Machine Learning for Economists

Ensemble Learning

葛雷

中国人民大学经济院

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中国人民大學
RENMIN UNIVERSITY OF CHINA

Midterm Overview

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- Professional and future model work for the main contributors
- Better than some of the grad dissertations. Why? (Don't waste two years of young talents)

Modern Long Target

- No long target and career planning, so metrics is far from real job market for genius
- Long Target: please check Tianqi Chen. 8 years ago he was also a Chinese undergrad like u https://tqchen.com/

Modern Long Target vs Traditional Short Target

- Traditional Target:
  卷身边的人 Like KNN model, then you fall in the trap of 驭民五术. 驭民五术 is not for young talents
- Modern Target:
  The young talents like you should challenging genius around the world

Challenging the world? Yes we can

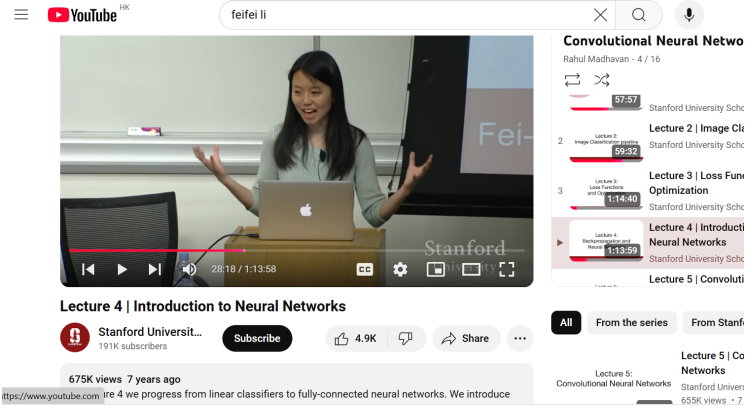
- Challenging genius around the world, crazy?
- Yes we can
- What is the drivering force for our future in age of AI? https://human-intelligence.org/national-iq

How to achieve Modern Long Target

- 顶会 (equal chance young grad students vs Sargent if u have innovations)
- 顶刊
- 顶赛

What the young talent should look like?

She was a first year Grad student same age, same IQ as you



Why modern framework?

- It is a modern sport only for the young
- Opportunities only for young talents to show themselves (Why?)
- Hard for free riders (Even your future mentors can not steal your ideas)

Importance of Real Presentation

- Next year summer camp for the grad schools & grad research
- Next next next year job interviews
- Next $\times$ N year to be a Quant
- It is competitive game only for young talents

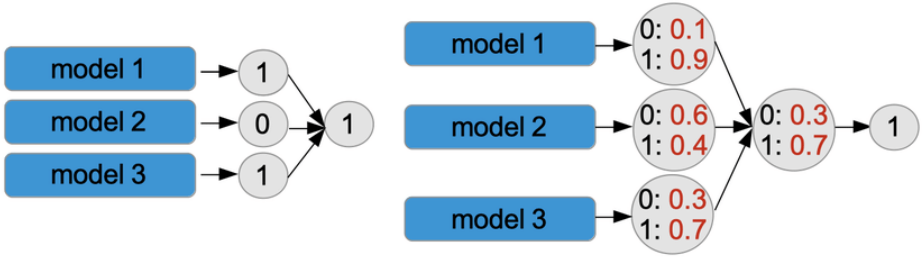
Coding tips

- These skills just need training, no training no improvement
- Yes, it is what we need from you for the grad camp, grad study, work.
- Do not discouraged if your modeling skill is lagged behind, others just start earlier since they have better info. Now or Never.

