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Boosted Trees for Risk Prognosis

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Machine Learning for Health Care 2018

August 22, 2019

Objective: Survival Analysis

Predictions should be individualized

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We study the survival distribution which describes the time to event probability as a function of a patient's covariates,

$$S(t|\boldsymbol{x}_i) = \mathbb{P}(T_i > t|\boldsymbol{x}_i) \tag{1}$$

Problem: Heterogeneous patients.

- The average predictions of many current methods are not enough to accurately assess a patient's health state and progression.
- Complex diseases often result in nonlinear relationships between $\boldsymbol{x}_i$ and T_i.
- Simple approximations of S lead to misdiagnoses for large portions of patients with atypical disease presentation.

Examples: **chronic** or **multimorbid** patients whose risk factors are poorly understood (e.g. cardiovascular diseases and elderly patients).

Our Approach

Flexible Boosting Algorithm for Survival Analysis

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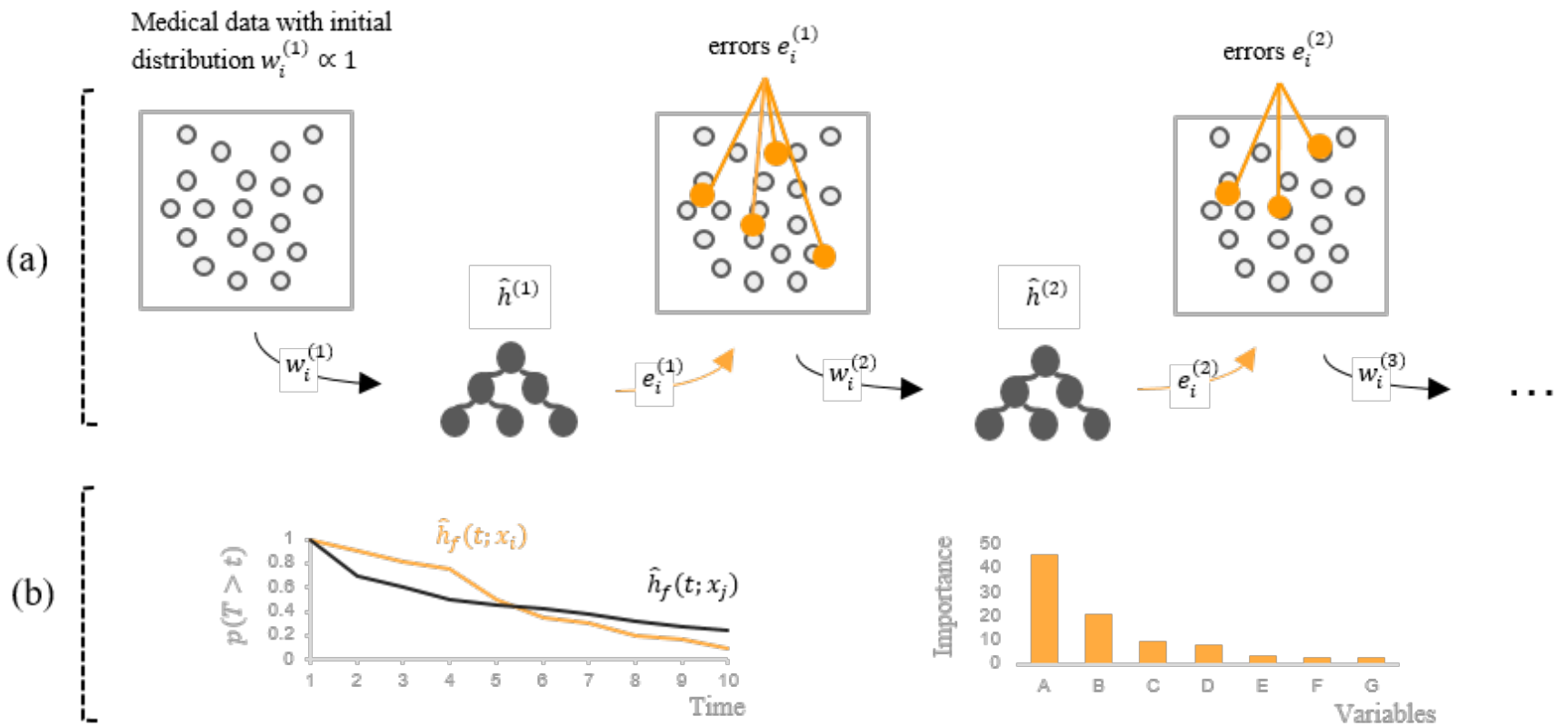
Focus on complex patterns and subgroups of patients that are consistently being mis-estimated

• We estimate a collection of nonparametric survival estimators sequentially where *each one of them* is designed to improve predictions on those patients that have been previously mis-estimated.

Advantages

- ▷ Efficient scheme for learning in high-dimensional settings.
- ▷ No a-priori assumptions on patient behaviour.
- ▷ Very flexible and thus able to provide *individualized* predictions.

Outline of the Algorithm



Experiments and Results

Performance improvements for patients at risk of Cardiovascular diseases

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- **Preventive care** : UK Biobank and MAGGIC.
- **End stage cardiac patients**: UNOS.
- **Co-morbid patients**: SEER.

Models	UNOS	MAGGIC	UK Bio.	SEER-I	SEER-II
Cox	0.603 ± 0.04	0.645 ± 0.01	0.679 ± 0.02	0.772 ± 0.03	0.740 ± 0.03
CBL	0.605 ± 0.04	0.644 ± 0.01	0.679 ± 0.02	0.774 ± 0.03	0.738 ± 0.04
CBM	0.635 ± 0.03	0.625 ± 0.01	0.673 ± 0.02	0.768 ± 0.03	0.740 ± 0.04
CindexBoost	0.564 ± 0.06	0.592 ± 0.01	0.655 ± 0.03	0.764 ± 0.03	0.742 ± 0.04
SRF	0.634 ± 0.04	0.642 ± 0.01	0.627 ± 0.01	0.686 ± 0.03	0.680 ± 0.01
CSRF	0.635 ± 0.05	0.652 ± 0.02	0.638 ± 0.02	0.755 ± 0.03	0.717 ± 0.04
SurvivalBoost.R	0.636 ± 0.03	0.676 ± 0.02	0.702 ± 0.02	$\mathbf{0.780 \pm 0.03}$	$\mathbf{0.752 \pm 0.03}$
SurvivalBoost.T	$\mathbf{0.647 \pm 0.04}$	$\mathbf{0.675 \pm 0.04}$	$\mathbf{0.725 \pm 0.03}$	0.775 ± 0.04	0.740 ± 0.04

Table 1: C-index figures (higher better) and standard deviations on all data sets.

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Try our survival prediction tool at:

mlhcprojects.shinyapps.io/survival_boosting_app