BiMat - Group Testing Use case

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This use case will introduce the user to the functionalities about how to perform an statistical analysis of a group of bipartite networks (matrices). For doing that we will use the data from Flores et Al 2011. This data consist of 38 bipartite adjacency matrices of different sizes. Each matrix is named according to the first author paper from which it was extracted. We will perform an analysis of modularity and nestedness in the entire set.

Add the source to the matlab path

```
g = genpath('matlab'); addpath(g);
close all; %close all open figures
```

We need also to load the data from which we will be working on

```
load group_testing_data.mat;
```

Creating a Group Testing object

If the number of random matrices and the null model are not assigned, 100 and AVERAGE are used as default. Here we will use 100 random matrices with the EQUIPROBABLE null model

```
gp = GroupStatistics(grouptesting.matrices);    % Create the main object
```

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Perform an statistical analysis in the set of matrices

Suppose that we are interested in calculating the modularity and nestedness using the NTC algorithm as Flores et Al 2011 did. In addition, following the approach of Flores et Al 2011, we want to use the equiprobable model as null model in our random networks. The way to perform this analysis is by running the next lines:

```
gp.replicates = 100; %How many random networks we want for each matrix
gp.null_model = @NullModels.EQUIPROBABLE; %Our Null model
gp.modul_class = @AdaptiveBrim; %Algorithm for modularity.
gp.do_temp = 1; % Perform NTC analysis (default)
gp.do_modul = 1; % Perform Modularity analysis (default)
gp.do_nest = 0; % Do not perform NODF analysis
gp.DoGroupTesting(); % Perform the analysis.
gp.names = grouptesting.name;
```

```
Testing Matrix: 1 . . .
```

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The random matrix was created without this constraint instead.
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to remove those objects.
Warning: The class file for 'StatisticalTest' has been changed; but the ch
objects based on the old class file still exist. If you use those objects,
results. You can use the 'clear' command to remove those objects. See 'hel
```

```
to remove those objects.
Testing Matrix: 36 . . .
Warning: The class file for 'StatisticalTest' has been changed; but the ch
objects based on the old class file still exist. If you use those objects,
results. You can use the 'clear' command to remove those objects. See 'hel
to remove those objects.
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objects based on the old class file still exist. If you use those objects,
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to remove those objects.
Warning: The class file for 'StatisticalTest' has been changed; but the ch
objects based on the old class file still exist. If you use those objects,
results. You can use the 'clear' command to remove those objects. See 'hel
to remove those objects.
Testing Matrix: 37 . . .
Warning: The class file for 'StatisticalTest' has been changed; but the ch
objects based on the old class file still exist. If you use those objects,
results. You can use the 'clear' command to remove those objects. See 'hel
to remove those objects.
Warning: The class file for 'StatisticalTest' has been changed; but the ch
objects based on the old class file still exist. If you use those objects,
results. You can use the 'clear' command to remove those objects. See 'hel
to remove those objects.
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to remove those objects.
Warning: The class file for 'StatisticalTest' has been changed; but the ch
objects based on the old class file still exist. If you use those objects,
results. You can use the 'clear' command to remove those objects. See 'hel
to remove those objects.
Testing Matrix: 38 . . .
Not possible to create a matrix with non isolated nodes.
The random matrix was created without this constraint instead.
Consider to modify Options.ALLOW_ISOLATED_NODES and/or Options.INCLUDE_EMP

Not possible to create a matrix with non isolated nodes.
The random matrix was created without this constraint instead.
Consider to modify Options.ALLOW_ISOLATED_NODES and/or Options.INCLUDE_EMP

Not possible to create a matrix with non isolated nodes.
The random matrix was created without this constraint instead.
```

```
Consider to modify Options.ALLOW_ISOLATED_NODES and/or Options.INCLUDE_EMP

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Warning: The class file for 'StatisticalTest' has been changed; but the ch
objects based on the old class file still exist. If you use those objects,
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Warning: The class file for 'StatisticalTest' has been changed; but the ch
objects based on the old class file still exist. If you use those objects,
results. You can use the 'clear' command to remove those objects. See 'hel
to remove those objects.
```

Notice that `DoGroupTesting` method prints informatino about the current networks that is being analyzed, such that the user will know at every moment the current status of the analysis. After the analysis is finished a simple statistical measure to say that a matrix is nested and/or modular is to chose a two tail p-value = 0.05 as Flores et al 2011 did. Therefore, the next lines of code will show how many matrices are found nested and/or modular

