VICTORIA UNIVERSITY OF WELLINGTON
Te Whare Wananga o te Upoko o te Ika a Maui

School of Engineering and Computer Science

COMP 307 — Lecture 06

Machine Learning 3

Decision Tree Learning Method

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Outline

- Decision tree learning vs learned decision trees
- How to build a decision tree using set of instances
- How to measure a DT node: (im)purity measures
- Numeric attributes: splitting points

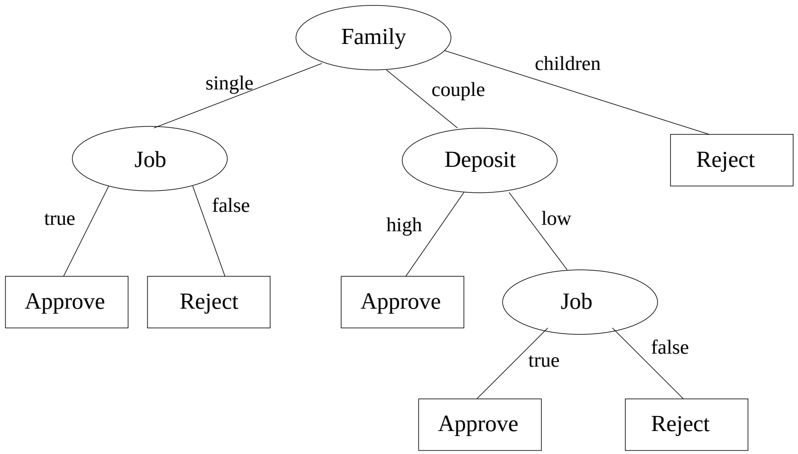
Decision Trees vs Decision Tree Learning

- Representation of the classifier: *decision trees*
  - An alternative representation for classifiers
  - Symbolic, not probabilistic
  - "Easier" to interpret
- Learning process: *decision tree learning (method)*
  - Specify a procedure for deciding on a class
  - One of the oldest classification learning methods in AI
  - Also developed independently in Statistics/Operations Research
- Decision tree = decision tree learning?

Example (Training) Data Set

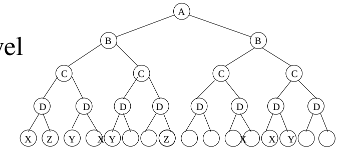
	Job	**Deposit**	**Family**	**Class**
A	true	low	single	Approve
B	true	low	couple	Approve
C	true	low	single	Approve
D	true	high	single	Approve
E	false	high	couple	Approve
1	true	low	couple	Reject
2	false	low	couple	Reject
3	true	low	children	Reject
4	false	low	single	Reject
5	false	high	children	Reject

Decision Trees

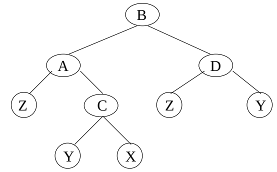


Building Decision Trees

- You can always build a decision tree trivially
  - Choose some order on the attributes
  - Build tree with one attribute for each level
  - Label each leaf with appropriate class



- Problems
  - Each leaf represents a possible instance
  - All we are doing is remembering every instance — no generalisation, no prediction, no learning



- Solution
  - Find a small decision tree
  - capture the common features of instances
  - probably generalise to predict classes for unseen instances

Building A Good Decision Tree

- Input: Instances described by attribute-value pairs
- Output: a “good” decision tree classifier
  – Critical issue: choosing which attribute to use next
- DT algorithm:

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Examine set of instances in the root node
 If set is "pure" enough, or no more attributes
   then stop
 Else
   Construct subsets of instances in the subnodes
   Compute average "purity" of subnodes
   Choose the best attribute
Recurse on each subnode
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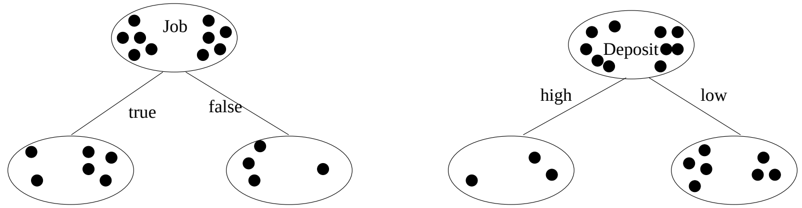
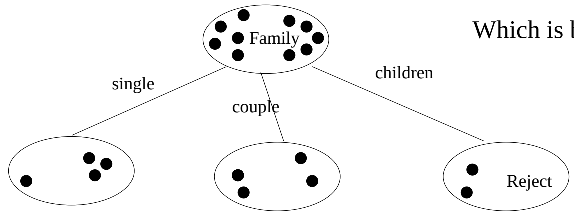
Decision Tree Building

Choose the best attribute



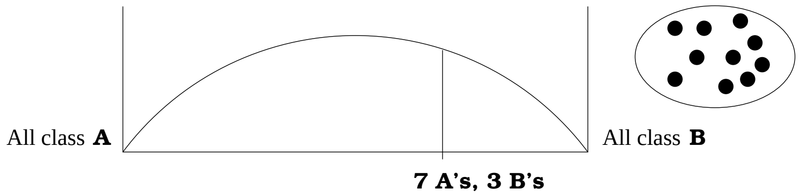


Which is best?

