Multiobjective Machine Learning

Michael Emmerich LIACS, April 23 2014,
NiCaiA Colloquium: Winterbourne House, Birmingham

Leiden University
The Netherlands

Brief Summary

Basic Principles

Binary Classifier Optimization

Three Way Classification

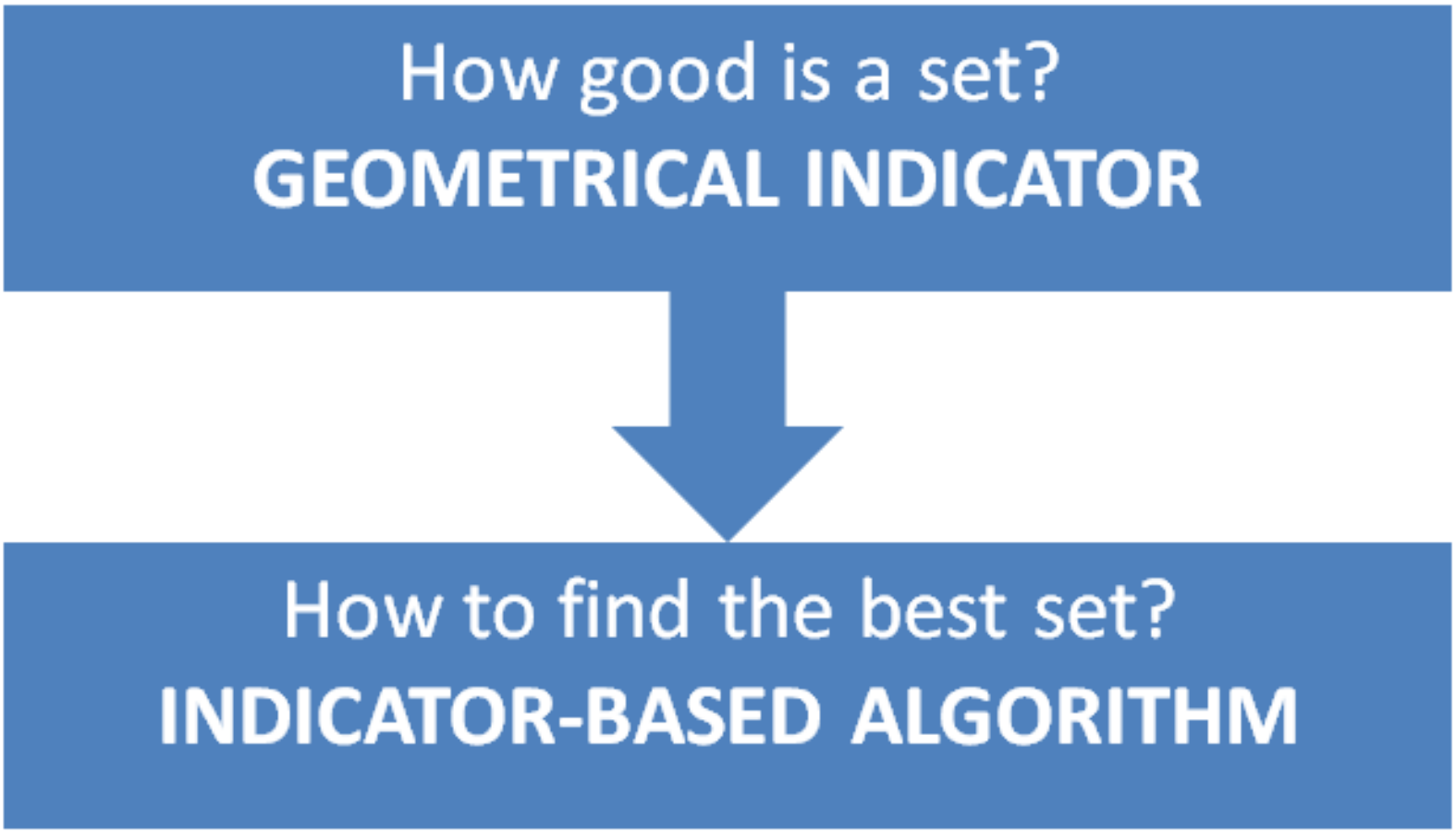
Parsimony as a Third Objective

Three Class Classifier Optimization

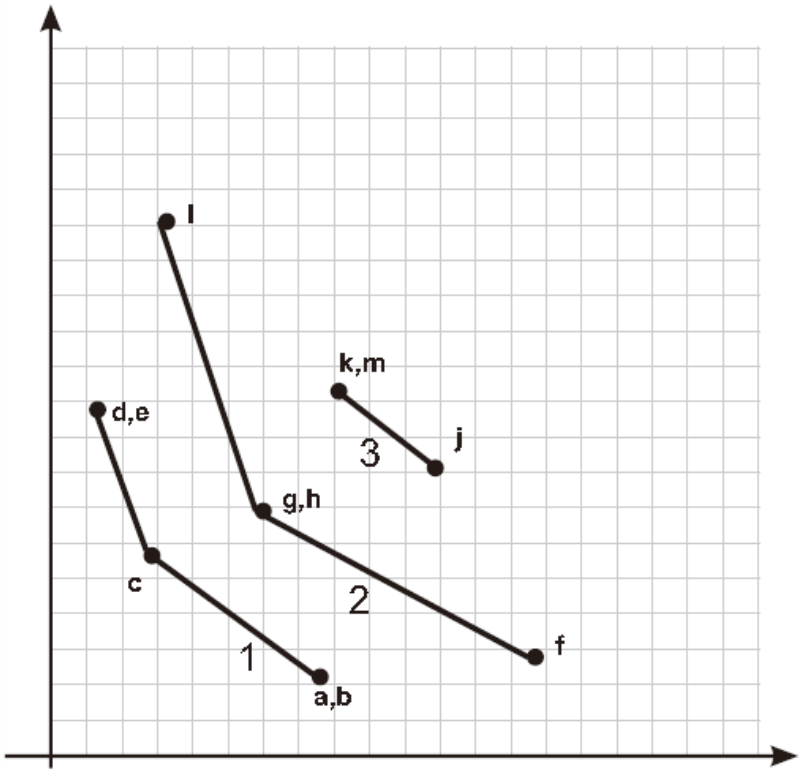
