Teaching about decision trees for classificaton problems

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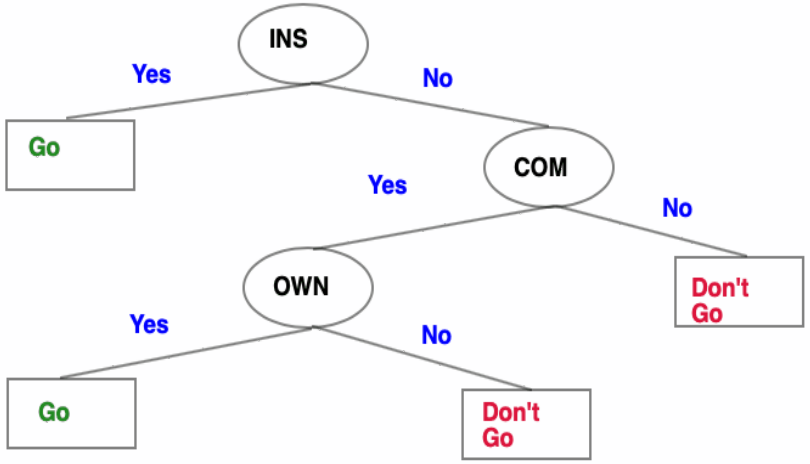
How do you decide to attend a conference?

- Inspiration (INS): Will the conference give me new inspirations for my work?
- Community (COM): Will I connect with colleagues?
- Own results (OWN): Do I have new ideas and results to present?



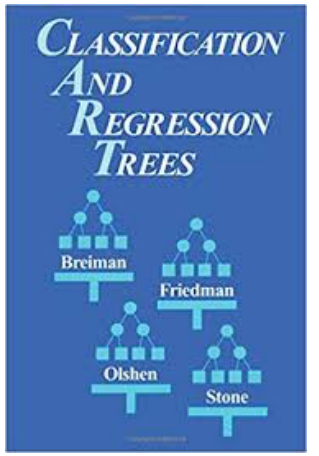
Decision algorithms in complex, „risky“ situations

- Medical diagnosis and intervention
- Financial investment
- Risk analysis
- Pattern recognition

Decision Trees

To make sense of these data, discover structure, etc. we need tools that are

- flexible and robust
- Simple enough to understand
- Provide results that are easy to interpret

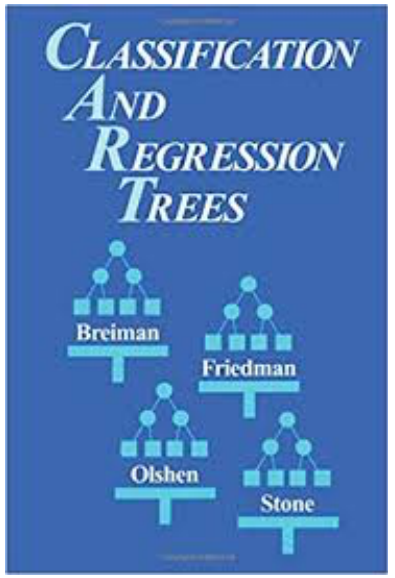


$\Rightarrow$ Classification And Regression Trees (CART)

(Implementation: Powerful Algorithms)

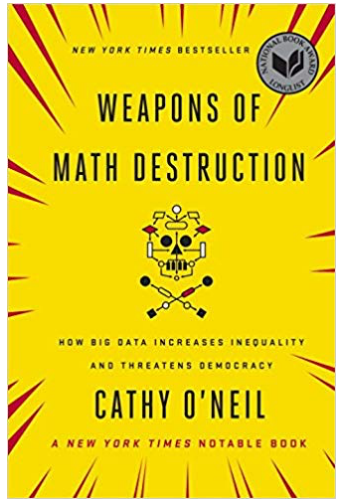
"Our philosophy in data analysis is to look at the data from a number of different viewpoints. Tree structured methods offer an interesting alternative for looking at classification and problems. It has sometimes given clues to data structure not apparent from a linear regression analysis. Like any tool, its greatest benefit lies in its intelligent and sensible application."

