NATIONAL INSTITUTE OF TECHNOLOGY SILCHAR

Cachar, Assam

B.Tech. VIth Sem

Subject Code: CS-321

Subject Name: Social Network Analysis Lab

Submitted By:

Name : Subhojit Ghimire

Sch. Id. : 1912160

Branch : CSE – B

AIM: TO ANALYZE THE NETWORK DISTRIBUTION BY INCORPORATING THE FOLLOWING CENTRALITY MEASURES AND MENTION THE SIGNIFICANCE OF EACH OF THE MEASURES.

CENTRALITY MEASURES: DEGREE CENTRALITY, BETWEENNESS CENTRALITY, EIGENVECTOR CENTRALITY.

DATASETS: KARATE CLUB NETWORK, FOOTBALL.

THEORY:

1. **Degree Centrality:** It finds the most central vertex in terms of number of connections. It can be calculated using the following formula:

$$C_D(v_i) = \frac{\deg(v_i)}{n-1}$$

where, n is the number of nodes in the network

2. **Betweenness Centrality:** It finds the vertices that appear maximum number of times in the shortest path between two vertices. It can be calculated using the following formula:

$$C'_B(v_i) = \frac{C_B(v_i)}{\frac{(n-1)(n-2)}{2}}$$

where, $C_B(v_i) = \sum_{v_s = v_i = v_t \in V,\ s<t} \frac{\sigma_{s,t}(v_i)}{\sigma_{s,t}}$ is node betweenness

and, n is the number of nodes in the network

3. **Eigenvector Centrality:** It finds the vertices that are connected to important vertices. It can be calculated using the following formula:

$$C_E(v_i) = \frac{1}{\lambda} \sum_{v_{j \in V}} A_{i,j} C_E(v_j)$$

where, $C_E(v_j)$ is the Eigenvector Centrality of node 'j'

and, λ is a constant such that Ax = λx; x is eigenvector of the adjacency matrix A.

CODE:

```
import matplotlib.pyplot as plt
import networkx as nx

import urllib.request
import io
import zipfile

# FOOTBALL CLUB
url = "http://www-personal.umich.edu/~mejn/netdata/football.zip"
sock = urllib.request.urlopen (url)
sockRead = io.BytesIO (sock.read ())
sock.close ()

zf = zipfile.ZipFile (sockRead)
txt = zf.read ("football.txt").decode ()
gml = zf.read ("football.gml").decode ()
gml = gml.split ("\n") [1:]

FC = nx.parse_gml (gml)

# KARATE CLUB
KC = nx.karate_club_graph ()

# Graph Node Setting
options = {
    "node_color": "red",
    "node_size": 50,
    "linewidths": 0,
    "width": 0.1,
}

# DEGREE CENTRALITY
CD_KC = nx.degree_centrality (KC) # Degree Centrality for Karate Club
print ("\nDEGREE CENTRALITY: KARATE CLUB\n")
print (['%s %0.2f'%(node, CD_KC [node]) for node in CD_KC])

CD_FC = nx.degree_centrality (FC) # Degree Centrality for Football Club
print ("\nDEGREE CENTRALITY: FOOTBALL CLUB\n")
print (['%s %0.2f'%(node, CD_FC [node]) for node in CD_FC])


# BETWEENNESS CENTRALITY
CB_KC = nx.betweenness_centrality (KC, normalized = True, endpoints = False) #
Betweenness Centrality for Karate Club
print ("\nBETWEENNESS CENTRALITY: KARATE CLUB\n")
print (['%s %0.2f'%(node, CB_KC [node]) for node in CB_KC])
```

```
CB_FC = nx.betweenness_centrality (FC, normalized = True, endpoints = False) #
Betweenness Centrality for Football Club
print ("\nBETWEENNESS CENTRALITY: FOOTBALL CLUB\n")
print (['%s %0.2f'%(node, CB_FC [node]) for node in CB_FC])

# EIGENVECTOR CENTRALITY
CE_KC = nx.eigenvector_centrality (KC) # Eigenvector Centrality for Karate
Club
print ("\nEIGENVECTOR CENTRALITY: KARATE CLUB\n")
print (['%s %0.2f'%(node, CE_KC [node]) for node in CE_KC])

CE_FC = nx.eigenvector_centrality(FC) # Eigenvector Centrality for Football
Club
print ("\nEIGENVECTOR CENTRALITY: FOOTBALL CLUB\n")
print (['%s %0.2f'%(node, CE_FC [node]) for node in CE_FC])

# NETWORK GRAPHS
plt.figure (figsize = (15, 15))
plt.title ("KARATE CLUB NETWORK")
nx.draw_networkx (KC, with_labels = True, **options)

plt.figure (figsize = (15, 15))
plt.title ("FOOTBALL CLUB NETWORK")
nx.draw_networkx (FC, with_labels = True, **options)

plt.show ()
```

