000e+30
 3.01074000e+31 3.65891000e+32 4.44663000e+33 5.40393000e+34
 6.56733000e+35 7.98119000e+36 9.69944000e+37 1.17876000e+39]
[1.80000000e+01 1.72162580e+02 2.04215566e+03 2.49660086e+04
```

```
 3.03415798e+05 3.68713387e+06 4.48090630e+07 5.44559030e+08
 6.61795556e+09 8.04271571e+10 9.77421000e+11 1.18785000e+13
 1.44357000e+14 1.75436000e+15 2.13205000e+16 2.59105000e+17
 3.14887000e+18 3.82678000e+19 4.65064000e+20 5.65186000e+21
 6.86863000e+22 8.34736000e+23 1.01444000e+25 1.23284000e+26
 1.49826000e+27 1.82081000e+28 2.21281000e+29 2.68920000e+30
 3.26814000e+31 3.97173000e+32 4.82680000e+33 5.86594000e+34
 7.12881000e+35 8.66354000e+36 1.05287000e+38 1.27954000e+39]
[1.90000000e+01 1.42463824e+02 1.53562847e+03 1.87910890e+04
 2.28642788e+05 2.77898029e+06 3.37724589e+07 4.10432005e+08
 4.98792748e+09 6.06176364e+10 7.36678000e+11 8.95276000e+12
 1.08802000e+14 1.32225000e+15 1.60692000e+16 1.95286000e+17
 2.37329000e+18 2.88423000e+19 3.50517000e+20 4.25979000e+21
 5.17686000e+22 6.29137000e+23 7.64582000e+24 9.29187000e+25
 1.12923000e+27 1.37234000e+28 1.66778000e+29 2.02684000e+30
 2.46319000e+31 2.99348000e+32 3.63794000e+33 4.42114000e+34
 5.37295000e+35 6.52968000e+36 7.93544000e+37 9.64383000e+38]
[2.00000000e+01 1.30429452e+02 1.55858852e+03 1.92288722e+04
 2.33569297e+05 2.83863234e+06 3.44967803e+07 4.19235663e+08
 5.09491574e+09 6.19178534e+10 7.52480000e+11 9.14479000e+12
 1.11135000e+14 1.35061000e+15 1.64138000e+16 1.99475000e+17
 2.42420000e+18 2.94610000e+19 3.58035000e+20 4.35116000e+21
 5.28790000e+22 6.42632000e+23 7.80982000e+24 9.49118000e+25
 1.15345000e+27 1.40177000e+28 1.70356000e+29 2.07031000e+30
 2.51602000e+31 3.05769000e+32 3.71597000e+33 4.51597000e+34
 5.48820000e+35 6.66974000e+36 8.10565000e+37 9.85069000e+38]
[2.10000000e+01 1.28496475e+02 1.55226918e+03 1.90241384e+04
 2.31697660e+05 2.81553269e+06 3.42166035e+07 4.15829390e+08
 5.05352178e+09 6.14147954e+10 7.46366000e+11 9.07049000e+12
 1.10232000e+14 1.33964000e+15 1.62805000e+16 1.97855000e+17
 2.40450000e+18 2.92216000e+19 3.55126000e+20 4.31580000e+21
 5.24494000e+22 6.37411000e+23 7.74637000e+24 9.41407000e+25
 1.14408000e+27 1.39038000e+28 1.68972000e+29 2.05349000e+30
 2.49558000e+31 3.03285000e+32 3.68578000e+33 4.47928000e+34
 5.44361000e+35 6.61555000e+36 8.03979000e+37 9.77065000e+38]
[2.20000000e+01 1.44901744e+02 1.85277782e+03 2.25213089e+04
 2.73806211e+05 3.32731338e+06 4.04368175e+07 4.91423238e+08
 5.97220379e+09 7.25794176e+10 8.82048000e+11 1.07194000e+13
 1.30272000e+14 1.58318000e+15 1.92401000e+16 2.33823000e+17
 2.84162000e+18 3.45338000e+19 4.19685000e+20 5.10038000e+21
 6.19842000e+22 7.53286000e+23 9.15459000e+24 1.11255000e+26
 1.35206000e+27 1.64314000e+28 1.99689000e+29 2.42680000e+30
 2.94925000e+31 3.58419000e+32 4.35582000e+33 5.29357000e+34
 6.43321000e+35 7.81819000e+36 9.50135000e+37 1.15469000e+39]
[2.30000000e+01 1.42666221e+02 1.77193491e+03 2.12569723e+04
 2.58499607e+05 3.14126961e+06 3.81760265e+07 4.63947591e+08
 5.63829640e+09 6.85214845e+10 8.32733000e+11 1.01201000e+13
 1.22988000e+14 1.49466000e+15 1.81644000e+16 2.20750000e+17
 2.68274000e+18 3.26030000e+19 3.96220000e+20 4.81521000e+21
```

