CS 474/574 Machine Learning
3. Decision Trees

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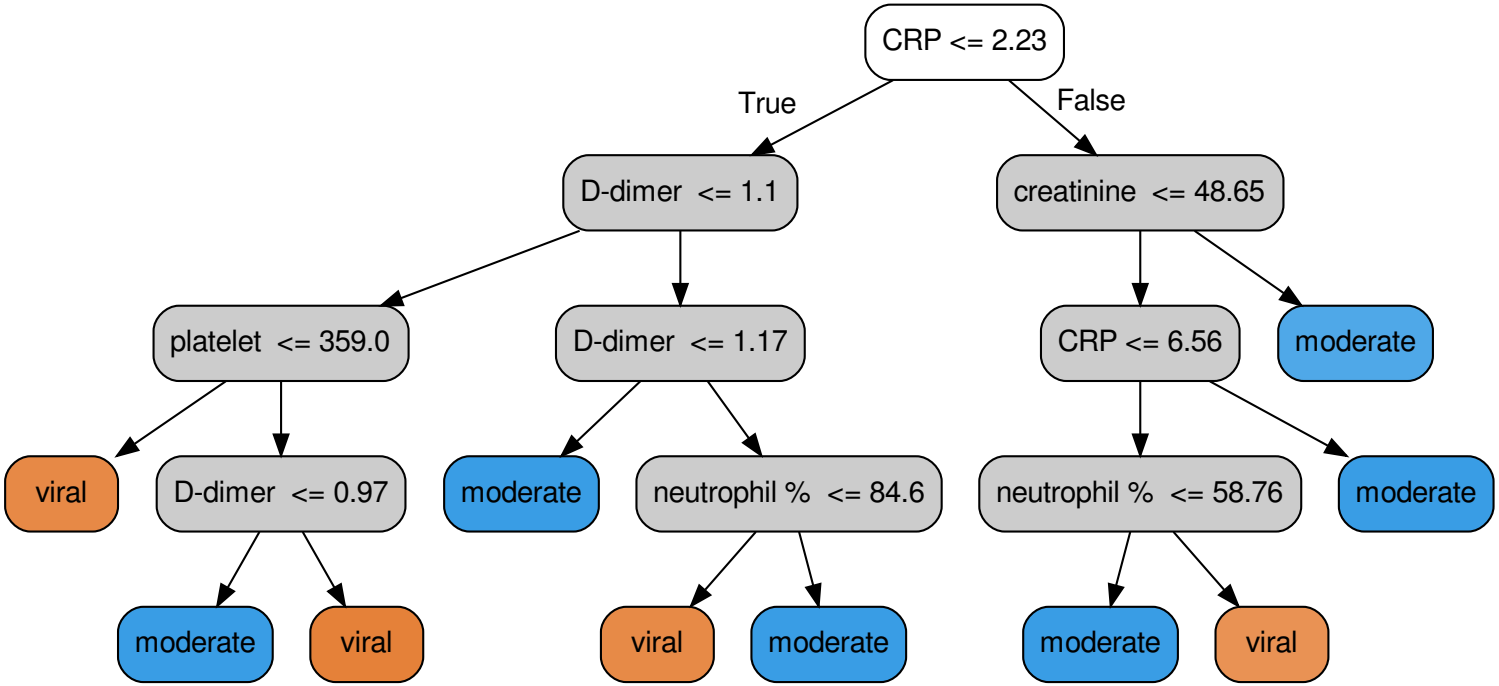
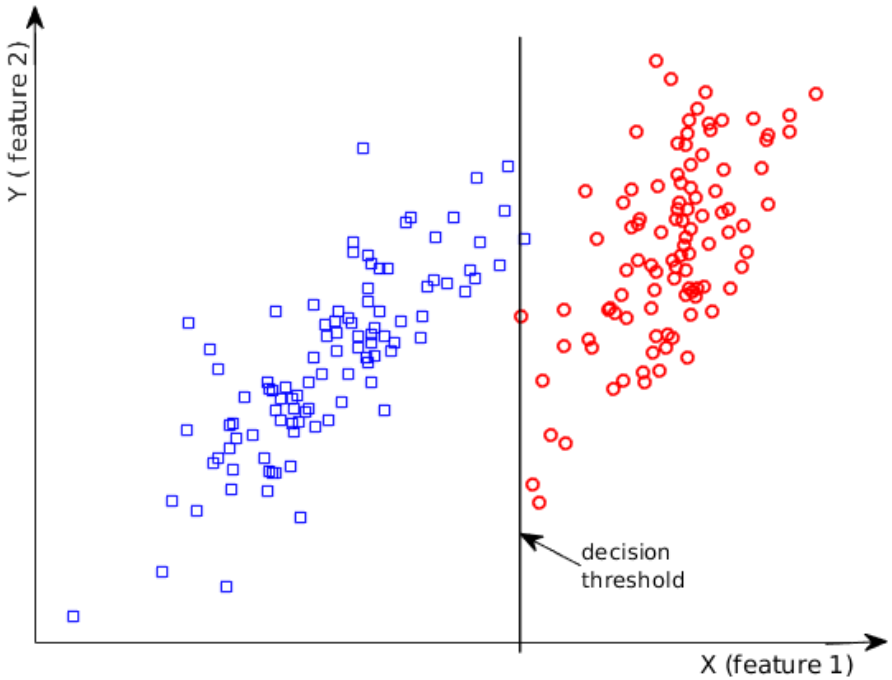
March 12, 2023

