In [1]:
```
##Price Prediction
```

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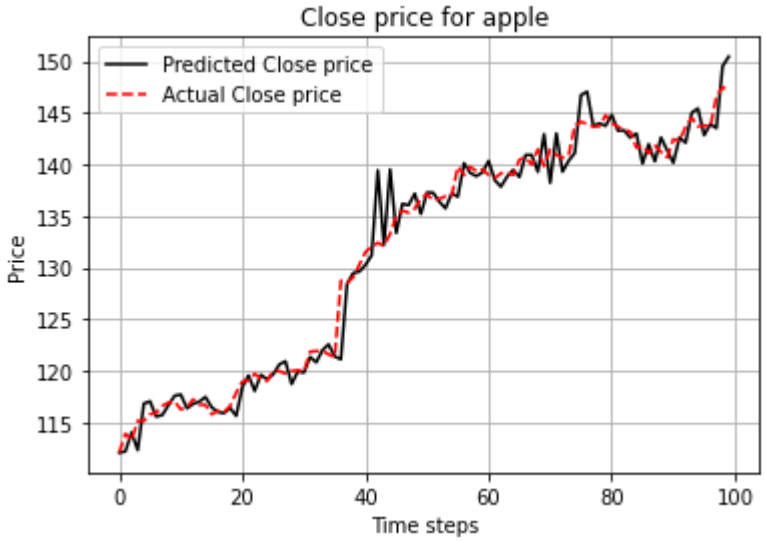
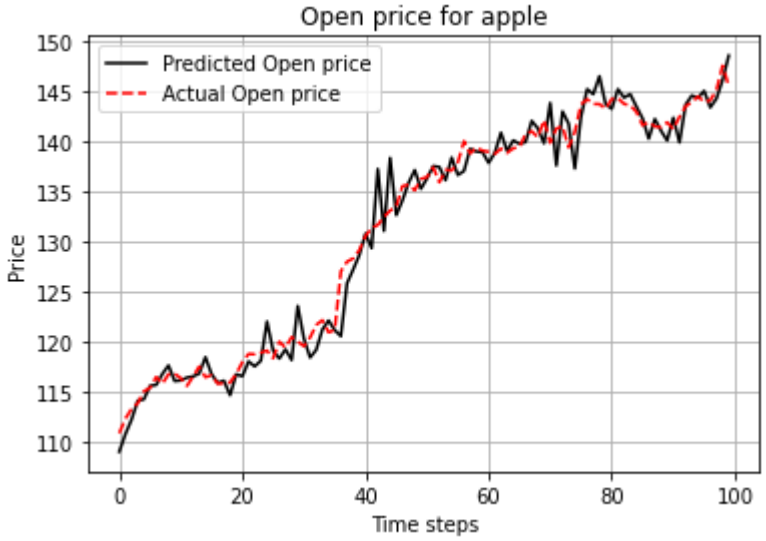
```
import warnings
import time
import sys
import numpy as np
import matplotlib.pyplot as plt
from hmmlearn import hmm

warnings.filterwarnings("ignore", category=DeprecationWarning)

PLOT_SHOW=True
PLOT_TYPE = False

NUM_TEST = 100
K = 50
NUM_ITERS=10000

STOCKS=['apple.csv','cmcst.csv','google.csv']
#NUM_STATES=12
#FILE_NAME='HistoricalQuotes.csv'
#TRAIN_CHUNK_SIZE=100

#dirichlet_params = np.array([1., 20., 20., 20.])
#dirichlet_params = np.random.randint(1,50,NUM_STATES)
labels = ['Close','Open','High','Low']
likelihood_vect = np.empty([0,1])
aic_vect = np.empty([0,1])
bic_vect = np.empty([0,1])

# Possible number of states in Markov Model
STATE_SPACE = range(2,15)

# Calculating Mean Absolute Percentage Error of predictions
def calc_mape(predicted_data, true_data):
    return np.divide(np.sum(np.divide(np.absolute(predicted_data - true_data), tr


for stock in STOCKS:
    dataset = np.genfromtxt(stock, delimiter=',')
    predicted_stock_data = np.empty([0,dataset.shape[1]])
    likelihood_vect = np.empty([0,1])
    aic_vect = np.empty([0,1])
    bic_vect = np.empty([0,1])
    for states in STATE_SPACE:
        num_params = states**2 + states
        dirichlet_params_states = np.random.randint(1,50,states)
        #model = hmm.GaussianHMM(n_components=states, covariance_type='full', sta
        model = hmm.GaussianHMM(n_components=states, covariance_type='full', tol=
        model.fit(dataset[NUM_TEST:,:])
        if model.monitor_.iter == NUM_ITERS:
            print('Increase number of iterations')
            sys.exit(1)
        likelihood_vect = np.vstack((likelihood_vect, model.score(dataset)))
        aic_vect = np.vstack((aic_vect, -2 * model.score(dataset) + 2 * num_param
        bic_vect = np.vstack((bic_vect, -2 * model.score(dataset) +  num_params *

    opt_states = np.argmin(bic_vect) + 2
```