Base Knowledge for Ensemble

- Voting
- Bootstrap
- Bagging

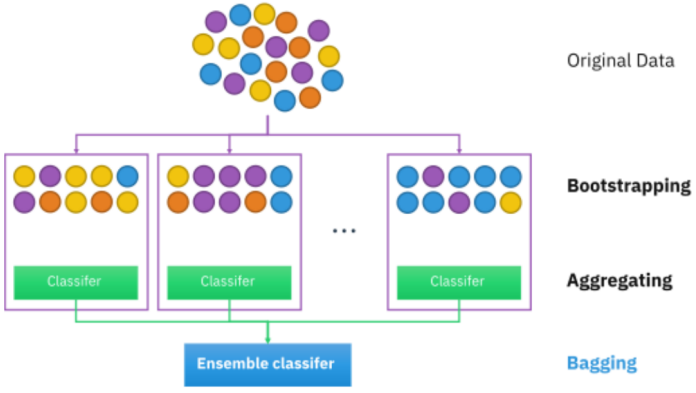
Voting: Hard vs Soft



Bootstrap

- Random sampling with replacement
- The basic idea of bootstrapping is that inference about a population from sample data (sample population)
- Why we need it? Make model more robust

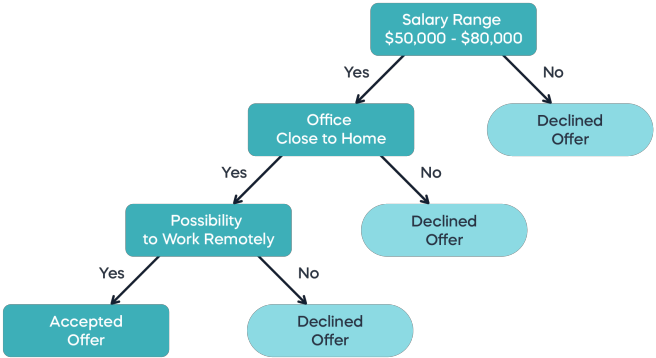
Bagging = Bootstrap+ Aggregating



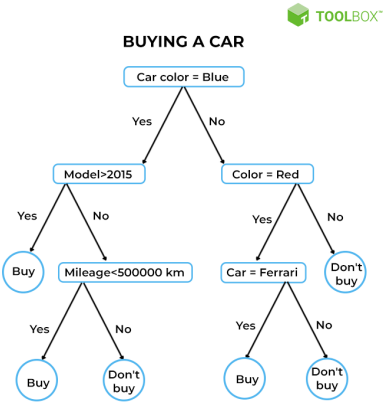
Ensemble Models

- Gradient Boosting
- Random Forest

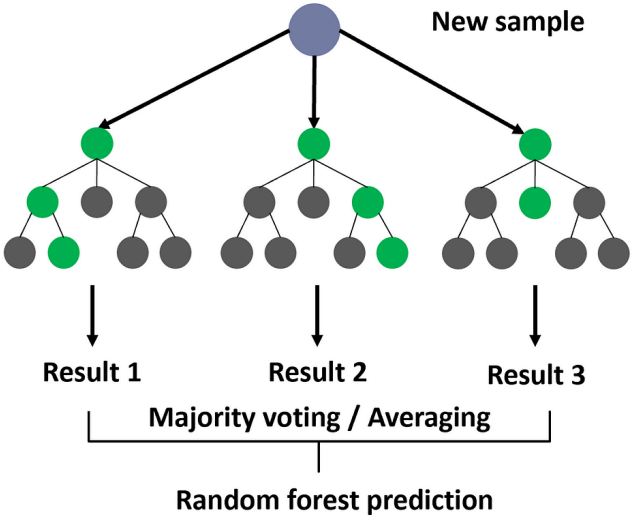
Base element: Decision Tree



Base element: Decision Tree



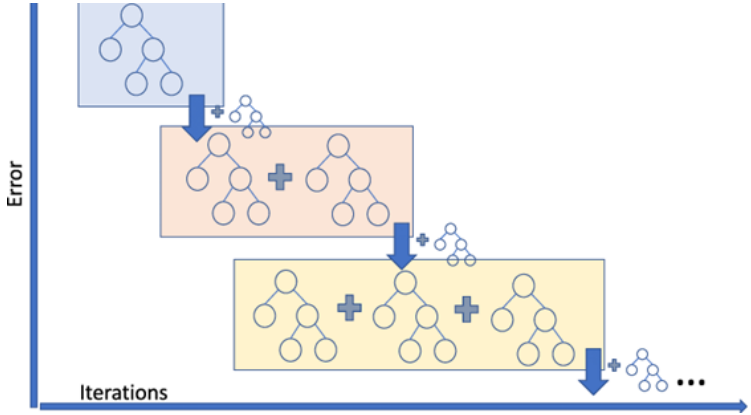
Random Forest



Boosting

$$
\begin{aligned}
\hat{y}_i^{(0)} &= 0 \\
\hat{y}_i^{(1)} &= f_1(x_i) = \hat{y}_i^{(0)} + f_1(x_i) \\
\hat{y}_i^{(2)} &= f_1(x_i) + f_2(x_i) = \hat{y}_i^{(1)} + f_2(x_i) \\
&\cdots \\
\hat{y}_i^{(t)} &= \sum_{k=1}^{t} f_k(x_i) = \hat{y}_i^{(t-1)} + f_t(x_i)
\end{aligned}
$$

Gradient Boosting



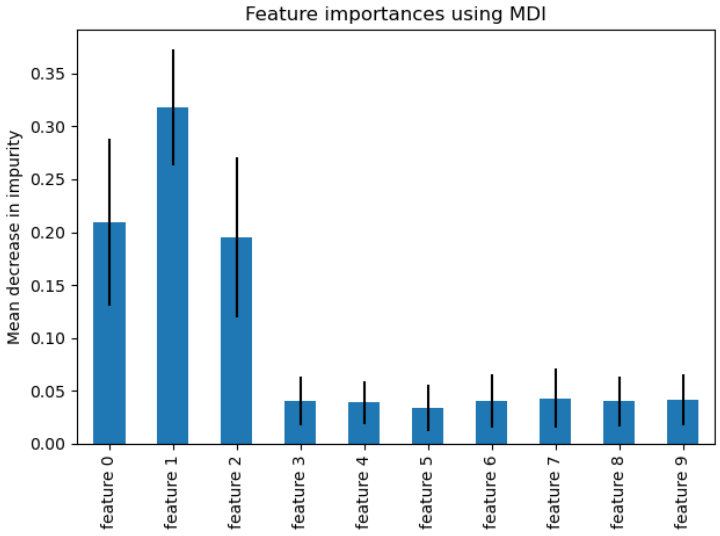
Question

Why not boosting OLS?

Feature Importance of Tree Based Model

- Feature importance can help to identify the most relevant features for a given model and data set.
- There are different methods for calculating feature importance
- Usually computational heavy to calculate, tree-based models comes with handy feature importance

Feature Importance



Three Feature Importance for the Tree Based Model

- Gain Value: gain in term of the Loss function
- Weight Value: weight in term of the leaves
- Cover Value: cover in term of sample

Gain Value

