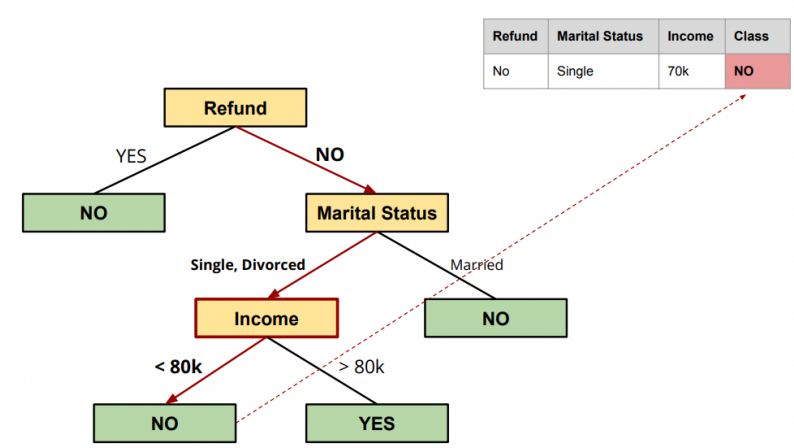
Lecture 11 Decision Trees

- Decision trees can be used to predict classes based upon a yes no pathway



Refund	Marital Status	Income	Class
No	Single	70k	NO

- Hunt's Algorithm
  - Hunt's Algorithm is a classic recursive decision tree learning algorithm. It builds a decision tree by repeatedly splitting the dataset based on attribute values to create pure subsets (i.e., subsets where all instances belong to the same class).
  - Base Cases:
    - If split and all data points in the same class
      - Predict that class
    - If split and no data points
      - Predict a reasonable class
  - Splitting
    - Choosing the attribute and condition that most effectively divies the dataset into purer subsets – groups where the data points mostly belong to the same class
    - Goal: reduce impurity at each data point. A good split results in the same classes represented amoungst data points
    - Binary Split
      - Split the attribute into two groups
      - Ex age > 30 and age< 30 or weather = sunny vs, weather != sunny
    - Multi-way split
      - The attribute is split into multiple groups one group for each unique value
      - Ex. Attribute = weather w categories sunny, rainy or overcast -> 3 branches for the split
  - GINI Index
    - Metric used to evaluate how "pure" a dataset is after a split in a decision tree algorithm

GINI index

$$GINI(t) = 1 - \sum_j p(j|t)^2$$

NO	1
YES	7

p(NO | t) = ⅛
p(YES | t) = ⅞

GINI(t) = 1 - 1/64 - 49/64 = 14/64

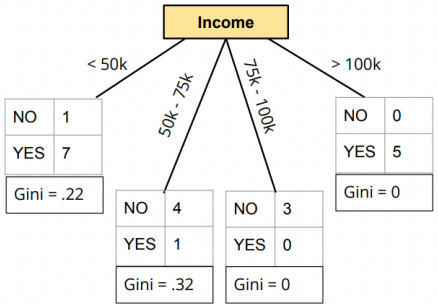
NO	4
YES	3

p(NO | t) = 4/7
p(YES | t) = 3/7

GINI(t) = 1 - 16/49 - 9/49 = 24/49

- GINI of the Split
  - nt= number of data points at node t
  - n = number of data points before the split (parent node)

GINI of the split



$$GINI_{split} = \sum_{t=1}^{k} \frac{n_t}{n} GINI(t)$$

n = 21

$GINI_{split}$ = .22 * 8/21
+ .32 * 5/21
+ 0 * 3/21
+ 0 * 5/21
= .16

- Limitations
  - Easy to construct a tree that is too complex and overfits the data
  - Solutions
    - Early termination : stop before the tree is fully grown – use a majorirt vote at the leaf node
      - Stop at some specific depth
      - Stop if size of node is below some threshold
      - Store if gini does not improve
    - Pruning : trim tree based on assigned values
- Extensions
  - Entropy

$$\text{Entropy}(t) = -\sum_j p(j|t) \log(p(j|t))$$

  - Misclassification Error

$$\text{Error}(t) = 1 - \max_j (p(j|t))$$