Data Mining Classification

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What is Classification?

- Assigning an object to a certain class based on its similarity to previous examples of other objects
- Can be done with reference to original data or based on a model of that data
- E.g: Me: "Its round, green, and edible"
  You: "It's an apple!"

Usual Examples

- Classifying transactions as genuine or fraudulent – e.g credit card usage, insurance claims, cell phone calls
- Classifying prospects as good or bad customers
- Classifying engine faults by their symptoms

Certainty

- As with most data mining solutions, a classification usually comes with a degree of certainty.
- It might be the probability of the object belonging to the class or it might be some other measure of how closely the object resembles other examples from that class

Techniques

- Non-parametric, e.g. K-nearest neighbour
- Mathematical models, e.g. neural networks
- Rule based models, e.g. decision trees

Predictive / Definitive

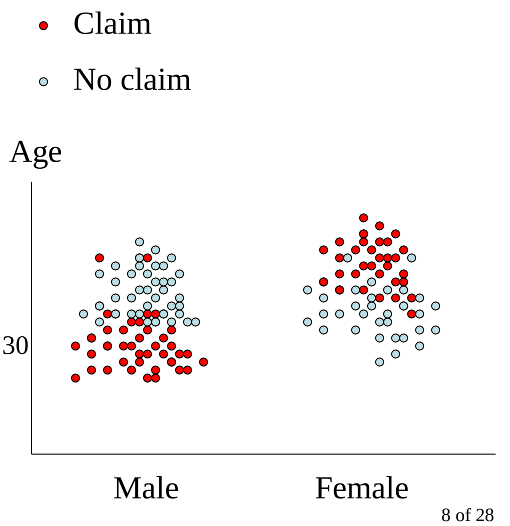
- Classification may indicate a propensity to act in a certain way, e.g. a prospect is likely to become a customer. This is predictive.
- Classification may indicate similarity to objects that are definitely members of a given class, e.g. small, round, green = apple

Simple Worked Example

- Risk of making a claim on a motor insurance policy
  - This is a predictive classification – they haven't made the claim yet, but do they look like other people who have?
  - To keep it simple, let's look at just age and gender

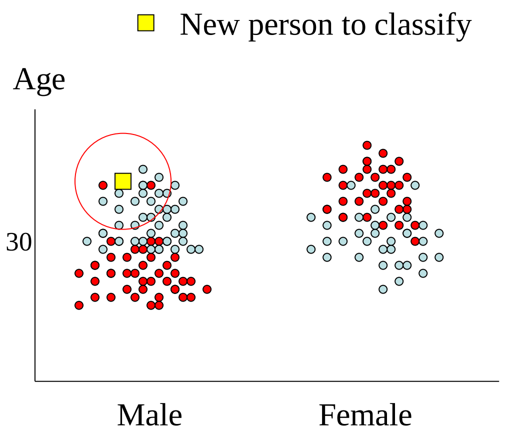
The Data

Age	Gender	Claim?
46	Male	No
36	Male	No
39	Female	No
24	Male	Yes
19	Male	Yes
41	Female	Yes
20	Female	No
38	Male	No
33	Male	No
19	Female	No
25	Male	No
25	Female	No
24	Male	Yes
35	Male	No
19	Female	No
42	Male	No
23	Female	No



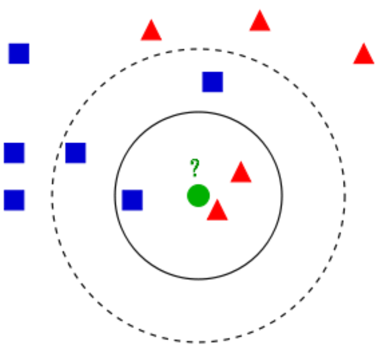
K-Nearest Neighbour

- Performed on raw data
- Count number of other examples that are close
- Winner is most common