Towards Multi-Class Classification

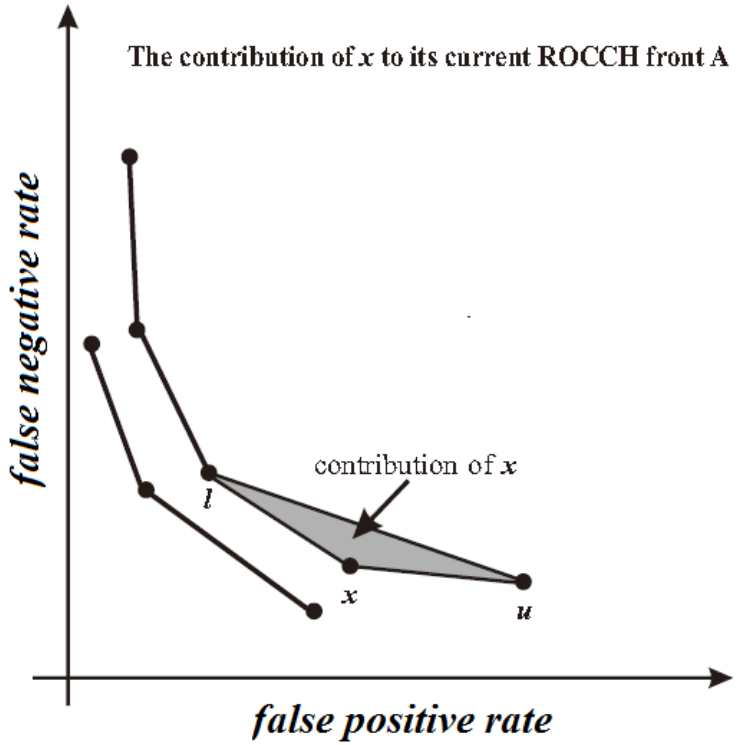
Summary and outlook

Design Approach: Set-oriented Optimization



Binary Classifier Optimization





Wang, P., Emmerich, M., Li, R., Tang, K., Baeck, T., and X. Yao (2014). Convex Hull-Based Multi-objective Genetic Programming for Maximizing Receiver Operating Characteristic Performance. IEEE TEVC

