DSTA

Chapter IV - WWW, Wiki and Online social networks.

This solution notebook is taken from the notebook for Ch. 4 of Caldarelli-Cheesa's textbook (CC).

Please see the class repository for the datasets and the **exercise notebook**.

```
import numpy as np

import matplotlib.pyplot as plt

import networkx as nx
```

Get data from The Laboratory for Web Algorithmics

This is the page with the datasets: http://law.di.unimi.it/datasets.php

It is possible to download a network in a WebGraph format that is a compressed binary format.

The project provides various clients to extract the network strcture, in Java, C++ and in Python, py-web-graph: http://webgraph.di.unimi.it/.

In particular we got the graph and the related urls associated to each node of the .eu domain in 2005: http://law.di.unimi.it/webdata/eu-2005/.

We exctracted the graph in a form of an edge list and we also got the file with the list of urls in the same order of the node_id

```
ARCSFILE = './data/eu-2005_1M.arcs'
```

```python
#defining the eu directed graph
eu_DG = nx.DiGraph()
#retrieve just the portion of the first 1M edges of the .eu domain
#crawled in 2005
eu_DG = nx.read_edgelist(ARCSFILE, create_using = nx.DiGraph())

#generate the dictionary of node_is -> urls
file_urls = open(ARCSFILE)

count = 0

dic_nodid_urls = {}

while True:
    next_line = file_urls.readline()

    if not next_line:
        break

    next_line[:-1]
    dic_nodid_urls[str(count)] = next_line[:-1]
    count = count+1

file_urls.close()

#generate the strongly connected component
scc = [(len(c),c) for c in sorted( nx.strongly_connected_components \
                               (eu_DG), key=len, reverse=True)][0][1]

eu_DG_SCC = eu_DG.subgraph(scc)
```

```python
l = [e for e in eu_DG_SCC.edges]
```

```python
l[:5]
```

```
[('49694', '30617'),
 ('49694', '31620'),
 ('49694', '32622'),
 ('49694', '32623'),
 ('49694', '35178')]
```

Retrieving data through the Twitter API usign the Twython module

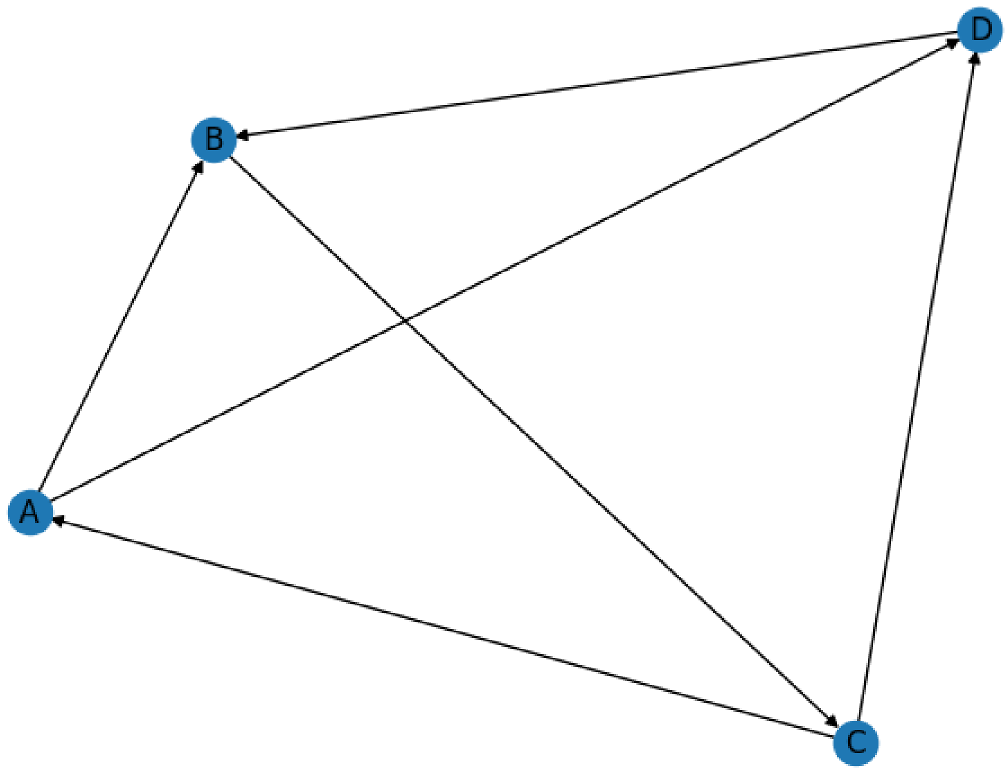
This part is not in use anymore as the TwitterAPI does not generally serve data anymore: we get a 403 error.

