CS-E5740 Complex Networks, Answers to exercise set 5

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Problem 1

a)

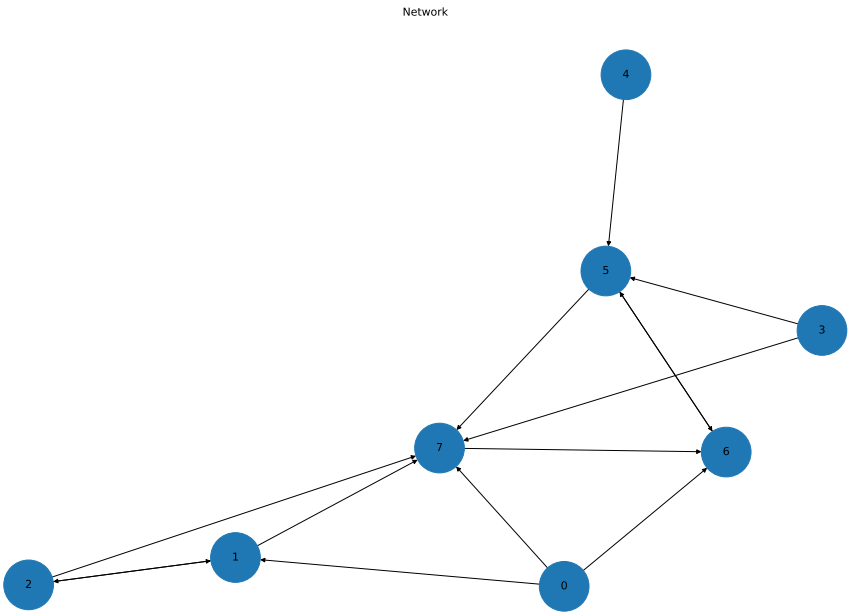

Figure 1: visualize pagerank network

b)