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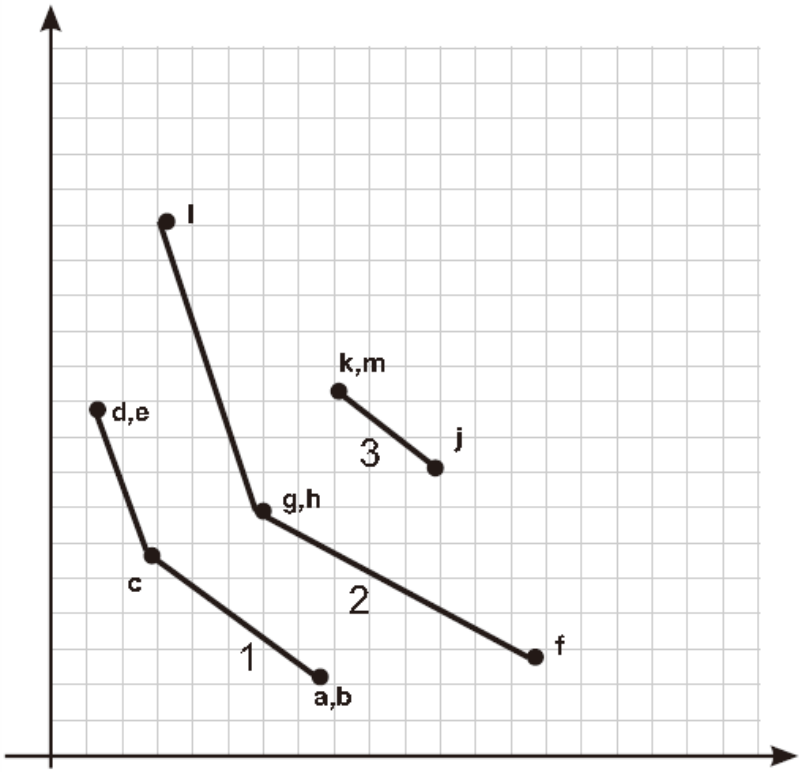