OUTPUT:

```
PS C:\Users\subho> python -u "d:\Documents\NITS\Semester VI\(LAB) CS321 SNA\lab1.py"

DEGREE CENTRALITY: KARATE CLUB

['0 0.48', '1 0.27', '2 0.30', '3 0.18', '4 0.09', '5 0.12', '6 0.12', '7 0.12', '8 0.15', '9 0.06', '10 0.09', '11 0.03', '1
2 0.06', '13 0.15', '14 0.06', '15 0.06', '16 0.06', '17 0.06', '18 0.06', '19 0.09', '20 0.06', '21 0.06', '22 0.06', '23 0.
15', '24 0.09', '25 0.09', '26 0.06', '27 0.12', '28 0.09', '29 0.12', '30 0.12', '31 0.18', '32 0.36', '33 0.52']

DEGREE CENTRALITY: FOOTBALL CLUB

['BrighamYoung 0.11', 'FloridaState 0.11', 'Iowa 0.11', 'KansasState 0.11', 'NewMexico 0.10', 'TexasTech 0.11', 'PennState 0.
11', 'SouthernCalifornia 0.11', 'ArizonaState 0.10', 'SanDiegoState 0.10', 'Baylor 0.09', 'NorthTexas 0.09', 'NorthernIllinoi
s 0.09', 'Northwestern 0.10', 'WesternMichigan 0.09', 'Wisconsin 0.11', 'Wyoming 0.10', 'Auburn 0.10', 'Akron 0.10', 'Virgini
aTech 0.10', 'Alabama 0.10', 'UCLA 0.10', 'Arizona 0.10', 'Utah 0.10', 'ArkansasState 0.09', 'NorthCarolinaState 0.10', 'Ball
State 0.09', 'Florida 0.10', 'BoiseState 0.08', 'BostonCollege 0.10', 'WestVirginia 0.10', 'BowlingGreenState 0.10', 'Michiga
n 0.10', 'Virginia 0.09', 'Buffalo 0.10', 'Syracuse 0.10', 'CentralFlorida 0.07', 'GeorgiaTech 0.10', 'CentralMichigan 0.10',
 'Purdue 0.10', 'Colorado 0.10', 'ColoradoState 0.09', 'Connecticut 0.06', 'EasternMichigan 0.10', 'EastCarolina 0.10', 'Duke
 0.10', 'FresnoState 0.10', 'OhioState 0.10', 'Houston 0.10', 'Rice 0.10', 'Idaho 0.08', 'Washington 0.10', 'Kansas 0.09', 'S
outhernMethodist 0.11', 'Kent 0.09', 'Pittsburgh 0.10', 'Kentucky 0.09', 'Louisville 0.09', 'LouisianaTech 0.09', 'LouisianaM
onroe 0.07', 'Minnesota 0.10', 'MiamiOhio 0.10', 'Vanderbilt 0.10', 'MiddleTennesseeState 0.08', 'Illinois 0.10', 'Mississipp
iState 0.10', 'Memphis 0.10', 'Nevada 0.11', 'Oregon 0.10', 'NewMexicoState 0.10', 'SouthCarolina 0.10', 'Ohio 0.09', 'IowaSt
ate 0.10', 'SanJoseState 0.10', 'Nebraska 0.10', 'SouthernMississippi 0.09', 'Tennessee 0.10', 'Stanford 0.10', 'WashingtonSt
ate 0.10', 'Temple 0.10', 'Navy 0.10', 'TexasA&M 0.10', 'NotreDame 0.10', 'TexasElPaso 0.10', 'Oklahoma 0.10', 'Toledo 0.08',
 'Tulane 0.10', 'Mississippi 0.10', 'Tulsa 0.11', 'NorthCarolina 0.10', 'UtahState 0.08', 'Army 0.10', 'Cincinnati 0.10', 'Ai
rForce 0.09', 'Rutgers 0.09', 'Georgia 0.09', 'LouisianaState 0.09', 'LouisianaLafayette 0.07', 'Texas 0.10', 'Marshall 0.09'
, 'MichiganState 0.10', 'MiamiFlorida 0.09', 'Missouri 0.09', 'Clemson 0.09', 'NevadaLasVegas 0.11', 'WakeForest 0.09', 'Indi
ana 0.10', 'OklahomaState 0.09', 'OregonState 0.09', 'Maryland 0.10', 'TexasChristian 0.10', 'California 0.10', 'AlabamaBirmi
ngham 0.09', 'Arkansas 0.09', 'Hawaii 0.10']
```