Decision Trees (DTs)



- A binary tree. Each node is a Boolean comparison on a feature.
- Each node **split** into two branches. Continues to one of the two.
- Root node: the beginning. Leaf node: the decision.
- May not visit all features. May visit a feature more than once.
- What will be the class for a sample with the following feature values? CPR= 2.7, creatinine = 50

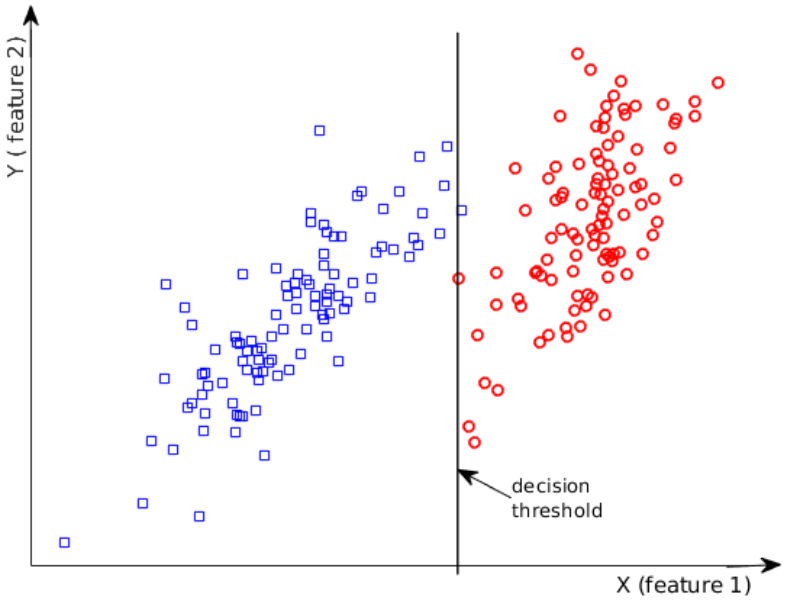
Constructing a DT(-based classifier)



- Two things need to be determined at each node: feature and threshold.
- Thresholds can be values of training samples on a feature.
- Exhaustive search. Complexity: O(NM), N: number of features, M: number of samples.

- Intuition: Each node cuts the plane into two halves. It's better to have less mixture of two classes on each half.
- Given a Boolean condition S, Gini impurity is $g(S) = \sum_{c=\pm 1} Pr(class = c|S) \cdot (1 - Pr(class = c|S)) = 1 - \sum_{c=\pm 1} Pr^2(class = c|S)$. If all samples belong to one class, then $g(S) = 0$ thus least impure and hence most pure.