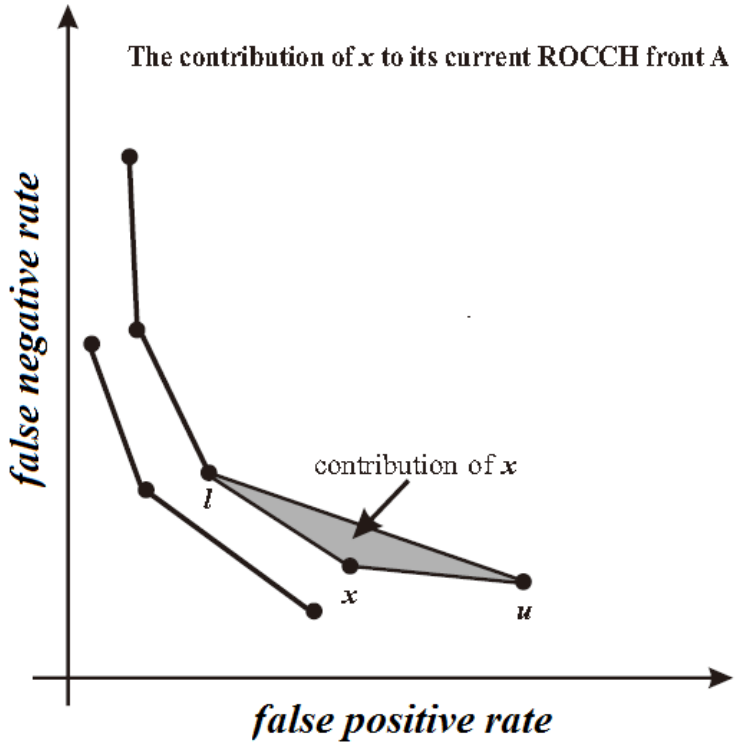

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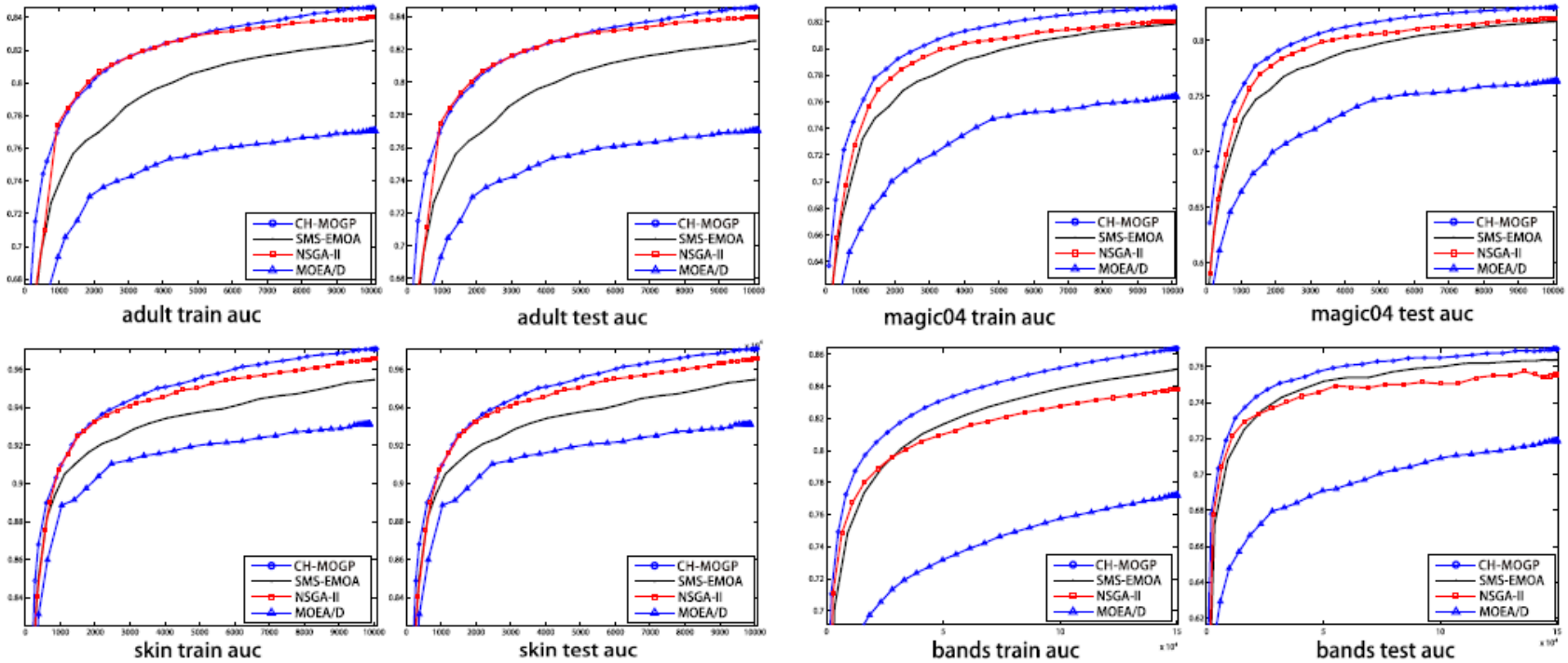

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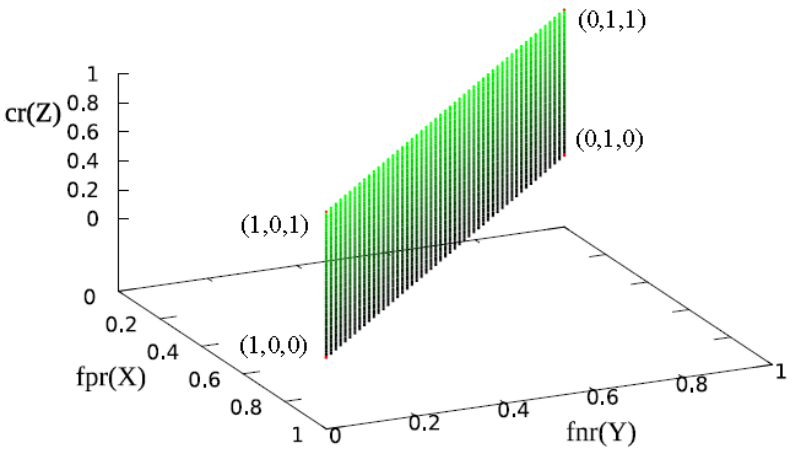
Three-Way Classifier Optimization



