In [1]:

```
import pandas as pd
import numpy as np
import time

Train = pd.read_excel("TrainSet.xlsx")
Train.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 39722 entries, 0 to 39721
Data columns (total 73 columns):
 #   Column                       Non-Null Count  Dtype
---  ------                       --------------  -----
 0   nr. sessions                 39722 non-null  int64
 1   total km                     39722 non-null  float64
 2   km Z3-4                      39722 non-null  float64
 3   km Z5-T1-T2                  39722 non-null  float64
 4   km sprinting                 39722 non-null  float64
 5   strength training            39722 non-null  int64
 6   hours alternative            39722 non-null  float64
 7   perceived exertion           39722 non-null  float64
 8   perceived trainingSuccess    39722 non-null  float64
 9   perceived recovery           39722 non-null  float64
 10  nr. sessions.1               39722 non-null  int64
 11  total km.1                   39722 non-null  float64
 12  km Z3-4.1                    39722 non-null  float64
 13  km Z5-T1-T2.1                39722 non-null  float64
```

In [2]:

```
Train.head(10)
```

Out[2]:

	nr. sessions	total km	km Z3-4	km Z5-T1-T2	km sprinting	strength training	hours alternative	perceived exertion	perceived trainingSuccess	per re
0	1	5.8	0.0	0.6	1.2	0	0.00	0.11	0.00	
1	0	0.0	0.0	0.0	0.0	0	0.00	-0.01	-0.01	
2	1	0.0	0.0	0.0	0.0	1	0.00	0.10	0.00	
3	0	0.0	0.0	0.0	0.0	0	0.00	-0.01	-0.01	
4	1	0.0	0.0	0.0	0.0	0	1.08	0.08	0.00	
5	1	16.4	10.0	0.0	0.0	1	0.00	0.11	0.00	
6	1	0.0	0.0	0.0	0.0	0	1.00	0.10	0.00	
7	1	5.2	0.0	0.5	1.2	0	0.00	0.10	0.00	
8	0	0.0	0.0	0.0	0.0	0	0.00	-0.01	-0.01	
9	1	0.0	0.0	0.0	0.0	1	0.00	0.10	0.00	

10 rows × 73 columns

In [3]:

```
Train.describe()
```

Out[3]:

	nr. sessions	total km	km Z3-4	km Z5-T1-T2	km sprinting	strength training
count	39722.000000	39722.000000	39722.000000	39722.000000	39722.000000	39722.000000
mean	0.832838	6.991433	0.677139	0.585399	0.076119	0.117466
std	0.581688	7.404181	2.257641	1.818250	0.494930	0.327637
min	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
25%	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
50%	1.000000	6.000000	0.000000	0.000000	0.000000	0.000000
75%	1.000000	12.000000	0.000000	0.000000	0.000000	0.000000
max	2.000000	55.900000	42.200000	48.000000	40.000000	2.000000

8 rows × 73 columns

Data cleaning

In [4]:

```
import numba

# Clear invalid data: Exclude the data that has not experienced any sports training for 7 da
@numba.njit(parallel=True)
def judge_sum(a, b, c, d, e, f, g):
    return a + b + c + d + e + f + g

def DataClear(data):
    columns_original = data.columns
    data_original = data.values
    judge = judge_sum(data_original[:,0], data_original[:,10], data_original[:,20], data_ori
                      data_original[:,40], data_original[:,50], data_original[:,60])

    index = np.where(judge!=0)
    data_new = data_original[index]
    return pd.DataFrame(data_new, columns=columns_original)
```

In [5]:

```
import time

start = time.time()

Train_Clear = DataClear(Train)

end = time.time()
print("Train samples:", Train_Clear.shape[0],"time:", end-start)
```

```
Train samples: 37629 time: 0.8131198883056641
```

In [6]:

```
Train_Clear.describe()
```

Out[6]:

	nr. sessions	total km	km Z3-4	km Z5-T1-T2	km sprinting	strength training
count	37629.000000	37629.000000	37629.000000	37629.000000	37629.000000	37629.000000
mean	0.879162	7.380310	0.714802	0.617960	0.080353	0.124000
std	0.562543	7.416278	2.313770	1.862741	0.508173	0.335421
min	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
25%	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
50%	1.000000	6.800000	0.000000	0.000000	0.000000	0.000000
75%	1.000000	12.300000	0.000000	0.000000	0.000000	0.000000
max	2.000000	55.900000	42.200000	48.000000	40.000000	2.000000

