DNA_06.2

August 29, 2016

1 Dynamic Network Analysis of Enron Email Network Comparisons

In [1]:
```
import pandas as pd
import numpy as np
import networkx as nx
import seaborn as sns
import matplotlib.pyplot as plt
import scipy as sc
import random
from scipy.signal import *
from numpy.linalg import *
from sklearn.decomposition import *
from sklearn.metrics import mean_squared_error
from sklearn import ensemble
#plotting parameters
%matplotlib inline
sns.set(style="whitegrid", color_codes=True, context='paper')
```

In [2]:
```
from matplotlib import rcParams
rcParams['font.family'] = 'serif'
rcParams['font.sans-serif'] = ['CMU Serif']
rcParams['font.weight']=['heavy']
import matplotlib.pyplot as plt
```

In [4]:
```
plt.rc('axes', grid=False, titlesize='large', labelsize='large',labelweight
plt.rc('lines', linewidth=4)
plt.rc('figure', figsize = (12,6),titlesize='large',titleweight='black')
plt.rc('font', weight='heavy', size=11)
plt.rc('grid',linewidth=5)
```

In [7]:
```
sns.set_palette(sns.cubehelix_palette(10, hue=0.3, reverse=True, rot=-0.55,
```

2 Get attribute data

In [71]:
```
lap = pd.read_excel('attribute_data/lap_att.xlsx')
adj = pd.read_excel('attribute_data/adj_att.xlsx')
mod = pd.read_excel('attribute_data/mod_att.xlsx')
```

In [72]:
```
lap.head()
```

Out[72]:
```
     AvgDeg    AvgBet    AvgClo   AvgLoad   AvgKatz  AvgDensity  AvgAlgCor
0  0.475524  1.000000  0.810523  0.475524  0.267944   -0.318532        1.0
1 -0.027972  0.250903  0.509903 -0.027972  0.069435   -0.419219        1.0
2  0.388112  1.000000  0.785809  0.388112  0.282044   -0.622808        1.0
3  1.000000  1.000000  1.000000  1.000000  1.000000    1.000000        1.0
4  0.559441  1.000000  0.835787  0.559441  0.423789   -0.054825        1.0

   AvgClustCoff    AvgEig   InstAmp    ...        StatRat  MeanCurv  \
0     -1.000000  0.177194  0.679834    ...       0.407864 -0.242635
1     -0.000165 -0.044891  0.305093    ...       0.570795 -0.269438
2     -1.000000 -0.127797  0.450396    ...       0.836955 -0.337965
3     -1.000000  1.000000  1.000000    ...      -1.000000  1.000000
4     -1.000000  0.403160  0.860240    ...       0.074177  0.108395

   SubgraphStat    1-Zeta  LogKPCARatioChg  NormNMFRatioChg  NormFAbel  \
0     -1.000000  1.000000        -0.015620        -1.000000  -0.543745
1      0.766117 -0.766117        -0.059551        -0.573875  -0.352246
2      0.873376 -0.873376         0.012093        -0.780922  -0.276008
3      0.421859 -0.421859        -0.079774        -0.869723  -1.000000
4      0.763599 -0.763599         0.019315        -0.673657  -0.702049

       NRMS       RMS  Emergence
0  0.000000  0.722464   0.000000
1  0.134441  0.551228  -0.205409
2  0.045739  0.604070   0.390743
3  0.189878  0.887236   1.000000
4  0.126025  0.688637  -0.972473

[5 rows x 33 columns]
```

In [73]:
```
coldrop = lap.columns[:9]
```

In [74]:
```
lap.drop(coldrop, axis=1, inplace=True)
mod.drop(coldrop, axis=1, inplace=True)
adj.drop(coldrop, axis=1, inplace=True)
```