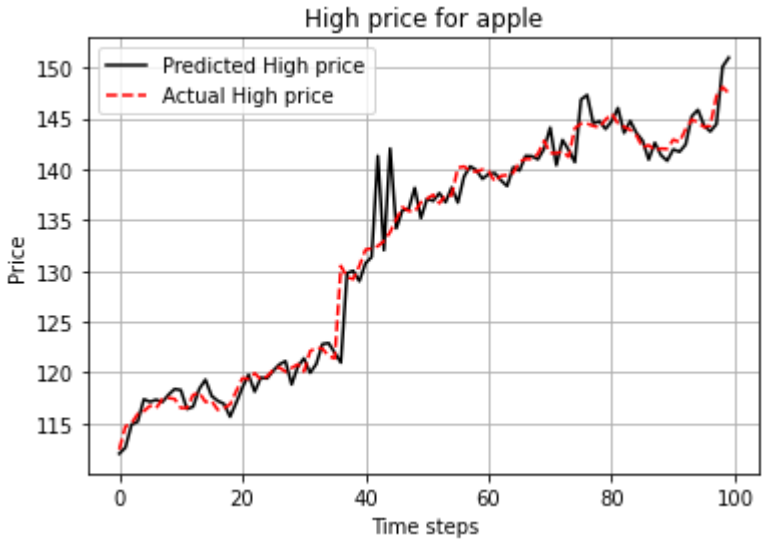
```
print('Optimum number of states are {}'.format(opt_states))

for idx in reversed(range(NUM_TEST)):
    train_dataset = dataset[idx + 1:,:]
    test_data = dataset[idx,:];
    num_examples = train_dataset.shape[0]
    #model = hmm.GaussianHMM(n_components=opt_states, covariance_type='full',
    if idx == NUM_TEST - 1:
        model = hmm.GaussianHMM(n_components=opt_states, covariance_type='ful
    else:
        # Retune the model by using the HMM paramters from the previous itera
        model = hmm.GaussianHMM(n_components=opt_states, covariance_type='ful
        model.transmat_ = transmat_retune_prior
        model.startprob_ = startprob_retune_prior
        model.means_ = means_retune_prior
        model.covars_ = covars_retune_prior

    model.fit(np.flipud(train_dataset))

    transmat_retune_prior = model.transmat_
    startprob_retune_prior = model.startprob_
    means_retune_prior = model.means_
    covars_retune_prior = model.covars_

    if model.monitor_.iter == NUM_ITERS:
        print('Increase number of iterations')
        sys.exit(1)
    #print('Model score : ', model.score(dataset))
    #print('Dirichlet parameters : ',dirichlet_params)

    iters = 1;
    past_likelihood = []
    curr_likelihood = model.score(np.flipud(train_dataset[0:K - 1, :]))
    while iters < num_examples / K - 1:
        past_likelihood = np.append(past_likelihood, model.score(np.flipud(tr
        iters = iters + 1
    likelihood_diff_idx = np.argmin(np.absolute(past_likelihood - curr_likeli
    predicted_change = train_dataset[likelihood_diff_idx,:] - train_dataset[l
    predicted_stock_data = np.vstack((predicted_stock_data, dataset[idx + 1,:
np.savetxt('{}_forecast.csv'.format(stock),predicted_stock_data,delimiter=',

mape = calc_mape(predicted_stock_data, np.flipud(dataset[range(100),:]))
print('MAPE for the stock {} is '.format(stock),mape)

if PLOT_TYPE:
    hdl_p = plt.plot(range(100), predicted_stock_data);
    plt.title('Predicted stock prices')
    plt.legend(iter(hdl_p), ('Close','Open','High','Low'))
    plt.xlabel('Time steps')
    plt.ylabel('Price')
    plt.figure()
    hdl_a = plt.plot(range(100),np.flipud(dataset[range(100),:]))
    plt.title('Actual stock prices')
    plt.legend(iter(hdl_p), ('Close','Open','High','Low'))
    plt.xlabel('Time steps')
    plt.ylabel('Price')
else:
```

