Classification and Regression

- Decision Trees can be used for both

X1	X2	Y
0.268	0.266	Bad
0.219	0.372	Bad
0.517	0.573	Bad
0.269	0.908	Good
0.181	0.202	Bad
0.519	0.898	Good
0.563	0.945	Bad
0.129	0.661	Bad

0.2 0.2 → $\boxed{?}$ → Bad

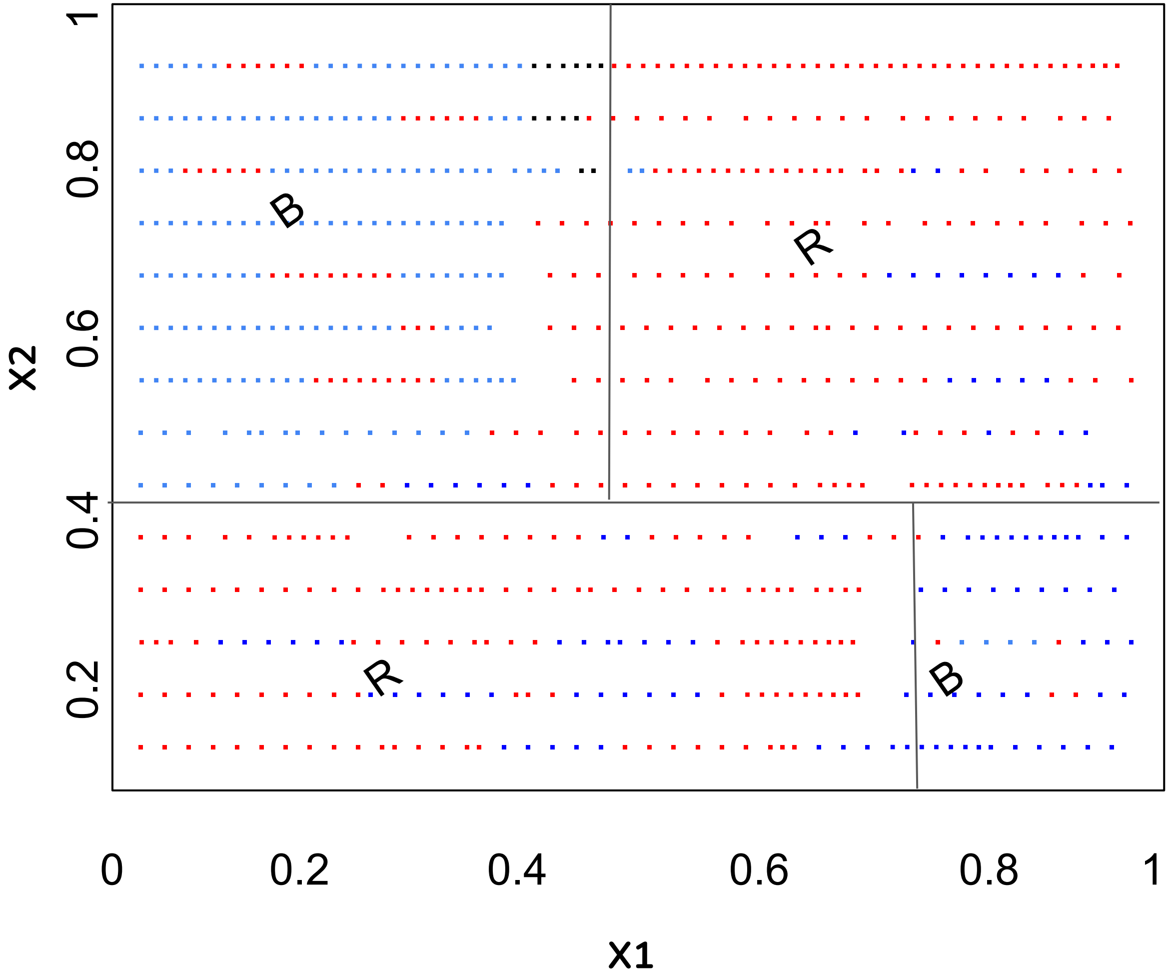
CART

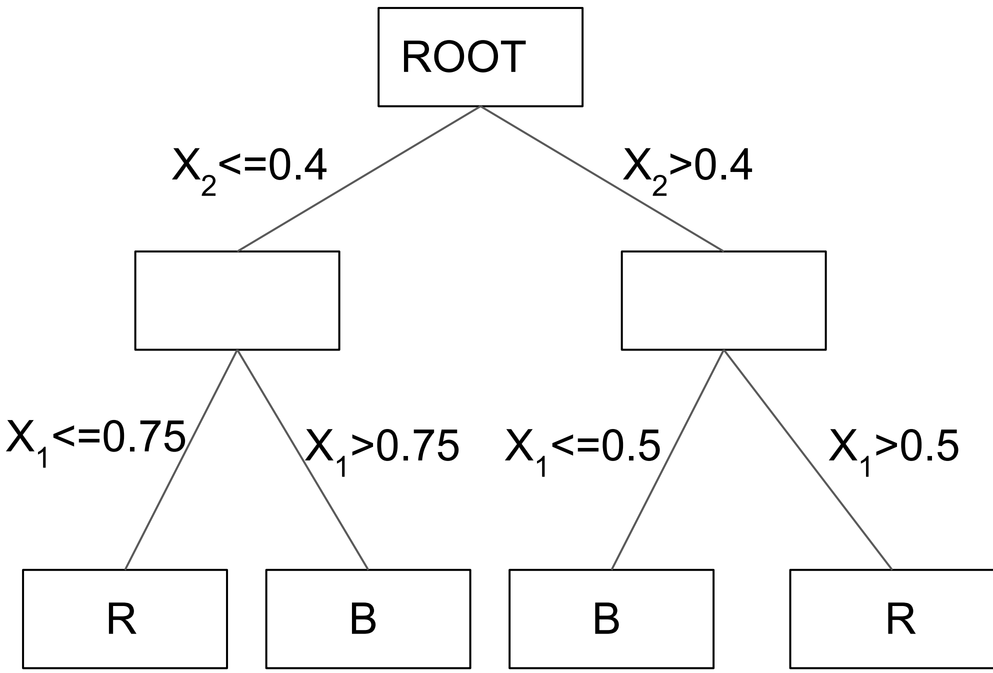
- Classification
  - Spam / not Spam
  - Admit to ICU /not
  - Lend money / deny
  - Intrusion detections

X1	X2	Y
0.268	0.266	64.41
0.219	0.372	28.08
0.517	0.573	95.76
0.269	0.908	15.84
0.181	0.202	41.83
0.519	0.898	25.20
0.563	0.945	9.44
0.129	0.661	82.77

- Regression
  - Predict stock returns
  - Pricing a house or a car