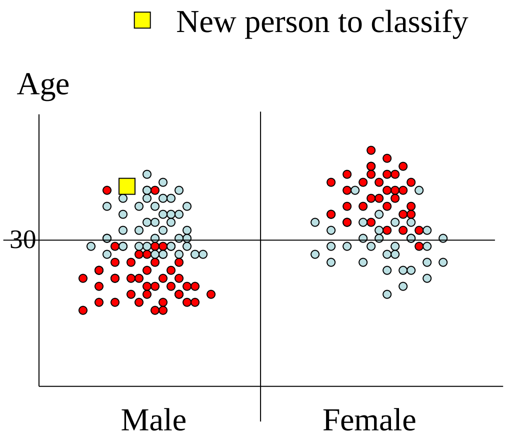
K-Nearest Neighbour

- Should the test sample (green circle) be the **1st** class (blue squares) or the **2nd** class (red triangles)?
- If k = 3 (solid line circle), it is assigned to the 2nd class because there are 2 triangles and only 1 square inside the inner circle.
- If k = 5 (dashed line circle) it is assigned to the 1st class (3 squares vs. 2 triangles).



Rule Based

- If Gender = Male and Age < 30 then *Claim*
- If Gender = Male and Age > 30 then *No Claim*
- Etc …

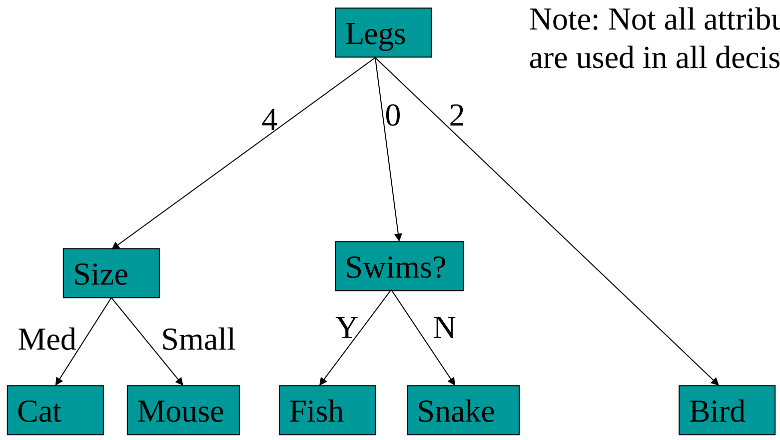


Decision Trees

- A good automatic rule discovery technique is the **decision tree**
- Produces a set of branching decisions that end in a classification
- Works best on nominal attributes – numeric ones need to be split into bins

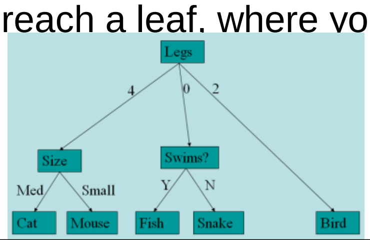
A Decision Tree

Note: Not all attributes are used in all decisions



Making a Classification

- Each node represents a single variable
- Each branch represents a value that variable can take
- To classify a single example, start at the top of the tree and see which variable it represents
- Follow the branch that corresponds to the value that variable takes in your example
- Keep going until you reach a leaf, where your object is classified!

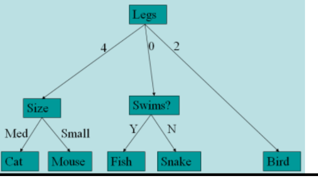


Tree Structure

- There are lots of ways to arrange a decision tree
- Does it matter which variables go where?
- Yes:
  - You need to optimise the number of correct classifications
  - You want to make the classification process as fast as possible

A Tree Building Algorithm

- Divide and Conquer:
  - Choose the variable that is at the top of the tree
  - Create a branch for each possible value
  - For each branch, repeat the process until there are no more branches to make (i.e. stop when all the instances at the current branch are in the same class)
  - But how do you choose which variable to split?