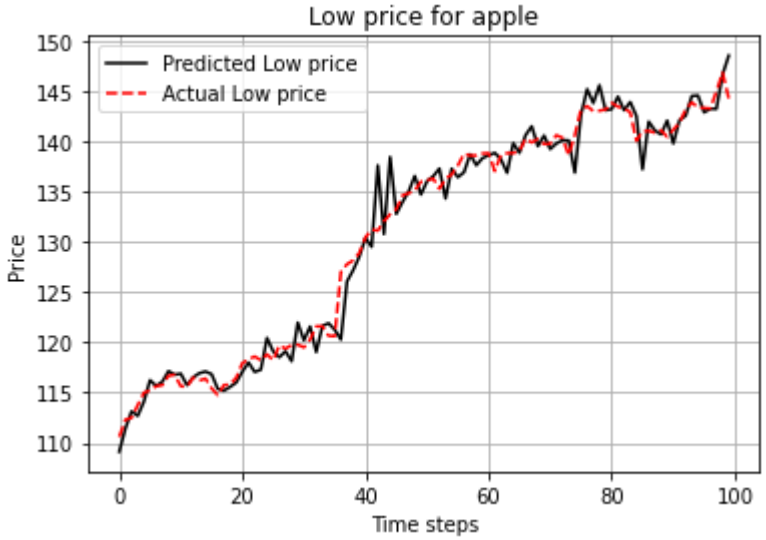
```
        for i in range(4):
            plt.figure()
            plt.plot(range(100), predicted_stock_data[:,i],'k-', label = 'Predict
            plt.plot(range(100),np.flipud(dataset[range(100),i]),'r--', label = '
            plt.xlabel('Time steps')
            plt.ylabel('Price')
            plt.title(labels[i]+' price'+ ' for '+stock[:-4])
            plt.grid(True)
            plt.legend(loc = 'upper left')


    if PLOT_SHOW:
        plt.show(block=False)
```

```
Optimum number of states are 13
MAPE for the stock apple.csv is  [0.00888693 0.00980546 0.00920139 0.00866747]
```