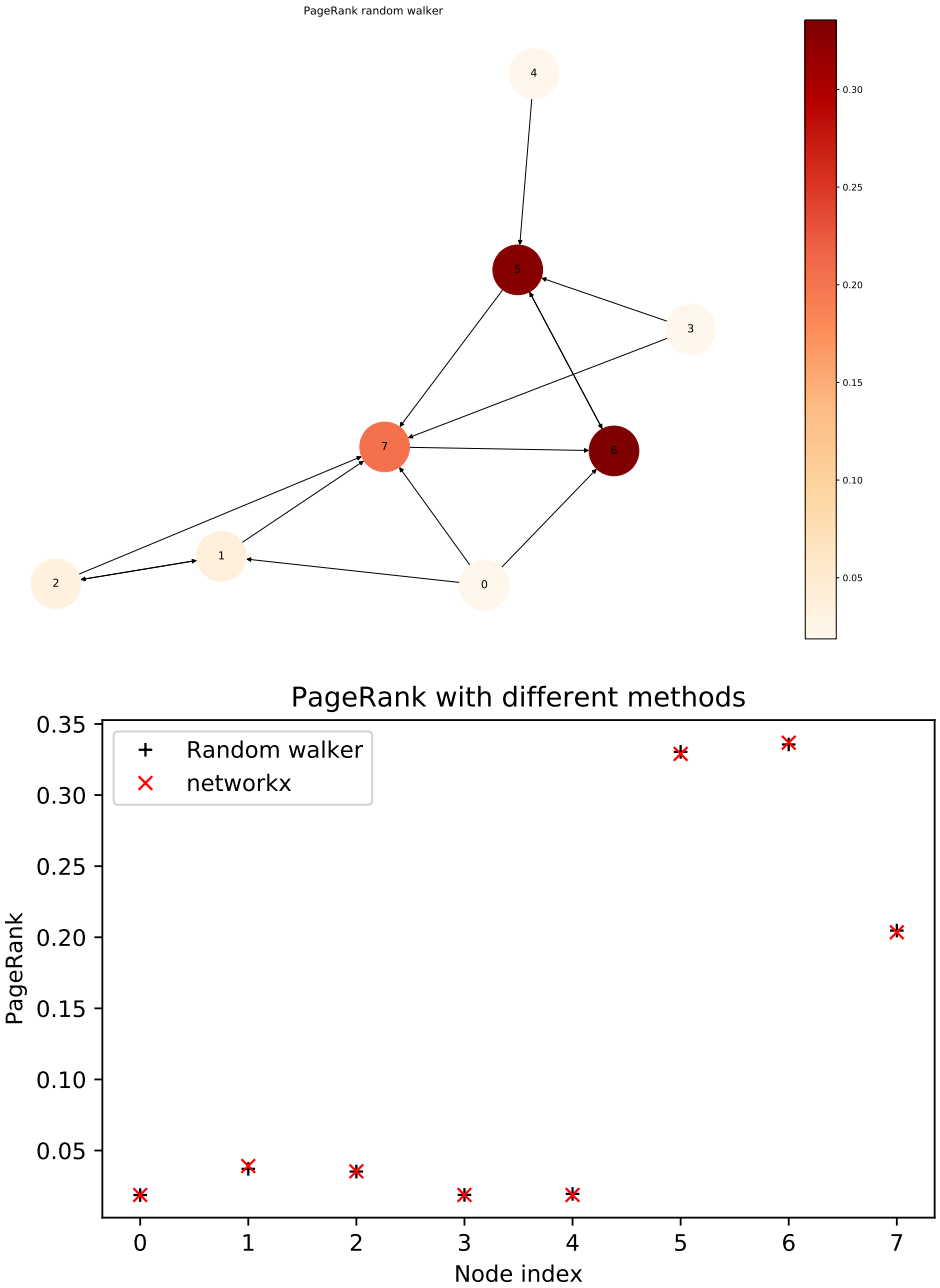

Figure 2: visualize pagerank random walk

c)

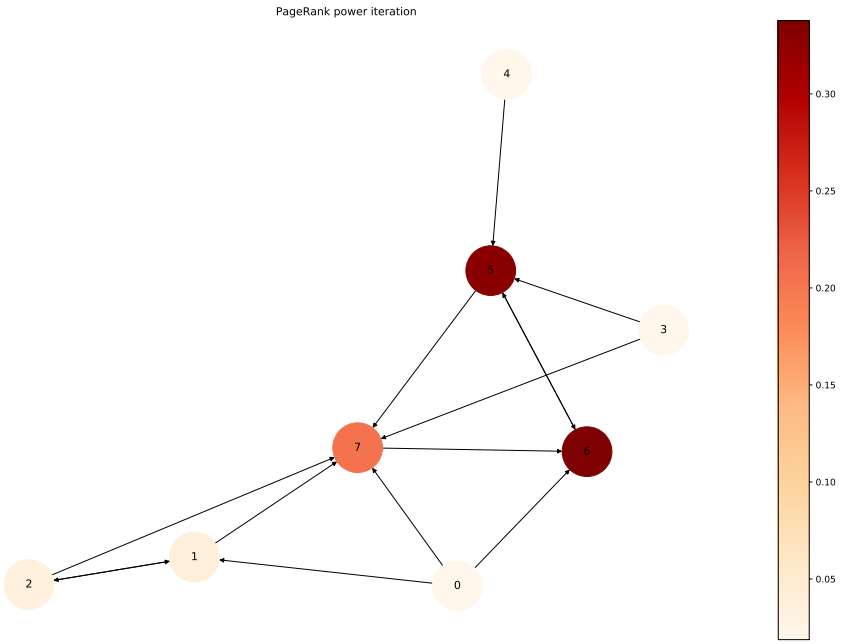

Figure 3: visualize pagerank of power iteration

d)