8 rows × 73 columns

In [7]:

```
def Padding(data):
    day_7 = data[0:10]
    day_6 = data[10:20]
    day_5 = data[20:30]
    day_4 = data[30:40]
    day_3 = data[40:50]
    day_2 = data[50:60]
    day_1 = data[60:70]
    day_8 = np.zeros(10,dtype=float) # padding
    data_reshape = np.vstack((day_1,day_2,day_3,day_4,day_5,day_6,day_7,day_8))

    return data_reshape

@numba.njit()
def TransformInt(data):
    return int(data)

def List_to_arr(data_list, data):
    new_data = []
    data_information = []

    for i in range(len(data_list)):
        temp_feature = data_list[i]
        temp_information = data[i]
        if np.sum(temp_feature[:,0]) != 0:

            new_data.append(temp_feature)
            data_information.append(temp_information)

    new_data = np.array(new_data)
    data_information = np.array(data_information)
    ID = data_information[:,0]
    Label = np.array(list(map(TransformInt,data_information[:,1])))
    Date = data_information[:,2]

    return new_data, ID, Label, Date


```

In [8]:

```
import time

start = time.time()

Train_reshape = list(map(Padding, Train_Clear.values))
Train_Feature, Train_ID, Train_Label, Train_Date = List_to_arr(Train_reshape,Train_Clear.val

end = time.time()

print("time:",end-start,
      f"\n Original TrainSet: {np.array(Train_reshape).shape}",
      )
```

```
time: 0.8144659996032715
 Original TrainSet: (37629, 8, 10)
```

Gramian Angular Field

In [9]:

```
n_sample = 37133
```

The original time series

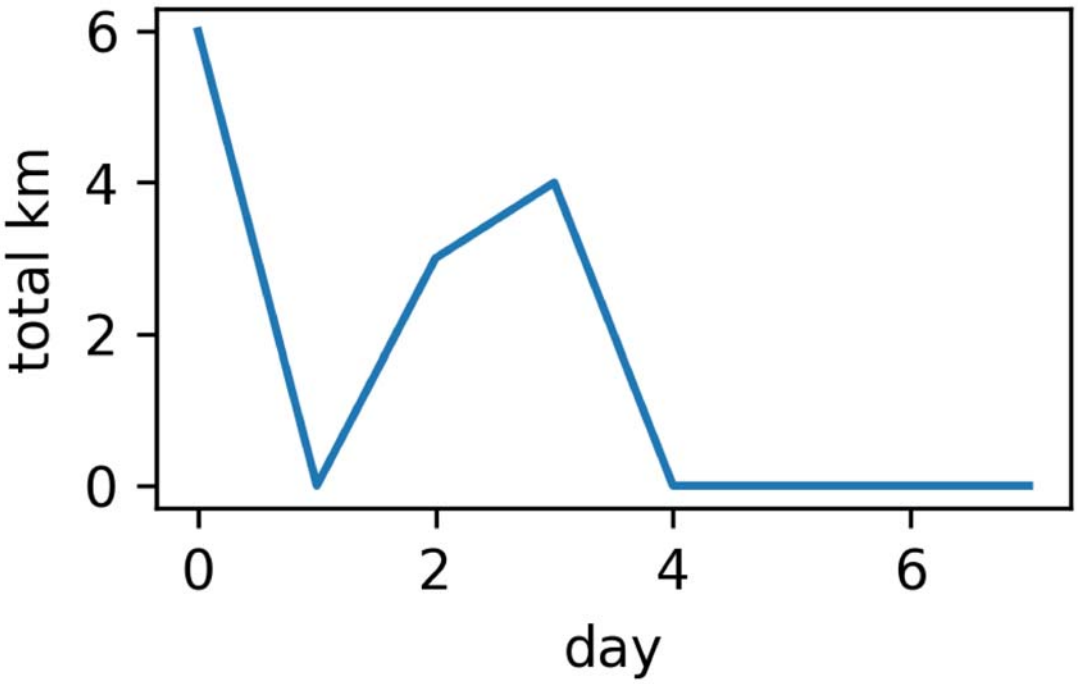
In [32]:

```
import matplotlib.pyplot as plt

X_new = Train_Feature[n_sample,:,1] # With "total km" for example
X_sample = [list(range(0, 8, 1)), X_new]

fig = plt.figure(figsize=(3,2),dpi=300,edgecolor='black')
plt.plot(X_sample[0], X_sample[1])

plt.xlabel("day")
plt.ylabel("total km")
plt.tight_layout()
plt.show()
```