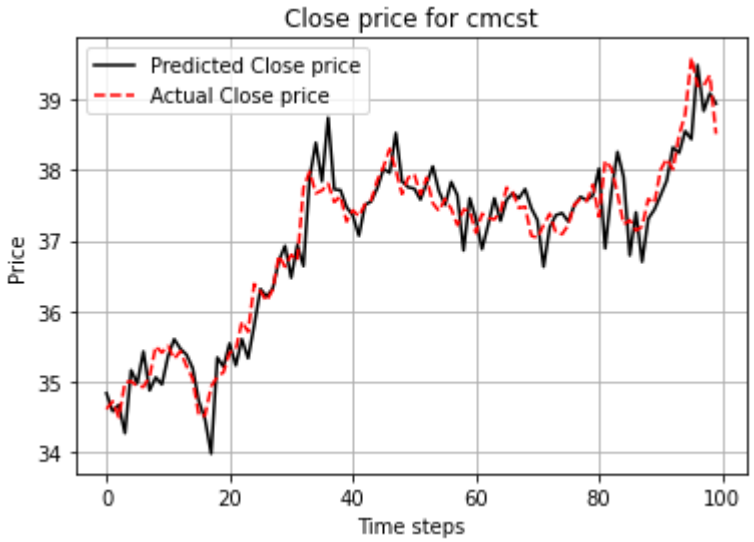


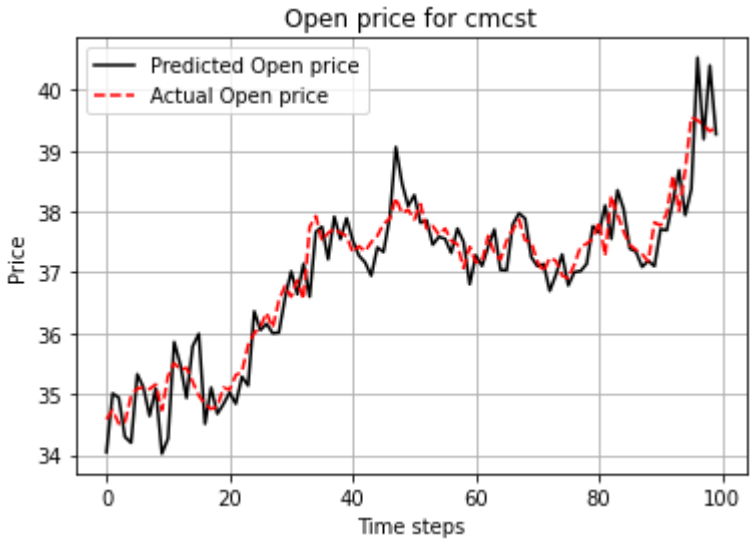


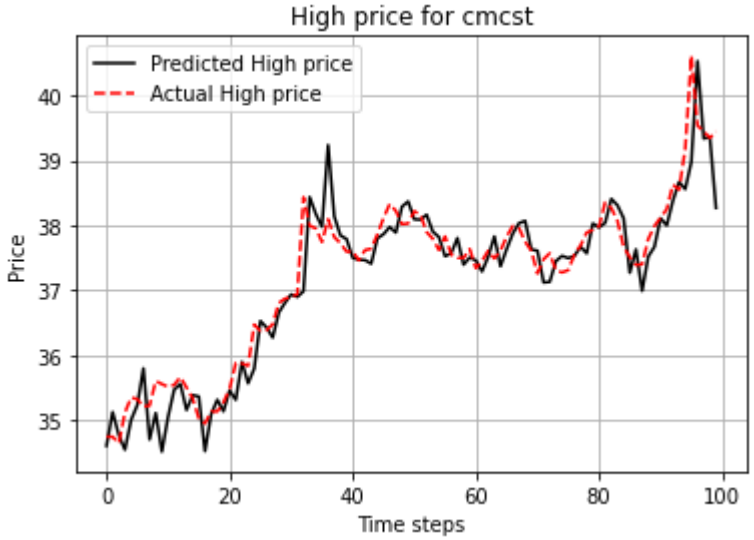


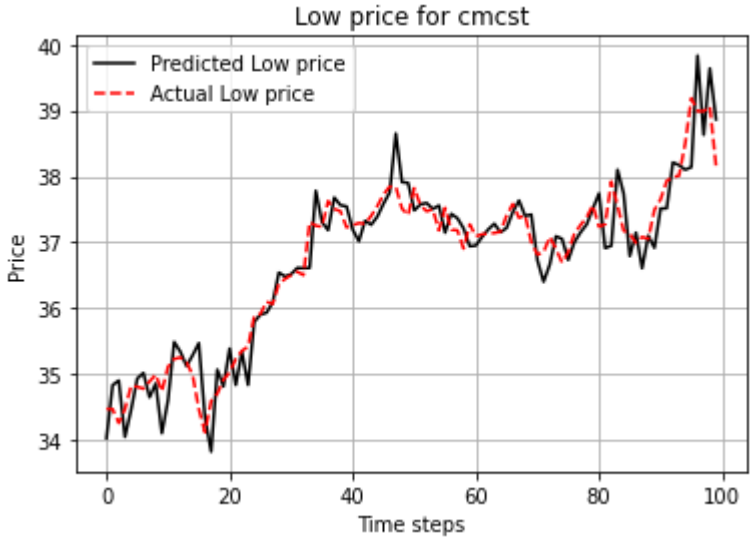



```
Optimum number of states are 14
MAPE for the stock cmcst.csv is  [0.00781854 0.00942235 0.0075632  0.00799607]
```

