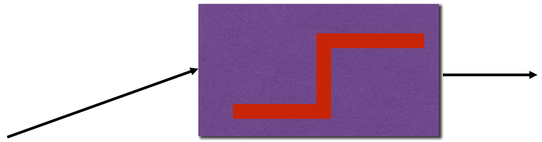
Ensembles

What are ensembles

- Ensembles are predictors defined as an average/vote over “base” or “weak” predictors.
- Weak learner is faced with a variant of the original prediction problem.
- Ensembles come in two main flavors:
  - Boosting based Ensembles
  - Bootstrap based Ensembles.

An Ensemble of trees



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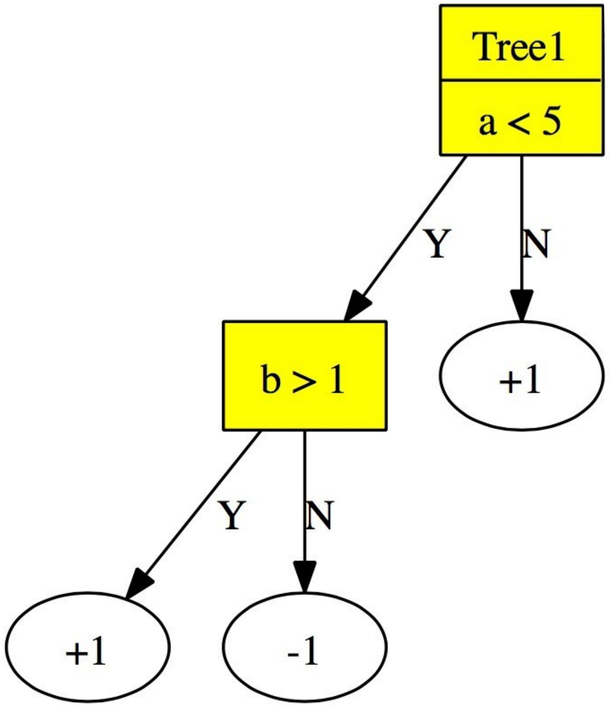
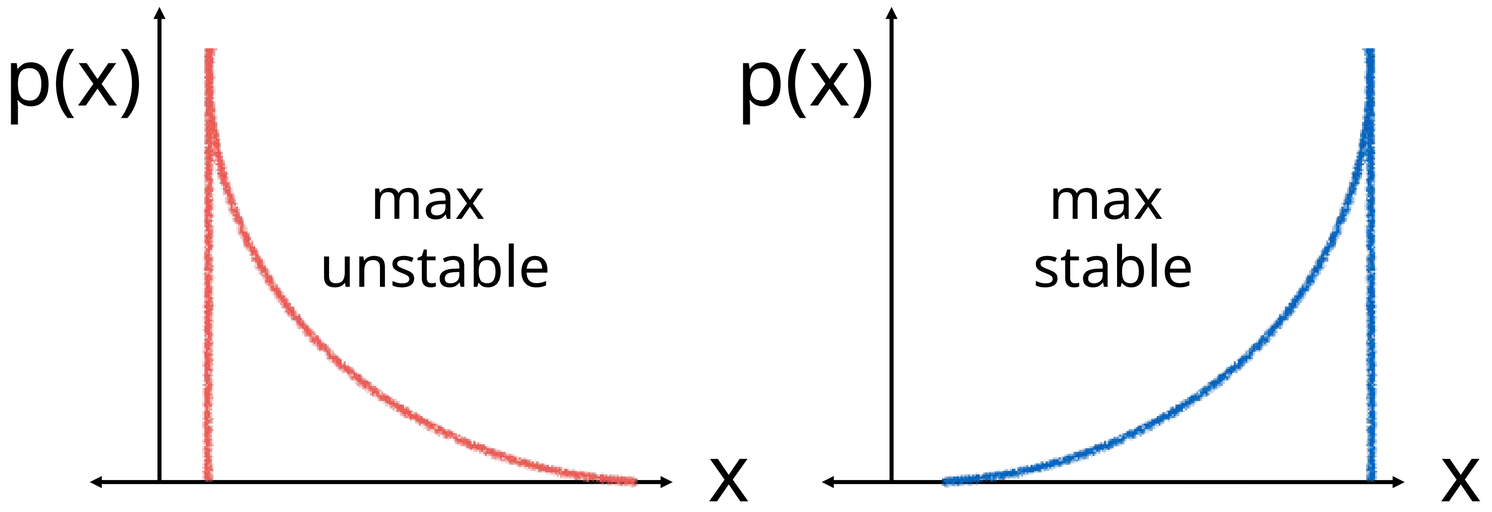