In [75]:
```
lap.head()
```

Out[75]:
```
    InstAmp  InstPhase  InstFreq     Power  dInstAmp  d2InstAmp   InstAcc
0  0.679834   0.535455 -1.000000  0.021345 -0.565983  -0.539313 -0.707491
1  0.305093  -0.578269 -0.393695 -0.364336 -0.587010  -0.455499  0.708190
2  0.450396   0.214700 -0.052958 -0.367204 -0.566478  -0.483079 -0.006052
3  1.000000  -0.207114  1.000000  1.000000 -0.560284   1.000000  0.103005
4  0.860240   0.812100 -0.845407  0.340239 -1.000000   0.122943 -0.161020

   cosInstPhase    A_wt_IF   A_wt_IP    ...        StatRat  MeanCurv  \
0      0.249334 -1.000000  0.796844    ...       0.407864 -0.242635
```

```
1     -0.261313 -0.235448 -0.838336    ...       0.570795 -0.269438
2     -0.457223  0.015942  0.204171    ...       0.836955 -0.337965
3      1.000000  1.000000 -0.359857    ...      -1.000000  1.000000
4      0.560408 -0.708792  0.771960    ...       0.074177  0.108395

   SubgraphStat    1-Zeta  LogKPCARatioChg  NormNMFRatioChg  NormFAbel  \
0     -1.000000  1.000000        -0.015620        -1.000000  -0.543745
1      0.766117 -0.766117        -0.059551        -0.573875  -0.352246
2      0.873376 -0.873376         0.012093        -0.780922  -0.276008
3      0.421859 -0.421859        -0.079774        -0.869723  -1.000000
4      0.763599 -0.763599         0.019315        -0.673657  -0.702049

       NRMS       RMS  Emergence
0  0.000000  0.722464   0.000000
1  0.134441  0.551228  -0.205409
2  0.045739  0.604070   0.390743
3  0.189878  0.887236   1.000000
4  0.126025  0.688637  -0.972473

[5 rows x 24 columns]
```

In [76]:
```
mod.max()
```

Out[76]:
```
InstAmp            1.000000
InstPhase          1.000000
InstFreq           1.000000
Power              1.000000
dInstAmp           1.000000
d2InstAmp          1.000000
InstAcc            1.000000
cosInstPhase       1.000000
A_wt_IF            1.000000
A_wt_IP            1.000000
PowerSpecDen       1.000000
ResDist            1.000000
ZeroCrossRate      1.000000
LogSpecCentroid    1.000000
StatRat            1.000000
MeanCurv           1.000000
SubgraphStat       1.000000
1-Zeta             1.000000
LogKPCARatioChg    1.000000
NormNMFRatioChg    1.000000
NormFAbel          1.000000
NRMS               0.193777
RMS                0.745719
Emergence          1.000000
dtype: float64
```