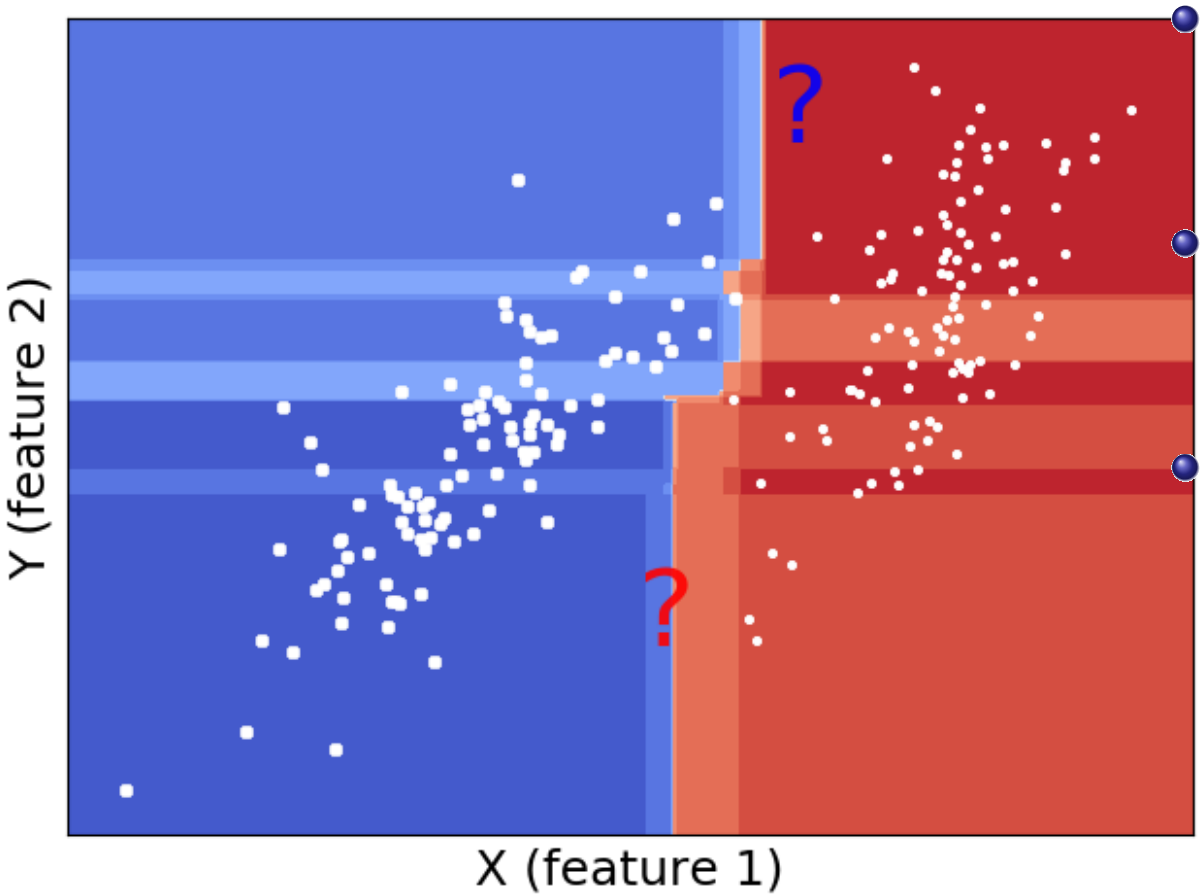
Constructing a DT(-based classifier) (cond.)



- Consider impurity on both ends, i.e., $F > T$ and $F \leq T$. Expectation of impurity: $E(F,T) = P(F > T)g(F > T) + P(F \leq T)g(F \leq T)$
- Another way to determine impurity is **entropy**.

- When to stop the split? Depends on 3 **hyperparameters**: the maximum height of the tree, the minimum Gini impurity, and the minimum sample pool
- A good tutorial by Victor Zhou
- How to use it for regression? Sklearn example

Random Forests



- a collection (technically an ensemble) of DTs that share t same set of hyperparameters.
- Member DTs are trained independently using random samples and random features.
- Final decision is the majority vote of all member DTs.