

Community Structure Detection for
Overlapping Modules through Mathematical
Programming in Protein Interaction Networks
Supporting Information

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	iMod	Louvain	QCUT
Rat			
Degree	2.50E-32	2.19E-33	4.30E-31
Betweenness	1.87E-40	3.51E-40	7.22E-37
Eigenvector	7.57E-07	8.22E-07	3.99E-07
E. coli			
Degree	1.37E-29	7.51E-28	6.03E-27
Betweenness	2.62E-43	6.69E-41	6.05E-40
Eigenvector	2.25E-07	4.43E-07	4.06E-07
Yeast			
Degree	3.00E-40	2.36E-43	4.55E-46
Betweenness	5.28E-72	6.83E-67	1.34E-64
Eigenvector	1.37E-49	7.42E-53	8.36E-54
Human			
Degree	1.61E-260	< 2.2e-16	2.67E-292
Betweenness	< 2.2e-16	< 2.2e-16	< 2.2e-16
Eigenvector	1.53E-124	5.12E-173	2.42E-170

Table S1: The significance values for the comparison of isolated nodes with connector nodes (topological features).

	iMod	Louvain	QCUT
Rat			
ALL GO	8.70E-05	2.90E-04	1.29E-04
MF	1.35E-04	2.43E-03	1.19E-03
BP	2.01E-03	1.50E-03	1.11E-03
CC	4.06E-03	8.81E-03	7.66E-03
Domains	1.80E-01	1.96E-01	7.67E-02
E. coli			
ALL GO	6.50E-05	4.32E-05	4.32E-05
MF	5.72E-04	1.88E-04	1.88E-04
BP	3.57E-01	4.64E-01	4.64E-01
CC	6.41E-01	8.15E-01	8.15E-01
Domains	3.63E-03	2.35E-02	2.35E-02
Yeast			
ALL GO	9.63E-01	5.43E-01	2.10E-01
MF	3.31E-01	3.78E-01	8.63E-01
BP	3.96E-01	2.70E-01	1.12E-01
CC	1.20E-01	5.73E-01	5.99E-01
Domains	8.86E-06	3.47E-05	2.92E-04
Human			
ALL GO	4.59E-26	3.28E-28	3.97E-30
MF	2.18E-16	5.41E-19	1.24E-19
BP	3.84E-12	1.83E-15	1.04E-14
CC	7.14E-30	2.96E-27	3.78E-29
Domains	2.54E-10	2.03E-09	2.48E-09

Table S2: The significance values for the comparison of isolated nodes with connector nodes (functional features).

	iMod	Louvain	QCUT
E. coli	2.65E-04	9.99E-03	9.83E-04
Yeast	7.64E-04	1.11E-03	1.30E-03
Human	3.16E-15	1.31E-15	4.25E-19

Table S3: Essentiality results summary, where p-values less than 0.01 indicate that connector nodes in the corresponding organism are significantly enriched for essential genes.

Network	Soft partitions	Jaccard
	iMod+OverMod vs. Louvain+OverMod	0.7222
Rat	iMod+OverMod vs. QCUT+OverMod	0.7647
	Louvain+OverMod vs. QCUT+OverMod	0.6607
	iMod+OverMod vs. Louvain+OverMod	0.6721
E. coli	iMod+OverMod vs. QCUT+OverMod	0.8035
	Louvain+OverMod vs. QCUT+OverMod	0.7719
	iMod+OverMod vs. Louvain+OverMod	0.8767
Yeast	iMod+OverMod vs. QCUT+OverMod	0.7979
	Louvain+OverMod vs. QCUT+OverMod	0.8606
	iMod+OverMod vs. Louvain+OverMod	0.7786
Human	iMod+OverMod vs. QCUT+OverMod	0.7185
	Louvain+OverMod vs. QCUT+OverMod	0.7343

Table S4: The Jaccard index for each pair-wise comparison of sets of inter-connector nodes.

	iMod+OverMod	Louvain+OverMod	QCUT+OverMod
Rat			
Degree	2.14E-04	2.54E-03	7.90E-04
Betweenness	1.22E-02	1.09E-01	1.31E-01
Eigenvector	1.07E-02	4.05E-02	1.91E-02
E. coli			
Degree	1.48E-03	4.07E-04	8.94E-04
Betweenness	8.22E-02	7.51E-03	3.99E-02
Eigenvector	1.53E-02	1.14E-02	2.90E-03
Yeast			
Degree	1.02E-01	5.48E-02	1.06E-02
Betweenness	2.85E-04	7.03E-03	1.95E-03
Eigenvector	1.96E-03	1.38E-02	1.55E-03
Human			
Degree	3.09E-19	2.41E-03	4.58E-14
Betweenness	2.24E-08	2.93E-01	2.13E-07
Eigenvector	6.14E-06	2.13E-02	4.77E-01

Table S5: Summary of the significance values for the comparison between inter and intra-connectors based on topological measures.

	iMod+OverMod			Louvain+OverMod			QCUT+OverMod		
	Inter	Intra	p-value	Inter	Intra	p-value	Inter	Intra	p-value
Rat	0.4409	0.2818	7.24E-05	0.4409	0.2721	1.74E-04	0.4599	0.2685	2.11E-05
E. coli	0.3851	0.2176	4.33E-03	0.3892	0.2181	1.69E-03	0.3946	0.2137	1.78E-03
Yeast	0.3073	0.1441	7.93E-10	0.3079	0.1562	2.32E-06	0.3006	0.1607	2.12E-06
Human	0.5465	0.3188	1.81E-115	0.5351	0.3541	2.06E-107	0.5234	0.3443	3.09E-135

Table S6: Average participation coefficient for inter and intra-connectors with corresponding significance values.