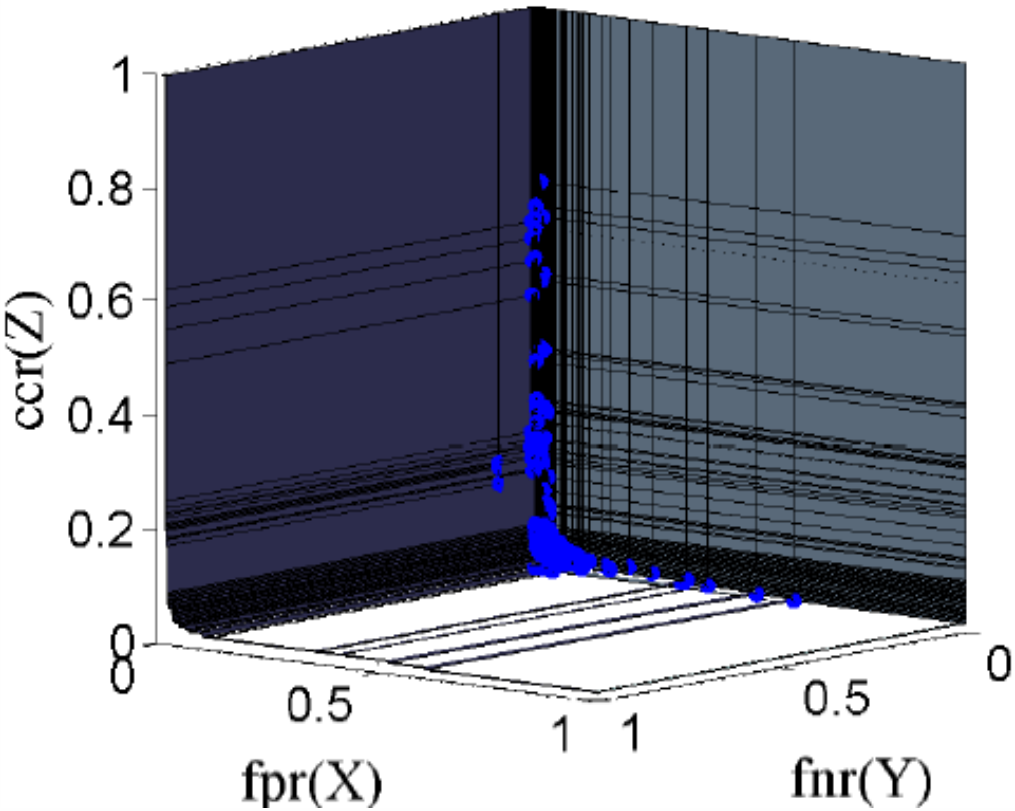
		True class: P	True class: N
Predicted class	P	True Positives	False Positives
	N	False Negatives	True Negatives
		Further Exam	

'It is better to not classify than to make a wrong classification' but, number of unclassified instances (further exam) $\rightarrow$ **min**.

Zhao, J., Basto V., Yevseyeva I., Emmerich, M.: Quadcriteria Optimization of Binary Classifiers: Error Rates, Coverage, and Complexity: Accepted for EVOLVE 2015, Springer AISC.