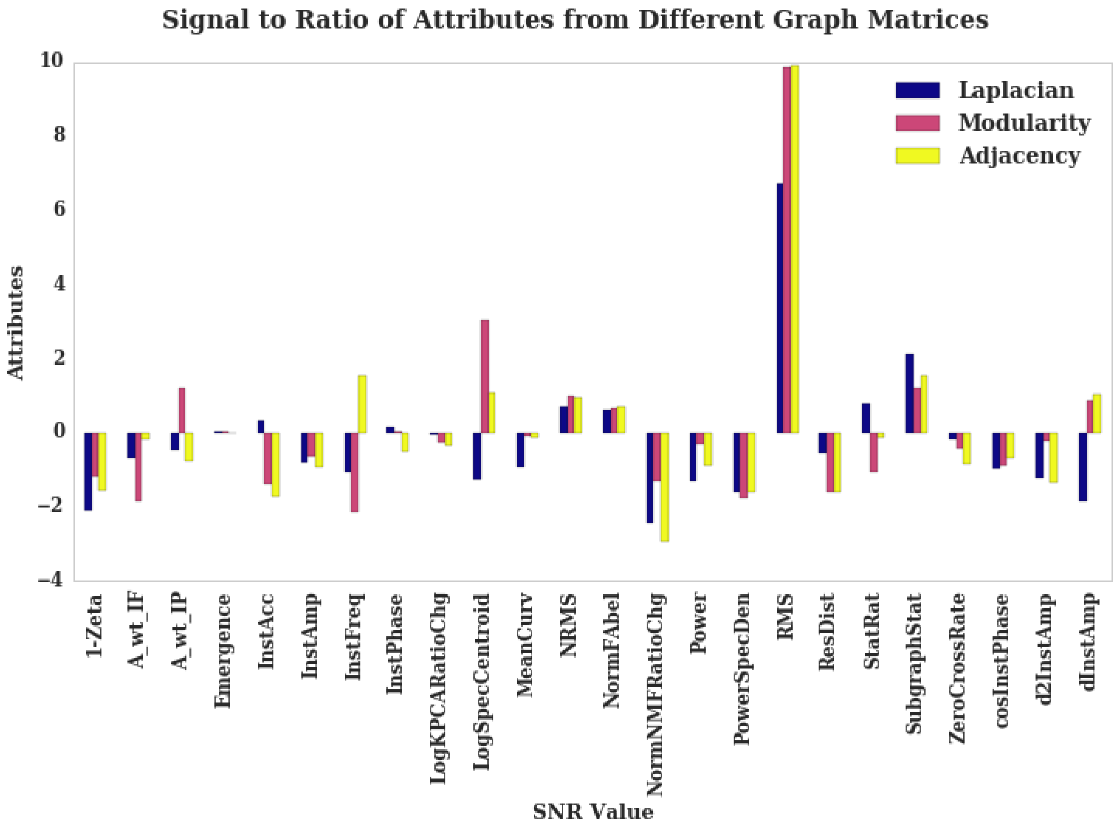
```
In [77]: months = ['Nov98', 'Dec98', 'jan_99', 'feb_99', 'mar_99', 'apr_99', 'may_9
                   'nov_99', 'dec_99', 'jan_2k', 'feb_2k', 'mar_2k', 'apr_2k', 'may
                   'nov_2k', 'dec_2k', 'jan_2k1', 'feb_2k1', 'mar_2k1', 'apr_2k1',
                   'oct_2k1', 'nov_2k1', 'dec_2k1', 'jan_2k2', 'feb_2k2', 'mar_2k2'

In [78]: att_only = lap.join(adj,rsuffix='_Adj').join(mod,rsuffix='_Mod')
         att_only.sortlevel(axis=1, inplace=True);

In [79]: att_only.head()

Out[79]:      1-Zeta  1-Zeta_Adj  1-Zeta_Mod   A_wt_IF  A_wt_IF_Adj  A_wt_IF_Mod  \
         0  1.000000    1.000000    1.000000 -1.000000    -0.065973    -0.578144
         1 -0.766117   -0.500770   -0.562061 -0.235448     0.000403    -0.270839
         2 -0.873376   -0.808032   -0.688113  0.015942    -0.065973    -0.578144
         3 -0.421859   -0.009407    0.339333  1.000000    -0.065973    -0.578144
         4 -0.763599   -0.427517   -0.195048 -0.708792     0.101108    -0.578144

              A_wt_IP  A_wt_IP_Adj  A_wt_IP_Mod  Emergence      ...         \
         0  0.796844     0.402595     0.448481   0.000000      ...
         1 -0.838336    -1.000000    -1.000000  -0.205409      ...
         2  0.204171     1.000000     0.448481   0.390743      ...
         3 -0.359857    -0.245437     0.448481   1.000000      ...
         4  0.771960    -0.359158     0.448481  -0.972473      ...

            ZeroCrossRate_Mod  cosInstPhase  cosInstPhase_Adj  cosInstPhase_Mod  \
         0          -1.000000      0.249334          0.912276          0.869867
         1          -0.904762     -0.261313         -0.339427         -0.038949
         2          -0.952381     -0.457223         -0.597742          0.009933
         3          -0.952381      1.000000          0.795405          0.243197
         4          -0.952381      0.560408          0.741131          1.000000

            d2InstAmp  d2InstAmp_Adj  d2InstAmp_Mod  dInstAmp  dInstAmp_Adj  \
         0  -0.539313      -0.741787      -0.070128 -0.565983      0.375510
         1  -0.455499      -0.811824       0.594556 -0.587010      0.465306
         2  -0.483079      -0.602222      -0.070128 -0.566478      0.375510
         3   1.000000       1.000000      -0.070128 -0.560284      0.375510
         4   0.122943       0.342754      -0.070128 -1.000000     -0.107077

            dInstAmp_Mod
         0      0.197628
         1      0.007620
         2      0.197628
         3      0.197628
         4      0.197628

         [5 rows x 72 columns]

In [106]: snr_lap = lap.mean()/lap.std()
          snr_mod = mod.mean()/mod.std()
          snr_adj = adj.mean()/adj.std()
```

```
In [111]: snr_df = pd.DataFrame([snr_lap,snr_mod,snr_adj])
```

```
In [114]: cname =  ['Laplacian','Modularity','Adjacency']
```