Fig.: Degree Centralities for every node in Karate Club and Football Club Network

```
BETWEENNESS CENTRALITY: KARATE CLUB

['0 0.44', '1 0.05', '2 0.14', '3 0.01', '4 0.00', '5 0.03', '6 0.03', '7 0.00', '8 0.06', '9 0.00', '10 0.00', '11 0.00', '1
2 0.00', '13 0.05', '14 0.00', '15 0.00', '16 0.00', '17 0.00', '18 0.00', '19 0.03', '20 0.00', '21 0.00', '22 0.00', '23 0.
02', '24 0.00', '25 0.00', '26 0.00', '27 0.02', '28 0.00', '29 0.00', '30 0.01', '31 0.14', '32 0.15', '33 0.30']

BETWEENNESS CENTRALITY: FOOTBALL CLUB

['BrighamYoung 0.03', 'FloridaState 0.02', 'Iowa 0.01', 'KansasState 0.02', 'NewMexico 0.01', 'TexasTech 0.01', 'PennState 0.
02', 'SouthernCalifornia 0.01', 'ArizonaState 0.01', 'SanDiegoState 0.01', 'Baylor 0.01', 'NorthTexas 0.01', 'NorthernIllinoi
s 0.01', 'Northwestern 0.02', 'WesternMichigan 0.01', 'Wisconsin 0.02', 'Wyoming 0.02', 'Auburn 0.02', 'Akron 0.01', 'Virgini
aTech 0.01', 'Alabama 0.02', 'UCLA 0.02', 'Arizona 0.01', 'Utah 0.01', 'ArkansasState 0.02', 'NorthCarolinaState 0.02', 'Ball
State 0.02', 'Florida 0.01', 'BoiseState 0.02', 'BostonCollege 0.01', 'WestVirginia 0.02', 'BowlingGreenState 0.01', 'Michiga
n 0.01', 'Virginia 0.01', 'Buffalo 0.01', 'Syracuse 0.02', 'CentralFlorida 0.01', 'GeorgiaTech 0.01', 'CentralMichigan 0.03',
 'Purdue 0.01', 'Colorado 0.01', 'ColoradoState 0.01', 'Connecticut 0.01', 'EasternMichigan 0.01', 'EastCarolina 0.01', 'Duke
 0.01', 'FresnoState 0.01', 'OhioState 0.02', 'Houston 0.02', 'Rice 0.01', 'Idaho 0.01', 'Washington 0.01', 'Kansas 0.01', 'S
outhernMethodist 0.02', 'Kent 0.00', 'Pittsburgh 0.01', 'Kentucky 0.01', 'Louisville 0.01', 'LouisianaTech 0.03', 'LouisianaM
onroe 0.01', 'Minnesota 0.02', 'MiamiOhio 0.02', 'Vanderbilt 0.01', 'MiddleTennesseeState 0.02', 'Illinois 0.02', 'Mississipp
iState 0.01', 'Memphis 0.01', 'Nevada 0.01', 'Oregon 0.01', 'NewMexicoState 0.02', 'SouthCarolina 0.02', 'Ohio 0.01', 'IowaSt
ate 0.02', 'SanJoseState 0.01', 'Nebraska 0.01', 'SouthernMississippi 0.01', 'Tennessee 0.01', 'Stanford 0.01', 'WashingtonSt
ate 0.01', 'Temple 0.01', 'Navy 0.03', 'TexasA&M 0.01', 'NotreDame 0.03', 'TexasElPaso 0.01', 'Oklahoma 0.01', 'Toledo 0.01',
 'Tulane 0.01', 'Mississippi 0.01', 'Tulsa 0.02', 'NorthCarolina 0.02', 'UtahState 0.01', 'Army 0.02', 'Cincinnati 0.02', 'Air
Force 0.01', 'Rutgers 0.01', 'Georgia 0.01', 'LouisianaState 0.01', 'LouisianaLafayette 0.01', 'Texas 0.01', 'Marshall 0.01'
, 'MichiganState 0.01', 'MiamiFlorida 0.02', 'Missouri 0.02', 'Clemson 0.01', 'NevadaLasVegas 0.02', 'WakeForest 0.00', 'Indi
ana 0.02', 'OklahomaState 0.01', 'OregonState 0.00', 'Maryland 0.01', 'TexasChristian 0.01', 'California 0.01', 'AlabamaBirmi
ngham 0.01', 'Arkansas 0.01', 'Hawaii 0.01']
```

