

Fast Cross-Validation for Incremental Learning

Pooria Joulani, András György, Csaba Szepesvári

Department of Computing Science
University of Alberta
Edmonton, Alberta

July 11, 2015



Appearing in the
International Joint Conference on Artificial Intelligence,
Buenos Aires, Argentina, July 2015.

A new cross-validation algorithm: TREECV!

A new cross-validation algorithm: TREECV!

- Speed up CV for **incremental, single-pass** algorithms.

A new cross-validation algorithm: TREECV!

- Speed up CV for **incremental, single-pass algorithms**.
 - ▶ k -fold CV: running time penalty $O(\log k)$ instead of $O(k)$!

A new cross-validation algorithm: TREECV!

- Speed up CV for **incremental, single-pass algorithms**.
 - ▶ k -fold CV: running time penalty $O(\log k)$ instead of $O(k)$!
 - ▶ **Leave-One-Out** in $O(\log n)$!

A new cross-validation algorithm: TREECV!

- Speed up CV for **incremental, single-pass algorithms**.
 - ▶ k -fold CV: running time penalty $O(\log k)$ instead of $O(k)$!
 - ▶ **Leave-One-Out in $O(\log n)$!**
- Does not rely on a specific

A new cross-validation algorithm: TREECV!

- Speed up CV for **incremental, single-pass algorithms**.
 - ▶ k -fold CV: running time penalty $O(\log k)$ instead of $O(k)$!
 - ▶ **Leave-One-Out in $O(\log n)$!**
- Does not rely on a specific
 - ▶ type of the learning problem (classification, regression, density estimation, etc.);

A new cross-validation algorithm: TREECV!

- Speed up CV for **incremental, single-pass algorithms**.
 - ▶ k -fold CV: running time penalty $O(\log k)$ instead of $O(k)$!
 - ▶ **Leave-One-Out in $O(\log n)$!**
- Does not rely on a specific
 - ▶ type of the learning problem (classification, regression, density estimation, etc.);
 - ▶ inner structure of the algorithm (e.g., QP, influence matrix, etc.);

A new cross-validation algorithm: TREECV!

- Speed up CV for **incremental, single-pass algorithms**.
 - ▶ k -fold CV: running time penalty $O(\log k)$ instead of $O(k)$!
 - ▶ **Leave-One-Out in $O(\log n)$!**
- Does not rely on a specific
 - ▶ type of the learning problem (classification, regression, density estimation, etc.);
 - ▶ inner structure of the algorithm (e.g., QP, influence matrix, etc.);
 - ▶ loss function used for CV (accuracy, F-measure, etc.).

A new cross-validation algorithm: TREECV!

- Speed up CV for **incremental, single-pass algorithms**.
 - ▶ k -fold CV: running time penalty $O(\log k)$ instead of $O(k)$!
 - ▶ **Leave-One-Out in $O(\log n)$!**
- Does not rely on a specific
 - ▶ type of the learning problem (classification, regression, density estimation, etc.);
 - ▶ inner structure of the algorithm (e.g., QP, influence matrix, etc.);
 - ▶ loss function used for CV (accuracy, F-measure, etc.).
- Easy **parallelization / distributed computing**.

A new cross-validation algorithm: TREECV!

- Speed up CV for **incremental, single-pass algorithms**.
 - ▶ k -fold CV: running time penalty $O(\log k)$ instead of $O(k)$!
 - ▶ **Leave-One-Out in $O(\log n)$!**
- Does not rely on a specific
 - ▶ type of the learning problem (classification, regression, density estimation, etc.);
 - ▶ inner structure of the algorithm (e.g., QP, influence matrix, etc.);
 - ▶ loss function used for CV (accuracy, F-measure, etc.).
- Easy **parallelization / distributed computing**.
- Theoretical bounds and experimental results on the speed and accuracy.

TREECV in action: Leave-One-Out CV estimation

- SVM Classification with PEGASOS (Shalev-Shwartz et al., 2011).
 - ▶ CV over the 0-1 loss.
- Least-square regression with SGD (Nemirovski et al., 2009).
 - ▶ CV over the squared loss.