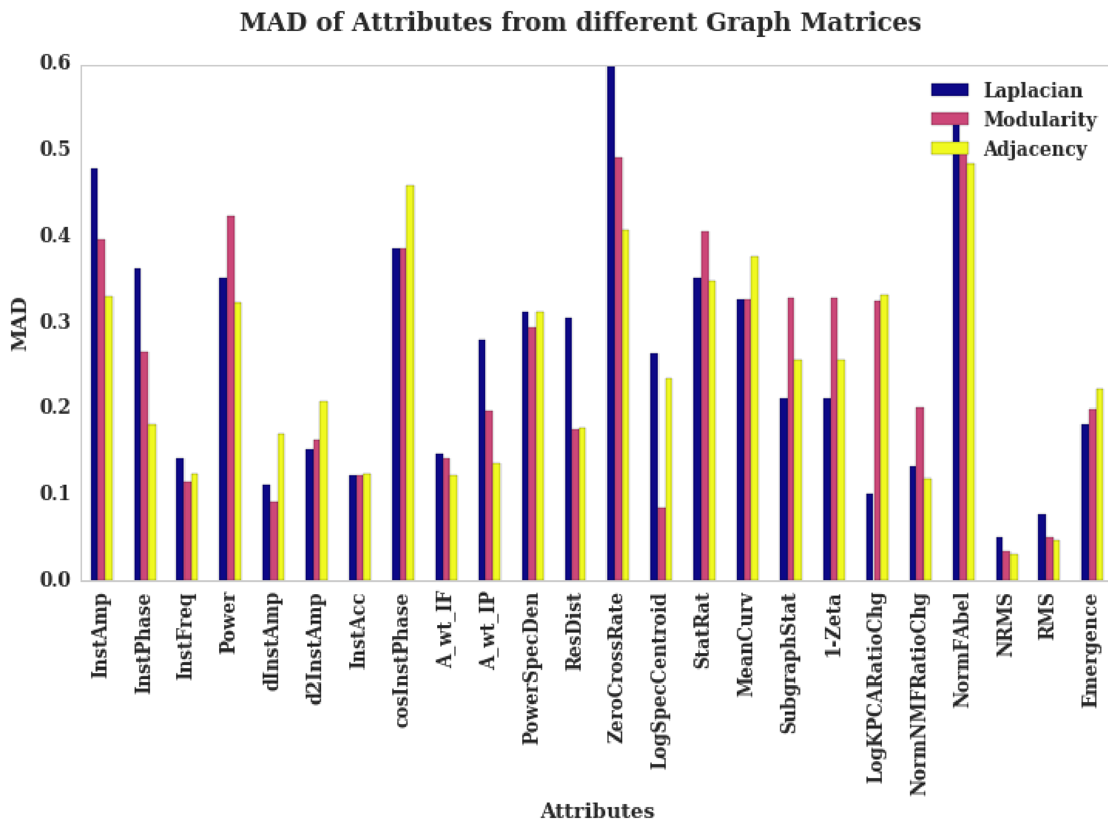
```
In [129]: snr_df =  snr_df.T
          snr_df.columns = cname
          snr_df.sortlevel(inplace=True)
```

```
In [248]: snr_df.plot.bar(figsize=(12,6), fontsize=12,cmap='plasma')
          plt.suptitle("Signal to Ratio of Attributes from Different Graph Matrices
          plt.legend(fontsize=14)
          plt.xlabel('SNR Value')
          plt.ylabel('Attributes')
          plt.savefig('images/snr_allatt_3mat.png')
```

