

	1 IA																				2 VIIIA															
1	<b>DC</b> Degree Centrality														<b>EC</b> Eigenvector Centrality																					
2	<b>BC</b> Betweenness Centrality		<b>CC</b> Closeness Centrality												<b>SC</b> Subgraph Centrality		<b>C<sub>COEF</sub></b> Clustering Coefficient		<b>C<sub>COEF</sub><sup>-1</sup></b> inverse CCOEF		<b>MNC</b> max. neighb. comp.		<b>EC<sub>COEF</sub></b> edge clustering coefficient		<b>PR</b> PageRank											
3	<b>RL</b> Rangelimited Betweenness		<b>IC</b> Information Centrality		3 IIIA		4 IVB		5 VB		6 VIB		7 VIIB		8 VIIIB		9 VIIIB		10 VIIIB		11 IB		12 IIB		<b>CC<sub>xxx</sub></b> odd Subgraph Centrality		<b>SC<sub>G</sub></b> loc. avg. Connectivity		<b>LAC</b> dens. max. neighb. comp.		<b>DMNC</b> sum of E <sub>COEF</sub>		<b>SEC<sub>COEF</sub></b> LeaderRank			
4	<b>BN</b> BottleNeck Centrality		<b>RC</b> Radiality Centrality		<b>IG</b> Integration		<b>DC<sub>xx</sub></b>		<b>BC<sub>xx</sub></b>		<b>CC<sub>xx</sub></b>		<b>ECC<sub>xx</sub></b>		<b>KS<sub>xx</sub></b>		<b>PR<sub>xx</sub></b>		<b>IG<sub>xx</sub></b>		<b>RC<sub>xx</sub></b>		<b>DC<sub>xxx</sub></b>		<b>BC<sub>xxx</sub></b>		<b>SC<sub>e</sub></b> even Subgraph Centrality		<b>KL</b> Clique Level		<b>COC<sub>COEF</sub></b> coexpr. weight CCOEF		<b>PEC<sub>coeff</sub></b> PCC×ECCOEF		<b>KS</b> KatzStatus	
5	<b>RWBC</b> RandomWalk Betweenness		<b>RWCC</b> RandomWalk Closeness		<b>CC<sub>2,3,4</sub></b> 2,3,4-localized-CC		<b>ECC<sub>xxx</sub></b>		<b>PR<sub>xxx</sub></b>		<b>KS<sub>xxx</sub></b>		<b>CCC<sub>COEF</sub></b>		<b>RC<sub>xxx</sub></b>		<b>IG<sub>xxx</sub></b>		<b>DCBC</b>		<b>BCCC</b>		<b>CCKS</b>		<b>KSPR</b>		<b>DCPR</b>		<b>β</b> Bipartivity		<b>SC<sub>2</sub></b> 2-localized-SC		<b>NC</b> Neighborhood Centrality		<b>EC<sub>2</sub></b> 2-localized-EC	
6	<b>σ</b> stress Centrality		<b>ECC</b> Eccentricity		<b>WDC</b> Weighted Degree		<b>DCECC</b>		<b>CCECC</b>		<b>BCECC</b>		<b>KSECC</b>		<b>PRECC</b>		<b>IGECC</b>		<b>DCCC</b>		<b>BCKS</b>		<b>CCPR</b>		<b>KSIG</b>		<b>DCIG</b>		<b>DCC<sub>COEF</sub></b>		<b>SC<sub>3</sub></b> 3-localized-SC		<b>LI</b> Lobby Index		<b>EC<sub>3</sub></b> 3-localized-EC	
7	<b>BC<sub>2,3,4</sub></b> 2,3,4-localized-BC		<b>ECC<sup>-1</sup></b> Inverse Eccentricity		<b>SDC</b> Sphere Degree Centrality		<b>DCRC</b>		<b>CCRC</b>		<b>BCRC</b>		<b>KSRC</b>		<b>PRRC</b>		<b>IGRC</b>		<b>DCKS</b>		<b>BCPR</b>		<b>CCIG</b>		<b>DCPR</b>		<b>BCIG</b>		<b>ECCRC</b>		<b>BCC<sub>COEF</sub></b> 4-localized-SC		<b>SC<sub>4</sub></b> 4-localized-SC		<b>EC<sub>4</sub></b> 4-localized-EC	

<p>Z mass</p> <p><b>C</b></p> <p>Name</p>	<p>Hybrid</p>
---	---------------

22	2	23	2	24	2	25	1	26	1	27	1	117	1
<b>FC</b>		<b>FD</b>		<b>US</b>		<b>DIS</b>		<b>ASS</b>		<b>DAM</b>		<b>UC</b>	
Functional Centrality		Functional Diversity		UniScore		Pairwise Dis- connectivity		Assortative Mixing		Damage		United compl. Centrality	

28	1	29	1	30	1	31	1	13	1	116	0	118	1
<b>EI</b>		<b>CM</b>		<b>N<math>\alpha</math>C</b>		<b>MC</b>		<b>HGI</b>		<b>HYP</b>		<b>HC</b>	
Essentiality Index		Complexity Measure		Normalized $\alpha$ Centrality		Moduland Centrality		Harary Graph Information		Hyperbolic Index		Harmonic Centrality	

- Schoch (University of Konstanz)

1. **(code)** Find the most important actors according to the degree centrality  $d_i = \frac{k_i}{n-1}$ , where  $n$  is the number of network nodes and  $k_i$  is the degree of node  $i$ . Which actors have the highest  $d_i$  (e.g., Hollywood, international, unknown)?
2. **(code)** Find the most important actors according to the clustering coefficient  $C_i = \frac{2t_i}{k_i(k_i-1)}$ , where  $k_i$  is the degree of node  $i$  and  $t_i$  is the number of triangles including node  $i$ . You should use the link triad counting algorithm from previous labs. Which actors have the highest  $C_i$  (e.g., Hollywood, international, unknown)?
3. **(homework)** Find the most important actors according to the  $\mu$ -corrected clustering coefficient  $C_i^\mu = \frac{2t_i}{k_i\mu}$ , where  $k_i$  is the degree of node  $i$ ,  $t_i$  is the number of triangles including node  $i$  and  $\mu$  is the maximum number of triangles over a link. You should use the link triad counting algorithm from

previous labs. Which actors have the highest  $C_i''$  (e.g., Hollywood, international, unknown)?

## II. Eigenvector centrality and PageRank algorithm

1. **(code)** Find the most important actors according to the eigenvector centrality  $e_i = \lambda_1^{-1} \sum_j A_{ij} e_j$ , where  $A$  is the network adjacency matrix and  $\lambda_1$  is a normalizing constant. You should use the power iteration algorithm shown below. Which actors have the highest  $e_i$  (e.g., Hollywood, international, unknown)?
2. **(code)** Find the most important actors according to the PageRank algorithm  $p_i = \alpha \sum_j A_{ij} \frac{p_j}{k_j} + \frac{1-\alpha}{n}$ , where  $A$  is the network adjacency matrix,  $n$  is the number of network nodes,  $k_i$  is the degree of node  $i$  and  $\alpha$  is the damping factor set to 0.85. You should use the PageRank algorithm shown below. Which actors have the highest  $p_i$  (e.g., Hollywood, international, unknown)?

```

input  graph G, precision  $\epsilon$ 
output eigenvector centrality  $E$ 
1:  $E \leftarrow$  array of ones
2: do
3:    $U \leftarrow$  array of zeros
4:   for nodes  $i \in N$  do
5:     for neighbors  $j \in \Gamma_i$  do
6:        $U[i] \leftarrow U[i] + E[j]$ 
7:    $u \leftarrow \|U\|$ 
8:   for nodes  $i \in N$  do
9:      $U[i] \leftarrow U[i] \cdot n/u$ 
10:   $\Delta \leftarrow \|E - U\|$ 
11:   $E \leftarrow U$ 
12: while  $\Delta > \epsilon$ 
13: return  $E$ 

```

```

input  graph G, damping  $\alpha$ , precision  $\epsilon$ 
output PageRank ranks  $P$ 
1:  $P \leftarrow$  array of  $n^{-1}$ -s
2: do
3:    $U \leftarrow$  array of zeros
4:   for nodes  $i \in N$  do
5:     for predecessors  $j \in \Gamma_i^{in}$  do
6:        $U[i] \leftarrow U[i] + P[j] \cdot \alpha/k_j^{out}$ 
7:    $u \leftarrow \|U\|$ 
8:   for nodes  $i \in N$  do
9:      $U[i] \leftarrow U[i] + (1 - \alpha)/n$ 
10:   $\Delta \leftarrow \|P - U\|$ 
11:   $P \leftarrow U$ 
12: while  $\Delta > \epsilon$ 
13: return  $P$ 

```

## III. Closeness and betweenness centrality

1. **(code)** Find the most important actors according to the closeness centrality  $\ell_i^{-1} = \frac{1}{n-1} \sum_{j \neq i} \frac{1}{d_{ij}}$ , where  $n$  is the number of network nodes and  $d_{ij}$  is the distance between nodes  $i$  and  $j$ . You should use the breadth-first search algorithm from previous labs. Which actors have the highest  $\ell_i^{-1}$  (e.g., Hollywood, international, unknown)?
2. **(homework)** Find the most important actors according to the betweenness centrality  $\sigma_i = \frac{1}{n^2} \sum_{st} \frac{g_{st}^i}{g_{st}}$ , where  $n$  is the number of network nodes,  $g_{st}$  is the number of shortest paths between nodes  $s$  and  $t$ , and  $g_{st}^i$  is the number of such paths through node  $i$ . Which actors have the highest  $\sigma_i$  (e.g., Hollywood, international, unknown)?