Voting Systems and Automated Reasoning: the QBFEVAL Case Study

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- Fundamental role in the advancement of the state of the art:
  - for developers: help to set research challenges
  - for users: assess the current technological frontier

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  - procedures based on voting systems
- We introduce measures to quantify desirable properties of the aggregation procedures.

Contribution

Using and evaluating social choice methods in automated reasoning systems contests

Agenda

- Preliminaries
- Procedures
- YASM
- Comparative measures
- Conclusions

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- Table RUNS with four attributes: SOLVER, INSTANCE, RESULT, and CPUTIME.
- RUNS is the only input required by an aggregation procedure.

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- **SAT competition:** uses a purse-based method where the score is obtained adding up a solution purse, a speed purse and a series purse.

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Assuming solvers as candidates to an election and instances as voters:

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- **Range voting:** similar to Borda count, but using multiplicative positional weights.
- **Schulze's method:** it is a Condorcet method that computes the Schwartz set to determine a winner. We use an extension of the single overall winner procedure, in order to make it capable of generating an overall ranking.

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  - $k_{s,i}$: Borda-like positional weight
  - $(1 + H_i)$: relative hardness of the instance; it rewards the solvers that solve hard instances
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- Total score $S_s = \sum_i S_{s,i}$

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- Kendall rank correlation coefficient τ as measure of homogeneity.

Homogeneity

	CASC	QBF	SAT	YASM	YASMv2	Borda	r.v.	Schulze
CASC	–	1	0.71	0.86	0.79	0.86	0.71	0.86
QBF		–	0.71	0.86	0.79	0.86	0.71	0.86
SAT			–	0.86	0.86	0.71	0.71	0.71
YASM				–	0.86	0.71	0.71	0.71
YASMv2					–	0.86	0.86	0.86
Borda						–	0.86	1
r. v.							–	0.86
Schulze								–

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- A high-fidelity aggregation procedure:
  - computes approximately the same scores for each solver
  - produces a final ranking where scores have a small variance-to-mean ratio

Fidelity

Method	Mean	Std	Median	Min	Max	IQ Range	F
QBF	182.25	7.53	183	170	192	13	88.54
CASC	182.25	7.53	183	170	192	13	88.54
SAT	87250	12520.2	83262.33	78532.74	119780.48	4263.94	65.56
YASM	46.64	2.22	46.33	43.56	51.02	2.82	85.38
YASMv2	1257.29	45.39	1268.73	1198.43	1312.72	95.11	91.29
Borda	984.5	127.39	982.5	752	1176	194.5	63.95
r. v.	12010.25	5183.86	12104	5186	21504	8096	24.12
SCHULZE	–	–	–	–	–	–	–

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RDT-stability

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INSTANCE_3
INSTANCE_4
INSTANCE_5
INSTANCE_6
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INSTANCE_8
INSTANCE_9
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INSTANCE_14
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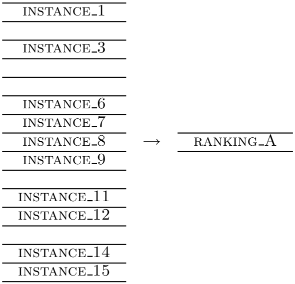

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RANKING_A
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INSTANCE_15

→

RANKING_A
RANKING_B

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Test set		Rankings
INSTANCE_2		
INSTANCE_3		
INSTANCE_4		
INSTANCE_5		
INSTANCE_6		
		RANKING_A
INSTANCE_8	→	RANKING_B
INSTANCE_9		RANKING_C
INSTANCE_10		
INSTANCE_14		
INSTANCE_15		

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INSTANCE_2
INSTANCE_3
INSTANCE_4
INSTANCE_5
INSTANCE_6
INSTANCE_8
INSTANCE_9
INSTANCE_10
INSTANCE_14
INSTANCE_15

→

RANKING_A
RANKING_B
RANKING_C

→

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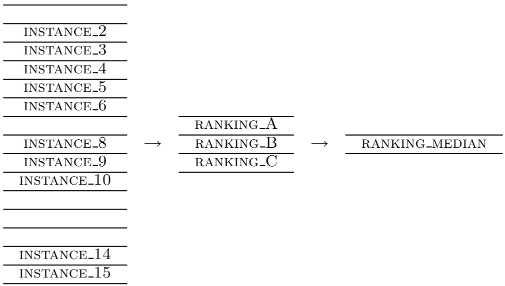

