network *mining*

introduction to *network analysis in Python* (*NetPy*)

Lovro Šubelj
University of Ljubljana
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mining *overview*

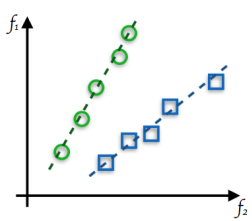
how to *mine* different *graphs/networks*?

how to *mine* network *nodes/links*?

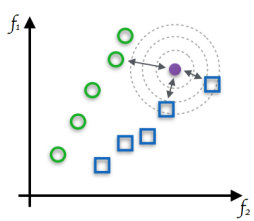
node/link clustering → revealing *similarity clusters*

node/link classification → predicting *discrete labels*

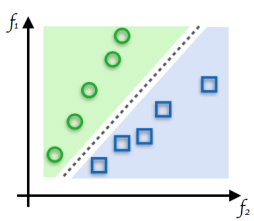
node/link regression → predicting *numerical values*



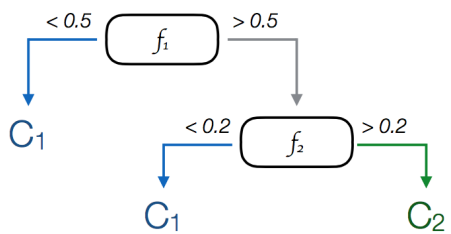
Regression



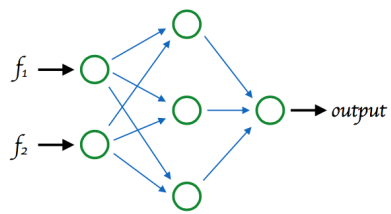
kNN



SVM



Decision Tree



ANN

mining *clustering*

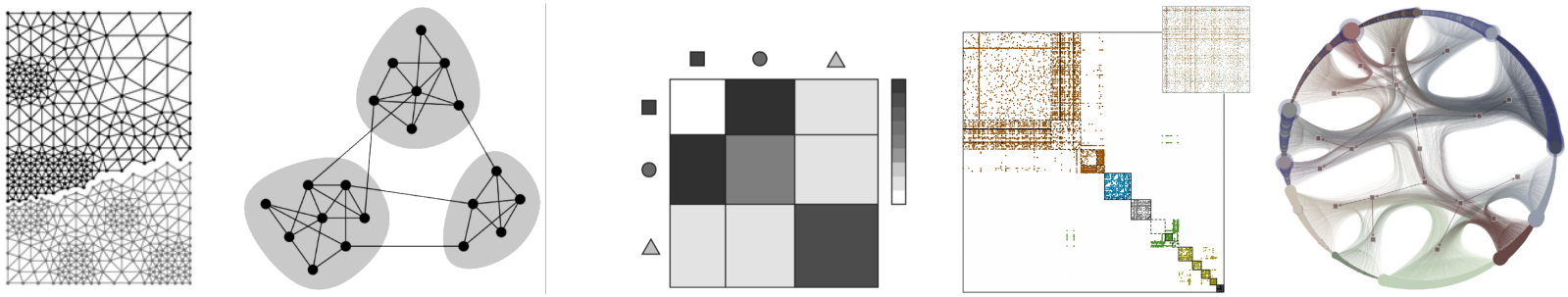
how to *cluster* network *nodes/links*?

— *graph partitioning* and *community detection* methods

for connected *assortative clusters* based on homophily

— *(stochastic) blockmodeling* and *role discovery* methods

also disconnected *disassortative clusters* based on equivalence



for *survey/user guide* see [For10, FH16]

mining *classification/regression*

how to *classify/regress* network *nodes/links*?