  - Weather predictions (temp, rain fall etc)
  - Economic growth predictions
  - Predicting sports scores

Visualizing Classification as a Tree

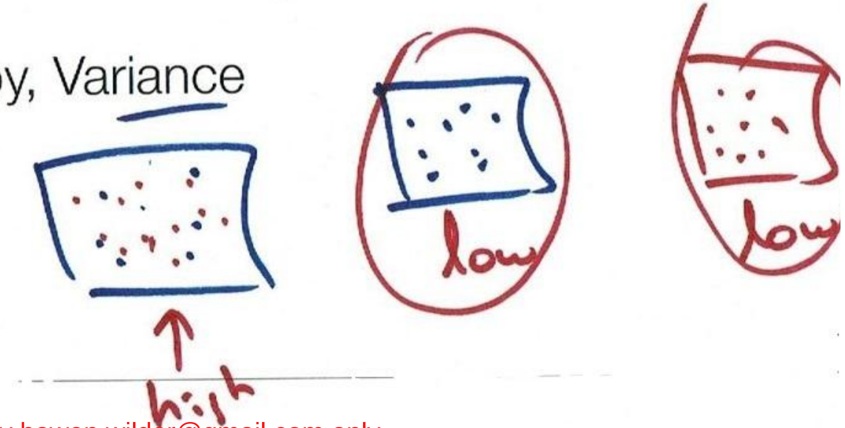




Metrics

- Algorithms for constructing decision trees usually work top-down, by choosing a variable at each step that best splits the set of items.
- Different algorithms use different metrics for measuring "best"
- These metrics measure how similar a region or a node is. They are said to measure the impurity of a region.
- Larger these impurity metrics the larger the "dissimilarity" of a nodes/regions data.
- Examples: Gini impurity, Entropy, Variance