```
  5.85187000e+22 7.11170000e+23 8.64275000e+24 1.05034000e+26
  1.27647000e+27 1.55127000e+28 1.88524000e+29 2.29111000e+30
  2.78436000e+31 3.38380000e+32 4.11228000e+33 4.99760000e+34
  6.07352000e+35 7.38108000e+36 8.97013000e+37 1.09013000e+39]]
```

```
# Obliczenie macierzy A
Phi, Lambda, b = DMD(X[:,:-1],Xprime[:,1:],5)

print("Phi:", Phi)
print("Lambda: ", Lambda)
print("b:", b)

print("Phi shape:", Phi.shape)
```

```
Phi: [[ -24.36076299  +0.j          -31.86669499  -5.12644821j
   -31.86669499  +5.12644821j   -6.28103261  -7.39061412j
    -6.28103261  +7.39061412j]
 [ -29.19154814  +0.j          -18.18293858 +14.69915503j
   -18.18293858 -14.69915503j  -23.36994581  -3.55337804j
   -23.36994581  +3.55337804j]
 [ -34.00813244  +0.j         -108.71694814  +8.21642082j
  -108.71694814  -8.21642082j  -45.69937817  +3.24225123j
   -45.69937817  -3.24225123j]
 [ -34.09003042  +0.j          -20.53561112+106.41305862j
   -20.53561112-106.41305862j   20.04466609 -42.88210017j
    20.04466609 +42.88210017j]
 [ -33.79642354  +0.j         -100.73382858 +21.55644839j
  -100.73382858 -21.55644839j  -56.87259924 +16.32239114j
   -56.87259924 -16.32239114j]
 [ -31.12652214  +0.j           55.66116954 -78.79578237j
    55.66116954 +78.79578237j   30.49053229 -10.9638434j
    30.49053229 +10.9638434j ]
 [ -33.58683998  +0.j           11.95589228 -10.46754489j
    11.95589228 +10.46754489j  -29.56266749  +6.07203621j
   -29.56266749  -6.07203621j]
 [ -25.72183304  +0.j            3.86864925 -10.84152798j
     3.86864925 +10.84152798j   -7.88325273  +3.51116009j
    -7.88325273  -3.51116009j]
 [ -27.70821312  +0.j          -19.75270304  +4.01239225j
   -19.75270304  -4.01239225j   -3.98850851  -3.29808j
    -3.98850851  +3.29808j   ]
 [ -31.73757514  +0.j          -99.15800107 +44.36566004j
   -99.15800107 -44.36566004j  -40.06972512  -0.54709481j
   -40.06972512  +0.54709481j]
 [ -33.15882066  +0.j           23.98205785 -99.63451305j
    23.98205785 +99.63451305j    1.06900089  +2.46869995j
     1.06900089  -2.46869995j]
 [ -30.82650361  +0.j           56.27119017 -13.59058767j
    56.27119017 +13.59058767j   33.18380111 -27.38786208j
    33.18380111 +27.38786208j]
```