--Breiman, Friedman, Olshen, Stone



Purpose of this talk

- Help to understand how decision trees built
  - How created?
  - What kind of choices?
  - Which measures of quality?
- Intro to data science: „supervised learning”
- Critically reflect on algorithms



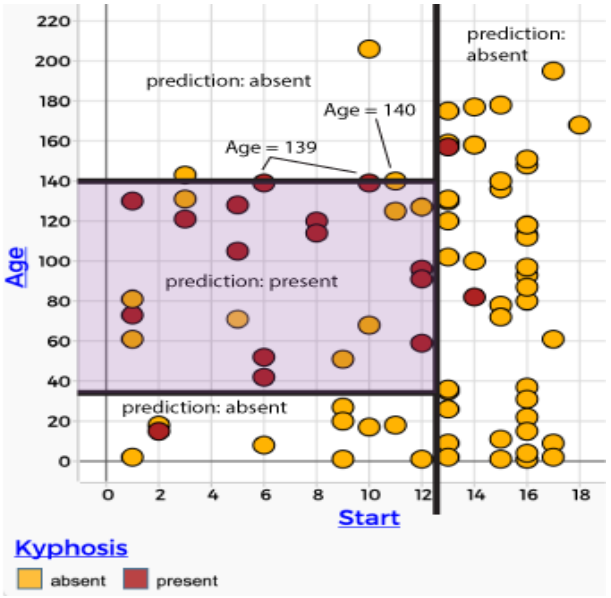
Decision algorithms

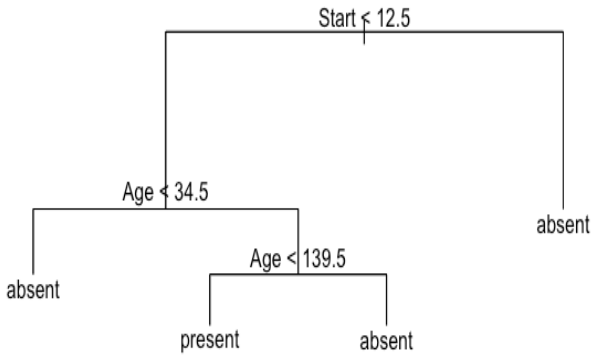
- Training sample: used for learning a decision rule
- Test sample: used for evaluating the quality of the decision rule

Example: Kyphosis after spinal surgery (Chambers & Hastie 1992)

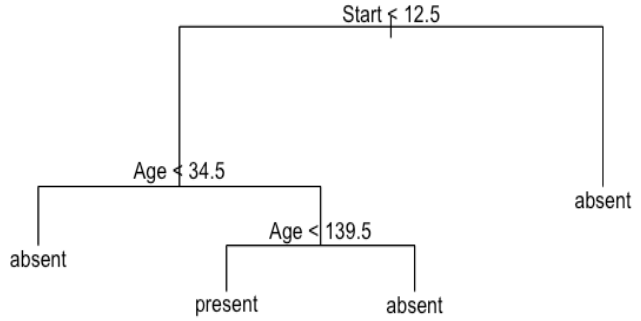
Sample 81 „cases“= children who after spinal surgery had or didn‘t have postoperative kyphosis (=a type of spinal deformation)

- `Age:` age of the child in months
- `Start:` the number of the first (topmost) vertebra operated on
- `Kyphosis:` indicates presence or absence of kyphosis





What makes a tree a good tree



- How and where to split?
  - Create regions where the data are more homogeneous;
    - Need some purity measure (open to creativity; e.g. Gini diver cross entropy, misclassification rate, ..)
- How to assign value to terminal node?
  - Majority vote (possibly weighted)
- When to stop tree growth? (Similar to variable selection in linear regression -> tendency for overfitting)
  - CART prunes an oversize tree based on cross-validation
  - Threshold for purity reduction
  - Minimum number of observations per node
  - Maximum number of nodes

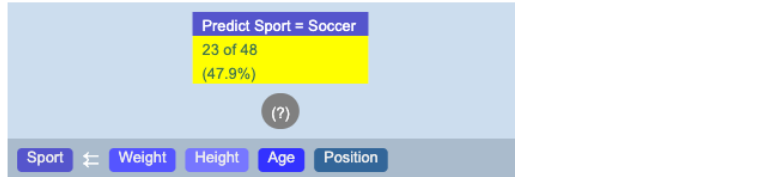
Teaching about classification trees: Crucial issues

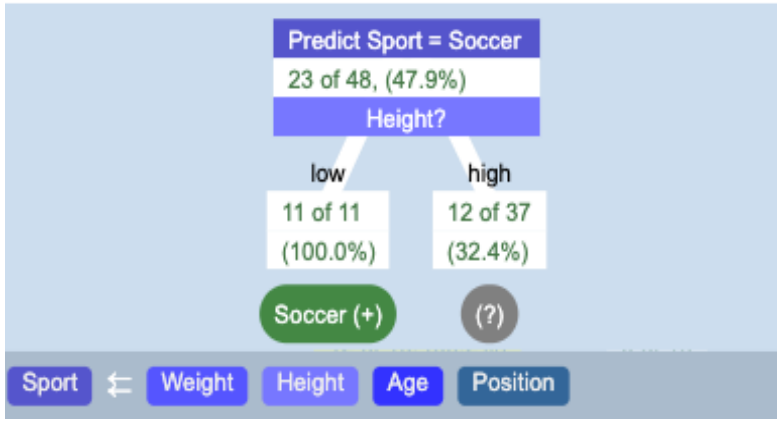
Based on experience at high school (data science course) and college (math teacher students):