```
fprintf('Number of nested matrices: %i\n',sum(gp.tempvals.percent >= 97.5));
fprintf('Number of modular matrices: %i\n',sum(gp.qb_vals.percent >= 97.5));
```

```
Number of nested matrices: 27
Number of modular matrices: 8
```

We can also show the entire set of results by calling:

```
gp.PrintResults();
```

```
Network,      Qb, Qb mean,Qb z-score,Qb percent,    NTC,NTC mean,NTC z-sco
```

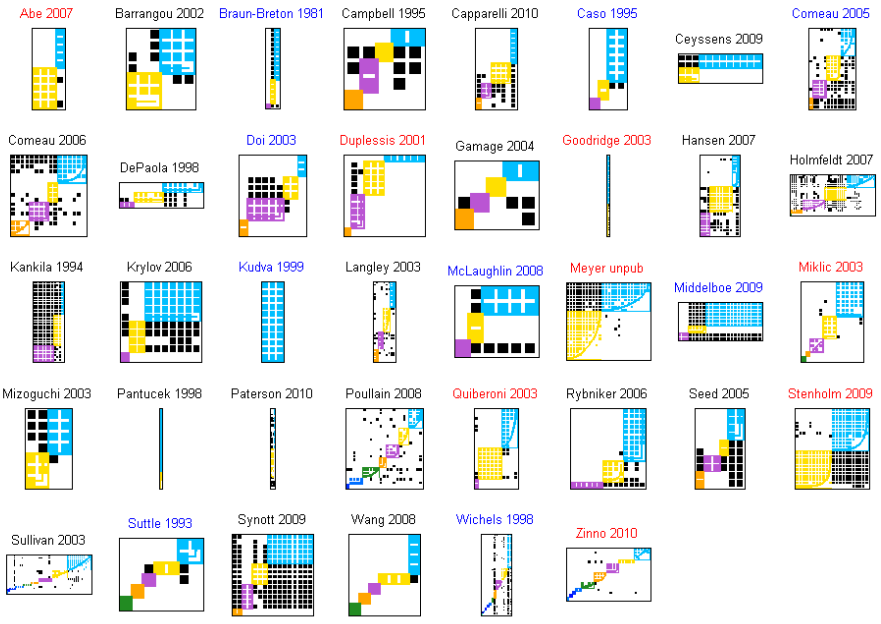
```
 1, 0.30992, 0.26097,    3.3211,       100,0.60166, 0.66968,   -0.709
 2,  0.2144, 0.21872,  -0.23696,        39,0.75082, 0.69691,    0.502
 3, 0.17556, 0.25914,   -7.5568,         0,0.99999, 0.61203,     4.78
 4, 0.22449,  0.2525,   -1.1601,         6,0.91927,  0.7482,     1.60
 5, 0.25652, 0.28094,   -1.6621,         6,0.94191,  0.5277,     6.27
 6,  0.2699, 0.32318,   -3.3501,         0,0.76003, 0.64906,     1.19
 7, 0.21403, 0.22098,  -0.53237,        30,0.95766, 0.66468,     2.94
 8,   0.174, 0.19577,   -2.7553,         0,0.76653, 0.42585,      7.1
 9, 0.21502, 0.22884,    -1.435,         9,0.79285, 0.44784,     6.33
10, 0.29191, 0.29322, -0.087331,        48,0.64773, 0.54953,     1.20
11, 0.24033, 0.29716,   -3.4689,         0,0.70138, 0.55091,     1.75
12,  0.4821, 0.41481,    3.2999,       100,0.88313, 0.62165,     3.14
13, 0.32099, 0.35395,   -1.1832,         7,0.74467, 0.72035,    0.212
14, 0.31667, 0.21266,    3.4131,        99,0.78013, 0.64694,     3.01
15, 0.20023, 0.20694,   -0.9917,        20,0.73148, 0.43105,     6.51
16, 0.18782, 0.18758,  0.044174,        52,0.80666, 0.32454,     16.9
17,0.045608,0.040607,    2.2655,        97,0.99859, 0.91852,     3.11
18,  0.1231, 0.13192,   -1.4908,         6,0.94712, 0.69218,      3.0
19,       0,       0,       NaN,         0,0.99998, 0.99998,   -0.994
20, 0.31027, 0.31386,  -0.27472,        36,0.64424, 0.46754,     3.28
21, 0.19136, 0.22599,   -1.5154,         1,0.97959, 0.76097,      2.0
22, 0.22015, 0.16836,   10.4607,       100,0.96851, 0.36018,     16.0
23, 0.08406, 0.10145,   -5.1761,         0,0.98762, 0.61406,     7.27
24,  0.4102, 0.34833,    3.8231,       100,0.70544, 0.54183,     2.64
25, 0.14966, 0.15918,  -0.57631,        20,0.92211, 0.88566,    0.383
26,0.053624,0.047798,    1.1188,        89,0.99459, 0.90366,     3.57
27, 0.20209, 0.19618,   0.84201,        79,0.82969, 0.43775,    10.91
28, 0.36501, 0.37867,  -0.86104,        21,0.79072, 0.58261,      5.0
29, 0.37622, 0.26006,    9.9598,       100,0.64478, 0.48129,     2.89
30, 0.33347,  0.3107,    1.5095,        96,0.85292, 0.51941,     5.27
31, 0.22893, 0.25446,    -1.395,         7,0.98194, 0.62186,     3.75
32, 0.18341, 0.11916,   17.6712,       100,0.96199, 0.41882,    12.46
33, 0.38678, 0.38623,  0.044745,        54,0.76799,  0.5734,     5.39
34,  0.4876, 0.54215,   -1.7993,         2,0.73009, 0.70883,    0.202
35,0.084203, 0.08528,  -0.30541,        42,0.94436, 0.67371,     4.34
36, 0.61983, 0.65438,  -0.92474,         9,0.96668, 0.69778,     2.79
37, 0.21057, 0.27327,   -8.0809,         0,0.88738, 0.42039,    14.00
38, 0.67805, 0.61562,     2.429,       100,0.82222, 0.72967,     2.37
```

Using a GroupStatistics object to create your own plots

We can use a GroupStatistics object (gp in this case) to create specific plots. Suppose we are interested in plotting all the matrices in modular sorting, such that the lables in the matrix are in red if the matrix is modular and in blue if it is antimodular. A simple script for performing this task will be:

```
n_rows = 5;
n_cols = 8;
modular_indices = gp.qb_vals.percent >= 97.5;
no_modular_indices = gp.qb_vals.percent <= 2.5;
figure(1);
for i = 1:gp.n_networks
```

```
    subplot(n_rows, n_cols, i);
    gp.networks{i}.plotter.use_labels = 0; %Do not show row/column labels
    gp.networks{i}.plotter.use_isocline = 0; %No isocline inside modules
    gp.networks{i}.plotter.PlotModularMatrix();
    col = 'black'; % Color for not significance
    if(modular_indices(i) == 1) % Color for significant modularity
        col = 'red';
    elseif(no_modular_indices(i) == 1) % Color for significant antimodularity
        col = 'blue';
    end
    title(gp.names{i},'Color',col, 'FontSize',10);
end
set(gcf,'Position', [148         213        1142         746]);
```



We may want to create a plot that compare the values of the networks with the random values of the null model. The next lines will show how to create such plot for the case of the NTC results

```
ntc_vals = gp.tempvals.value;
[~,sorted_indexes] = sort(ntc_vals); % I will plot in increasing NTC value

%Get random values and sort according to sorted_indexes
ntc_vals = ntc_vals(sorted_indexes);
mean_random_vals = gp.tempvals.mean(sorted_indexes);
random_values = gp.tempvals.random_values; %variable already sorted in rows
random_values = random_values(sorted_indexes,:); %sort in rows
names = gp.names(sorted_indexes);