— *relational learning* and *link mining* methods

machine learning methods using network structure

— *node/link structure* used as *learning features*

centrality, bridging, fragments, *egonets*, *clusters* etc.

node features from local *random walk exploration* →

DeepWalk [PARS14]
only *homophily*

node2vec [GL16]
also *equivalence*

struc2vec [FRS17]
only *structure*

for *survey* see [BCM11, ZPS+16]

mining *classification*

— *classification by clustering* in *APS citation* network [Šub15b]

		7 **journals**		91 **sections**	
class	**method**	**NMI**	**CA**	**NMI**	**CA**
clusters	spectrum	0.361	59.8%	0.380	38.6%
	modularity	0.339	68.1%	0.426	37.1%
	map equation	0.232	71.3%	0.416	48.1%
	block model	0.243	69.6%	0.392	45.3%
baselines	*neighbors*	-	63.9%	-	46.5%
	2-neighbors	-	71.5%	-	50.4%
	network	-	27.6%	-	17.9%

— *. . . by clustering* in *WikiLeaks reference* network [Šub15a]

		3 **privacies**		246 **embassies**	
class	**method**	**NMI**	**CA**	**NMI**	**CA**
clusters	*spectrum*	0.003	49.1%	0.658	47.9%
	modularity	0.048	59.2%	0.699	52.3%
	map equation	0.088	33.1%	0.654	37.1%
	block model	0.035	56.5%	0.625	37.6%
baselines	neighbors	-	14.2%	-	15.0%
	2-neighbors	-	27.7%	-	31.6%
	network	-	49.1%	-	1.4%

mining *regression*

— *regression by centrality* in *Slovenian highways* network

		traffic loads	
class	**centrality**	**Pearson**	**Spearman**
spectral	degree	0.278	0.275
	eigenvector	0.010	0.241
	PageRank	0.121	−0.149
distance	*closeness*	0.623	0.634
	betweenness	0.628	0.651
clustering	standard	0.000	0.000
	μ-corrected	0.000	0.230

— *. . . by centrality* in *Wikipedia web of trust* network [MAC11]

		users trust	
class	**centrality**	**Pearson**	**Spearman**
spectral	*degree*	0.013	0.316
	eigenvector	0.026	0.118
	PageRank	0.001	0.182
clustering	standard	0.134	0.115
	μ-corrected	0.127	0.199

mining *references*

Smriti Bhagat, Graham Cormode, and S. Muthukrishnan.
Node classification in social networks.
In *Social Network Data Analytics*. Springer, 2011.

Santo Fortunato and Darko Hric.
Community detection in networks: A user guide.
Phys. Rep., 659:1–44, 2016.

Santo Fortunato.
Community detection in graphs.
Phys. Rep., 486(3-5):75–174, 2010.

Daniel R. Figueiredo, Leonardo F. R. Ribeiro, and Pedro H. P. Saverese.
struc2vec: Learning node representations from structural identity.
In *Proceedings of the ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, pages 1–9, 2017.

Aditya Grover and Jure Leskovec.
node2vec: Scalable feature learning for networks.
In *Proceedings of the ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, pages 855–864, 2016.

Silviu Maniu, Talel Abdessalem, and Bogdan Cautis.
Casting a web of trust over Wikipedia: An Interaction-based approach.
In *Proceedings of the International Conference on World Wide Web*, pages 87–88, New York, NY, USA, 2011.

Bryan Perozzi, Rami Al-Rfou, and Steven Skiena.
DeepWalk: Online learning of social representations.
In *Proceedings of the ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, pages 701–710, 2014.

mining *references*

Lovro Šubelj.

Exploratory and predictive tasks of network community detection.
In *Proceedings of the International Conference on Network Science*, page 1, Zaragoza, Spain, 2015.

Lovro Šubelj.

Large network community detection in practical scenarios.
In *Proceedings of the International Workshop on Social Network Analysis*, page 78, Capri, Italy, 2015.

M. Zanin, D. Papo, P. A. Sousa, E. Menasalvas, A. Nicchi, E. Kubik, and S. Boccaletti.

Combining complex networks and data mining: Why and how.
Phys. Rep., 635:1–44, 2016.