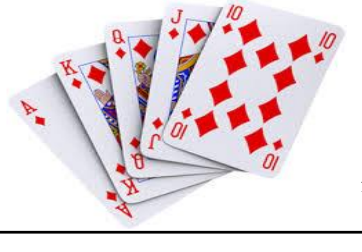


The ID3 Algorithm

- Split on the variable that gives the greatest information gain
- Information can be thought of as a measure of uncertainty
- Information is a measure based on the probability of something happening

Information Example

- If I pick a random card form a deck and you have to guess what it is, which would you rather be told:
- It is red (which has a probability of 0.5), or
- it is a picture card (which has a probability of 4/13 = 0.31)



Calculating Information

- The information associated with a single event:
  $I(e) = -\log(p_e)$
  where p_e is the probability of event e occurring, and log is the base 2 log
- I(Red) = -log(0.5) = 1
- I(Picture card) = -log(0.31) = 1.7
- I(Not Picture) = -log(9/13) = 0.53

Average Information

- The weighted average information across all possible values of a variable is called *Entropy.*
- It is calculated as the sum of the probability of each possible event times its information value:

$$H(X) = \sum P(x_i) I(x_i) = -\sum P(x_i) \log(P(x_i))$$

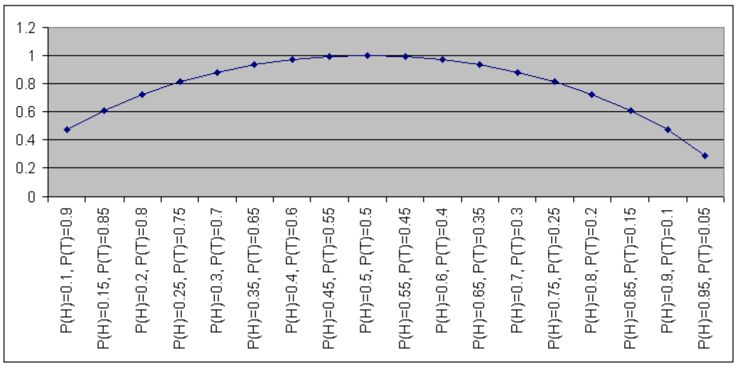
  where log is the base 2 log.

Entropy of IsPicture?

- I(Picture) = -log(4/13) = 1.7
- I(Not Picture) = -log(9/13) = 0.53
- H = (4/13)*1.7 + (9/13)*0.53 =0.89
- Entropy H(*X*) is a measure of uncertainty in variable *X*
- The more even the distribution of X becomes, the higher the entropy gets

Unfair Coin Entropy

- The more even the distribution of X becomes, the higher the entropy gets



Conditional Entropy

- We now introduce conditional entropy: H(*outcome* | *known*)
- The uncertainty about the outcome, given that we know *known*

Information Gain

- If we know H(*Outcome*)
- And we know H(*Outcome* | *Input*)
- We can calculate how much *Input* tells us about *Outcome* simply as:

  H(*Outcome*) - H(*Outcome* | *Input*)
- This is the information gain of *Input*

Picking the Top Node

- ID3 picks the top node of the network by calculating the information gain of the output class for each input variable, and picks the one that removes the most uncertainty
- It creates a branch for each value the chosen variable can take

Adding Branches

- Branches are added by making the same information gain calculation for data defined by the location on the tree of the current branch
- If all objects at the current leaf are in the same class, no more branching is needed
- The algorithm also stops when all the data has been accounted for

Solve It Yourself

Person	Hair Length	Weight	Age	Class
Homer	0"	250	36	M
Marge	10"	150	34	F
Bart	2"	90	10	M
Lisa	6"	78	8	F
Maggie	4"	20	1	F
Abe	1"	170	70	M
Selma	8"	160	41	F
Otto	10"	180	38	M
Krusty	6"	200	45	M
Comic	8"	290	38	?

Other Classification Methods

- You will meet a certain type of neural network in a later lecture – these too are good at classification
- There are many, many, many other methods for building classification systems