In [33]:

```
#fig.savefig("C:\\Users\\47762\\Desktop\\Figure\\original time series.jpg")
```

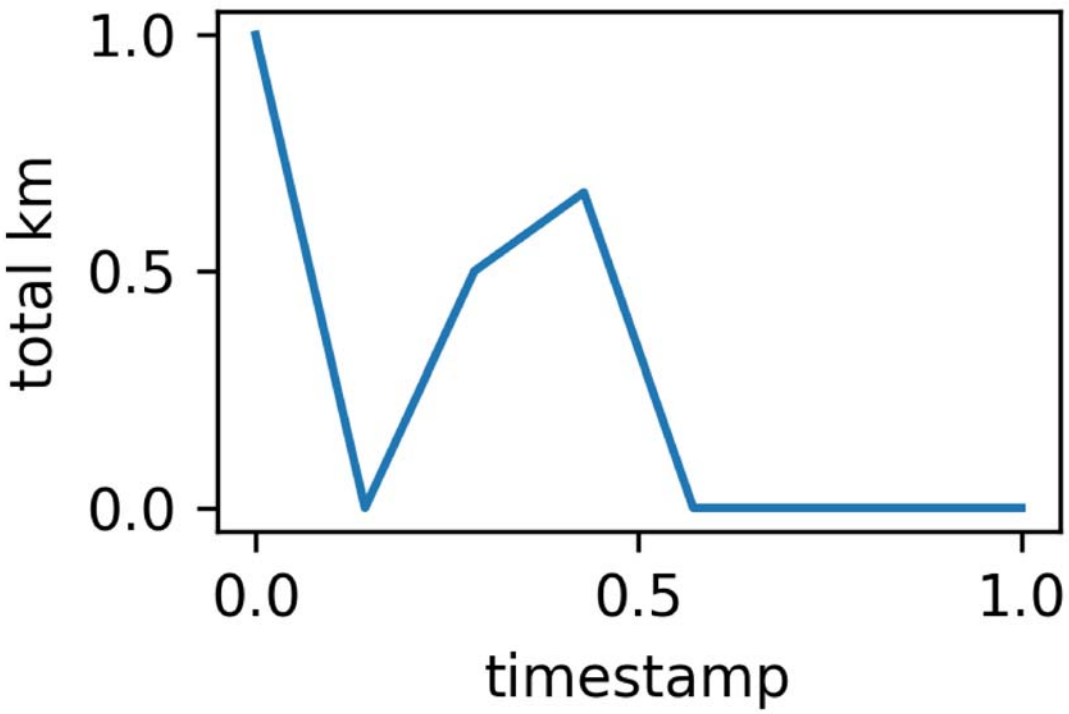
Time series after normalization

In [34]:

```
from pyts.preprocessing import MinMaxScaler

# normalization
scaler = MinMaxScaler()
X_sample_scaler = scaler.transform(X_sample)

fig = plt.figure(figsize=(3,2),dpi=300,edgecolor='black')
plt.plot(X_sample_scaler[0,:], X_sample_scaler[1,:])
plt.xlabel("timestamp")
plt.ylabel("total km")
plt.tight_layout()
plt.show()
```