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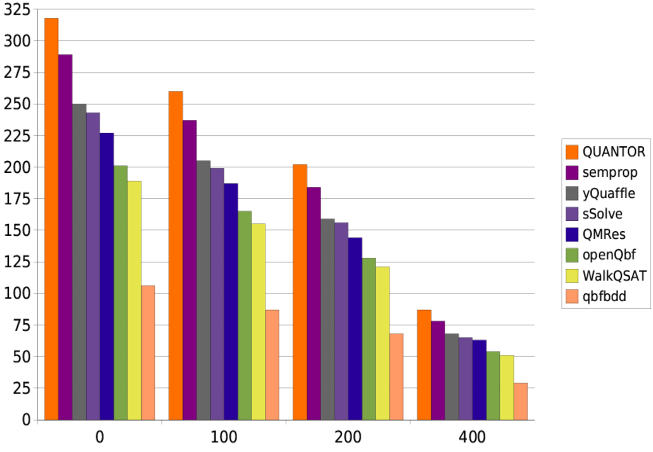

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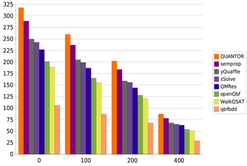

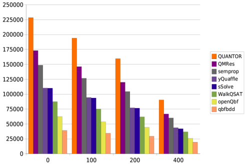

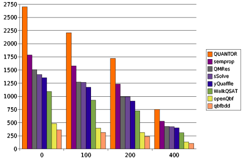

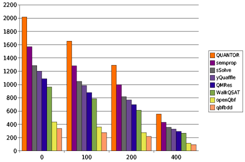

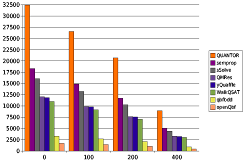

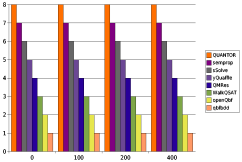

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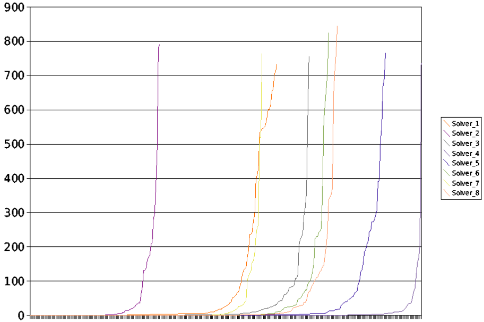

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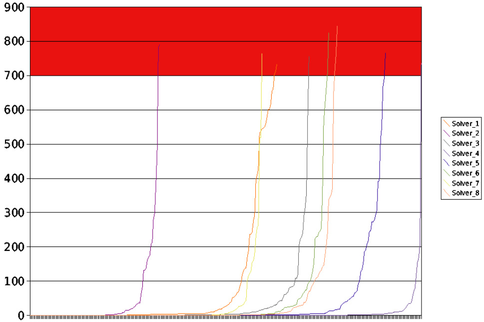

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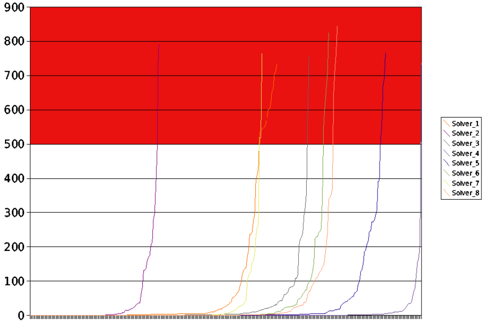

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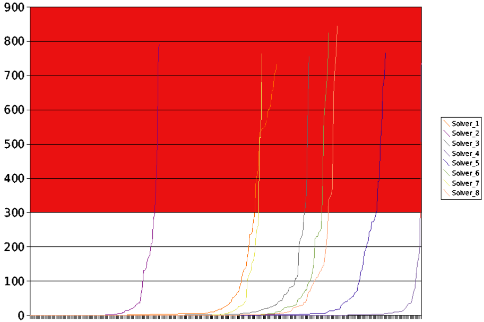

