ELO: interpretable score of model predictive power

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October 9, 2019

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Problems

Team	AUC
Erkut & Mark,Google AutoML	0.618492
Erkut & Mark	0.616913
Google AutoML	0.615982
Erkut & Mark,Google AutoML,Sweet Deal	0.615858
Sweet Deal	0.615766
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ALDAPOP	0.615040
9hr Overfitness	0.614371
Shlandryn	0.614132
Erin (H2O AutoML 100 mins)	0.612657

Table: Top 10 results of KaggleDays SF competition in 2019. https://www.kaggle.com/antgoldbloom/analyzing-kaggledays-sf-competition-data/notebook

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Weakness 1: There is no interpretation of differences in performance

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Weakness 1: There is no interpretation of differences in performance

Weakness 2: There is no procedure for assessing the significance of the difference in performances

k	AUC AutoML_1	AUC AutoML_2
1	0.8	0.9
2	0.8	0.78
3	0.8	0.78
4	0.8	0.78
Mean AUC	**0.8**	**0.81**

Table: Artifficial results from 4-fold cross-validation.

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Weakness 3: You cannot assess the stability of the performance in cross-validation folds

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Asian Ensemble	0.8043
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Weakness 4: You cannot compare performances between data sets

What is Elo ranking system?

Elo is used in:

- chess
- football and basketball ratings

Pros: The difference between Elo ratings of two players can be transferred into probabilities of winning when they play against each other.

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- rating is calculated on the basis of two components, result of match and rating of the opponent, The scores are updated after each match

$$E_1 = \frac{1}{1 + 10^{\frac{(S_1 - S2)}{400}}}.$$

$$S_1' = S_1 + K(A_1 - E_1),$$

Calculating ELO for predictive power

Let $p_{i,j}$ be the probability of model M_i wining with model M_j

$$logit(p_{i,j}) = \beta_{M_i} - \beta_{M_j}.$$

For larger number of models:

$$logit(p_{i,j}) = \beta_{M_1} x_{M_1} + \beta_{M_2} x_{M_2} + ... + \beta_{M_k} x_{M_n}$$

where

$$x_{M_a} = \begin{cases} 1 & \text{if } a = i \\ -1 & \text{if } a = j \\ 0 & \text{otherwise} \end{cases}$$

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We use logistic regression with contrast matrix.

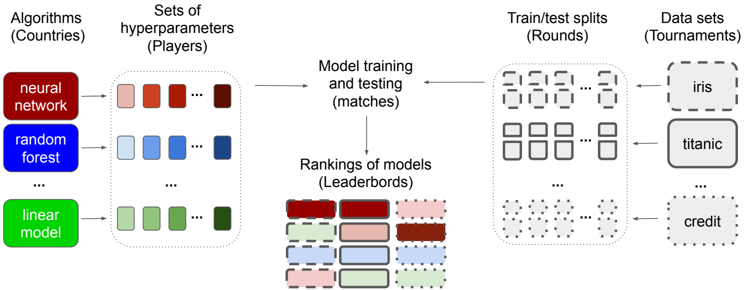
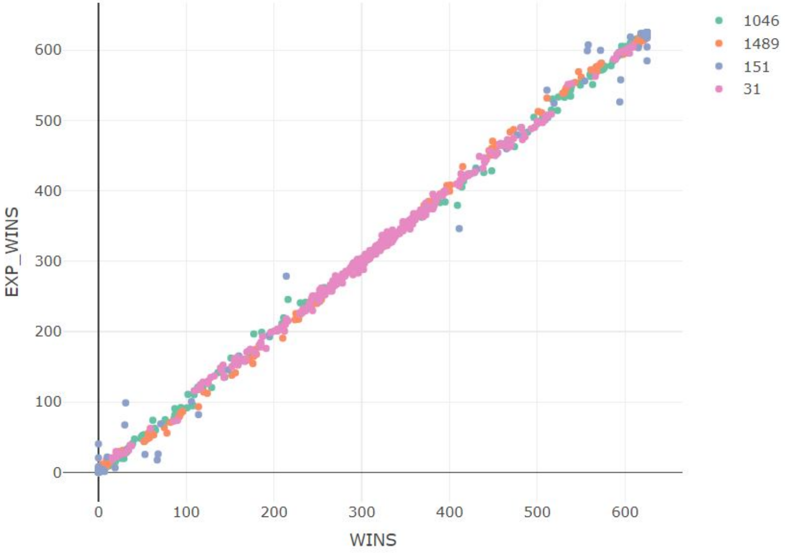