Measuring Purity

- Need a measure of how "pure" a node is
  - all one class $\longrightarrow$ pure $\longrightarrow$ can predict the class
  - mixture of classes $\longrightarrow$ impure $\longrightarrow$ have to ask more questions
- Several functions
  - probability based
  - information theory based
  - ... ...
- Choose the attribute whose children have the best purity

(Im)Purity Measure: P(A)P(B)



- Impurity:

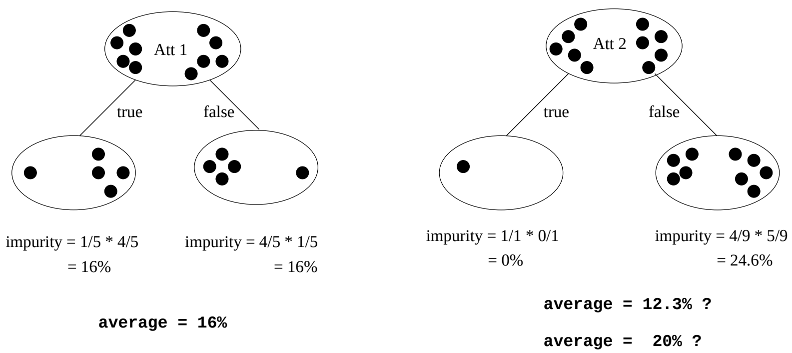
$$P(A)P(B) = \frac{m}{m+n} \times \frac{n}{m+n} = \frac{mn}{(m+n)^2}$$

m: number of A's, n: number of B's

- Goodness of attribute:
  - average impurity of subnodes

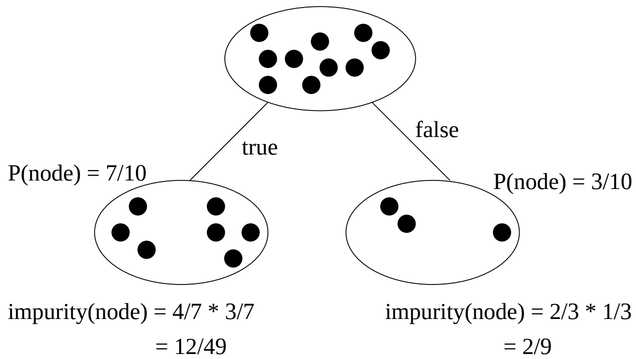
Weighting the Impurities

- How do we take the average?



- Need to weight the nodes by probability of going to node:

Weighting the Impurities (Continued)

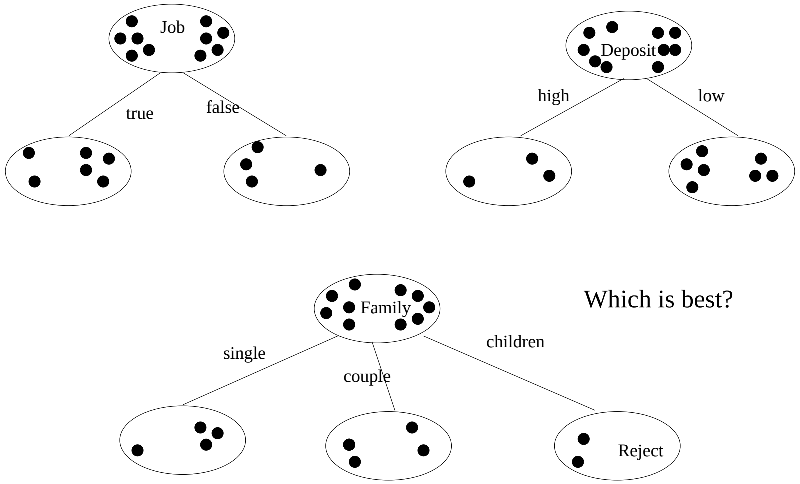


- Goodness of attribute $=$ weighted average impurity of subnodes
  $= \sum_i [P(node_i) \times impurity(node_i)]$

  $= (7/10 \times 12/49) + 3/10 \times 2/9 + = 84/490 + 6/90 = 0.238$

Decision Tree Building

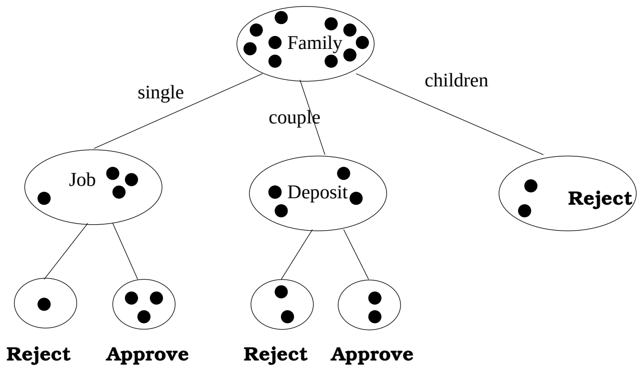
Choose the best attribute



Learning Decision Trees

- Job:
  - true: 6/10 instances (4 approved, 2 rejected)
  - false: 4/10 instances (1 approved, 3 rejected)
  - impurity of node 1: $2/6 \times 4/6$
  - impurity of node 2: $3/4 \times 1/4$
  - weighted impurity: $6/10 \times (2/6 \times 4/6) + 4/10 \times (3/4 \times 1/4) = 21\%$
- Deposit:
  - weighted impurity: $3/10 \times (1/3 \times 2/3) + 7/10 \times (4/7 \times 3/7) = 24\%$
- Family:
  - weighted impurity: $4/10 \times (1/4 \times 3/4) + 4/10 \times (2/4 \times 2/4) + 2/10 \times (0/2 \times 2/2) = 18\%$
- Which one should we choose?

Decision Tree Building



- Identify and label pure nodes
- Recurse on impure nodes
  - $\longrightarrow$ Consider attributes “Job” and “Deposit”

Summary

- Decision tree learning vs learned decision trees
- Method of building a decision tree: DT learning algorithm
- Purity measures: weighted average impurities
- Next lecture:
  - numeric attributes: splitting points
  - Perceptron learning
- Suggested reading: section 20.5 (2nd edition) or section 18.7 (3rd edition) and web