```
 [ -33.19909885  +0.j           12.55075401 -53.04733778j
    12.55075401 +53.04733778j  -46.15854317 +26.21593464j
   -46.15854317 -26.21593464j]
 [ -32.63263003  +0.j           54.60683269 +11.40460118j
    54.60683269 -11.40460118j    4.53481757 -20.13384369j
     4.53481757 +20.13384369j]
 [ -37.736263    +0.j          -64.78969693-170.66118732j
   -64.78969693+170.66118732j  -19.79154969 -11.66456348j
   -19.79154969 +11.66456348j]
 [ -33.36351119  +0.j            5.26773185 -48.9865702j
     5.26773185 +48.9865702j   -20.44714542  +6.32806511j
   -20.44714542  -6.32806511j]
 [ -36.21599272  +0.j            0.6406593  +45.66444657j
     0.6406593  -45.66444657j  -18.83220596 -21.72582694j
   -18.83220596 +21.72582694j]
 [ -27.29579902  +0.j          -12.25550894 -67.11718994j
   -12.25550894 +67.11718994j   -4.64301424  -0.27177836j
    -4.64301424  +0.27177836j]
 [ -27.8812912   +0.j           -1.61601498 -38.79394801j
    -1.61601498 +38.79394801j   -9.81893409  +1.42117969j
    -9.81893409  -1.42117969j]
 [ -27.65473121  +0.j           31.68585495-100.51655561j
    31.68585495+100.51655561j  -21.52117205 +24.96478061j
   -21.52117205 -24.96478061j]
 [ -32.68218535  +0.j           23.58002498 +80.72541645j
    23.58002498 -80.72541645j    7.53109426 -34.59419814j
     7.53109426 +34.59419814j]
 [ -30.85488148  +0.j          -29.7135403  +23.45777142j
   -29.7135403  -23.45777142j   31.39066568 -35.21245545j
    31.39066568 +35.21245545j]]
Lambda:  [[ 147.69224596  +0.j            0.          +0.j
     0.          +0.j            0.          +0.j
     0.          +0.j        ]
 [   0.          +0.j         -187.1335073 +173.64594121j
     0.          +0.j            0.          +0.j
     0.          +0.j        ]
 [   0.          +0.j            0.          +0.j
  -187.1335073 -173.64594121j    0.          +0.j
     0.          +0.j        ]
 [   0.          +0.j            0.          +0.j
     0.          +0.j           67.9615023  +39.08470136j
     0.          +0.j        ]
 [   0.          +0.j            0.          +0.j
     0.          +0.j            0.          +0.j
    67.9615023  -39.08470136j]]
b: [[-1.27239745e+21-1.90662979e+04j]
 [ 9.51610605e+18+2.92253423e+19j]
 [ 9.51610605e+18-2.92253423e+19j]
 [-1.47827910e+20-2.52738254e+20j]
```

```
 [-1.47827910e+20+2.52738254e+20j]]
Phi shape: (22, 5)
```

```
# Wykresy
## Plot Mode 2
vortmin = -5
vortmax = 5
V2 = np.copy(np.real(np.reshape(Phi[:,1], (11,2))))
V2 = V2.T

# normalize values... not symmetric
minval = np.min(V2)
maxval = np.max(V2)

if np.abs(minval) < 5 and np.abs(maxval) < 5:
    if np.abs(minval) > np.abs(maxval):
        vortmax = maxval
        vortmin = -maxval
    else:
        vortmin = minval
        vortmax = -minval

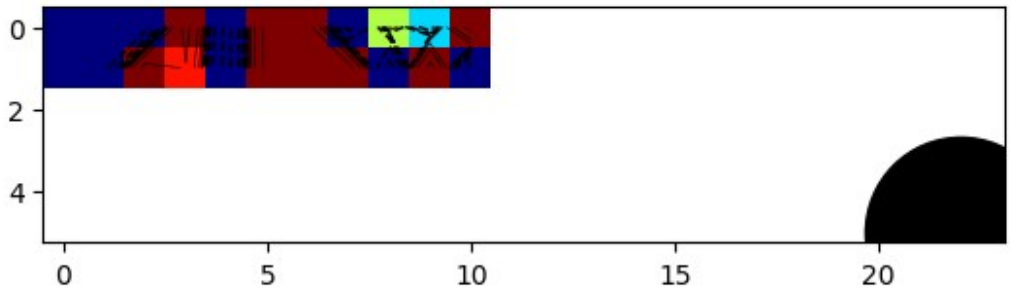
V2[V2 > vortmax] = vortmax
V2[V2 < vortmin] = vortmin

plt.imshow(V2,cmap='jet',vmin=vortmin,vmax=vortmax)

cvals = np.array([-4,-2,-1,-0.5,-0.25,-0.155])
plt.contour(V2,cvals*vortmax/5,colors='k',linestyles='dashed',linewidt
hs=1)
plt.contour(V2,np.flip(-cvals)*vortmax/5,colors='k',linestyles='solid'
,linewidths=0.4)

plt.scatter(22,5,5000,color='k') # draw cylinder


plt.show()
```




```
V2 = np.real(np.reshape(Phi[:,1], (2,11)))
```

```
# plt.hist(np.real(Phi).reshape(-1),128)
plt.hist(V2.reshape(-1),128)
plt.show()
```