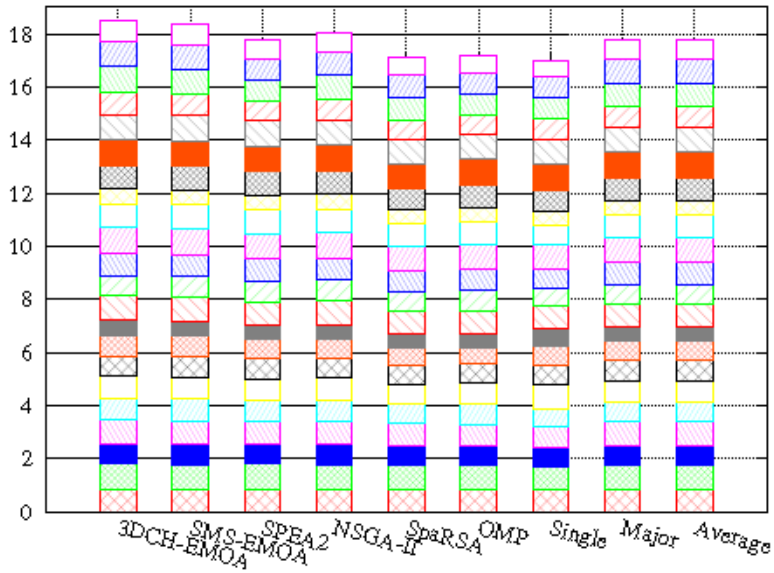
Parsimony as a Third Objective

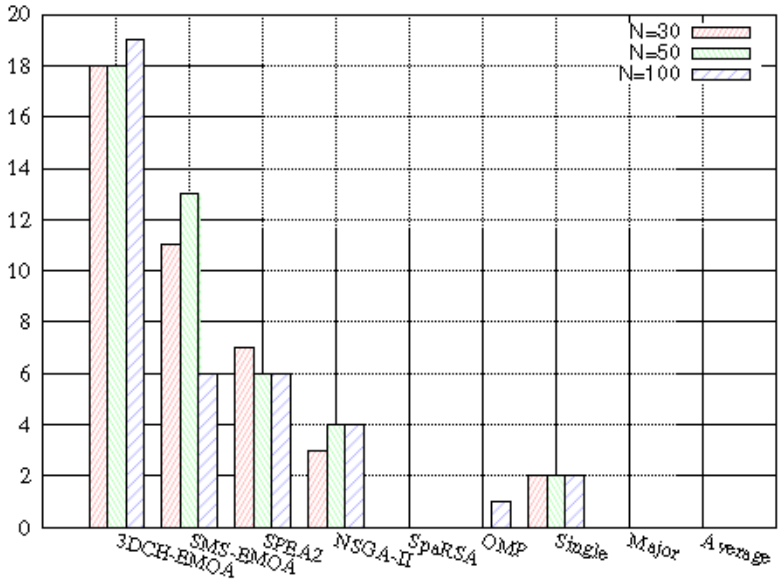
Ockham chooses a razor



Basto-Fernandes, V., Yevseyeva, I., Frantz, R. Z., Grilo, C., Díaz, N. P., and Emmerich, M. (2014). An automatic generation of textual pattern rules for digital content filters. Procedia Technology, 16, 806-812.

Parsimony as a third objective

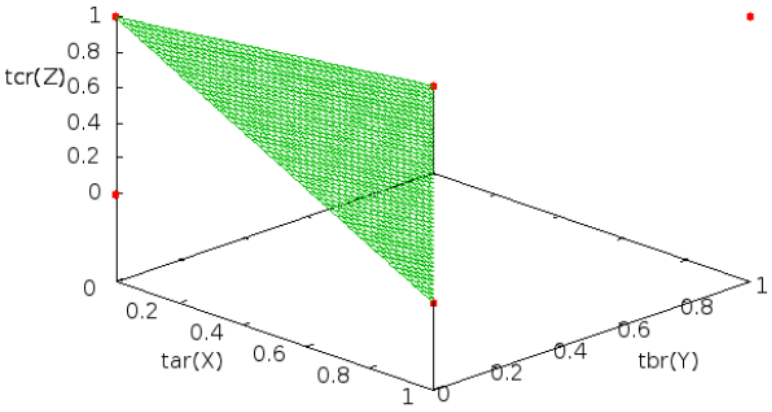




Multiobjective Sparse Ensemble Learning by Means of Evolutionary Algorithms (MOSE)

Jiaqi Zhao, Licheng Jiao, Fang Liu, Lin Li, Vitor Basto Fernandes, Iryna Yevseyeva, and Michael Emmerich (2015): Submitted for IEEE PAMI