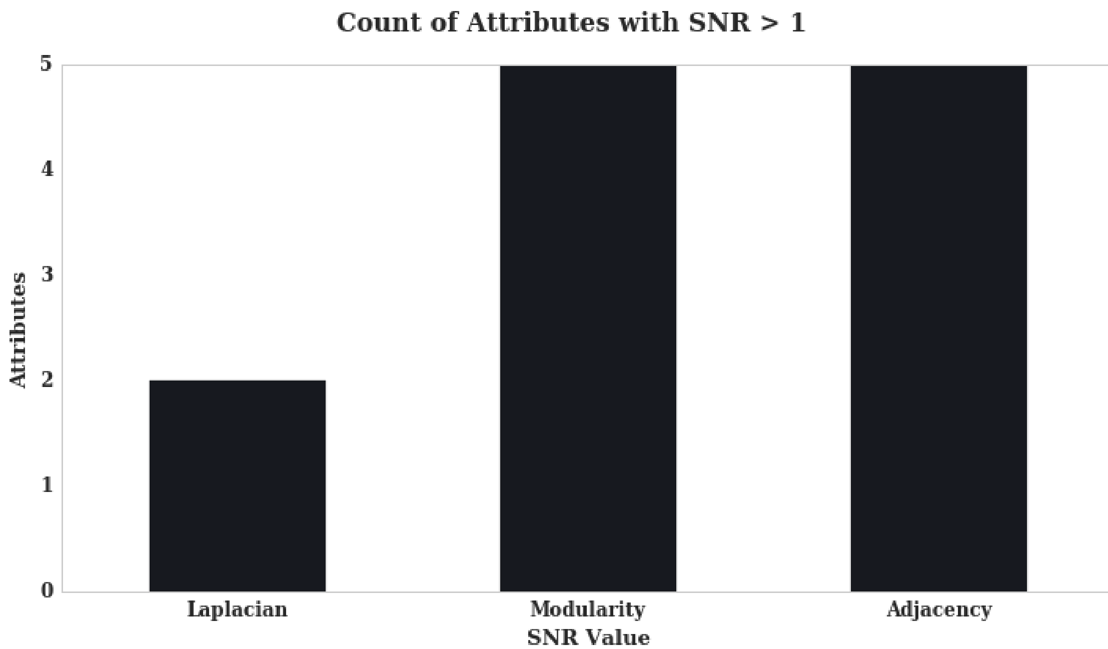



```
In [247]: mad_lap = lap.mad()
          mad_adj = adj.mad()
          mad_mod = mod.mad()

          mad_all = pd.DataFrame([mad_lap,mad_mod,mad_adj]).T
          mad_all.columns = ['Laplacian','Modularity','Adjacency']
```

```
mad_all.plot.bar(fontsize=12, cmap='plasma',figsize=(12,6))
plt.suptitle('MAD of Attributes from different Graph Matrices', fontsize=
plt.xlabel('Attributes')
plt.ylabel('MAD')
plt.legend(loc=1,fontsize=12)
plt.savefig('images/mad_allatt_3mat.png')
```




```
In [232]: snr_df[snr_df > 1].count().plot.bar(rot=0, fontsize=12)
          plt.suptitle("Count of Attributes with SNR > 1", fontsize=16)
          plt.xlabel('SNR Value')
          plt.ylabel('Attributes')
          plt.savefig('images/snrcount.png')
```