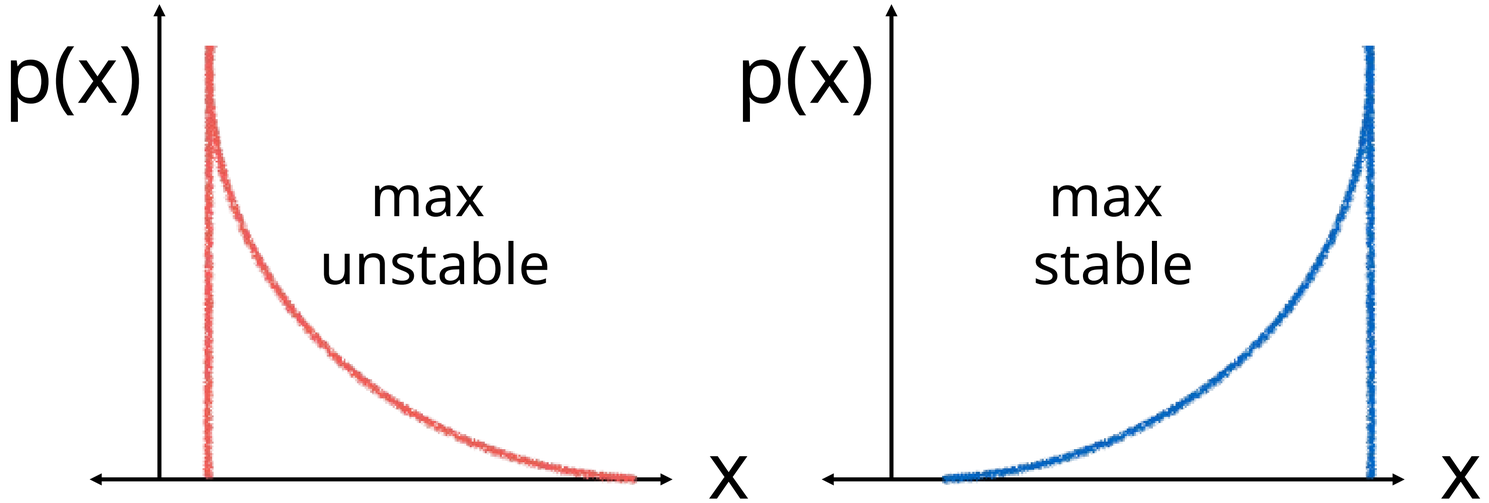
Stability of statistics

- Quantities we want to estimate: mean, std, median, min, max
- Stable estimator: varies little from sample to sample.
- Median is the most stable, mean is less stable, std still less.
- The variation of max depends on the distribution.
- Direct estimation of stability: use several independent datasets. (requires a lot of data).



The Bootstrap

- A method for estimating out-of-sample variation
- Instead of collecting truly independent samples, we create semi-independent samples from the given sample.
- **S** : Original sample of size N.
- Bootstrap sample: select N examples from **S** independently at random with replacement.
- Use bootstrap samples as if they were independent samples.



1990

An Introduction to the Bootstrap

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Bagging = bootstrap aggregation

- Decision trees have high data variation.
  - i.e. the generated tree is sensitive to small changes in the training set.
- To reduce the variation, we take a majority vote over several runs, each using an independent random resample of the training data.
- **Bootstrap:** Running an algorithm over random resampling.
- Trees can be learned in parallel
- The result is a reduction in variation with no increase in the bias.

Random Forests

- Based on bagging trees.
- Additional randomization: before choosing which leaf to split and how, choose a random subset of the features.
- Decreases the correlation between different trees.
- Speeds up the learning process.
- All trees get equal weight (1.0)
- All trees can be learned in parallel.

Gradient Tree Boosting

- The trees are trained sequentially, one after the other.
- Each tree is trained using a **weighted** training set. The weights represent the gradient of the loss function.
- Each tree receives a different weight.
- Stochastic gradient boosting: use random resampling of the training set a.k.a. Bagging.

Summary

- Ensemble learning in Spark ML
- Bagging = Bootstrap Aggregation
- Random Forests
- Boosted Gradient trees.