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Power Iteration for a 10**4 nodes network takes 1.4728020876646042 seconds
Power Iteration for a 26*10**6 nodes network takes 3829.285427927971 seconds
Naive random walker for a 10**3 nodes network takes 47.98100366195043 seconds
Naive random walker for a 26*10**6 nodes network takes 1247506.0952107112 seconds
```

Figure 4: estimate of time

e) 1.What is the connection between degree k or in-degree k_{in} and PageRank?
The in-degree has a connection with PageRank. The node with higher in-degree will have higher page rank value because tehy have more neighbour contributions when the algorithm runs.
2.How does PageRank change if the node belongs to a strongly connected component?
If the node belongs to a SCC, we could see this node as more in-degree than out-degree, which will lead to higher and higher pageRank value. This might end up as a dead end sometimes.
3.How could this information be used in improving the power iteration algorithm given in part c)?
We could add very tiny (very small weight) link for every node to each other nodes. This will help solve the dead ends.

f) When node index <= 4, the higher d has lower pagerank value. When node index >= 5, the higher d has higher pagerank value. When d = 0, the page rank value is more or less the same regardless of the node index. When d starts to grow, the node 5,6,7 ranks more and has higher page rank value since they have higher in-degree.

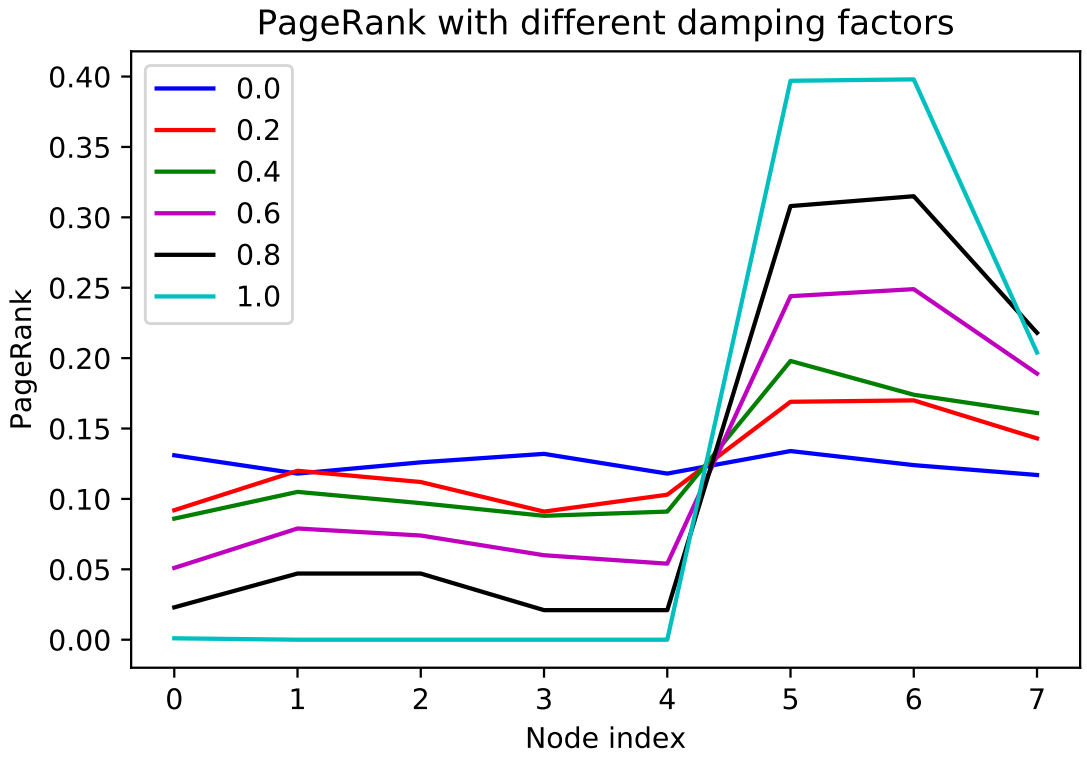

Figure 5: Investigate the role of the damping factor d

g) We could see that social-network has the same in-degree and out-degree as 82. So does the social-network-analysis with degree 73. They are both among the highest pagerank. Those two might are strong connected components that means they will have high pagerank value. Among the highest page rank, graph-theory and mathematics both don't have the highest in-degree or out-degree, which is very interesting. A hypothesis why this happen might be they connected to very "powerful" components. And although small-world-experiment ranks both in the highest in-degree and highest out-degree, but not in the highest pagerank. The reason might because of the property and the parameter p of small world network.

```
---Highest PageRank:---
0.035193190714322 59 : Graph_theory
0.020361350619844 69 : Social_network
0.016771511398301818 : Mathematics
0.016462083632076074 : Social_network_analysis
0.014703296264824403 : Social_networking_service
---Highest In-degree:---
82 : Social_network
73 : Social_network_analysis
63 : Small_world_experiment
62 : Social_networking_service
62 : Orkut
---Highest Out-degree:---
140 : Network_science
82 : Social_network
73 : Social_network_analysis
67 : Small-world_network
65 : Small_world_experiment
```