Fig.: Betweenness Centralities for every node in Karate Club and Football Club Network

```
EIGENVECTOR CENTRALITY: KARATE CLUB

['0 0.36', '1 0.27', '2 0.32', '3 0.21', '4 0.08', '5 0.08', '6 0.08', '7 0.17', '8 0.23', '9 0.10', '10 0.08', '11 0.05', '1
2 0.08', '13 0.23', '14 0.10', '15 0.10', '16 0.02', '17 0.09', '18 0.10', '19 0.15', '20 0.10', '21 0.09', '22 0.10', '23 0.
15', '24 0.06', '25 0.06', '26 0.08', '27 0.13', '28 0.13', '29 0.13', '30 0.17', '31 0.19', '32 0.31', '33 0.37']

EIGENVECTOR CENTRALITY: FOOTBALL CLUB

['BrighamYoung 0.11', 'FloridaState 0.10', 'Iowa 0.12', 'KansasState 0.11', 'NewMexico 0.10', 'TexasTech 0.10', 'PennState 0.
11', 'SouthernCalifornia 0.12', 'ArizonaState 0.11', 'SanDiegoState 0.11', 'Baylor 0.09', 'NorthTexas 0.08', 'NorthernIllinoi
s 0.07', 'Northwestern 0.11', 'WesternMichigan 0.08', 'Wisconsin 0.12', 'Wyoming 0.10', 'Auburn 0.08', 'Akron 0.08', 'Virgini
aTech 0.08', 'Alabama 0.08', 'UCLA 0.11', 'Arizona 0.11', 'Utah 0.10', 'ArkansasState 0.08', 'NorthCarolinaState 0.09', 'Ball
State 0.07', 'Florida 0.08', 'BoiseState 0.07', 'BostonCollege 0.09', 'WestVirginia 0.09', 'BowlingGreenState 0.08', 'Michiga
n 0.11', 'Virginia 0.08', 'Buffalo 0.08', 'Syracuse 0.09', 'CentralFlorida 0.06', 'GeorgiaTech 0.09', 'CentralMichigan 0.08',
 'Purdue 0.10', 'Colorado 0.10', 'ColoradoState 0.10', 'Connecticut 0.05', 'EasternMichigan 0.07', 'EastCarolina 0.09', 'Duke
 0.09', 'FresnoState 0.12', 'OhioState 0.11', 'Houston 0.09', 'Rice 0.12', 'Idaho 0.07', 'Washington 0.10', 'Kansas 0.09', 'S
outhernMethodist 0.12', 'Kent 0.08', 'Pittsburgh 0.09', 'Kentucky 0.08', 'Louisville 0.08', 'LouisianaTech 0.08', 'LouisianaM
onroe 0.05', 'Minnesota 0.10', 'MiamiOhio 0.08', 'Vanderbilt 0.08', 'MiddleTennesseeState 0.06', 'Illinois 0.11', 'Mississipp
iState 0.08', 'Memphis 0.08', 'Nevada 0.13', 'Oregon 0.11', 'NewMexicoState 0.09', 'SouthCarolina 0.08', 'Ohio 0.08', 'IowaSt
ate 0.10', 'SanJoseState 0.12', 'Nebraska 0.10', 'SouthernMississippi 0.08', 'Tennessee 0.08', 'Stanford 0.11', 'WashingtonSt
ate 0.10', 'Temple 0.09', 'Navy 0.09', 'TexasA&M 0.10', 'NotreDame 0.10', 'TexasElPaso 0.12', 'Oklahoma 0.10', 'Toledo 0.07',
 'Tulane 0.09', 'Mississippi 0.08', 'Tulsa 0.12', 'NorthCarolina 0.09', 'UtahState 0.08', 'Army 0.09', 'Cincinnati 0.09', 'Air
Force 0.09', 'Rutgers 0.08', 'Georgia 0.07', 'LouisianaState 0.07', 'LouisianaLafayette 0.06', 'Texas 0.10', 'Marshall 0.08'
, 'MichiganState 0.11', 'MiamiFlorida 0.08', 'Missouri 0.09', 'Clemson 0.08', 'NevadaLasVegas 0.11', 'WakeForest 0.08', 'Indi
ana 0.11', 'OklahomaState 0.09', 'OregonState 0.10', 'Maryland 0.09', 'TexasChristian 0.11', 'California 0.11', 'AlabamaBirmi
ngham 0.07', 'Arkansas 0.07', 'Hawaii 0.12']
```

Fig.: Eigenvector Centralities for every node in Karate Club and Football Club Network

NETWORK GRAPHS FOR KARATE CLUB AND FOOTBALL CLUB