%Find the limits of the error bars using two tail p-value=0.05
sup_bound = random_values(:,round(gp.replicates * 0.975));
low_bound = random_values(:,round(gp.replicates * 0.025));
```

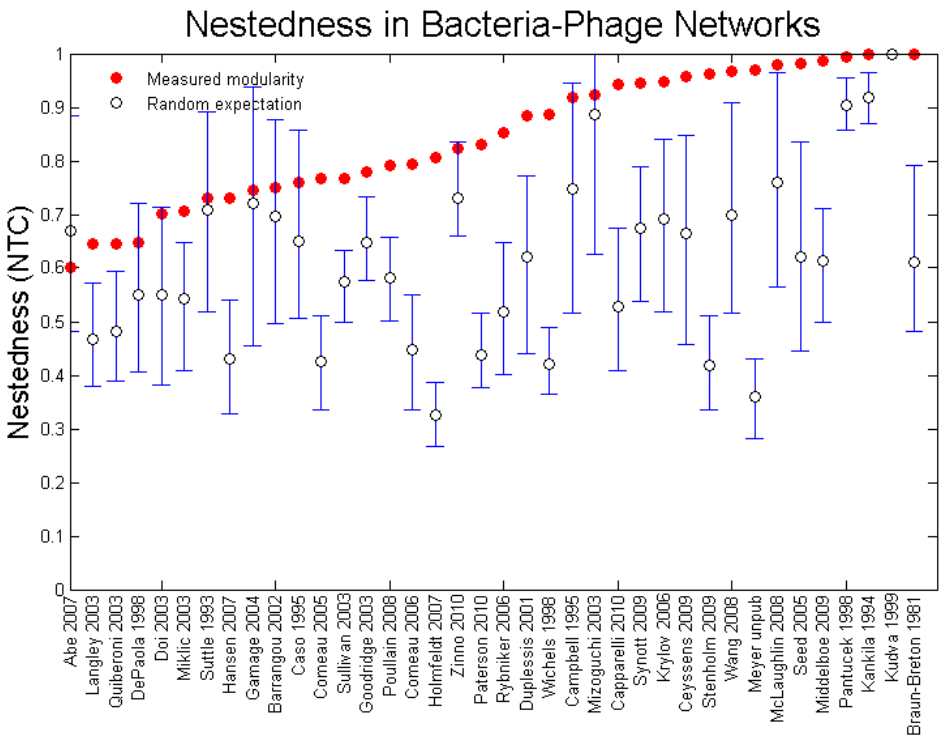
```
%Plot the data of the real matrices
figure(2);
plot(1:gp.n_networks, ntc_vals,'o','MarkerFaceColor','red','MarkerEdgeColor','red'
hold on;
%Plot the data of the random values
errorbar(1:gp.n_networks, mean_random_vals, mean_random_vals - low_bound, ...,
    sup_bound - mean_random_vals, 'o','MarkerFaceColor','white','MarkerEdgeColor',
hold off;

%Write the labels
set(gca,'xticklabel',[]);
for i=1:gp.n_networks
    tmph=text(i,-0.01,names(i));
    set(tmph,'HorizontalAlignment','right');
    set(tmph,'rotation',90);
    set(tmph,'fontsize',10);
end

%Labels in title, y-axis and legends
tmplh = legend('Measured modularity','Random expectation',1,'Location','NorthWest'
legend('boxoff')
title('Nestedness in Bacteria-Phage Networks','fontsize',20);
ylabel('Nestedness (NTC)','fontsize',16);

%Give format to the matrix
xlim([1 1+gp.n_networks]);
ylim([0 1]);

%Give appropiate size to the figure window
set(gcf,'Position',[91   135   859   505]);
set(gca,'Units','pixels');
set(gcf,'Position', [91   135   859   505+150])
apos = get(gca,'position');
apos(2) = apos(2) + 82;
set(gca,'position',apos);
set(gcf,'position',[91   135   859   596]);
```



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