Three-Class Classifier Optimization

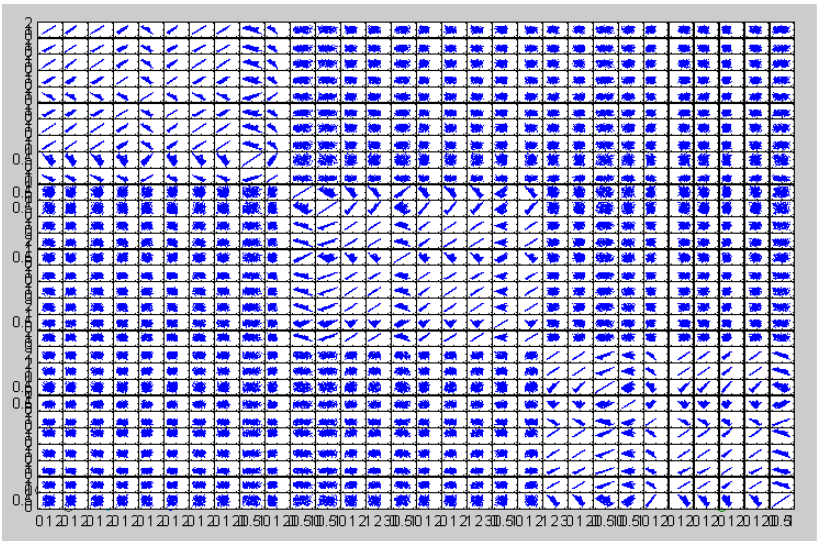


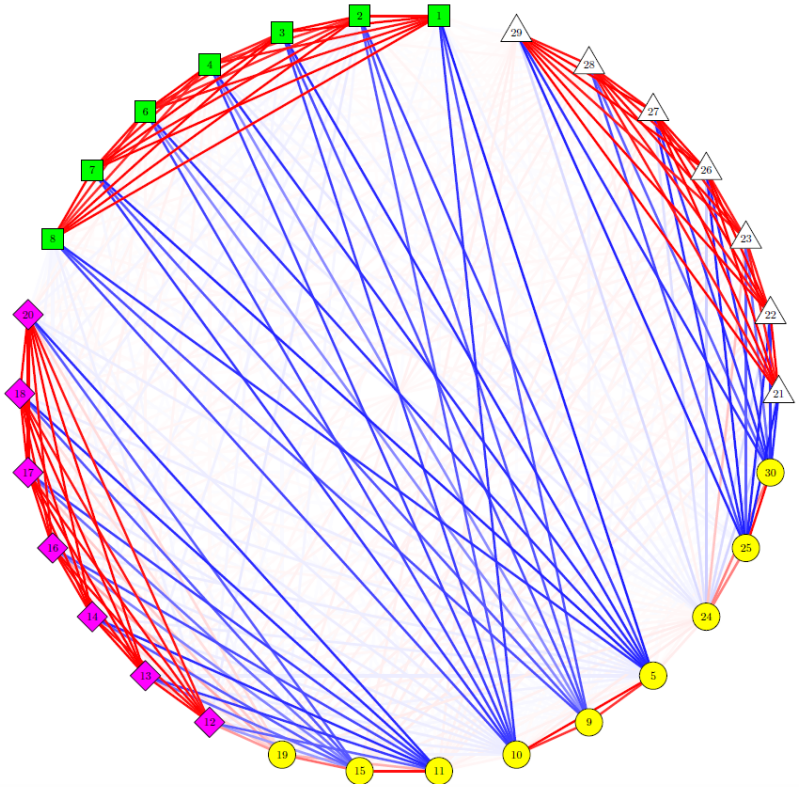
Predicted class \ True class	A	B	C
A	True A	False Ab	False Ac
B	False Ba	True B	False Bc
C	False Ca	False Cb	True C

Zhao, J., Fernandes, V. B., Jiao, L., Yevseyeva, I., Maulana, A., Li, R., and Emmerich, M. (2014). Multiobjective Optimization of Classifiers by Means of 3-D Convex Hull Based Evolutionary Algorithm. arXiv preprint arXiv:1412.5710. (submitted for: IEEE TEVC)

Multi-Class Classifier Optimization

Each class is objective ⇒ Many objectives





Asep Maulana, Zhongzhou Lian, Jing Liu, Michael Emmerich: Reducing Complexity in Many Objective Optimization Using Community Detection, Accepted for IEEE CEC)

What we achieved in NICaiA

- Problem Formulations: ROC/Binary, VUS/Ternary Classifiers, Three Way, Sparse, Many-Class (work in progress)
- New Algorithms: CH-EMOA, 3D-CHEMOA, MOSE, CoDeMO
- New Performance Indicators: AUCH, VUS, Gini Pareto
- Applications: Sparse Classifiers, UCI, SPAM-Classifiers

List of all coauthors: Pu Wang, Jing Liu, Ke Tang, Jiaqi Zhao, Xin Yao, Asep Maulana, Vitor Basto, Iryna Yevseyeva, Rui Li, Thomas Bäck, Zhongzhou Lian, Fang Liu, Lin Li, M.E.
Thanks: NICaiA Project People, EU 7th Framework for facilitating/inspiring this research.

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