TECHNISCHE UNIVERSITÄT DARMSTADT

Knowledge Engineering Group

A Re-evaluation of the Over-Searching Phenomenon in Inductive Rule Learning

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Motivation

- Phenomenon of over-searching is well known [3] but not shown for most of the rule learning heuristics
- In [3] only one heuristic was used and no true Exhaustive Search was employed (approximation with a beam of 512)
- we extend their work to 9 different heuristics (some of them were tuned in [1,2]) and a true exhaustive search
- we want to answer the question whether Separate-and-conquer algorithms can improve from more extensive search

Setup

- Simple Separate-and-conquer algorithm implemented in the *SeCo*-Framework
  - Hill-Climbing Search, Exhaustive Search and Beam Search (for a trade-off between them)
  - implements Forward Pruning (important for the runtime)
  - classification by decision list (ordered binarization)
- Experiments
  - 22 datasets from UCI (arbitrary selection, only nominal attributes)
  - av. accuracy with 10-fold CV

Search strategies

- *Hill-Climbing* ⊕ only refine 1 rule ⊖ may get stuck in local optima
- *Beam Search* ⊕ refine *b* rules simultaneously ⊖ higher runtime
- *Exhaustive Search* ⊕ create all possible rules ⊖ highest runtime ⊕ cannot get stuck in local optima

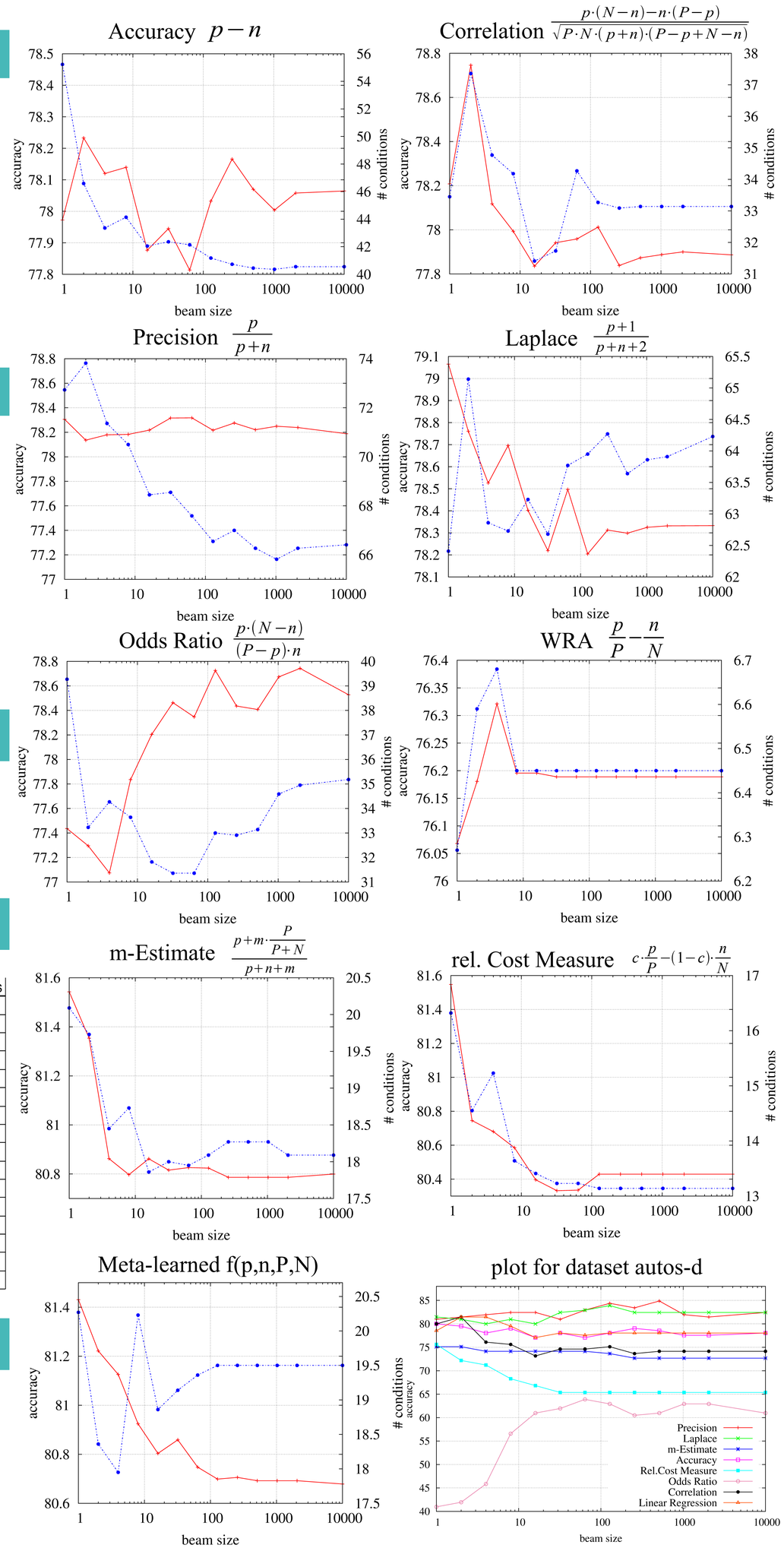
Results

- Exhaustive Search finds longer rules with higher coverage (cf. Table)
- Experiment 2: Only induce one single rule per class
  - confirms findings of previous experiment
  - models only lack about 10% av. accury behind
  - Precision and Laplace have significantly smaller theories
  - all heuristics improve from Exhaustive Search except the Meta-learned one

heuristic	beam	# rules	# conds	#conds/#rules
Accuracy	1	20.23	55.23	2.73
	exhaus.	13.00	40.55	3.12
Correlation	1	12.55	33.45	2.67
	exhaus.	11.23	33.14	2.95
Precision	1	27.68	72.73	2.63
	exhaus.	20.36	66.41	3.26
Laplace	1	24.23	62.41	2.58
	exhaus.	19.73	64.23	3.26
Odds Ratio	1	11.64	39.27	3.38
	exhaus.	11.5	35.18	3.06
WRA	1	3.32	6.27	1.89
	exhaus.	3.18	6.45	2.03
m-Estimate	1	8.36	20.09	2.40
	exhaus.	7.05	18.09	2.57
rel. Cost Measure	1	7.00	16.32	2.33
	exhaus.	5.32	13.14	2.47

Discussion

- over-searching phenomenon depends on the heuristic
  - Odds Ratio and Precision gain performance
  - more complex heuristics lose performance
- heuristics that work well in Hill-Climbing do not profit from Exhaustice Search or Beam Search
- different requirements for heuristics used in Hill-Climbing and Exhaustive Search



red solid line: av. accuracy, blue dotted line: av. # conditions

References

[1] Frederik Janssen and Johannes Fürnkranz: *An empirical investigation of the trade-off between consistency and coverage in rule learning heuristics*. In *T.Horvath, F.Boulicaut, and M.Berthold*, Editors, Proceedings of the 11th International Conference on Discovery Schience, Budapest, Hungary, 2008.

[2] Frederik Janssen and Johannes Fürnkranz: *On meta-learning rule learning heuristics*. In Proceedings of the 7th IEEE Conference on Data Mining (ICDM-07), pages 529-534, Omaha, NE. 2007.

[3] J.R. Quinlan and R.M. Cameron-Jones: *Oversearching and layered search in empirical learning*. In Proceedings of the 14th International Conference on Artificial Intelligence, pages 1019-1024, Montreal, Canada, 1995. Morgan Kaufmann.

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