Figure: Our novel concept of Elo-based model ranking. Colors represent machine learning algorithms, gradients represent sets of hyperparameters, border styles represent data set.

Expected vs. Actual Results



EloML

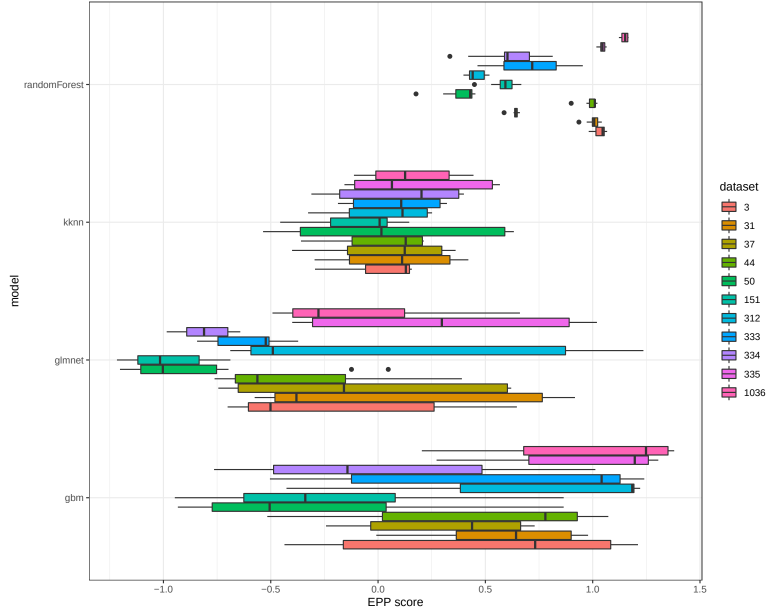
The advantages of ELO

1. ELO score provides the direct interpretation in terms of probability

$$p_{i,j} = invlogit(\beta_{M_i} - \beta_{M_j}) = \frac{e^{\beta_{M_i} - \beta_{M_j}}}{1 + e^{\beta_{M_i} - \beta_{M_j}}}.$$

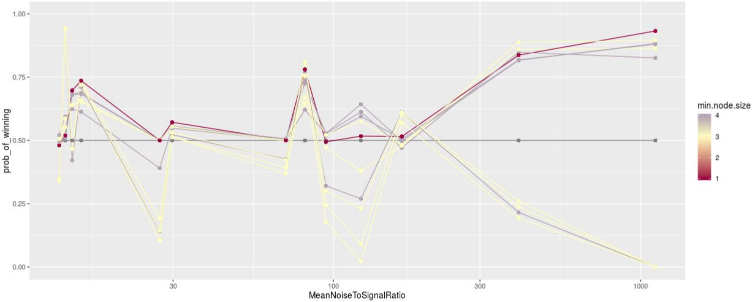
2. There is a procedure for assessing the significance of the difference in performances
3. You can assess the stability of the performance in cross-validation folds
4. You can compare performances between data sets

Tunability



randomForest
kknn
glmnet
gbm
model
−1.0
−0.5
0.0
0.5
1.0
1.5
EPP score
dataset
3
31
37
44
50
151
312
333
334
335
1036

Comparison between datasets



https://github.com/ModelOriented/EloML