Exploring the Reduction of Configuration Spaces of Workflows

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Objectives

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- **Examine the performance of a large set of workflows** (portfolio), ML algorithms + hyperparameters, on selected datasets (i.e., obtain metadata of past experiments with workflows).
- **Apply the workflow reduction method** to the portfolio & obtain the reduced set of workflows
- **Compare the performance** of the **initial and reduced portfolios** on a new dataset (use leave-one-out evaluation)

Workflows studied

Tasks/Datasets → **Preprocessing** (Feature selection (future work)) → **Model** (Classifier & hyperparameter seetings) → **Accuracy / Loss**

1690 different workflows

41 datasets from OpenML

4 classification algorithms

\# hyperparam. settings

Classif. Alg.	Description	#Workflows
SVM	SVM	300
LogR	Logistic Regression	220
LD	Linear Discriminant	90
RF	Random Forest	1080

Workflow Reduction

Our **method** is an improved/revised version of Abdulrahman et al. (2019).

Phase 1 - Prune Low (PL):

- **Use a given portfolio of workflows;**
- **Use the existing performance metadata** obtained in prior tests;
- **Identify the top performing workflows** (pipelines) for each dataset:
  top 5% of workflows based on accuracy and
  top 5% of workflows based on A3R (combines accuracy and time));
- **Remove all workflows** that are **not top performers.**

Phase 2 – Prune Redundant (PR)

- **Eliminate** the workflows that **are redundant**

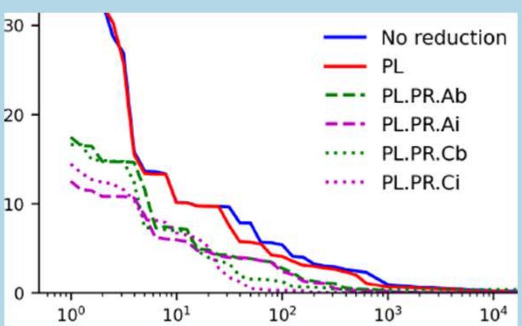
Two types of redundancy tests:
- cover test (PR.C);
- cover + accuracy test (PR.A);

Two modes:
- batch (b);
- iterative reduction (i).

Generating Predictions

- We use the **average ranking method (AR*)** (Abdulrahman et al. 2018), as the **workflow recommendation method**.
  It is easy to define different configuration spaces (sets of workflows).
- Method AR* **converts each portfolio** of workflows **into a ranking** using the available performance metadata.
- The **ranking is followed** to **generate class predictions** for the target dataset.
- This enables to **calculate the performance/loss**, as tests proceed.
- **Evaluation** follows the **leave-one-out (LOO)** strategy for each dataset. The mean loss is returned.

Resulting Loss Curves



Time (sec.)

Loss curves different variants of the reduction method

Results

Mean loss (area under loss curve)

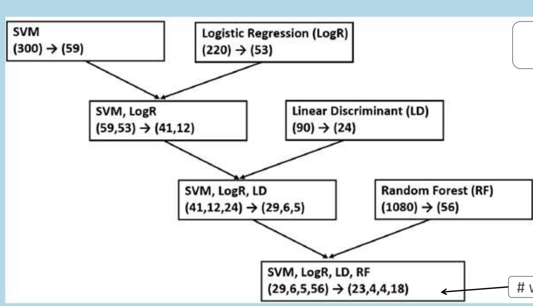
Reduction method	Size SVM	Size LogR	Size LD	Size RF	Size total	Size %	MIL %	Loss 10^6 %
No reduction	300	220	90	1080	1690	100.0	6.57	0.00
PL	247	202	70	727	1248	73.7	6.30	0.00
PL.PR.Ab	216	81	37	137	471	27.9	3.31	0.02
PL.PR.Ai	123	38	17	88	266	15.7	3.18	0.02
PL.PR.Cb	26	1	3	26	56	3.3	3.02	0.38
PL.PR.Ci	23	4	4	18	49	2.9	3.42	0.06

Effects of reduction on the portfolio size and loss

Reduction method	Elim. None	Elim. SVM	Elim. LogR	Elim. LD	Elim. RF
No reduction	6.57	7.99	6.72	6.65	3.83
PL	6.30	7.80	6.47	6.36	3.83
PL.PR.Ab	3.31	7.32	3.26	3.34	3.77
PL.PR.Ai	3.18	7.96	3.17	3.32	3.76
PL.PR.Cb	3.02	7.08	3.20	3.27	4.35
PL.PR.Ci	3.42	7.30	3.76	3.23	4.36

Ablation study: Effects of eliminating certain subsets of workflows on loss

Iterative Reduction



Method PL.PR.Ci

\# workflows

Conclusions and Future Work

Conclusions

- The reduction method PL.PR.Ci
  It identified **49 useful workflows** out of 1690. Final loss 0.38%.
- The reduction method PL.PR.Ai is **safer to use**:
  It identified **266 useful workflows.** Final loss 0.02%.
- The workflows compete for place in the selected set.
  SVM workflows occupy more paces than e.g., LogR
  Ablation study confirms that they are more important than e.g., LogR.

Future Work

- Examine the **effects of preprocessing** (feature selection)
- **Transfer the final portfolio** to other MtL/AutoML systems
  Exploit the reduction method in other MtL/AutoML systems

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