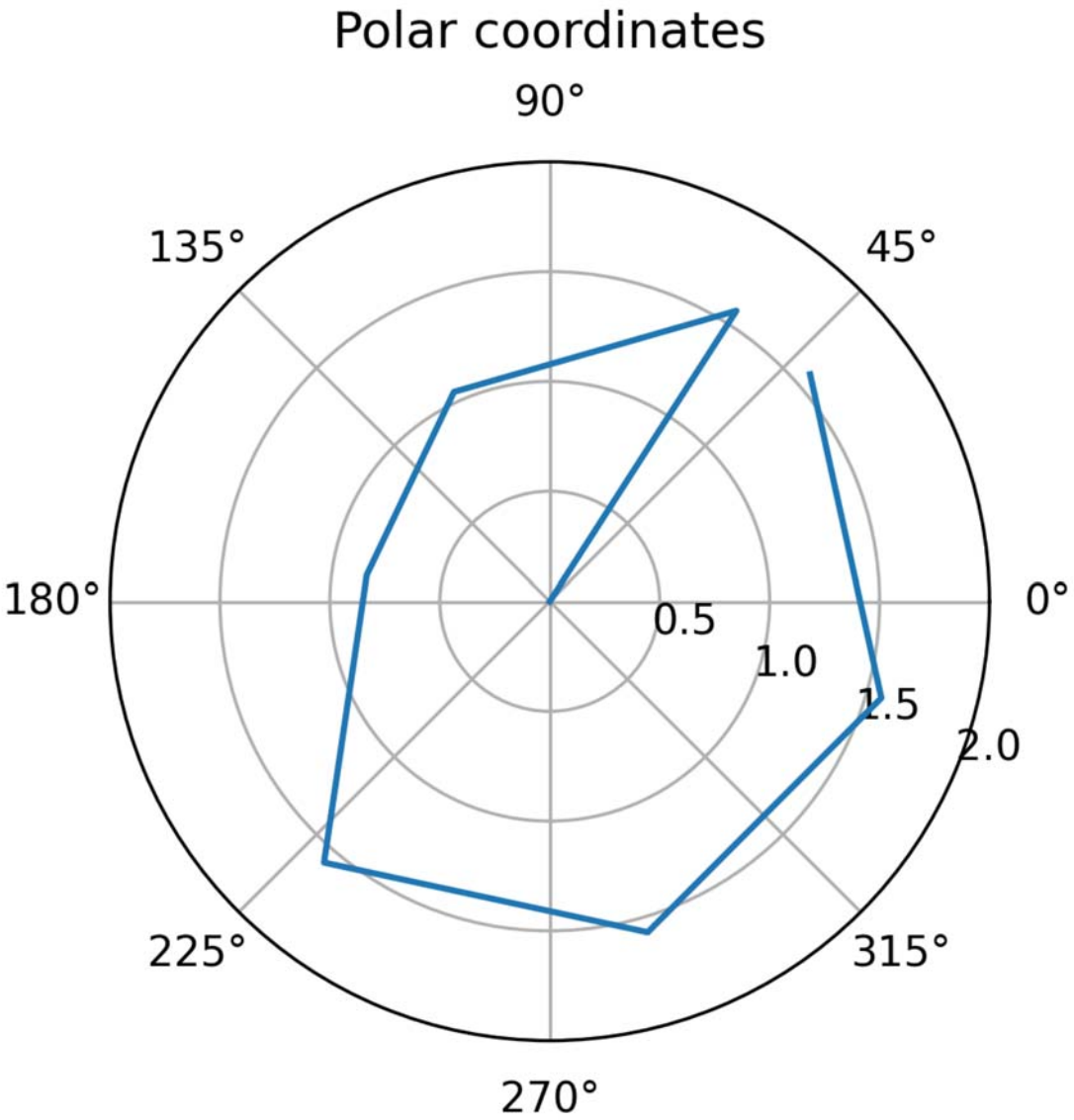
In [35]:

```
#fig.savefig("C:\\Users\\47762\\Desktop\\Figure\\scaler time series.jpg")
```

Polar coordinate system

In [36]:

```
arccos_X = np.arccos(X_sample_scaler[1,:])
fig, ax = plt.subplots(figsize=(6,4),dpi=300,subplot_kw={'projection': 'polar'})
ax.plot(X_sample[0], arccos_X)
ax.set_rmax(2)
ax.set_rticks([0.5, 1, 1.5, 2]) # Less radial ticks
ax.set_rlabel_position(-22.5) # Move radial labels away from plotted line
ax.grid(True)
ax.set_title("Polar coordinates", va='bottom')
plt.tight_layout()
plt.show()
```



In [37]:

```
#fig.savefig("C:\\Users\\47762\\Desktop\\Figure\\coordinates time series.jpg")
```