The Gain implies the relative contribution of the corresponding feature to the model calculated by taking each feature's contribution for each tree in the model. A higher value of this metric when compared to another feature implies it is more important for generating a prediction.

Weight Value (or frequency)

The weight value is the percentage representing the relative number of times a particular feature occurs in the trees of the model. In the above example, if feature1 occurred in 2 splits, 1 split and 3 splits in each of tree1, tree2 and tree3; then the weight for feature1 will be $2+1+3 = 6$. The frequency for feature1 is calculated as its percentage weight over weights of all features.

Cover Value

The Cover metric means the relative number of observations related to this feature. For example, if you have 100 observations, 4 features and 3 trees, and suppose feature1 is used to decide the leaf node for 10, 5, and 2 observations in tree1, tree2 and tree3 respectively; then the metric will count cover for this feature as $10+5+2 = 17$ observations. This will be calculated for all the 4 features and the cover will be 17 expressed as a percentage for all features' cover metrics.

Example

Feature	Gain	Cover	Frequence
xxx	2.276101e-01	0.0618490331	1.913283e-02
xxxx	2.047495e-01	0.1337406946	1.373710e-01
xxxx	1.239551e-01	0.1032614896	1.319798e-01
xxxx	6.269780e-02	0.0431682707	1.098646e-01
xxxxx	6.004842e-02	0.0305611830	1.709108e-02

Ensemble Framework

- Voting & Average
- Stacking & Blending

What & Why model blending?