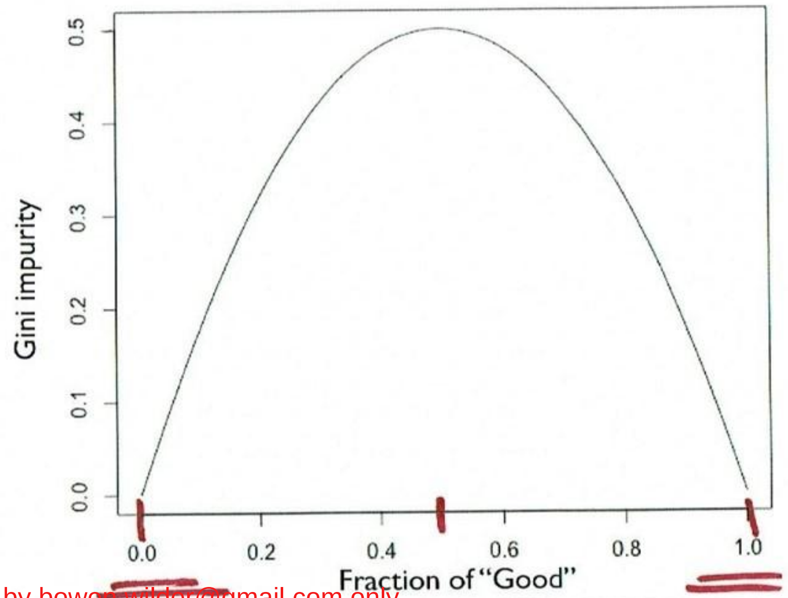
?



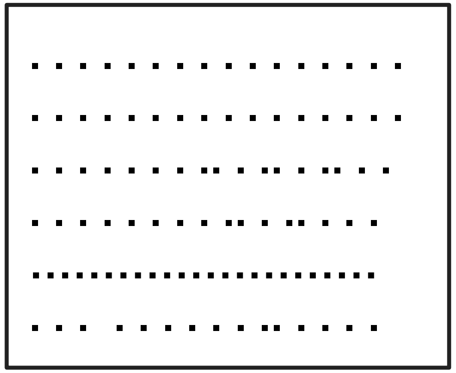
Gini impurity

- Used by the CART
- Is a measure of how often a randomly chosen element from the set would be incorrectly labeled if it was randomly labeled according to the distribution of labels in the subset.
- Can be computed by summing the probability of an item with label i being chosen (p_i), times the probability of a mistake $(1 - p_i)$ in categorizing that item.
- Simplifying gives, the Gini impurity of a set:

$$1 - \sum_{i=1}^{J} p_i^2$$



P1	P2	P3



P1

P2

P3

P1(1-P1) = P1P2 + P1P3

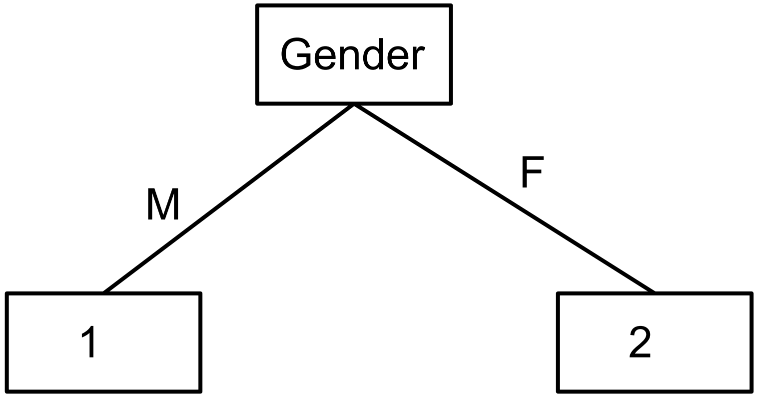
P2(1-P2) = P2P1 + P2P3

P3(1-P3) = P3P1 + P3P2

$$\Sigma P_i(1-P_i) = \Sigma P_i - \Sigma P_i^2 = 1 - \Sigma P_i^2$$

CART: An Example

Cust_ID	Gender	Occupation	Age	Target
1	M	Sal	22	1
2	M	Sal	22	0
3	M	Self-Emp	23	1
4	M	Self-Emp	23	0
5	M	Self-Emp	24	1
6	M	Self-Emp	24	0
7	F	Sal	25	1
8	F	Sal	25	0
9	F	Sal	26	0
10	F	Self-Emp	26	0



