AutoML: Algorithm Selection

Bonus: Combinatorial Problems

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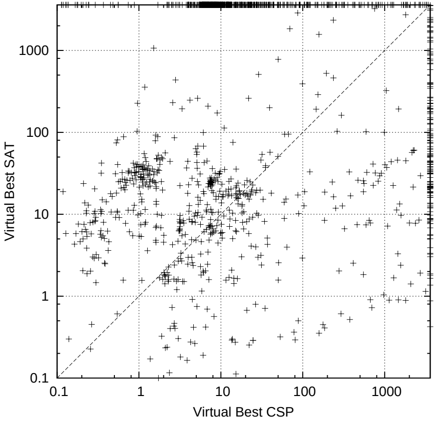
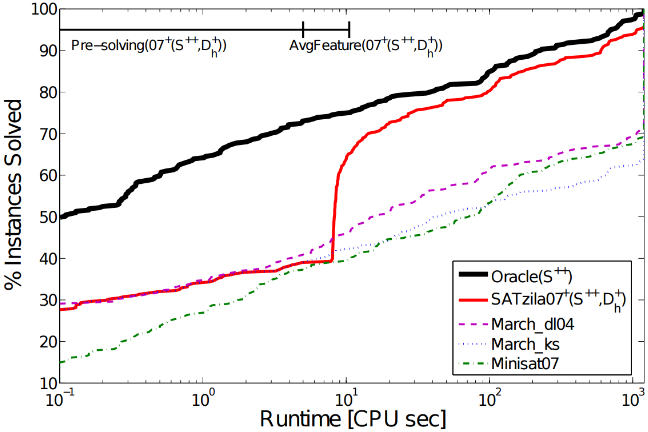
Motivation

- Algorithm Selection applied in many other domains
- success and performance improvements for combinatorial and optimization problems in AI dwarfs those in machine learning
- important application area of AI facilitating cross-disciplinary collaborations and advances

Motivation: Performance Differences [Barry et al. 2014] I



Motivation: Leveraging the Differences [Xu et al. 2008]



Algorithms [Huberman et al. 1997]

- constraint solvers
- search strategies
- modeling choices
- different types of consistency

Features

- number of variables, number of clauses/constraints/...
- ratios
- order of variables/values
- connectivity clause/constraints–variable graph or variable graph
- number of nodes/propagations within time limit
- estimate of search space size
- tightness of problem/constraints
- ...

Example System – SATzilla [Xu et al. 2008]

- portfolio of 7 SAT solvers, trained on 4811 problem instances
- syntactic (33) and probing features (15)
- ridge regression to predict log runtime for each solver, choose the solver with the best predicted performance
- later version uses random forests to predict better algorithm for each pair, aggregation through simple voting scheme
- pre-solving, feature computation time prediction, hierarchical model, selection of algorithms to include in portfolio based on overall performance
- won several competitions

Benchmark library – ASlib [Bischl et al. 2015]

- `https://github.com/coseal/aslib_data`
- SAT, CSP, QBF, ASP, MAXSAT, OR, ML...
- includes data used frequently in the literature that you may want to evaluate your approach on
- more scenarios in the pipeline
- `http://aslib.net`

Tools

autofolio	`https://bitbucket.org/mlindauer/autofolio/`
LLAMA	`https://bitbucket.org/lkotthoff/llama`
SATzilla	`http://www.cs.ubc.ca/labs/beta/Projects/SATzilla/`

(Much) More Information [Kotthoff. 2014]

Comments? Suggestions? Corrections?
Let me know!