Please proceed to the 'HITS algorithm' section below.

Hits algorithm

Create a simple labeled network: the 'four triangles' network

```
DG = nx.DiGraph()

DG.add_edges_from([('A','B'),('B','C'),('A','D'), \
                   ('D','B'),('C','D'),('C','A')])

#plot the graph
nx.draw(DG, with_labels = True)
```



The network has a certain symmetry: each node has in-degree of 2 and out-degree of 1 or vice versa.

Direct implementation of the HITS algorithm by Kleinberg.

```
def HITS_algorithm(DG, K=1000):
    ''' input: -a networkx DiGraph
               -the K maximum number of iterations

        output: two dictionaries containing the hub and authority scores, resp.
    '''

    auth={}
    hub={}
```

```
    for n in DG.nodes():
        auth[n]=1.0
        hub[n]=1.0

    for k in range(K):

        norm = 0.0

        for n in DG.nodes():

            auth[n]=0.0

            # REMINDER: a predecessor of a node n is a node m
            # such that there is a direct edge from m to n
            for p in DG.predecessors(n):
                auth[n] += hub[p]

            norm += auth[n]**2.0

        norm = norm**0.5

        for n in DG.nodes():
            auth[n] = auth[n]/norm

        norm=0.0

        for n in DG.nodes():
            hub[n] = 0.0

            for s in DG.successors(n):
                hub[n] += auth[s]

            norm += hub[n]**2.0

        norm=norm**0.5

        for n in DG.nodes():
            hub[n]=hub[n]/norm

        return auth,hub
```

Let's put HITS to test.

```
(auth, hub) = HITS_algorithm(DG, K=100)

print (auth)
print (hub)
```

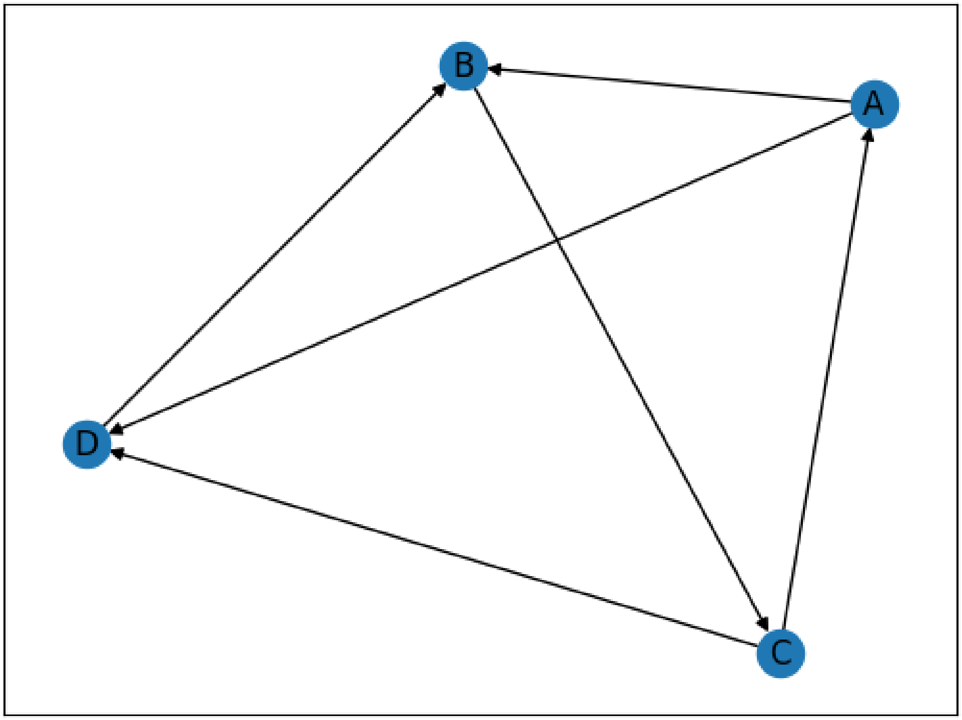
```
{'A': 0.31622776601683794, 'B': 0.6324555320336759, 'C': 0.31622776601683794, 'D': 0.63245553
{'A': 0.7302967433402215, 'B': 0.18257418583505539, 'C': 0.5477225575051661, 'D': 0.36514837
```

Q1. Use built in hits function to find hub and authority scores.

Can you spot the differences in result?

```
nx.draw_networkx(DG, with_labels = True)

# your solution here.

hubs, authorities = nx.hits(DG, max_iter = 1000, normalized = True)

print("Hub Scores: ", hubs)
print("Authority Scores: ", authorities)
```

```
Hub Scores:  {'A': 0.4450418679126289, 'B': -7.441283228224162e-17, 'C': 0.35689586789220956
Authority Scores:  {'A': 0.19806226419516162, 'B': 0.3568958678922094, 'C': -1.340872905174
```



Adjacency matrix representation with basic operations

We refrain from using the standard `Numpy` methods for transposing and multiplying matrices.

```
def matrix_transpose(M):

    M_out=[]

    for c in range(len(M[0])):

        M_out.append([])

        for r in range(len(M)):
            M_out[c].append(M[r][c])

    return M_out


def matrix_multiplication(M1, M2):
```

```
    M_out=[]

    for r in range(len(M1)):

        M_out.append([])

        for j in range(len(M2[0])):
            e=0.0

            for i in range(len(M1[r])):
                e+=M1[r][i]*M2[i][j]

            M_out[r].append(e)

    return M_out
```

Now, let's test the home-brew functions.

```
adjacency_matrix1=[
                  [0,1,0,1],
                  [1,0,1,1],
                  [0,1,0,0]
                  ]

adjacency_matrix2 = matrix_transpose(adjacency_matrix1)

print ("Transpose adjacency matrix:", adjacency_matrix2)

res_mul = matrix_multiplication(adjacency_matrix1, adjacency_matrix2)

print ("Matrix multiplication:", res_mul)
```

```
Transpose adjacency matrix: [[0, 1, 0], [1, 0, 1], [0, 1, 0], [1, 1, 0]]
Matrix multiplication: [[2.0, 1.0, 1.0], [1.0, 3.0, 0.0], [1.0, 0.0, 1.0]]
```

Differently from the `Numpy` methods, our functions work with pure lists.

```
type(res_mul)
```

```
list
```

The Power-iterations algorithm: a direct implementation

```
adjacency_matrix=[
                  [0,1,0,1],
                  [1,0,1,1],
                  [0,1,0,0],
                  [1,1,0,0]
                  ]
vector=[
        [0.21],
        [0.34],
        [0.52],
        [0.49]
        ]

# For small examples, few iterations will be needed.
C = 100
```

```
for i in range(C):
    res = matrix_multiplication(adjacency_matrix, vector)

    norm_sq = 0.0

    for r in res:
        norm_sq = norm_sq+r[0]*r[0]

    vector = []

    for r in res:
         vector.append([r[0]/(norm_sq**0.5)])

print ("Maximum eigenvalue (in absolute value):", norm_sq**0.5)
print ("Eigenvector for the maximum eigenvalue:", vector)
```

```
Maximum eigenvalue (in absolute value): 2.1700864866260337
Eigenvector for the maximum eigenvalue: [[0.5227207256439814], [0.6116284573553772], [0.2818
```