Gramian Angular Summation Field

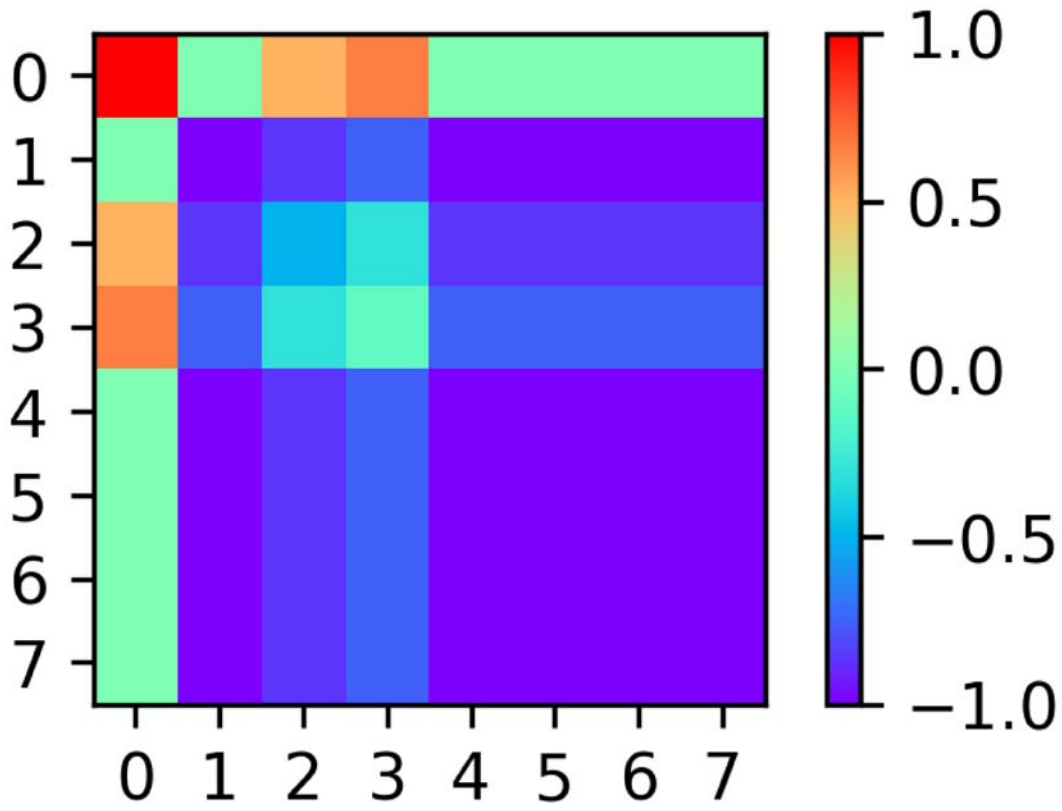
In [38]:

```
from matplotlib.pyplot import MultipleLocator

fig = plt.figure(figsize=(3,2),dpi=300,edgecolor='black')
field = [a+b for a in arccos_X for b in arccos_X]
gram = np.cos(field).reshape(8,8)
plt.imshow(pd.DataFrame(gram ).rename(index={0:1, 1:2, 2:3, 3:4, 4:5, 5:6, 6:7, 7:8},
                                      columns={0:1, 1:2, 2:3, 3:4, 4:5, 5:6, 6:7, 7:8}
ax = plt.gca()
major_locator=MultipleLocator(1)
ax.xaxis.set_major_locator(major_locator)
ax.yaxis.set_major_locator(major_locator)
plt.tight_layout()
plt.colorbar()
```

Out[38]:

<matplotlib.colorbar.Colorbar at 0x19d771d1f60>



In [39]:

```
#fig.savefig("C:\\Users\\47762\\Desktop\\Figure\\GASF.jpg")
```

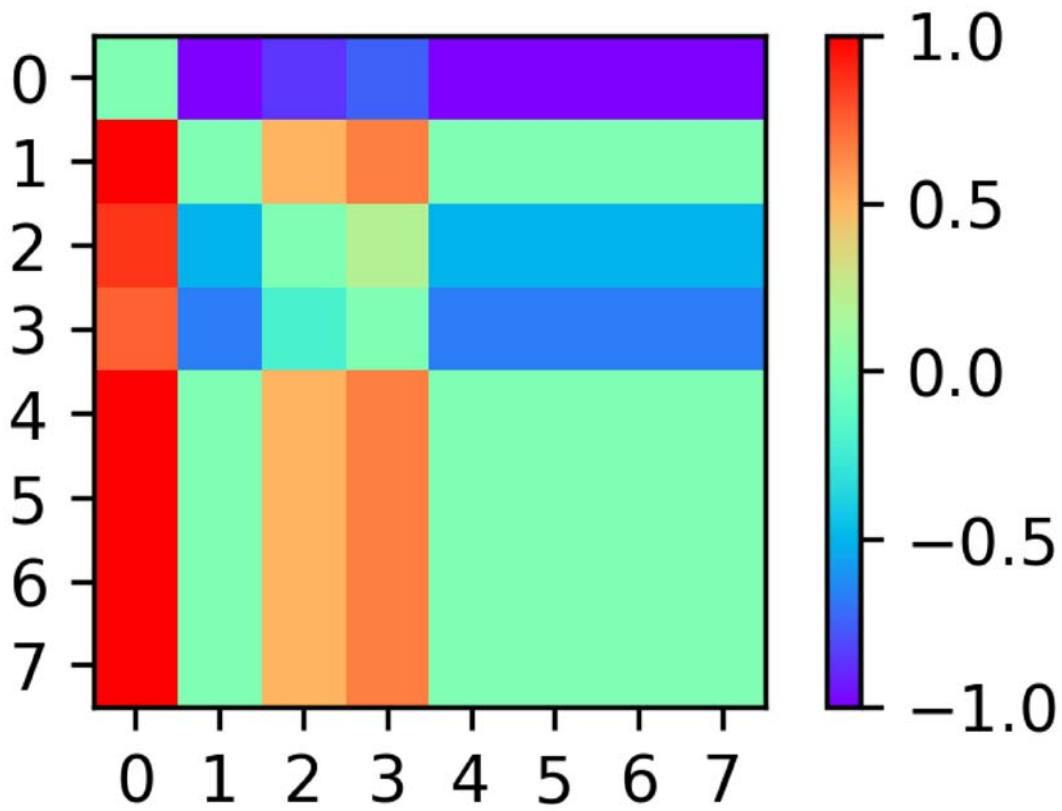
Gramian Angular Differential Field

In [40]:

```
fig = plt.figure(figsize=(3,2),dpi=300,edgecolor='black')
field = [a-b for a in arccos_X for b in arccos_X]
gram = np.sin(field).reshape(8,8)
plt.imshow(pd.DataFrame(gram ).rename(index={0:1, 1:2, 2:3, 3:4, 4:5, 5:6, 6:7, 7:8},
                                      columns={0:1, 1:2, 2:3, 3:4, 4:5, 5:6, 6:7, 7:8}
ax = plt.gca()
major_locator=MultipleLocator(1)
ax.xaxis.set_major_locator(major_locator)
ax.yaxis.set_major_locator(major_locator)
plt.tight_layout()
plt.imshow(gram, cmap='rainbow')
plt.colorbar()
```

Out[40]:

<matplotlib.colorbar.Colorbar at 0x19d78260748>



In [41]:

```
#fig.savefig("C:\\Users\\47762\\Desktop\\Figure\\GADF.jpg")
```

Markov Transition field Transformation

In [42]:

```
X_new = X_sample_scaler[1,:]
```

In [43]:

```
from pyts.preprocessing.discretizer import KBinsDiscretizer

n_bins = 5
strategy = 'quantile'
discretizer = KBinsDiscretizer(n_bins = n_bins, strategy = strategy, raise_warning = False)
X = X_new.reshape(1, -1)
X_disc = discretizer.fit_transform(X)[0]
X_disc
```

Out[43]:

```
array([3, 0, 2, 3, 0, 0, 0, 0], dtype=int64)
```

In [44]:

```
m_adj = np.zeros((n_bins,n_bins))
for k in range(len(X_disc) - 1):
    # matrix iteration
    index = X_disc[k]
    next_index = X_disc[k+1]
    m_adj[next_index][index] += 1

print(m_adj)
```

```
[[3. 0. 0. 2. 0.]
 [0. 0. 0. 0. 0.]
 [1. 0. 0. 0. 0.]
 [0. 0. 1. 0. 0.]
 [0. 0. 0. 0. 0.]]
```

In [45]:

```
mtm = m_adj/m_adj.sum(axis=0)
print(mtm)
```

```
[[0.75  nan 0.  1.  nan]
 [0.    nan 0.  0.  nan]
 [0.25  nan 0.  0.  nan]
 [0.    nan 1.  0.  nan]
 [0.    nan 0.  0.  nan]]

D:\Anaconda3\lib\site-packages\ipykernel_launcher.py:1: RuntimeWarning: invalid v
alue encountered in true_divide
  """Entry point for launching an IPython kernel.
```

In [46]:

```
n_t = len(X_disc)
mtf = np.zeros((n_t, n_t))

for i in range(n_t):
    for j in range(n_t):
        mtf[i, j] = mtm[X_disc[i]][X_disc[j]]*100
```

In [47]:

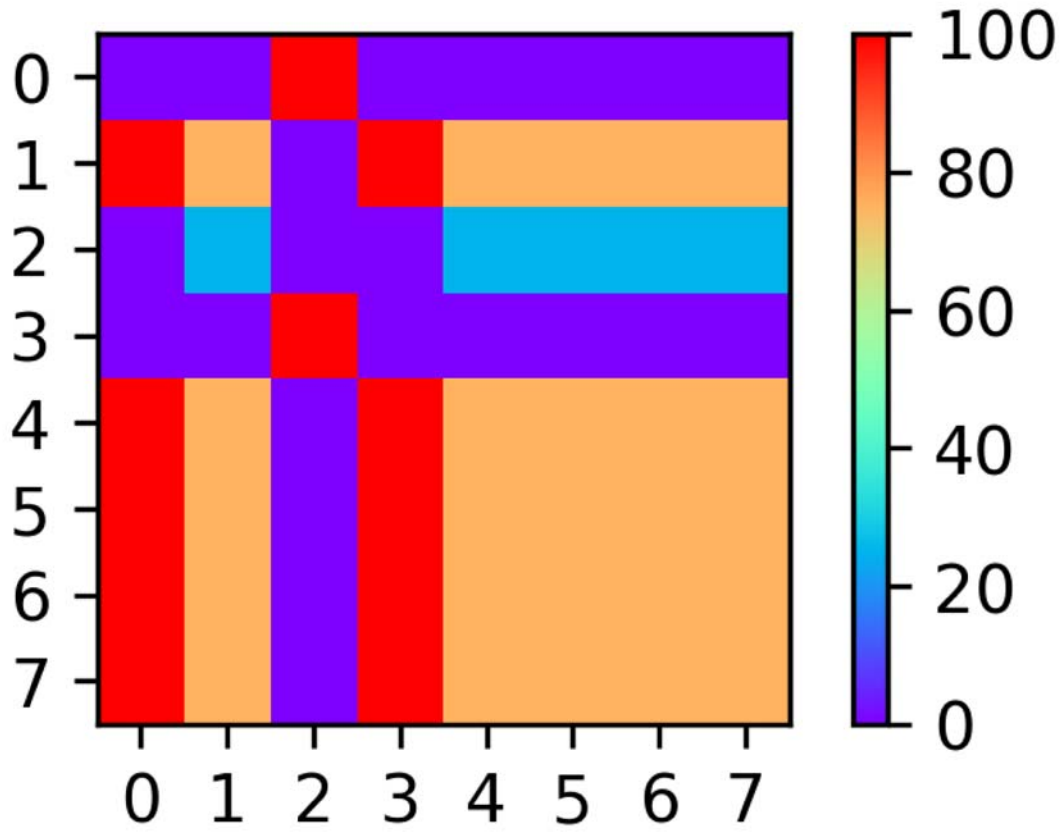
```
mtf
```

Out[47]:

```
array([[  0.,   0., 100.,   0.,   0.,   0.,   0.,   0.],
       [100.,  75.,   0., 100.,  75.,  75.,  75.,  75.],
       [  0.,  25.,   0.,   0.,  25.,  25.,  25.,  25.],
       [  0.,   0., 100.,   0.,   0.,   0.,   0.,   0.],
       [100.,  75.,   0., 100.,  75.,  75.,  75.,  75.],
       [100.,  75.,   0., 100.,  75.,  75.,  75.,  75.],
       [100.,  75.,   0., 100.,  75.,  75.,  75.,  75.],
       [100.,  75.,   0., 100.,  75.,  75.,  75.,  75.]])
```

In [48]:

```
fig = plt.figure(figsize=(3,2),dpi=300,edgecolor='black')
plt.imshow(pd.DataFrame(mtf ).rename(index={0:1, 1:2, 2:3, 3:4, 4:5, 5:6, 6:7, 7:8},
                                     columns={0:1, 1:2, 2:3, 3:4, 4:5, 5:6, 6:7, 7:8}
ax = plt.gca()
major_locator=MultipleLocator(1)
ax.xaxis.set_major_locator(major_locator)
ax.yaxis.set_major_locator(major_locator)
plt.tight_layout()
plt.colorbar()
plt.show()
```



In [49]:

```
#fig.savefig("C:\\Users\\47762\\Desktop\\Figure\\MTF.jpg")
```

Recurrence Plot Transformation

In [50]:

```
from scipy.spatial.distance import pdist, squareform

eps=0.10
steps=10
d = pdist(X_new[:,None])
d = np.floor(d/eps)
d[d>steps] = steps
Z = squareform(d)
d
```

Out[50]:

```
array([10.,  5.,  3., 10., 10., 10., 10.,  5.,  6.,  0.,  0.,  0.,  0.,
        1.,  5.,  5.,  5.,  5.,  6.,  6.,  6.,  6.,  0.,  0.,  0.,  0.,
        0.,  0.])
```

In [51]:

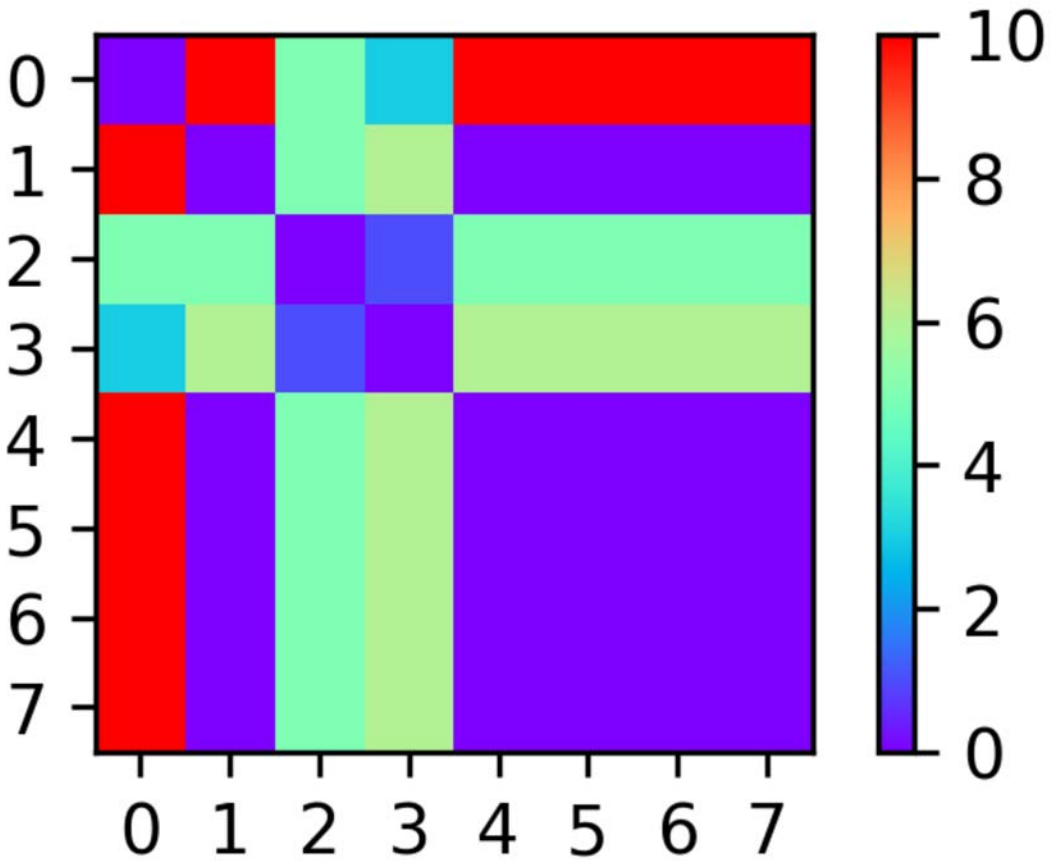
```
Z
```

Out[51]:

```
array([[ 0., 10.,  5.,  3., 10., 10., 10., 10.],
       [10.,  0.,  5.,  6.,  0.,  0.,  0.,  0.],
       [ 5.,  5.,  0.,  1.,  5.,  5.,  5.,  5.],
       [ 3.,  6.,  1.,  0.,  6.,  6.,  6.,  6.],
       [10.,  0.,  5.,  6.,  0.,  0.,  0.,  0.],
       [10.,  0.,  5.,  6.,  0.,  0.,  0.,  0.],
       [10.,  0.,  5.,  6.,  0.,  0.,  0.,  0.],
       [10.,  0.,  5.,  6.,  0.,  0.,  0.,  0.]])
```

In [52]:

```
fig = plt.figure(figsize=(3,2),dpi=300,edgecolor='black')
plt.imshow(pd.DataFrame(Z ).rename(index={0:1, 1:2, 2:3, 3:4, 4:5, 5:6, 6:7, 7:8},
                                   columns={0:1, 1:2, 2:3, 3:4, 4:5, 5:6, 6:7, 7:8}
ax = plt.gca()
major_locator=MultipleLocator(1)
ax.xaxis.set_major_locator(major_locator)
ax.yaxis.set_major_locator(major_locator)
plt.tight_layout()
plt.colorbar()
plt.show()
```



In [31]:

```
#fig.savefig("C:\\Users\\47762\\Desktop\\Figure\\RP.jpg")
```

In [ ]:

```

```