ML - RANDOM FORESTS AND GRADIENT BOOSTING

MGMT 675

AI-Assisted Financial Analysis

Kerry Back

OUTLINE

- Decision tree
- Random forest and gradient boosting
- Shapley values
- House price application

DECISION TREE

- Split dataset successively into subsets. Within each subset, $\hat{y} =$ mean of subset. Calculate MSE.
- Split on a single variable being above or below a threshold.
- Choose variable and threshold so that MSE will be as small as possible after the split.

- After each split, make further splits of all of the new subsets into even smaller subsets, for a specified number of times (# splits = depth).
- The prediction for any observation is the mean target value in its final group (leaf).

EXAMPLE

- Ask Julius to read irrelevant_features.xlsx.
- Ask Julius to fit a decision tree regressor with y1 as the target using all of the data as training data. Ask Julius to plot the tree.

RANDOM FOREST AND GRADIENT BOOSTING

RANDOM FOREST

- Generate random datasets of the same size as the original.
- Create the random datasets by randomly drawing rows from the original with replacement.
- Fit a decision tree to each random dataset.
- The prediction for any observation is the average of the predictions of the various trees.

- Randomization helps to avoid overfitting.
- Also control overfitting through:
  - max_depth = maximum number of times to split in each tree
  - max_features = number of features to look at when deciding how to split (a subset of features of that size is randomly chosen for each split)

GRADIENT BOOSTING

- Fit a decision tree.
- Look at its errors. Fit a new decision tree to predict the errors.
- New prediction is original plus a fraction of the prediction of original's error (fraction = learning rate).
- Look at the errors of the new predictions. Fit a new decision to predict these errors.
- Continue …

EXAMPLES

Ask Julius to train and test

- a random forest regressor
- a gradient boosting regressor

to predict y1 in irrelevant_features.xlsx.

Ask Julius to use GridSearchCV to

- find the best max_depth for the random forest regressor in (5, 10, 15, 20, 25)
- find the best learning rate for the gradient boosting regressor in (0.001, 0.005, 0.01, 0.05, 0.1, 0.2)

INTERPRETING MODELS: SHAPLEY VALUES

- The Shapley value for a feature at an observation is a measure of how much that feature contributed to the prediction at that observation.
- A summary of Shapley values is a bar chart showing the mean absolute contribution of each feature (mean across observations).
- A Shapley scatter plot for a feature plots all of the observations with the feature's value on the x axis and the

- Ask Julius to create a summary plot of the Shapley values for the random forest regressor with the best max_depth.
- Ask Julius to create a scatter plot of the Shapley values for the x1 feature.
- Ask Julius to create a scatter plot of the Shapley values for another feature.

VALUING HOUSES

DATA

- Download house_price.xlsx from the course website
- Upload the file to Julius.
- Ask Julius to read the data and describe it.
- Tell Julius that SalePrice is the target and the other columns are features.

NEW TOPICS

- Missing values. Possible solutions:
  - Fill in missing values
  - Drop columns with missing values
  - Drop rows with missing values
- Categorical variables. Convert to dummies.
- Scaling features. It is important for some models that features be on the same scale.

MISSING VALUES

Tell Julius to fill in missing values

- for categorical features with “None”
- for numeric features with 0.

DUMMY VARIABLES

Categorical

	Feature
Row1	Hi
Row2	Lo
Row3	Med
Row4	Med
Row5	Lo

Dummies

	Lo	Med	Hi
Row1	0	0	1
Row2	1	0	0
Row3	0	1	0
Row4	0	1	0
Row5	1	0	0

PIPELINE

Ask Julius to create a pipeline that

- transforms the qualitative features to dummy variables
- applies Standard Scaler to the numeric features
- applies a random forest regressor

TRAIN AND TEST

Ask Julius to train and test the pipeline.

FURTHER WORK

- Apply GridSearchCV to the pipeline to find best hyperparameters
- Replace random forest regressor with other models:
  - lasso regressor
  - ridge regressor
  - gradient boosting regressor