Putting it all together: computing HITS for the WWW strongly-connected component of the .eu domain

```
# Use operator.itemgetter(1) to sort the dictionary by value
import operator
```

```
# Your solution here

#Please assign your results to lists sorted_auth and sorted_hub, respectively.

print(eu_DG_SCC)

(auth,hub) = HITS_algorithm(eu_DG_SCC)

sorted_auth = sorted(auth.items(), key = operator.itemgetter(1))

sorted_hub = sorted(hub.items(), key = operator.itemgetter(1))
```

```
DiGraph with 17099 nodes and 380517 edges
```

```
#top ranking auth
print ("Top 5 by auth")

for p in sorted_auth[:5]:
    print (dic_nodid_urls[p[0]], p[1])

#top ranking hub
print ("Top 5 by hub")

for p in sorted_hub[:5]:
    print (dic_nodid_urls[p[0]], p[1])
```

```
Top 5 by auth
4467    4091 9.674263879950006e-05
3274    3280 9.674263879950006e-05
2960    750454 9.674263879950006e-05
3313    3310 9.674263879950006e-05
4437    4084 9.674263879950006e-05
Top 5 by hub
3307    3312 7.65711101120921e-07
```

```
3369    4085 7.65711101120921e-07
3339    3338 7.65711101120921e-07
3346    3346 7.65711101120921e-07
3336    508108 7.65711101120921e-07
```

Q2. Run the built-in `nx.hits` function; can you spot the differences in result?

```
# Your solution here

#Please assign your results to lists sorted_auth and sorted_hub, respectively.

hub, auth= nx.hits(eu_DG_SCC, max_iter = 50, normalized = True) #normalized True  normalized

#(auth,hub)=HITS_algorithm(eu_DG_SCC)
sorted_auth = sorted(auth.items(), key = operator.itemgetter(1))

sorted_hub = sorted(hub.items(), key = operator.itemgetter(1))
```

```
print ("Top-5 auth nodes:")

for p in sorted_auth[:5]:
    print (dic_nodid_urls[p[0]], p[1])

print ("Top-5 hub nodes:")

for p in sorted_hub[:5]:
    print (dic_nodid_urls[p[0]], p[1])
```

```
Top-5 auth nodes:
3156    3187 -3.2866319996381813e-19
3313    3322 -2.9549355349037844e-19
3080    3076 -2.547786081901056e-19
3339    3340 -2.0624561847182145e-19
3307    3294 -2.050951985713075e-19
Top-5 hub nodes:
3325    3322 -5.556868549573762e-22
3313    3320 -5.556868549573762e-22
3336    508108 -3.8785272207664974e-22
3315    3317 -3.8568931374220095e-22
3314    3307 -2.9869502881776103e-22
```

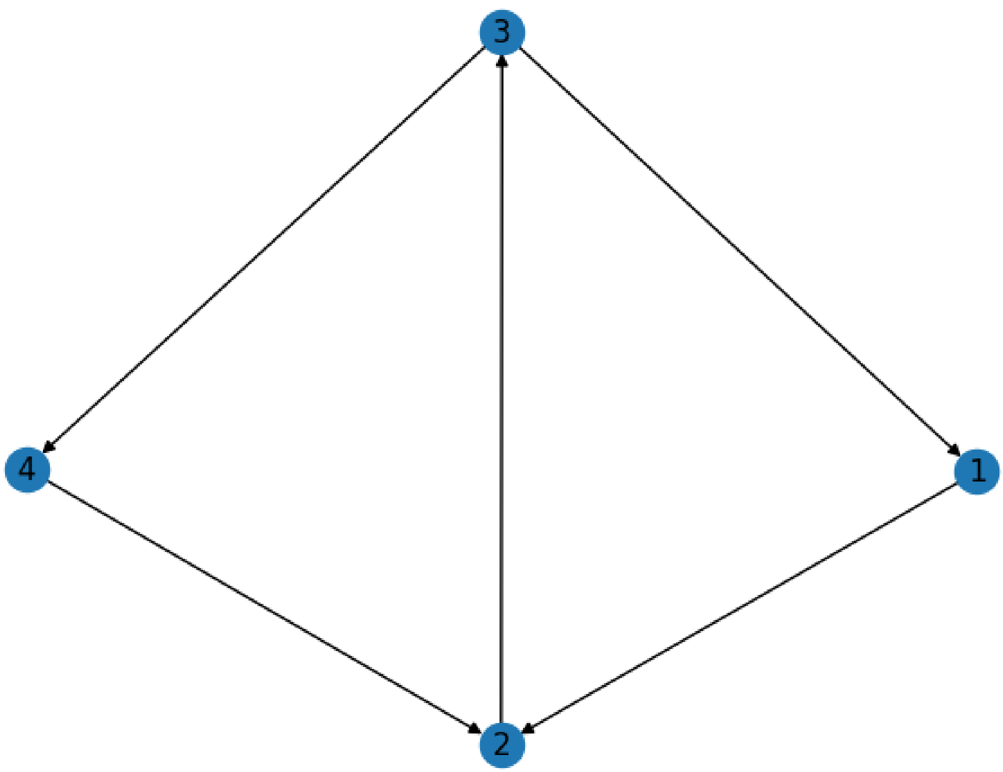
Compute the PageRank

```
def pagerank(graph, damping_factor = 0.85, max_iterations = 100, min_delta = 0.00000001):

    nodes = graph.nodes()

    graph_size = len(nodes)

    if graph_size == 0:
        return {}

    # itialize the page rank dict with 1/N for all nodes
    pagerank = dict.fromkeys(nodes, (1.0-damping_factor)*1.0/ graph_size)

    min_value = (1.0-damping_factor)/len(nodes)

    for i in range(max_iterations):
        #total difference compared to last iteraction
        diff = 0

        # computes each node PageRank based on inbound links
        for node in nodes:
            rank = min_value

            for referring_page in graph.predecessors(node):
                rank += damping_factor * pagerank[referring_page]/ \
                len(list(graph.neighbors(referring_page)))

            diff += abs(pagerank[node] - rank)

            pagerank[node] = rank

        #stop if PageRank has converged
        if diff < min_delta:
            break

    return pagerank
```