Algorithm Selection Literature Summary

Last update 21 November 2018

click headings to sort
click citations to expand

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citation	domain	features	predict what	predict how	predict when	portfolio	year
Langley 1983b, Langley 1983a	search	past performance	algorithm	hand-crafted and learned rules	offline and online	dynamic	1983
Carbonell et al. 1991	planning	problem domain features, search statistics	control rules	explanation-based rule construction	online	dynamic	1991
Gratch and DeJong 1992	planning	problem domain features, search statistics	control rules	probabilistic rule construction	online	dynamic	1992
Smith and Setliff 1992	software design	features of abstract representation	algorithms and data structures	simulated annealing	offline	static	1992
Aha 1992	machine learning	instance features	algorithm	learned rules	offline	static	1992
Brodley 1993	machine learning	instance and algorithm features	algorithm	hand-crafted rules	offline	static	1993
Kamel et al. 1993	differential equations	past performance, instance features	algorithm	hand-crafted rules	offline	static	1993
Minton 1993b, Minton 1993a, Minton 1996	CSP	runtime performance	algorithm	hand-crafted and learned rules	offline	dynamic	1993
Cahill 1994	software design	instance features	algorithms and data structures	frame-based knowledge base	offline	static	1994
Tsang et al. 1995	CSP	instance features	-	-	-	static	1995
Brewer 1995	software design	runtime performance	algorithms, data structures and their parameters	statistical model	offline	static	1995
Weerawarana et al. 1996, Joshi et al. 1996	differential equations	instance features	runtime performance	Bayesian belief propagation, neural nets	offline	static	1996
Borrett et al. 1996	CSP	search statistics	switch algorithm?	hand-crafted rules	online	static, static order	1996
Allen and Minton 1996	SAT, CSP	probing	runtime performance	hand-crafted rules	online	static	1996
Sakkout et al. 1996	CSP	search statistics	switch algorithm?	hand-crafted rules	online	static	1996
Huberman et al. 1997	graph colouring	past performance	resource allocation	statistical model	offline	static	1997
Gomes and Selman 1997b, Gomes and Selman 1997a	CSP	problem size and past performance	algorithm	statistical model	offline	static	1997
Cook and Varnell 1997	parallel search	probing	set of search strategies	decision trees, Bayesian classifier, nearest neighbour, neural net	online	static	1997
Fink 1997, Fink 1998	planning	past performance	resource allocation	statistical model, regression	offline	static	1997
Lobjois and Lemaître 1998	branch and bound	probing	runtime performance	hand-crafted rules	online	static	1998
Caseau et al. 1999	vehicle routing problem	runtime performance	algorithm	genetic algorithms	offline	static	1999
Howe et al. 1999	planning	instance features	resource allocation	linear regression	offline	static	1999
Terashima-Marín et al. 1999	scheduling	instance and search features	algorithm	genetic algorithms	offline	dynamic	1999
Wilson et al. 2000	software design	instance features	data structures	nearest neighbour	offline	static	2000
Beck and Fox 2000	job shop scheduling	instance feature changes during search	algorithm scheduling policy	hand-crafted rules	online	static	2000
Brazdil and Soares 2000	classification	past performance	ranking	distribution model	offline	static	2000
Lagoudakis and Littman 2000	order selection, sorting	instance features	remaining cost for each sub-problem	MDP	online	static	2000
Sillito 2000	CSP	probing	cost of solving problem	statistical model	offline	static	2000
Pfahringer et al. 2000	classification	instance features, probing	algorithm	9 different classifiers	offline	static	2000
Fukunaga 2000	TSP	past performance	resource allocation	performance simulation for different allocations	offline	static	2000
Soares and Brazdil 2000	machine learning	instance features	ranking	nearest neighbour	offline	static	2000
Gomes and Selman 2001	CSP, mixed integer programming	past performance	algorithm	statistical model	offline	dynamic	2001
Epstein and Freuder 2001, Epstein et al. 2002, Epstein et al. 2005, Epstein and Petrovic 2011	CSP	variable characteristics	algorithm	weights, hand-crafted rules	offline and online	dynamic	2001
Lagoudakis and Littman 2001	DPLL branching rules	instance features	remaining cost for each sub-problem	MDP	online	static	2001
Nareyek 2001	optimization	search statistics	expected utility of algorithm	reinforcement learning	offline and online	static	2001
Horvitz et al. 2001	CSP	instance and instance generator features, search statistics	runtime performance, restart parameters	Bayesian model	offline and online	static	2001

http://larskotthoff.github.io/assurvey/