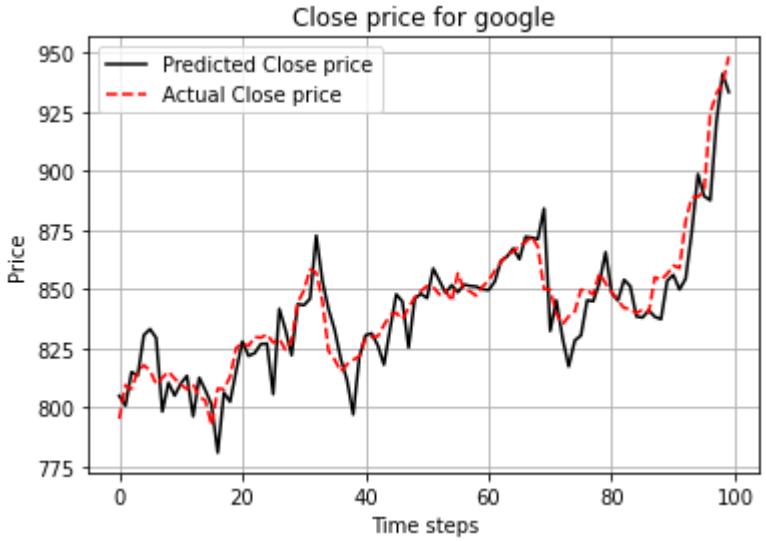


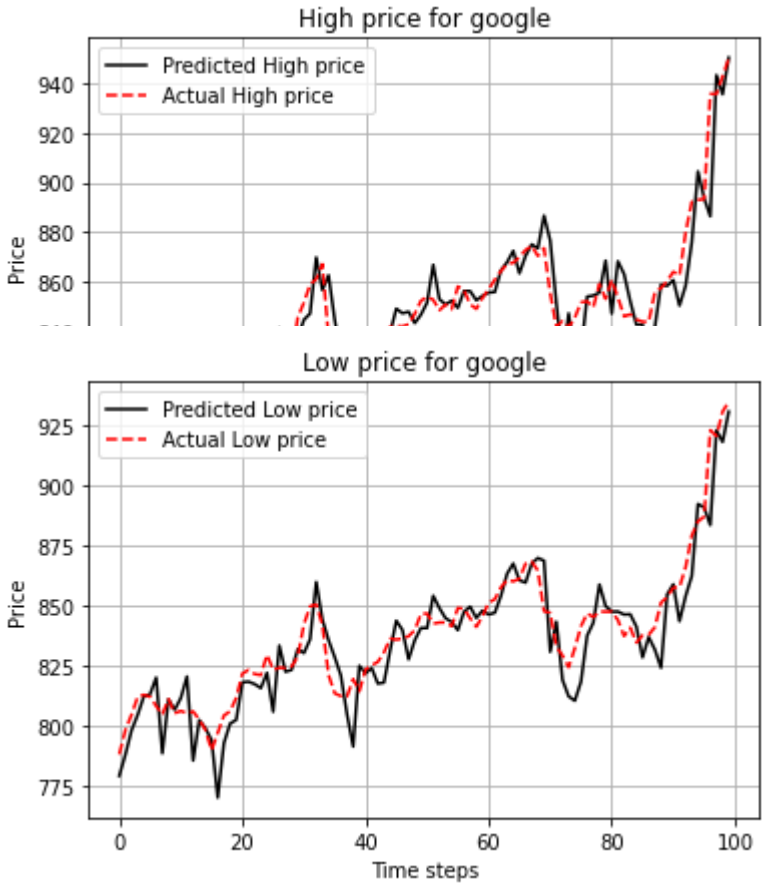

Open price for cmcst
Predicted Open price
Actual Open price
Price
Time steps
34
35
36
37
38
39
40
0
20
40
60
80
100


High price for cmcst
Predicted High price
Actual High price
Price
Time steps
35
36
37
38
39
40
0
20
40
60
80
100


Low price for cmcst
Predicted Low price
Actual Low price
Price
Time steps
34
35
36
37
38
39
40
0
20
40
60
80
100

```
Optimum number of states are 14
MAPE for the stock google.csv is  [0.00989672 0.00972749 0.00963705 0.0097885 ]
```




High price for google
Predicted High price
Actual High price
Price
940
920
900
880
860

Low price for google
Predicted Low price
Actual Low price
Price
925
900
875
850
825
800
775
0
20
40
60
80
100
Time steps