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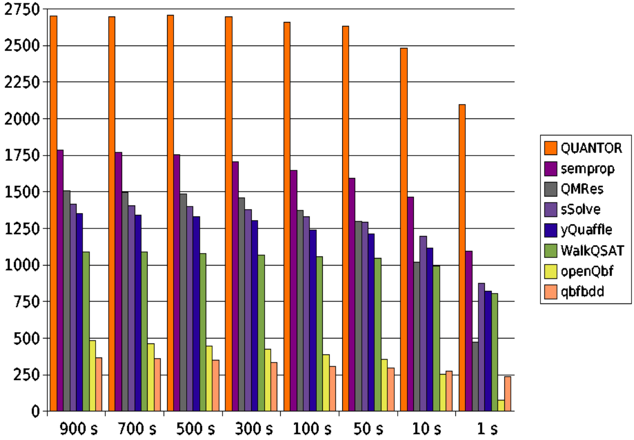

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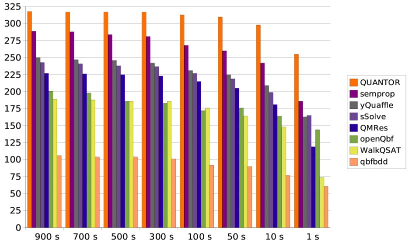

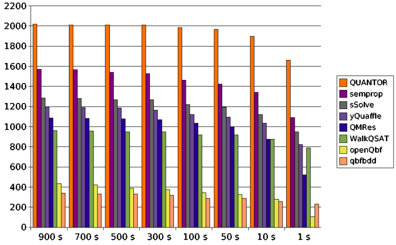

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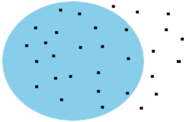

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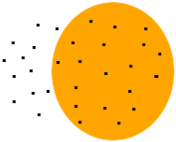

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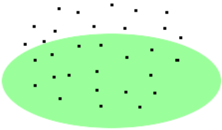

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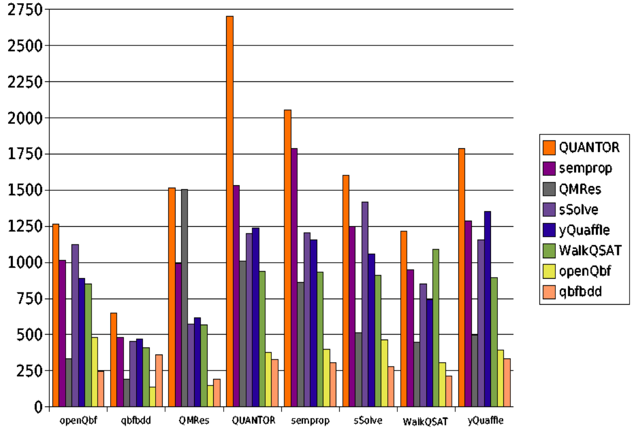

SBT-stability

	CASC/QBF	SAT	YASM	YASMv2	Borda	r. v.	Schulze
OPENQBF	0.43	0.57	0.36	0.64	0.79	0.79	0.79
QBFBDD	0.43	0.43	0.36	0.64	0.79	0.86	0.79
QMRES	0.64	0.86	0.76	0.79	0.71	0.86	0.79
QUANTOR	1	0.86	0.86	0.86	0.93	0.86	0.93
SEMPROP	0.93	0.71	0.71	0.79	0.93	0.86	0.93
SSOLVE	0.71	0.57	0.57	0.79	0.86	0.79	0.86
WALKQSAT	0.57	0.57	0.43	0.71	0.64	0.79	0.79
YQUAFFLE	0.71	0.64	0.57	0.71	0.86	0.86	0.93
Mean	0.68	0.65	0.58	0.74	0.81	0.83	0.85

Kendall rank correlation coefficient between the test sets.

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	SOTA-distance
CASC	1
QBF	1
SAT	0.71
YASM	0.86
YASM v2	0.79
Borda	0.86
range voting	0.71
Schulze	0.86

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- Increasing the time limit is not necessary useful, unless you increase it substantially (**DTL-stability**).
- The composition of the evaluation test set may heavily influence the final ranking (**SBT-stability**).

Conclusions

- Addition of the fidelity measure and improvement of the definition of SOTA-relevance.

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- YASMv2 is more powerful than YASM in terms of SBT-stability and fidelity.
- The fidelity measure shows the effectiveness of a hybrid approach such as YASMv2.

Possible Extensions

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- Investigation in the YASMv2 properties according to the framework of social choice theory.