The Networkx version of PageRank

```python
G = nx.DiGraph()

G.add_edges_from([(1, 2), (2, 3), (3, 4), (3, 1), (4, 2)])
#plot the network

nx.draw(G, with_labels = True)

#our Page Rank algorithm
res_pr=pagerank(G, max_iterations = 10000, min_delta = 0.00000001, damping_factor = 0.85)
print (res_pr)

#Networkx Pagerank function
print (nx.pagerank(G,max_iter = 10000))
```

```
{1: 0.17359086186340225, 2: 0.33260446516778386, 3: 0.3202137953926163, 4: 0.173590863041861
{1: 0.17359061775974502, 2: 0.33260554622228633, 3: 0.3202132182582236, 4: 0.173590617759745
```



The Twitter Mention Network

Please skip this section as we don't access Twitter/X data anymore; proceed to he `Scwiki` section below.

Community Detection for the `Scwiki` network

```
SCWIKI = './data/scwiki_edgelist.dat'

TITLES = './data/scwiki_page_titles.dat'
```

Warning: in `.eu` there are pages in the Sardinian language (and perhaps others) which require a specific coding on your own platform.

```
#load the directed and undirected version og the scwiki graph
scwiki_pagelinks_net_dir = nx.read_edgelist(SCWIKI, create_using = nx.DiGraph())

scwiki_pagelinks_net = nx.read_edgelist(SCWIKI)

#load the page titles
diz_titles = {}

file_titles = open(TITLES, 'r')

while True:
    next_line = file_titles.readline()

    if not next_line:
        break

    print (next_line.split()[0], next_line.split()[1])

    diz_titles[next_line.split()[0]] = next_line.split()[1]

file_titles.close()
```

```
14209 "Weird_Al"_Yankovic
13890 ''Assandira''
10258 'O_sole_mio
2361 'Onne
6118 (Sittin'_on)_The_Dock_of_the_Bay
6119 (Sittin'_on)_the_Dock_of_the_Bay
```

10062 ...altrimenti_ci_arrabbiamo!
11039 1054
11019 1065
16053 1082
11222 1090
12579 1096
11596 1100
16054 1110
16055 1138
11307 113_(nÃ¹meru_de_emerzÃ¨ntzia)
16056 1166
10560 118_-_ServÃ¬tziu_de_emerzÃ¨ntzia_sanidÃ
16057 1194
11598 1200
16058 1222
16059 1250
16060 1278
16061 1306
15041 1315
10934 1324
16062 1334
13534 1336
12350 1340
15040 1343
16063 1362
15039 1371
16064 1390
15038 1399
11590 1409
16065 1418
15037 1427
11067 1431
12108 1444
16066 1446
15036 1455
11054 1473
16067 1474
13112 1483
10971 1489
13533 1490
11055 1492
12135 1497
16068 1502