In [2]:
```
print(predicted_stock_data)
```

```
[[804.93   777.95   803.44   778.95  ]
 [800.73   788.69   815.84   787.815 ]
 [815.01   795.04   826.79   797.96  ]
 [813.46   800.56   828.19   804.4411]
 [830.63   812.15   831.02   812.15  ]
 [833.18   815.68   830.98   812.99  ]
 [829.41   825.46   832.5    819.9686]
 [798.29   807.76   806.29   788.335 ]
 [810.46   819.47   821.5    810.8514]
 [805.01   818.04   818.88   806.5   ]
 [810.16   825.91   821.     811.4514]
 [813.38   822.1    818.07   820.405 ]
 [796.25   797.46   798.0596 785.325 ]
 [812.59   799.65   813.02   802.18  ]
 [807.23   804.3    810.35   798.82  ]
 [801.19   791.33   798.17   793.848 ]
 [780.9    792.66   790.375  769.835 ]
 [806.32   789.62   803.855  792.594 ]
 [802.41   814.54   810.76   800.75  ]
 [815.68   798.47   810.76   802.3   ]
 [827.91   819.08   829.23   818.    ]
 [821.82   831.02   827.76   818.26  ]
 [823.01   829.42   828.64   817.24  ]
 [826.86   828.97   829.13   815.57  ]
 [827.01   821.76   825.73   821.94  ]
 [805.64   839.17   833.     805.715 ]
 [841.74   836.35   841.13   833.3451]
 [832.87   829.35   830.3    822.41  ]
 [822.13   830.44   831.7399 823.18  ]
 [843.73   826.5    837.39   831.87  ]
 [843.26   832.31   844.5228 830.22  ]
 [846.05   845.98   847.05   835.9601]
 [872.73   859.9    869.7436 859.885 ]
 [853.5    858.05   856.53   844.2002]
 [841.55   858.     862.53   835.5801]
 [832.75   843.63   844.5036 828.49  ]
 [820.39   830.39   830.29   820.84  ]
 [811.6    806.44   809.84   804.62  ]
 [797.06   793.06   794.79   791.181 ]
 [821.36   816.22   819.51   824.89  ]
 [830.54   827.49   829.6636 821.75  ]
 [831.36   826.17   836.9504 823.9826]
 [826.24   812.97   820.09   817.48  ]
 [818.11   831.68   837.98   817.8799]
 [833.38   838.45   839.3564 831.2901]
 [847.88   844.27   849.0086 843.706 ]
 [844.82   840.99   847.17   839.84  ]
 [825.37   838.76   847.7725 827.5999]
 [846.02   838.05   843.18   835.59  ]
 [848.11   841.11   846.57   840.6599]
 [846.27   850.34   851.43   840.65  ]
 [858.8    855.57   866.74   854.119 ]
 [853.7    855.17   852.89   849.    ]
 [848.46   852.68   850.69   844.7775]
 [851.76   844.96   852.26   843.1701]
```

```
[848.78   846.9    849.32   839.7722]
[852.01   853.78   856.16   847.4522]
[851.41   856.11   856.12   849.5999]
[851.17   848.95   852.41   844.8651]
[849.99   853.54   854.2    847.94  ]
[849.68   852.76   855.5364 846.3001]
[853.28   856.2    855.76   847.0399]
[862.04   854.26   864.49   854.09  ]
[863.895  868.56   867.829  863.34  ]
[867.3    867.51   872.39   867.59  ]
[862.72   860.32   863.32   860.5901]
[872.24   867.49   870.37   859.625 ]
[871.86   867.83   875.02   867.5699]
[871.2    874.38   873.4    869.89  ]
[884.17   872.     886.6428 868.765 ]
[832.37   870.64   876.6    830.709 ]
[845.34   845.28   851.27   843.295 ]
[829.5    833.3    828.03   819.    ]
[817.37   842.58   847.13   812.122 ]
[828.36   820.     827.72   810.3   ]
[830.48   831.6    831.74   818.265 ]
[845.36   843.36   853.895  837.48  ]
[844.97   852.59   854.31   842.87  ]
[852.9    862.2    855.5372 858.8245]
[865.7    850.67   868.44   849.8151]
[848.39   847.25   847.     847.4802]
[845.25   861.42   868.18   847.535 ]
[854.045  851.42   863.03   846.2853]
[851.34   848.06   852.065  846.415 ]
[838.51   838.11   842.4772 841.2501]
[838.06   841.86   842.5228 828.41  ]
[841.12   817.88   825.6    836.903 ]
[838.36   841.2    841.6228 831.6603]
[837.36   841.96   858.77   824.052 ]
[853.59   849.08   858.2472 854.74  ]
[856.12   866.615  860.615  858.9175]
[849.93   851.65   850.27   843.5   ]
[854.49   856.42   858.36   854.025 ]
[874.47   864.24   875.88   862.405 ]
[898.75   896.08   904.54   892.4502]
[889.44   900.52   893.73   891.0199]
[887.625  884.79   886.3774 883.66  ]
[920.86   935.71   943.49   923.235 ]
[941.12   919.3    935.74   918.38  ]
[933.43   939.98   950.575  931.015 ]]
```

In [ ]: