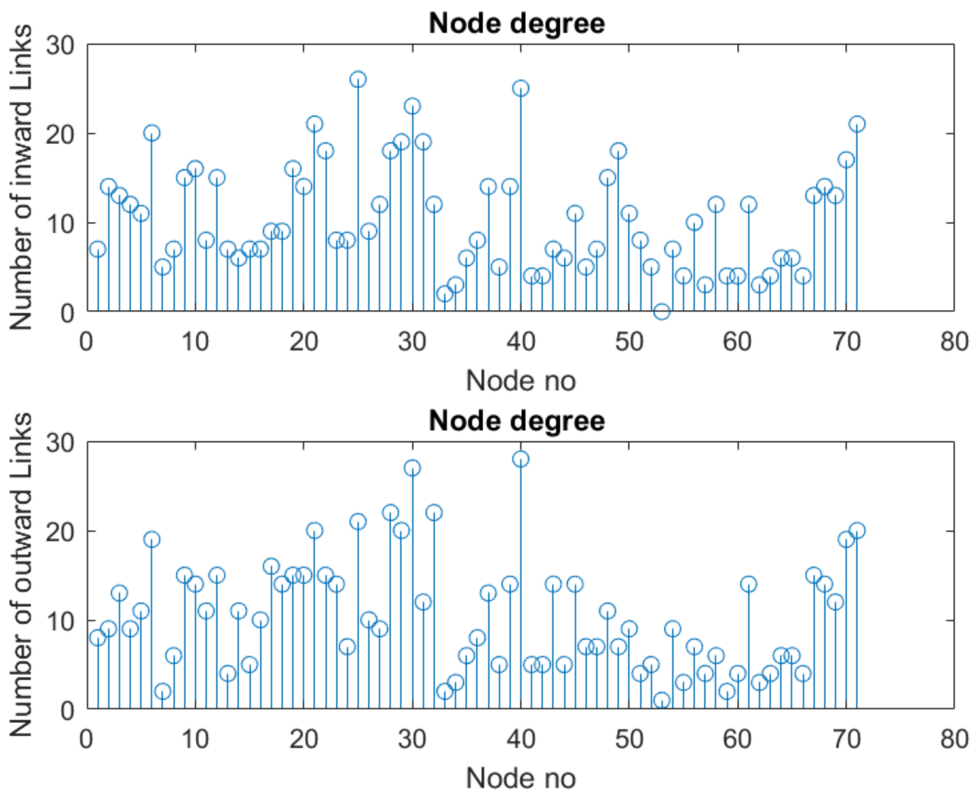
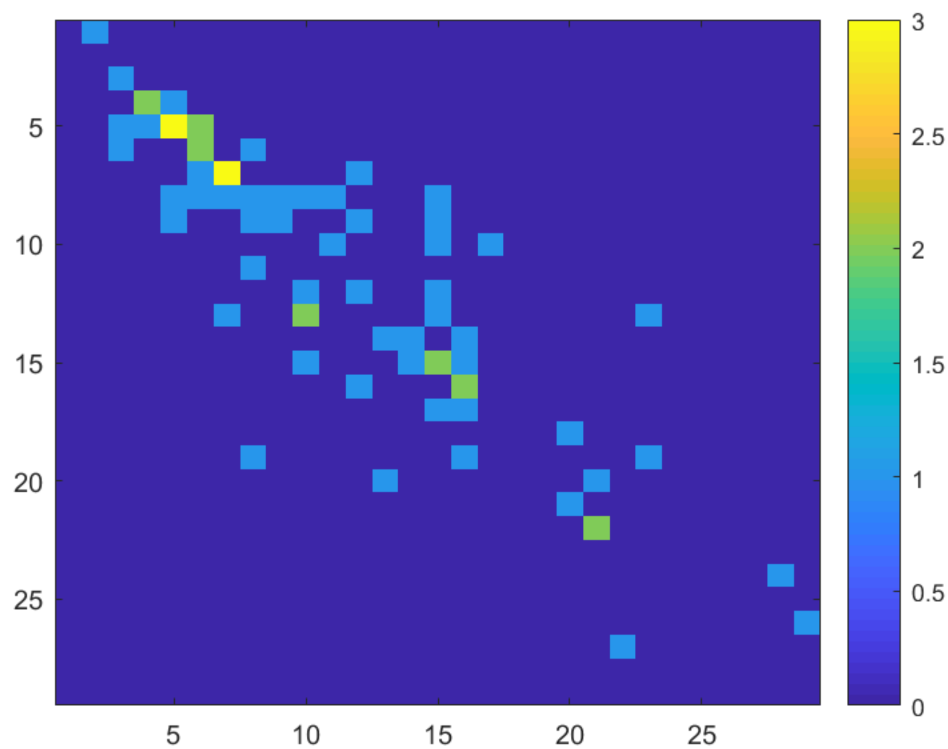
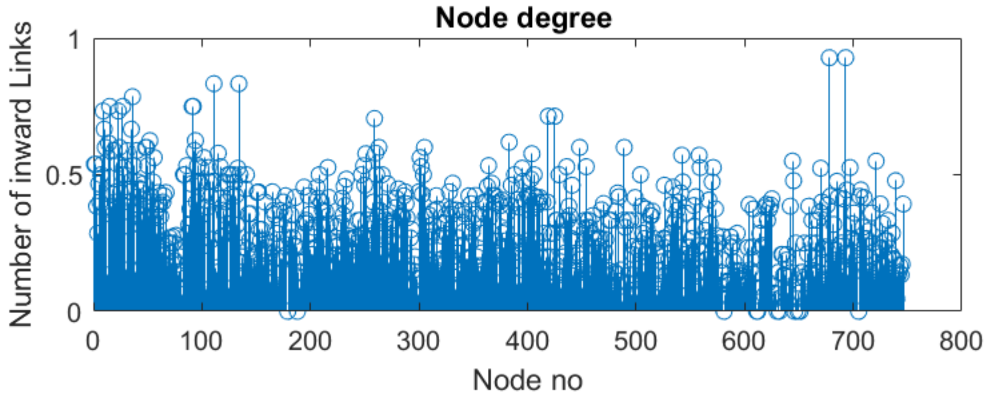
```
%Brain Connectivity
clear all
load('macaque71');
```

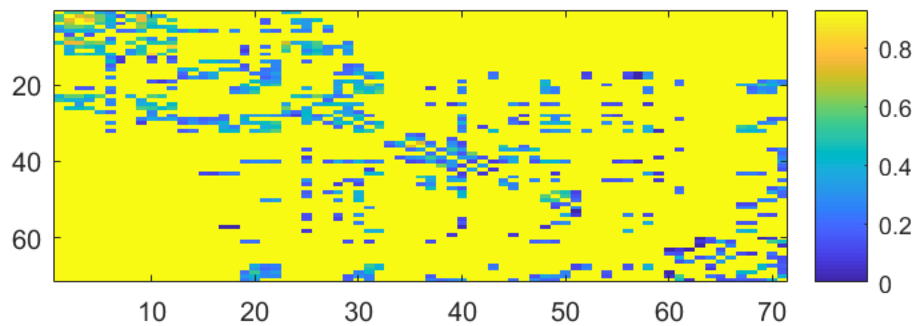
1)Degree and Similarity

```
%Node degree is the number of links connected to the node. The
 indegree
%   is the number of inward links and the outdegree is the number of
%   outward links.


[id,od,deg2] = degrees_dir(CIJ);% calculates both outward and inward
 links

figure();
subplot(2,1,1)
stem(id);
xlabel('Node no')
ylabel('Number of inward Links')
title('Node degree ')

subplot(2,1,2)
stem(od);
xlabel('Node no')
ylabel('Number of outward Links')
title('Node degree ')


 [J,J_od,J_id,J_bl] = jdegree(CIJ); % joint degree distribution matrix

figure();
imagesc(J);
colorbar();
%

[EC,ec,degij] = edge_nei_overlap_bd(CIJ);%   This function determines
 the neighbors of two nodes that are linked by an edge, and then
 computes their overlap.


figure();
subplot(2,1,1)
stem(ec);
xlabel('Node no')
ylabel('Number of inward Links')
title('Node degree ')

subplot(2,1,2)
imagesc(EC);
colorbar();
```


Node degree
Number of inward Links
Node no
Node degree
Number of outward Links
Node no






2) Density and Rentian Scaling

```
[kden,N,K] = density_dir(CIJ);%Density is the fraction of present
 connections to possible connections. Connection weights are ignored
 in calculations.
```

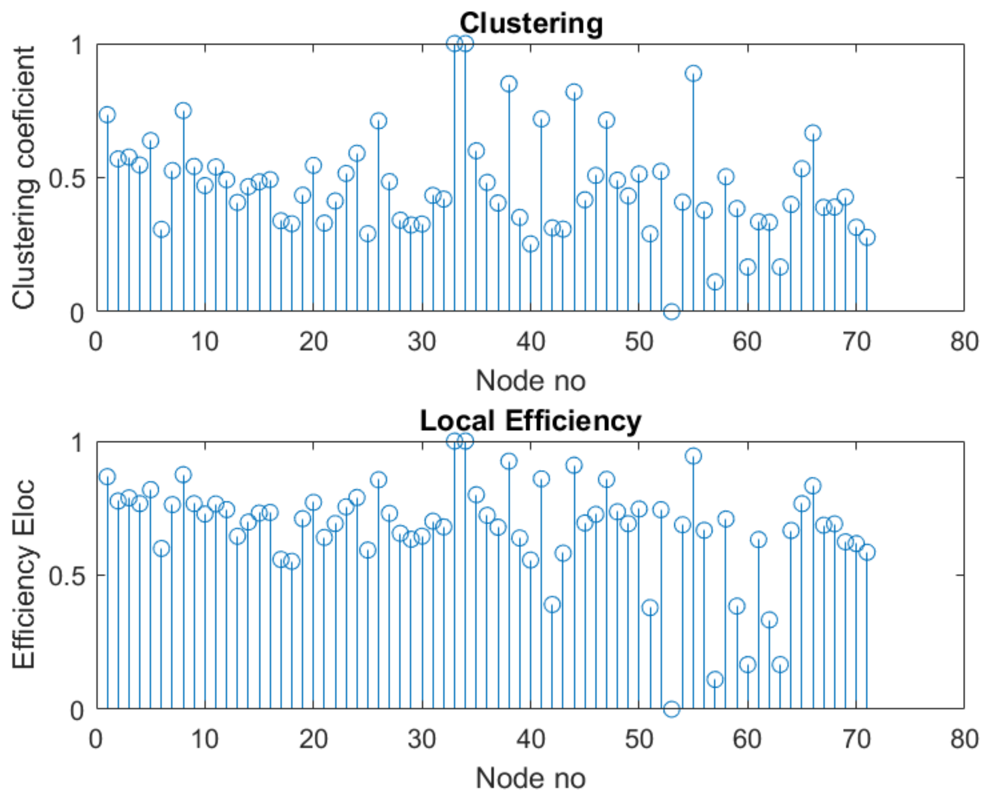
3) Clustering and Community Structure

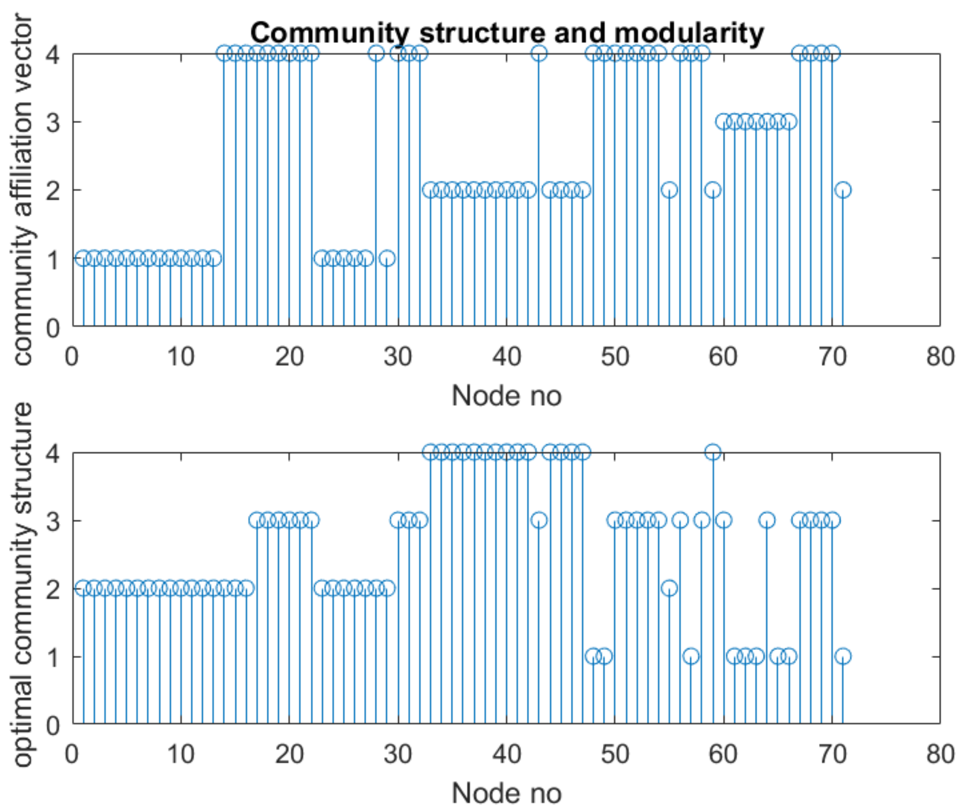
```
 C=clustering_coef_bd(CIJ); %he fraction of triangles around a node
 and is equivalent to the fraction of node's neighbors that are
 neighbors of each other.

 T=transitivity_bd(CIJ); %Transitivity:
 E=efficiency_bin(CIJ,1);% global efficiency (see below) computed on
 node neighborhoods, and is related to the clustering coefficient.
 figure();
subplot(2,1,1)
 stem(C);
 xlabel('Node no');
ylabel('Clustering coeficient');
title('Clustering');
subplot(2,1,2)
 stem(E);
 xlabel('Node no');
ylabel('Efficiency Eloc');
title('Local Efficiency');
```

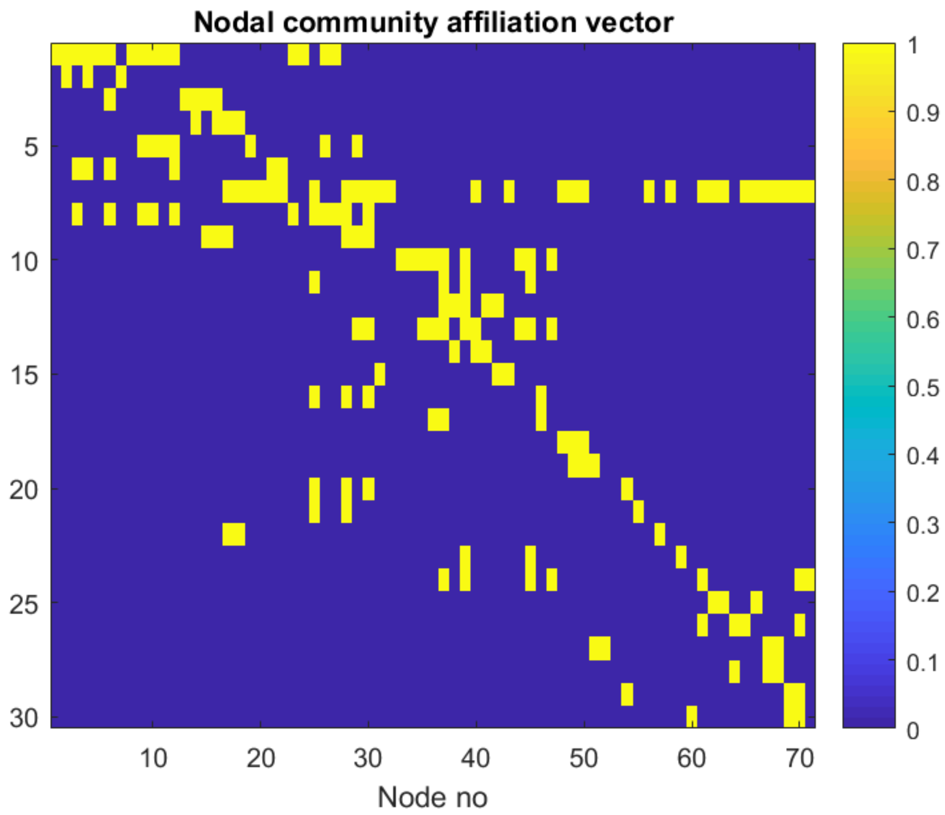
```
[M,Q]=community_louvain(CIJ);%Louvain community detection algorithm
 with added finetuning.
[Ci,Q2]=modularity_und(CIJ); % MODULARITY
 figure();
 subplot(2,1,1)
 stem(M);
 xlabel('Node no');
ylabel('community affiliation vector');
title('Community structure and modularity');
 subplot(2,1,2)
 stem(Ci);
 xlabel('Node no');
ylabel(' optimal community structure');

NCA=link_communities(CIJ);%

 figure();
imagesc(NCA);
colorbar();
 xlabel('Node no');
title('Nodal community affiliation vector');
```

```
hierarchy       1
hierarchy       2
hierarchy       3
hierarchy       4
hierarchy       5
hierarchy       6
hierarchy       7
hierarchy       8
hierarchy       9
hierarchy      10
hierarchy      11
hierarchy      12
hierarchy      13
hierarchy      14
hierarchy      15
hierarchy      16
hierarchy      17
hierarchy      18
hierarchy      19
hierarchy      20
hierarchy      21
hierarchy      22
hierarchy      23
hierarchy      24
hierarchy      25
hierarchy      26
hierarchy      27
hierarchy      28
hierarchy      29
hierarchy      30
hierarchy      31
hierarchy      32
```

| | |
|---|---|
| *hierarchy* | *87* |
| *hierarchy* | *88* |
| *hierarchy* | *89* |
| *hierarchy* | *90* |
| *hierarchy* | *91* |
| *hierarchy* | *92* |
| *hierarchy* | *93* |
| *hierarchy* | *94* |
| *hierarchy* | *95* |
| *hierarchy* | *96* |
| *hierarchy* | *97* |
| *hierarchy* | *98* |
| *hierarchy* | *99* |
| *hierarchy* | *100* |
| *hierarchy* | *101* |
| *hierarchy* | *102* |
| *hierarchy* | *103* |
| *hierarchy* | *104* |
| *hierarchy* | *105* |
| *hierarchy* | *106* |
| *hierarchy* | *107* |
| *hierarchy* | *108* |
| *hierarchy* | *109* |
| *hierarchy* | *110* |
| *hierarchy* | *111* |
| *hierarchy* | *112* |
| *hierarchy* | *113* |
| *hierarchy* | *114* |
| *hierarchy* | *115* |
| *hierarchy* | *116* |
| *hierarchy* | *117* |
| *hierarchy* | *118* |
| *hierarchy* | *119* |
| *hierarchy* | *120* |
| *hierarchy* | *121* |
| *hierarchy* | *122* |
| *hierarchy* | *123* |
| *hierarchy* | *124* |
| *hierarchy* | *125* |
| *hierarchy* | *126* |
| *hierarchy* | *127* |
| *hierarchy* | *128* |
| *hierarchy* | *129* |
| *hierarchy* | *130* |
| *hierarchy* | *131* |
| *hierarchy* | *132* |
| *hierarchy* | *133* |
| *hierarchy* | *134* |
| *hierarchy* | *135* |
| *hierarchy* | *136* |
| *hierarchy* | *137* |
| *hierarchy* | *138* |


Clustering
Clustering coeficient
Node no
Local Efficiency
Efficiency Eloc
Node no

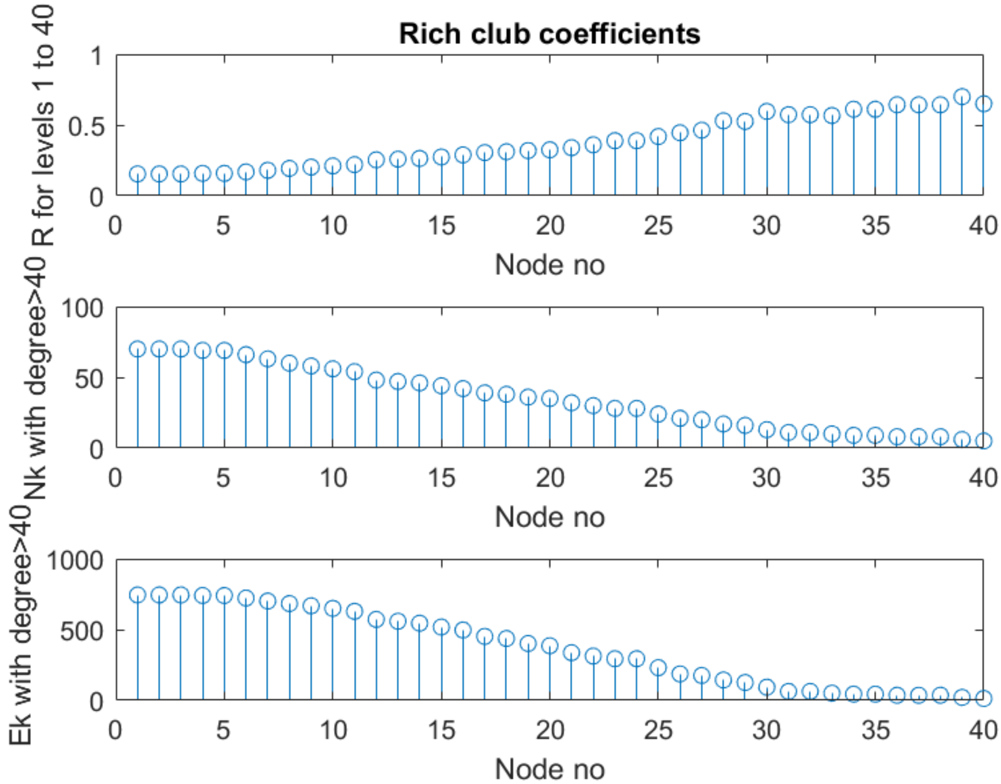

Community structure and modularity
community affiliation vector
Node no
optimal community structure
Node no

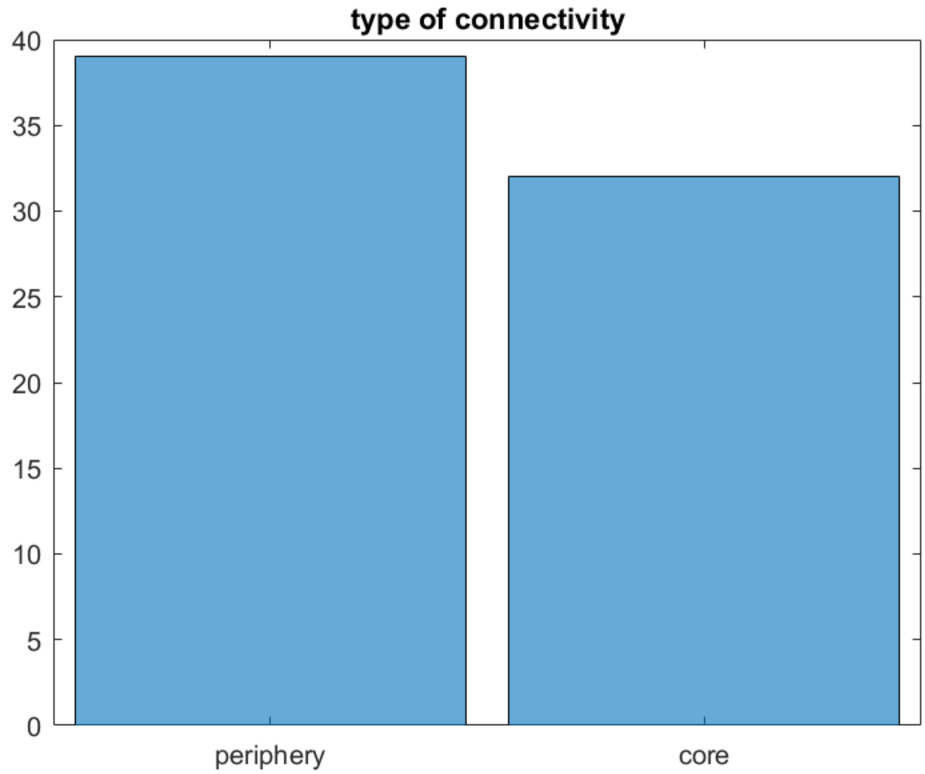



4)Assortativity and Core Structure

```
 r = assortativity_bin(CIJ,0); % Assortivity coefficient

 [R,Nk,Ek] = rich_club_bd(CIJ,40);% Rich club coefficients

 figure();
 subplot(3,1,1)
 stem(R);
 xlabel('Node no')
ylabel('R for levels 1 to 40')
title('Rich club coefficients')
 subplot(3,1,2)
 stem(Nk);
 xlabel('Node no')
ylabel('Nk with degree>40')
subplot(3,1,3)
 stem(Ek);
 xlabel('Node no')
ylabel(' Ek with degree>40')

[C, q]=core_periphery_dir(CIJ);% partition  into two non-overlapping
 groups of nodes
C = categorical(C,[0 1 ],{'periphery','core'});
figure();
histogram( C);
```

```
title('type of connectivity')
```

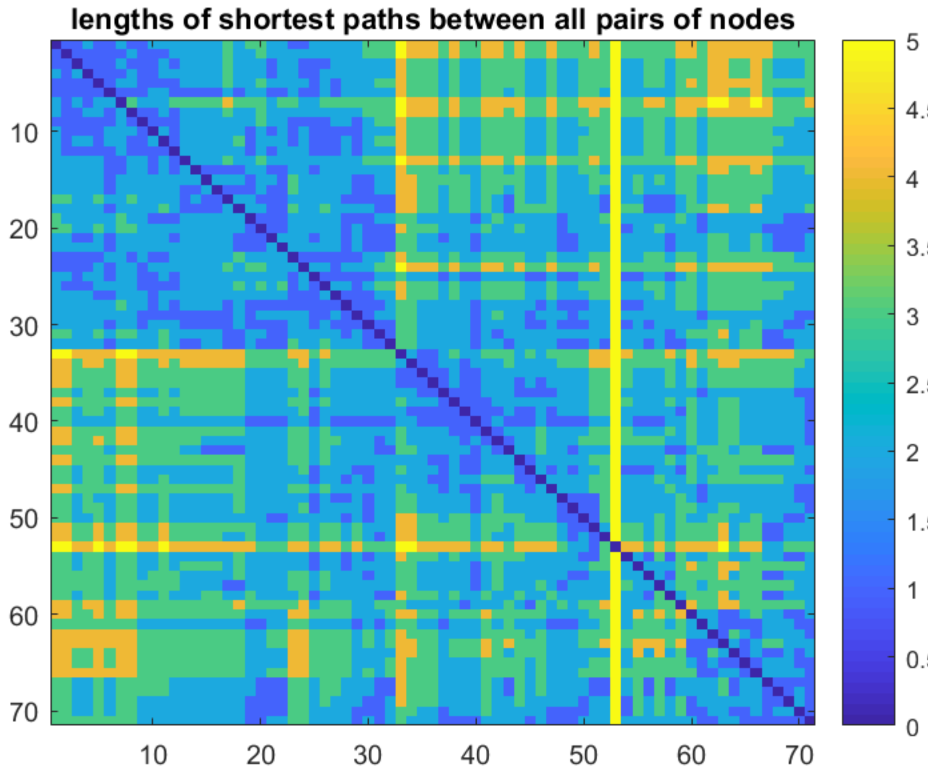





5) Paths and Distances

```
 [Pq,tpath,plq,qstop,allpths,util] = findpaths(CIJ,70,4,1);%sequences
 of linked nodes, that never visit a single node more than once.

 D=distance_bin(CIJ); % Distance matrix, shortest distance between
 nodes
  figure();
imagesc(D);
colorbar();
title('lengths of shortest paths between all pairs of nodes')
```

```
current pathlength (q) = 2   number of paths so far (up to q-1)= 19
current pathlength (q) = 3   number of paths so far (up to q-1)= 264
current pathlength (q) = 4   number of paths so far (up to q-1)= 3320
```