Root node : P1 = 0.4 , P2 = 0.6

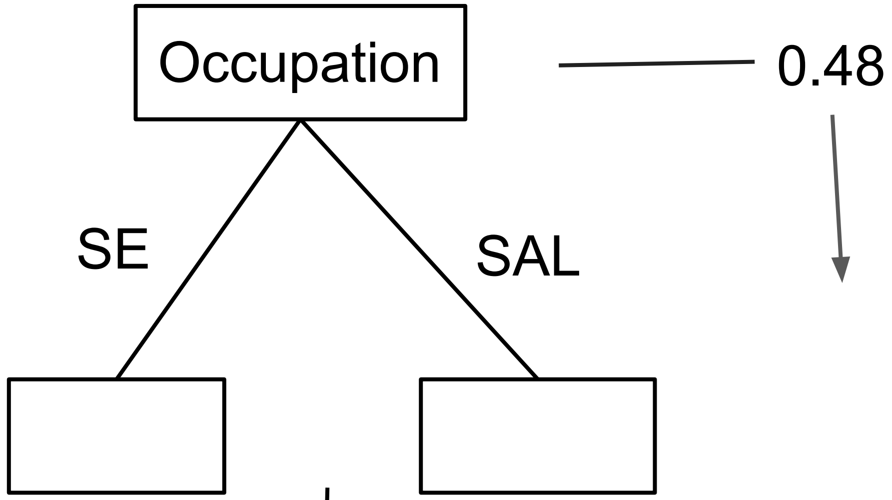
$GI = 1 - (0.4)^2 - (0.6)^2$

$= 0.48$

1. P1 = 0.5
   P2 = 0.5
   $1 - 0.5^2 - 0.5^2$
   $= 0.5$

2. P1 = 0.25
   P2 = 0.75
   $1 - 0.25^2 - 0.75^2$
   $= 0.375$

$GI = (6/10) * (0.5) + (4/10) * (0.375) = 0.45$

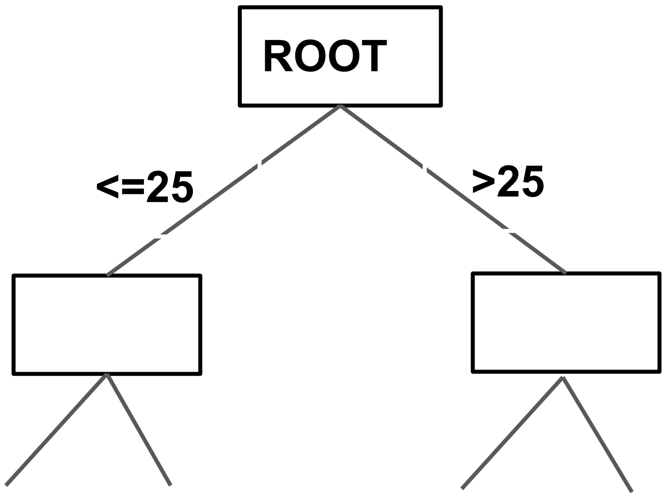


$$GI = 1 - 0.4^2 - 0.6^2 = 0.48$$

$$GI = 1 - 0.4^2 - 0.6^2 = 0.48$$

$$GI = (5/10) * (0.48) + (5/10) * (0.48) = 0.48$$

L R	Left	Right	Gini Split
<=22,>22	0.5	0.47	0.48
<=23,>23	0.5	0.44	0.47
<=24,>24	0.5	0.38	0.45
<=25,>25	0.5	0	0.40



0.48

↓

0.40

Gini Gain = 0.48-0.40 = 0.08