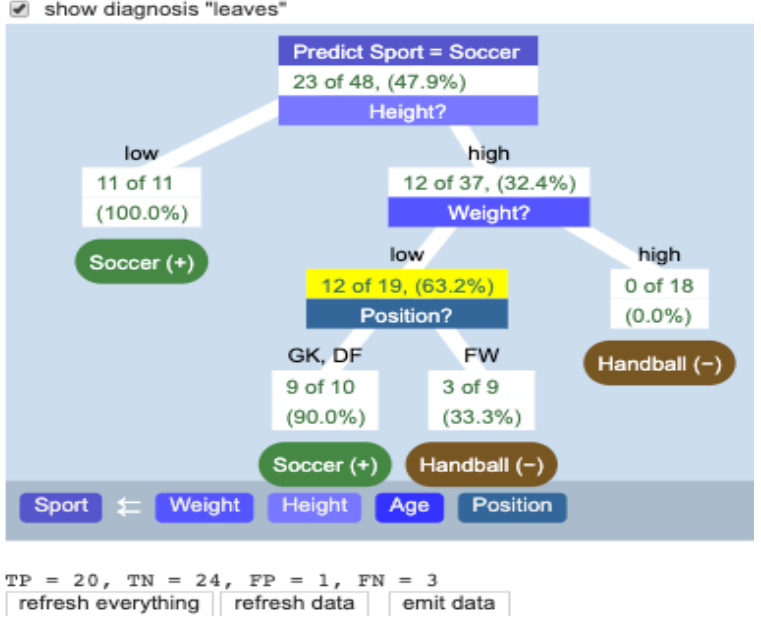
- Role of training sample
- Some choices seem haphazardly: how to justify?
- Meaning of nodes and purity measure
- Problem of oversized trees
- Assumptions and limitations

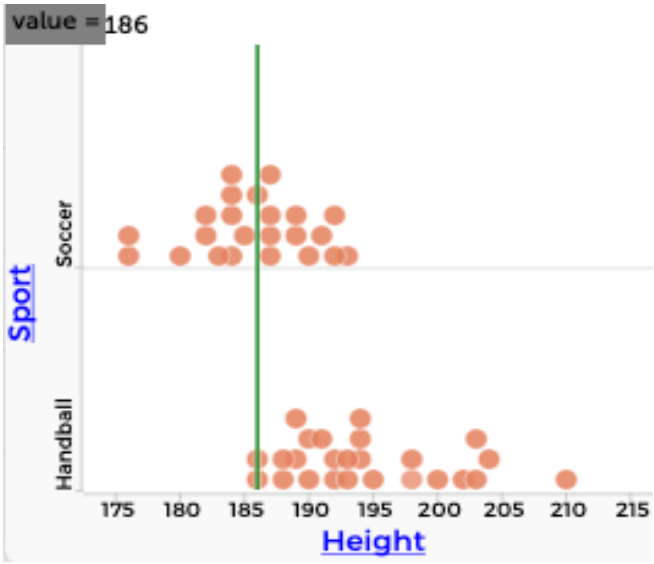
Teaching about classification trees: Solutions

- Step 1: Hands-on, with data cards
  - E.g. given a deck of 48 cards with infos about football and handball players (the „training sample“) with physical characteristics such as height, weight, age (as predictor) and their sport (target variable), develop a classification rule to „predict“ their sport. Then take another 10 cards (the „test sample“) to measure the quality of your decision rule
- Step 2: Technology, ARBOR - a plug-in tool to CODAP (developed by the second author)









- ARBOR slows down the algorithm, let‘s YOU decide next steps
- Lets YOU do the decisons stepwise and records a measure of tree quality
- YOU can define YOUR OWN measure of tree quality
- Very unlikely to result in the optimal tree, but YOU can investigate consequences of your choice of splitting criteria
- ARBOR allows you to use the CODAP capacity to find reasonable or good next steps

https://codap.concord.org/releases/latest/static/dg/en/cert/index.html#shared=100528

Xenobiologist: a data game diagnosing extraterrestrials

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Summary

- Classification and Regression Trees are an exploratory method to find structure is messy data
- Easy to interpret result
- Based on heavy algorithms,
- Entrance to Data Science methods like Random Forests, Bagging, Boosting
- ARBOR is a learning tool to better understand how CART works