- Use different models to predict one target
- For better performance
- We can see it frequently used by Kaggle.
- Of course, the professional quants use the complicated model blending in their stock, housing, risk model

Model Averaging: Yes just average

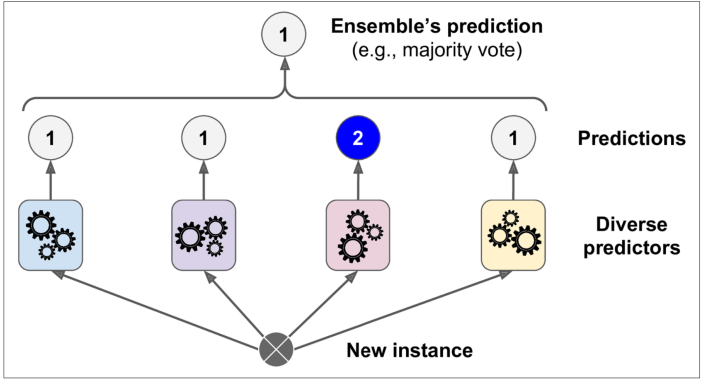


Figure 7-2. Hard voting classifier predictions

Model Blending: one model to rule all !!!

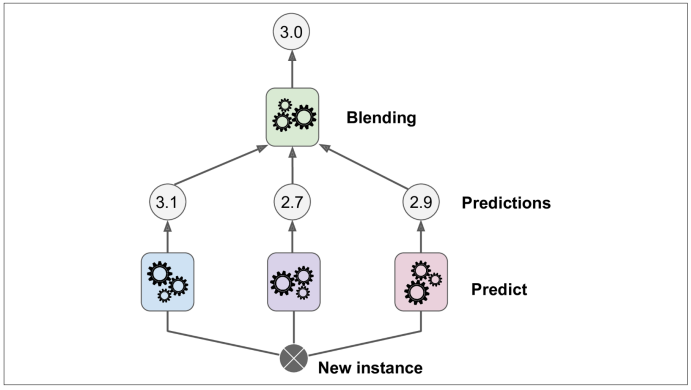
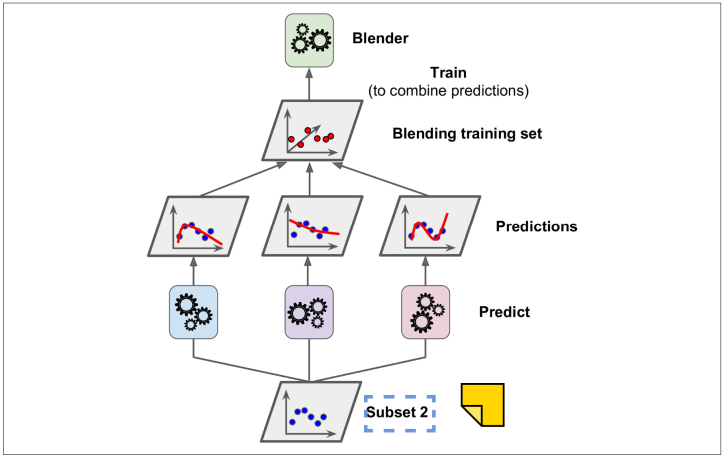


Figure 7-12. Aggregating predictions using a blending predictor

Model Blending: Careful

- you need to split the sample into two part
- one to train sub-models and one to train blender model

Sample Splitting is important



Questions

- Why Sample Splitting is importance
- Problem: Waste huge sample for holdout to training model blender
- Any better way to train model blender?

Ensemble algorithm paper (Chen 2016 XgBoost)

- Read model documentation
- Read original paper

Read model documentation

- Python codes examples
- User guide
- Brief Algorithms

Read original paper

- Detailed Algorithms
- Connections with other recent top research
- Math appendix
- Xgboost Documentation as an example (Link)

Good example for your future research

- With this study method, you can also study ANN, RNN, CNN, Keras, TensorFlow, Attention, BERT, ...
- All by yourself efficiently
- XGBoost: A Scalable Tree Boosting System (Link)

Homework: Read XgBoost (Chen 2016))

- XGBoost: A Scalable Tree Boosting System (Tianqi Chen, Carlos Guestrin 2016)
- (Chen Tianqi)
- Cold call questions next class

Reference

1. Hands-on Machine Learning with Scikit-Learn, Keras and TensorFlow (3rd edition)
2. geeksforgeeks
3. Kaggle
4. Wikipedia
5. ChatGPT
6. DeepSeek