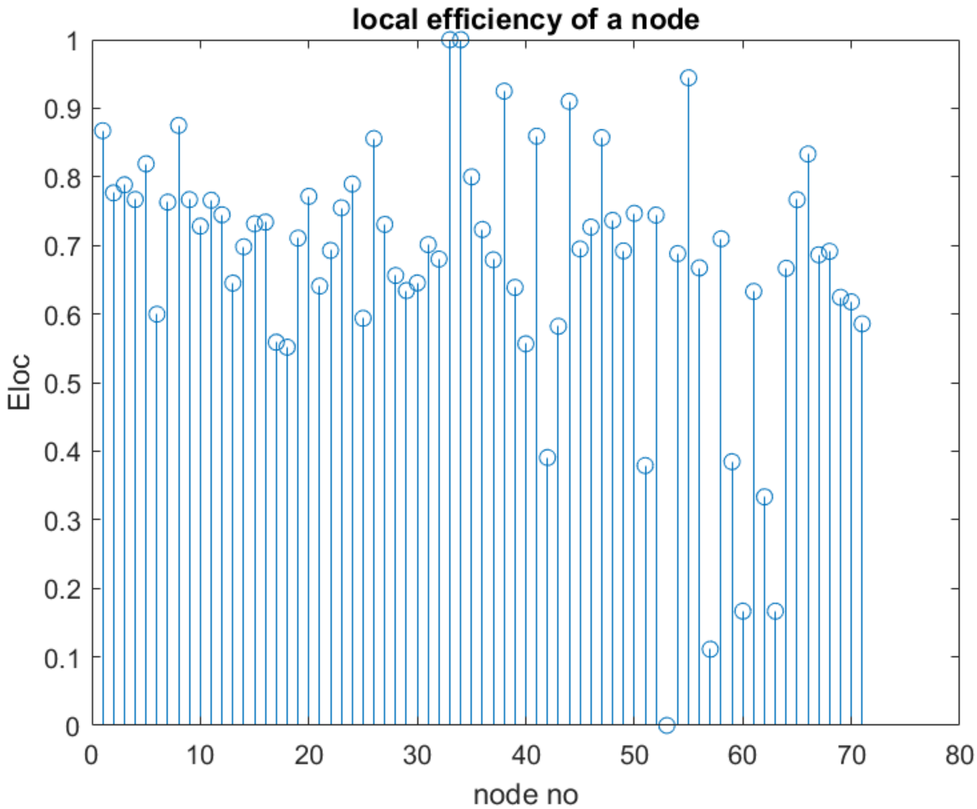


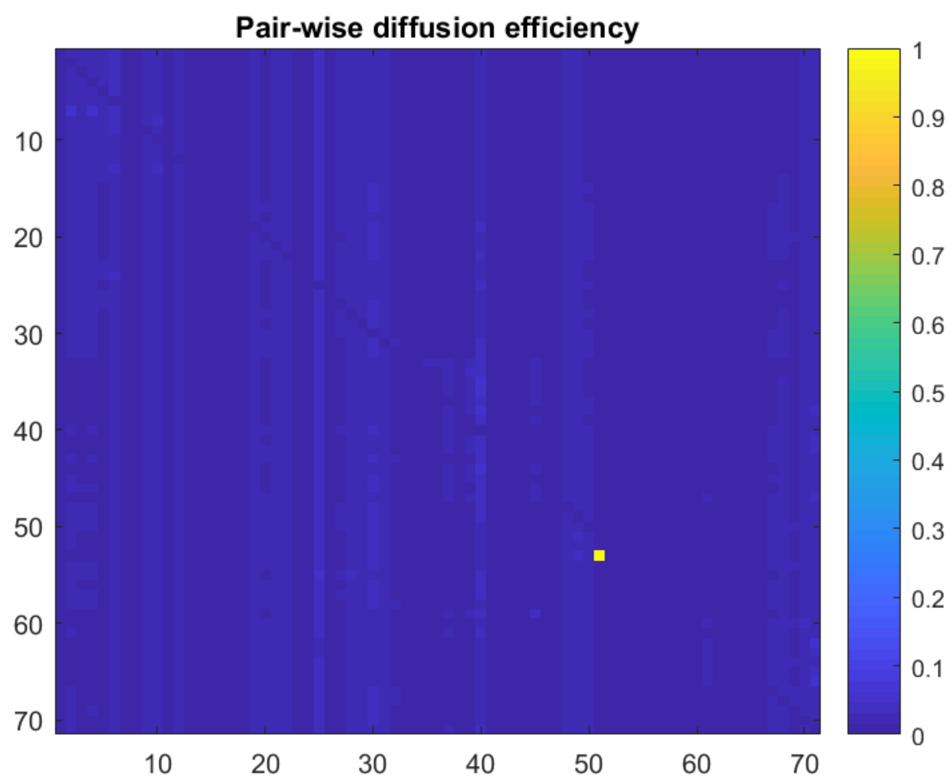

6)Efficiency and Diffusion

```
 Eloc=efficiency_bin(CIJ,1);%local efficiency is the global efficiency
 computed on the neighborhood of the node
  EGlo=efficiency_bin(CIJ,0);%global efficiency is the average of
 inverse shortest path length
 disp(EGlo);

   figure();
stem(Eloc);
title('local efficiency of a node');
xlabel('node no');
ylabel('Eloc');
 [GEdiff,Ediff] = diffusion_efficiency(CIJ);% DIFFUSION_EFFICIENCY
 Global mean and pair-wise diffusion efficiency
 disp(GEdiff);% Mean Global diffusion efficiency

   figure();
imagesc(Ediff);
colorbar();
title('Pair-wise diffusion efficiency');
```