In [164]:
```
mad_all.max()/2
```

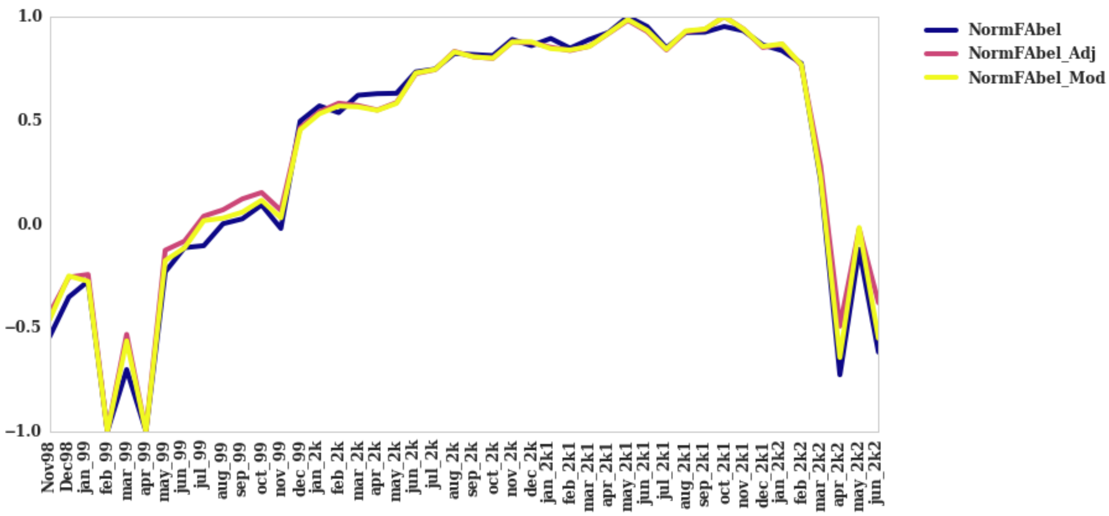
Out[164]:
```
Laplacian      0.299199
Modularity     0.252281
Adjacency      0.242036
dtype: float64
```

In [168]:
```
 att_only.columns[36:39]
```

Out[168]:
```
Index(['NormFAbel', 'NormFAbel_Adj', 'NormFAbel_Mod'], dtype='object')
```

In [187]:
```
att_only.iloc[:,36:39].plot.line(fontsize=12,cmap='plasma',rot=90)
plt.xticks(np.arange(len(months)), months);
plt.legend(fontsize=12, bbox_to_anchor=(1.05, 1), loc=2, borderaxespad=0.
```

