Complex Networks: Quiz #2

Due on Dec 5, 2018

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Problem 1

1. Make a program of counting the number of triangles in "karate club network". Show the code and its results.
1. Network data is available in the following sites.
http://www-personal.umich.edu/ mejn/netdata/
http://networkrepository.com/soc-karate.php

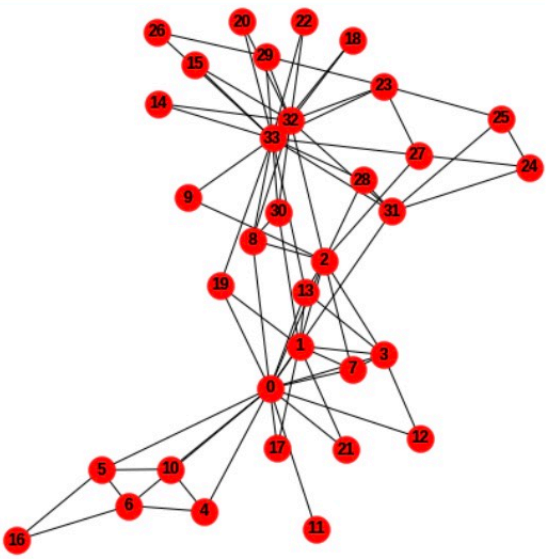
```
import networkx as nx
import matplotlib.pyplot as plt
import numpy as np

G = nx.karate_club_graph()
plt.figure(figsize=(6, 6))
nx.draw_spring(G, node_size=400, node_color='red', with_labels=True, font_weight='bold')

print("n =", nx.number_of_nodes(G))
print("m =", nx.number_of_edges(G))
A= nx.adjacency_matrix(G).todense()
print(A)
print(A*A)

print("sum", np.sum(A))
print("trace", np.trace(A))
```

```
n = 34
m = 78
[[0 1 1 ... 1 0 0]
 [1 0 1 ... 0 0 0]
 [1 1 0 ... 0 1 0]
 ...
 [1 0 0 ... 0 1 1]
 [0 0 1 ... 1 0 1]
 [0 0 0 ... 1 1 0]]
[[16  7  5 ...  0  3  4]
 [ 7  9  4 ...  1  2  3]
 [ 5  4 10 ...  3  1  6]
 ...
 [ 0  1  3 ...  6  1  2]
 [ 3  2  1 ...  1 12 10]
 [ 4  3  6 ...  2 10 17]]
sum 156
trace 0
```



Answer 1

The number of triangles is 45.

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

G = nx.karate_club_graph()
plt.figure(figsize=(6,6))
nx.draw_spring(G,node_size=400,node_color='red',with_labels=True,font_weight='bold')

print("n=",nx.number_of_nodes(G))
print("m=",nx.number_of_edges(G))

A=nx.adjacency_matrix(G).todense()
```

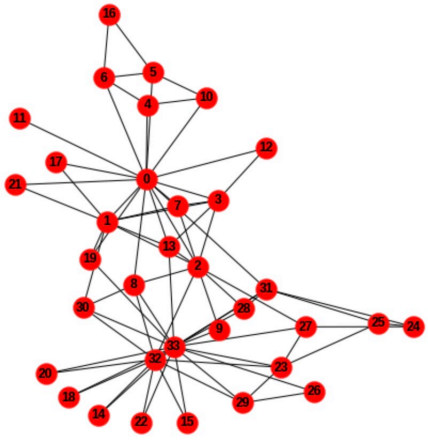
```
print(A)
print(A*A)
print("sum",np.sum(A))
print("trace",np.trace(A))

sum = 0
for i in range(0,34):
  sum = sum + nx.triangles(G, i)

print("tri",nx.triangles(G, nodes = None))
print("NUM_of_triangles",int(sum/3))
```

The result is as follows:

```
n= 34
m= 78
[[0 1 1 ... 1 0 0]
 [1 0 1 ... 0 0 0]
 [1 1 0 ... 0 1 0]
 ...
 [1 0 0 ... 0 1 1]
 [0 0 1 ... 1 0 1]
 [0 0 0 ... 1 1 0]]
[[16  7  5 ...  0  3  4]
 [ 7  9  4 ...  1  2  3]
 [ 5  4 10 ...  3  1  6]
 ...
 [ 0  1  3 ...  6  1  2]
 [ 3  2  1 ...  1 12 10]
 [ 4  3  6 ...  2 10 17]]
sum 156
trace 0
tri {0: 18, 1: 12, 2: 11, 3: 10, 4: 2, 5: 3, 6: 3, 7: 6, 8: 5, 9: 0, 10: 2, 11: 0, 12: 1, 13: 6,
                                                    14: 1, 15: 1, 16: 1, 17: 1, 18: 1, 19: 1, 20: 1,
                                                     21: 1, 22: 1, 23: 4, 24: 1, 25: 1, 26: 1, 27: 1
                                                    , 28: 1, 29: 4, 30: 3, 31: 3, 32: 13, 33: 15}
NUM_of_triangles 45
```



Problem 2

2. Compute the maximum number of triangles in a graph of 9 nodes.

Answer2

The number of triangles is maximum when each node is connected to others.
Also, there is no orders in triangles.
Therefore,
Maximum num of triangles $= C_9^3 = \frac{9!}{3!6!} = 84$

Problem 3

3. Draw a graph of 9 nodes and 12 edges that contains no triangles.

Answer3

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

G = nx.Graph()
G.add_nodes_from(range(1,10))
for i in range(3,9):
  G.add_edges_from([(1,i)])

for j in range(4,10):
  G.add_edges_from([(2,j)])

print("n =", nx.number_of_nodes(G))
print("m =", nx.number_of_edges(G))
print("tri",nx.triangles(G, nodes = None))

nx.draw_spring(G, node_size=400, node_color='red', with_labels=True, font_weight='bold')
```

The result is as follows:

```
n = 9
m = 12
tri {1: 0, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 0, 9: 0}
```