    0.4961

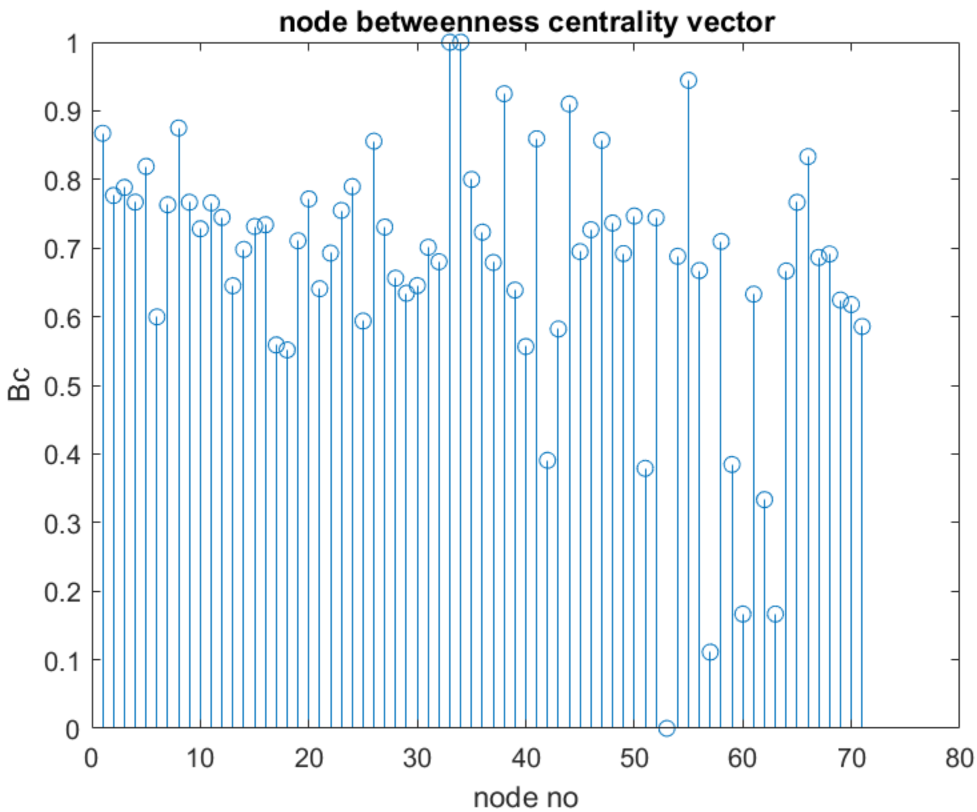
    0.0128

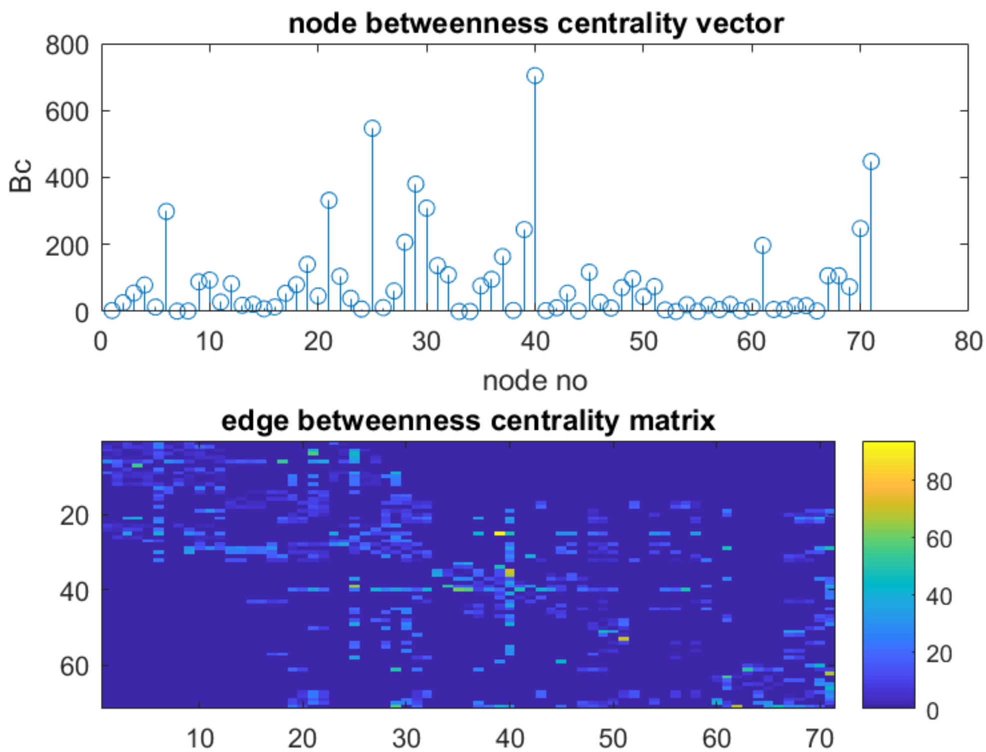

local efficiency of a node
Eloc
node no
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
10
20
30
40
50
60
70
80


Pair-wise diffusion efficiency
10
20
30
40
50
60
70
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

7)Centrality Measure

```
 BC=betweenness_bin(CIJ); %BETWEENNESS_BIN    Node betweenness
 centrality
   figure();
stem(Eloc);
title('node betweenness centrality vector');
xlabel('node no');
ylabel('Bc');

[EBC,BC_EDGE]=edge_betweenness_bin(CIJ);% Edge betweenness centrality
   figure();
   subplot(2,1,1)
stem(BC_EDGE);
title('node betweenness centrality vector');
xlabel('node no');
ylabel('Bc');
subplot(2,1,2)
imagesc(EBC);
colorbar();
title('edge betweenness centrality matrix');
```






8) Motifs

```
%   [f,F]=motif3funct_bin(CIJ); %Frequency of functional class-3
 motifs
%   [f_struct,F_struct]=motif3struct_bin(CIJ); %Frequency of
 structural class-3 motifs
```

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