Out[187]:
```
<matplotlib.legend.Legend at 0x7f63f26db7f0>
```

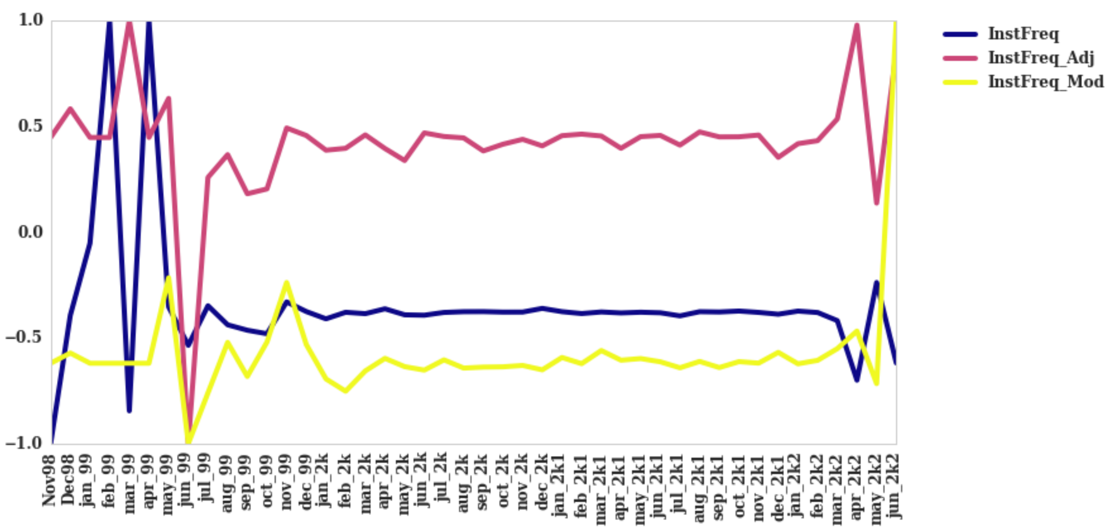



```
In [175]: att_only.columns[18:21]
```

```
Out[175]: Index(['InstFreq', 'InstFreq_Adj', 'InstFreq_Mod'], dtype='object')
```

```
In [186]: att_only.iloc[:,18:21].plot.line(fontsize=12,cmap='plasma', rot=90)
          plt.xticks(np.arange(len(months)), months);
          plt.legend(fontsize=12, bbox_to_anchor=(1.05, 1), loc=2, borderaxespad=0.
```

```
Out[186]: <matplotlib.legend.Legend at 0x7f63f26ee080>
```



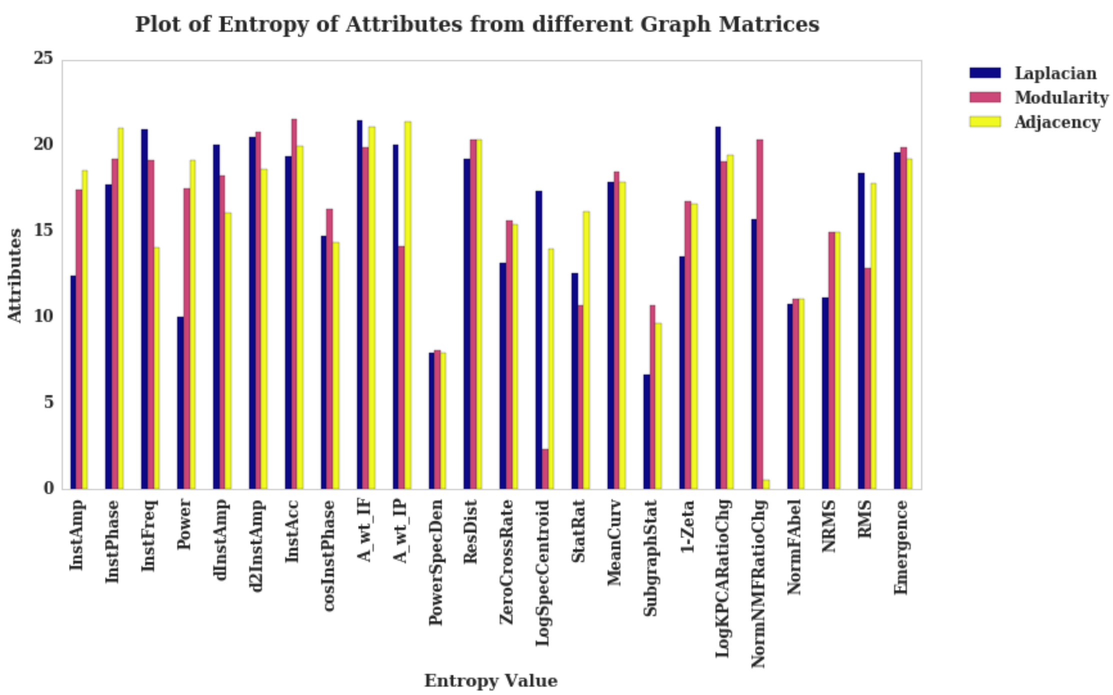

```
In [195]: from sklearn.preprocessing import *
```

```
In [201]: px_lap = lap.apply(lambda x: minmax_scale(x, feature_range=[0,1]))
          px_mod = mod.apply(lambda x: minmax_scale(x, feature_range=[0,1]))
          px_adj = adj.apply(lambda x: minmax_scale(x, feature_range=[0,1]))
```

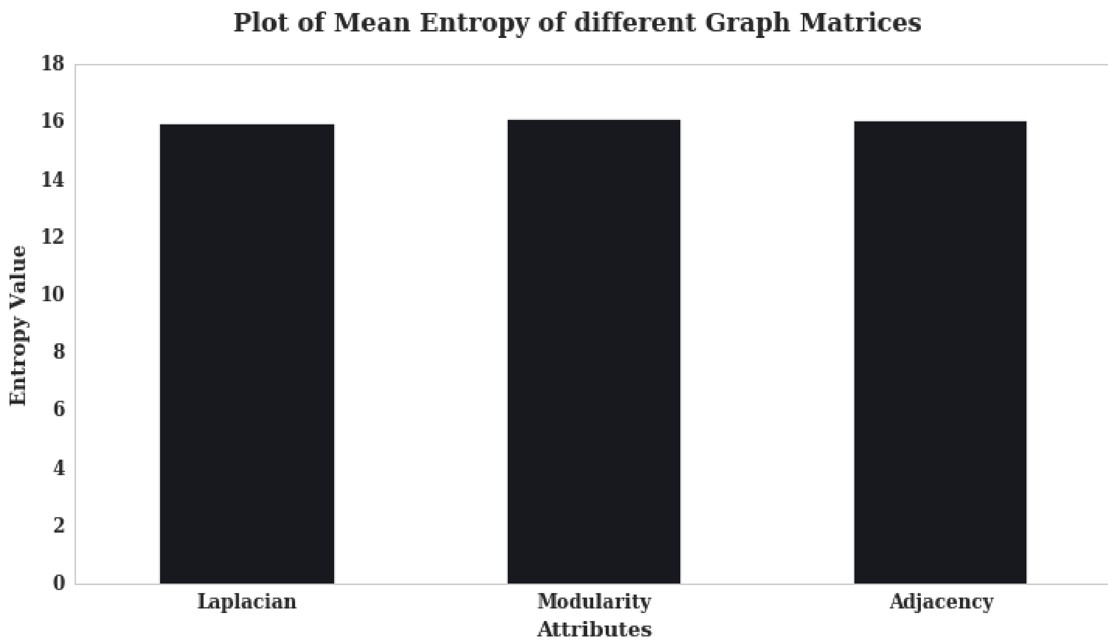
```
In [202]: ent_lap = -1* np.sum(px_lap*np.log2(px_lap))
          ent_mod = -1* np.sum(px_mod*np.log2(px_mod))
          ent_adj = -1* np.sum(px_adj*np.log2(px_adj))
```

```
In [203]: entropy_df = pd.DataFrame([ent_lap,ent_mod,ent_adj]).T
          entropy_df.columns = ['Laplacian','Modularity','Adjacency']
```

```
In [243]: entropy_df.plot.bar(figsize=(12,6), fontsize=12,cmap='plasma')
          plt.legend(fontsize=12, bbox_to_anchor=(1.05, 1), loc=2, borderaxespad=0.
          plt.suptitle("Plot of Entropy of Attributes from different Graph Matrices
          plt.xlabel('Entropy Value')
          plt.ylabel('Attributes')
          plt.savefig('images/entropy.png')
```




```
In [234]: entropy_df.mean().plot.bar(legend=False,fontsize=12, rot=0)
          plt.suptitle("Plot of Mean Entropy of different Graph Matrices", fontsize
          plt.ylabel('Entropy Value')
          plt.xlabel('Attributes')
          plt.savefig('images/entropy_mean.png')
```


Plot of Mean Entropy of different Graph Matrices
Entropy Value
0
2
4
6
8
10
12
14
16
18
Laplacian
Modularity
Adjacency
Attributes

In [ ]: