Primer on Machine Learning

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Lazy8

Contents

Machine Learning is Everywhere

- pattern detection and recognition (iphone touch ID, face ID, word autocomplete, speech to text)
- history based recommendation (youtube, facebook, google search, amazon,...)
  - products for customers
  - customers for providers
- email filtering and classification (gmail)

Machine Learning and Artificial Intelligence

1950s *[getting] machines to exhibit behavior, which if done by humans, would be assumed to involve the use of intelligence*[1]

now *computational methods to automatically learn and to improve with experience*[2]

ML[3] statistical ("statistical learning")

AI analytical (knowledge, logic)

[1] Arthur Samuel, 1983

[2] http://www.mlplatform.nl/what-is-machine-learning/

[3] may mean Maximum Likelihood: abbrev. not widely used

Machine Learning Now

- big data
  - data science, data mining, ...
  - myth: machine learning needs big data[4]
- fast computers
- emerging new methods
  - deep learning, reinfocement learning, ...

[4] see NY/SF homes toy data

General Outline

1. formulate task (EN, ST)
2. collect data (EN, ST)
3. "engineer" data (EN, PR, DSS, HPC)
4. modeling (ST, EN)
5. fit/learn/train model(s) on data (LIB, PR, HPC)
6. validate, select (LIB, ST, PR, HPC)
7. apply model to test data (LIB)
8. interpret results (EN, ST)
9. report (DOC)

skill set	
EN	expert knowledge
ST	statistics
PR	programming
DSS	domain spec. software
HPC	high performance computing
LIB	ML libraries[a]
DOC	LaTeX, Web

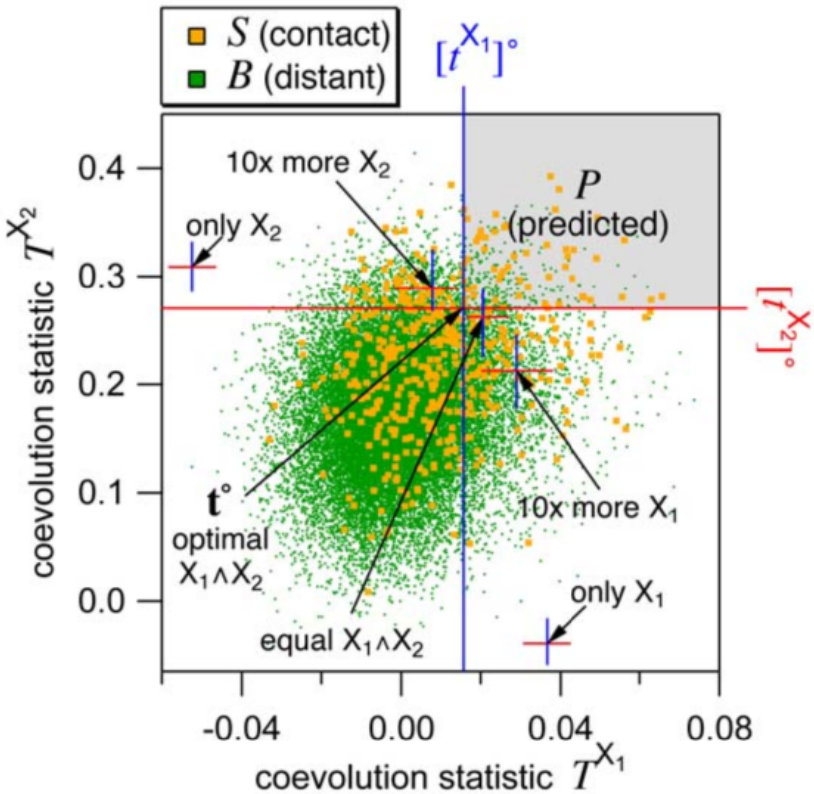
[a] Python, R, Java, Julia, Scala, Matlab

My Story with Machine Learning

Myth: it's like cooking

skill	2006	2017
expert knowledge	?	?
statistics	-	+
programming	-	+
domain spec. softw.	-	+
high perform. comp.	-	?
ML libraries	-	?
LaTeX, Web.	-	+

PLoS One. 2012;7(5):e36546.



Contents

Tasks

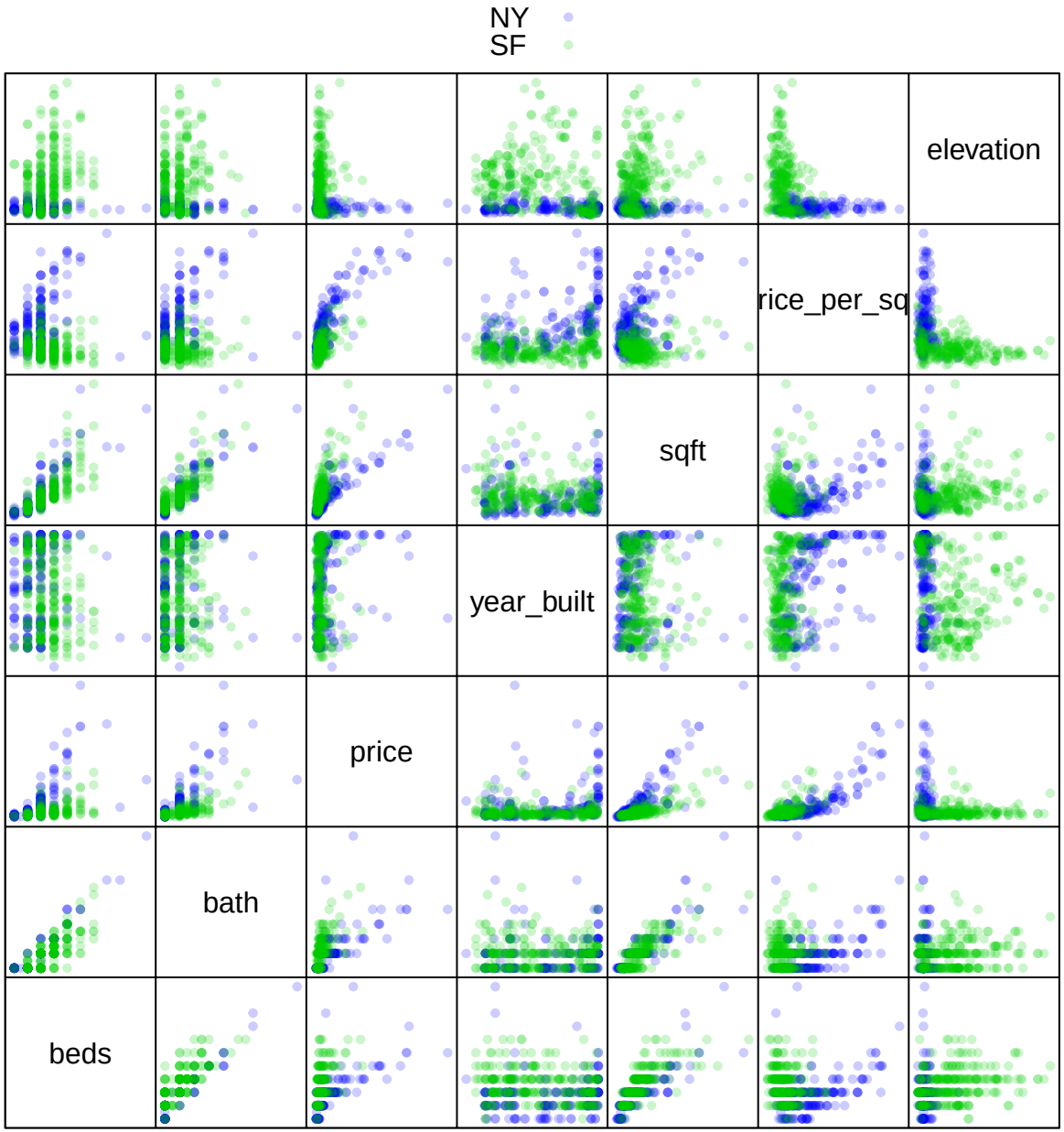
1. supervised learning: training *and* test data
   - prediction, classification
     - pattern recognition
     - business, medical, ... predictions & decisions
2. unsupervised learning: *only* training data
   - structure discovery
     - social, biol., tech. networks, associations,...
     - probabilistic expert systems
   - hypothesis testing, feature subset selection
     - research, marketing
   - matrix completion (imputation)
     - recommendation systems

The "Home" Data for Classification

Useless except for demonstration

observation	input features / variables				output
i	x_{i1}	x_{i2}	...	x_{ip}	y_i
home	price/sqft	elevation	...	beds	city
training data					
1	999	10	...	2	NY
2	1939	0	...	2	NY
⋮	⋮	⋮	⋮	⋮	⋮
491	764	163	...	1	SF
492	762	216	...	3	SF
test data					
493	1800	120	...	2	?
⋮	⋮	⋮	⋮	⋮	⋮

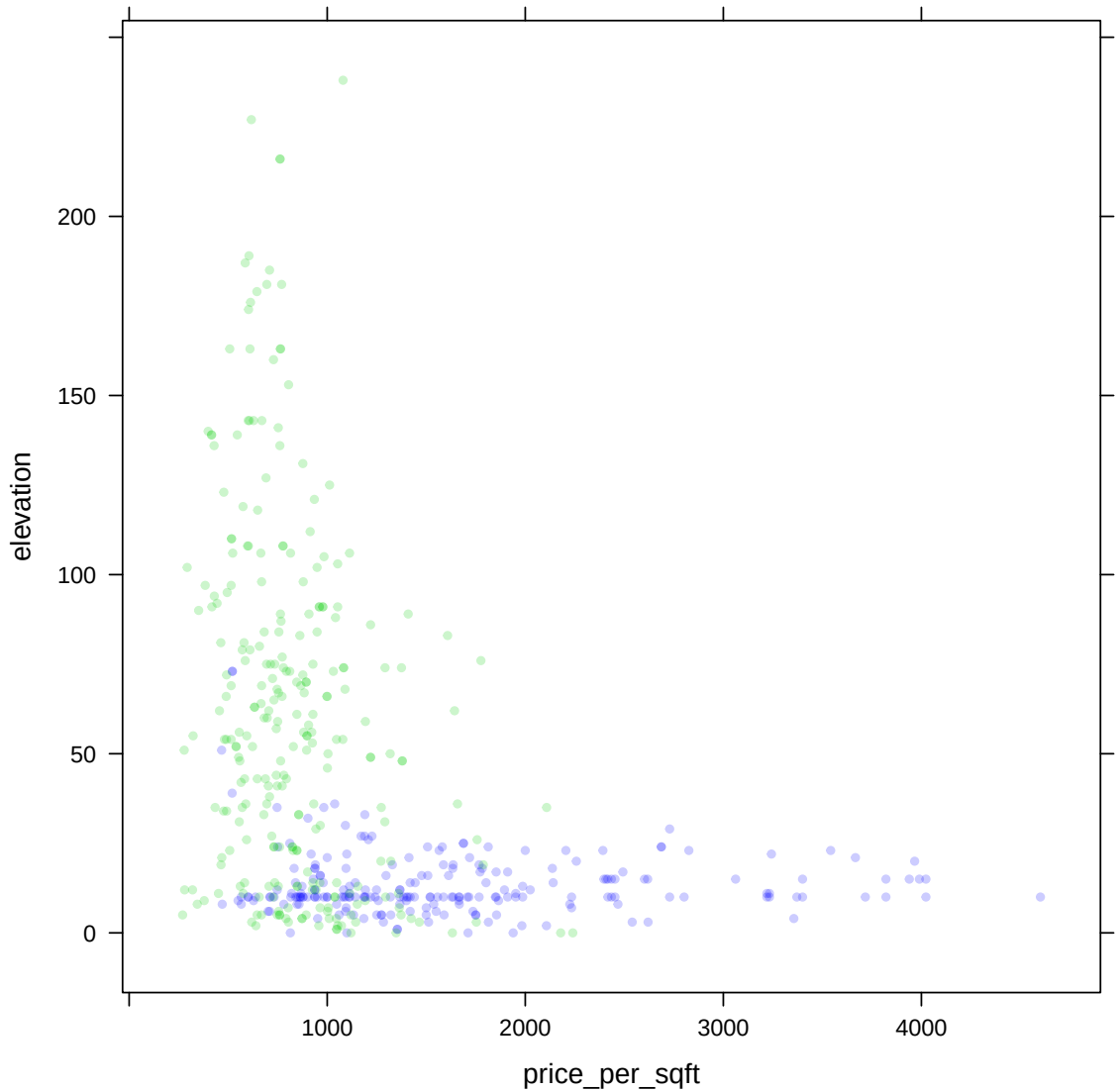
Home Data Overview



Scatter Plot Matrix

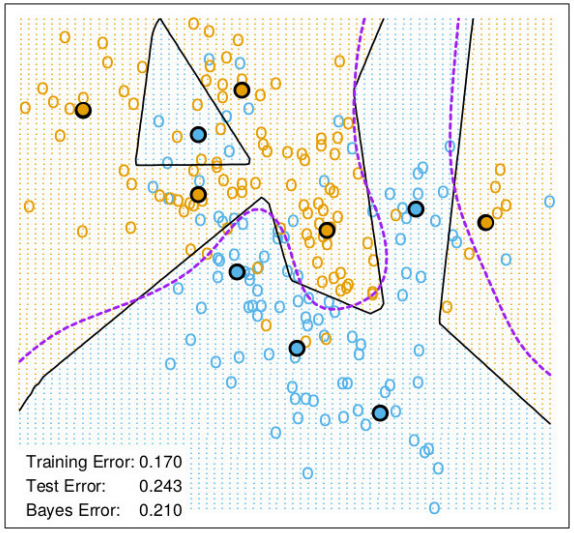
Informative Features

2 input features: 2D plots

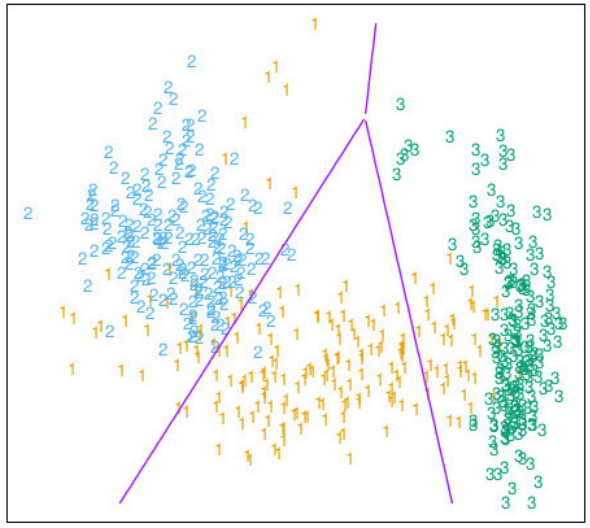


Models for Classification

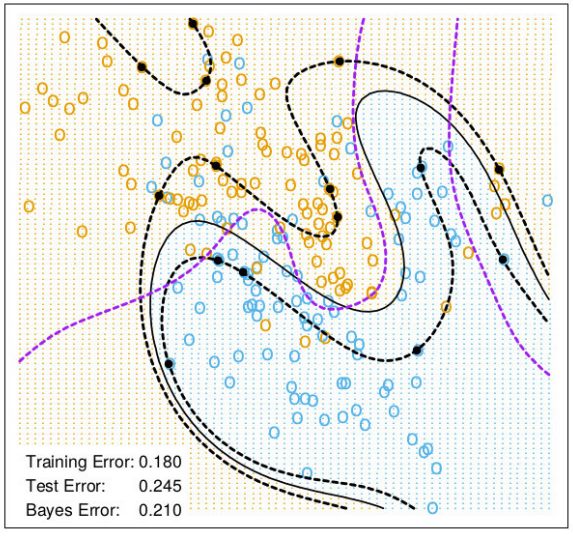
K-means classifier



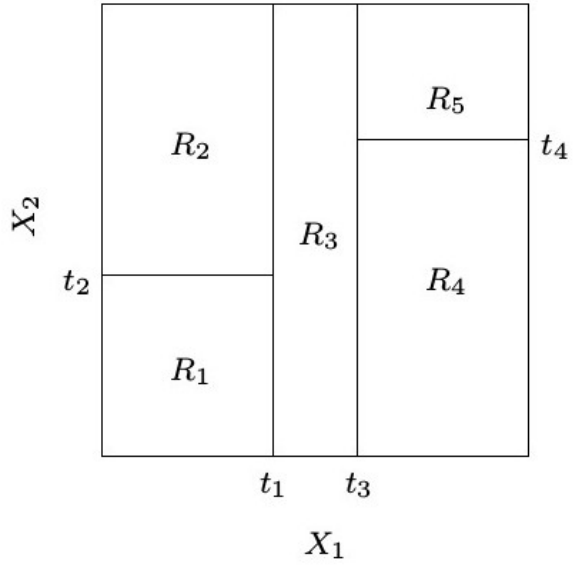
generalized linear regression



support vector machine



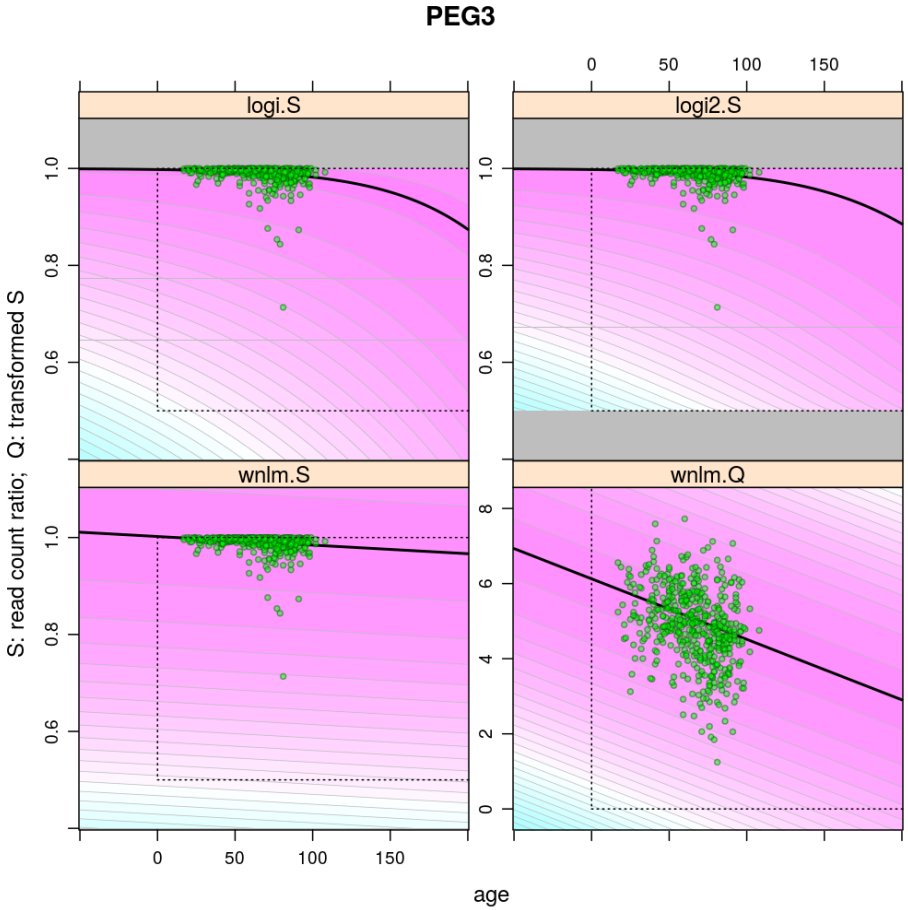
decision tree (inferior)



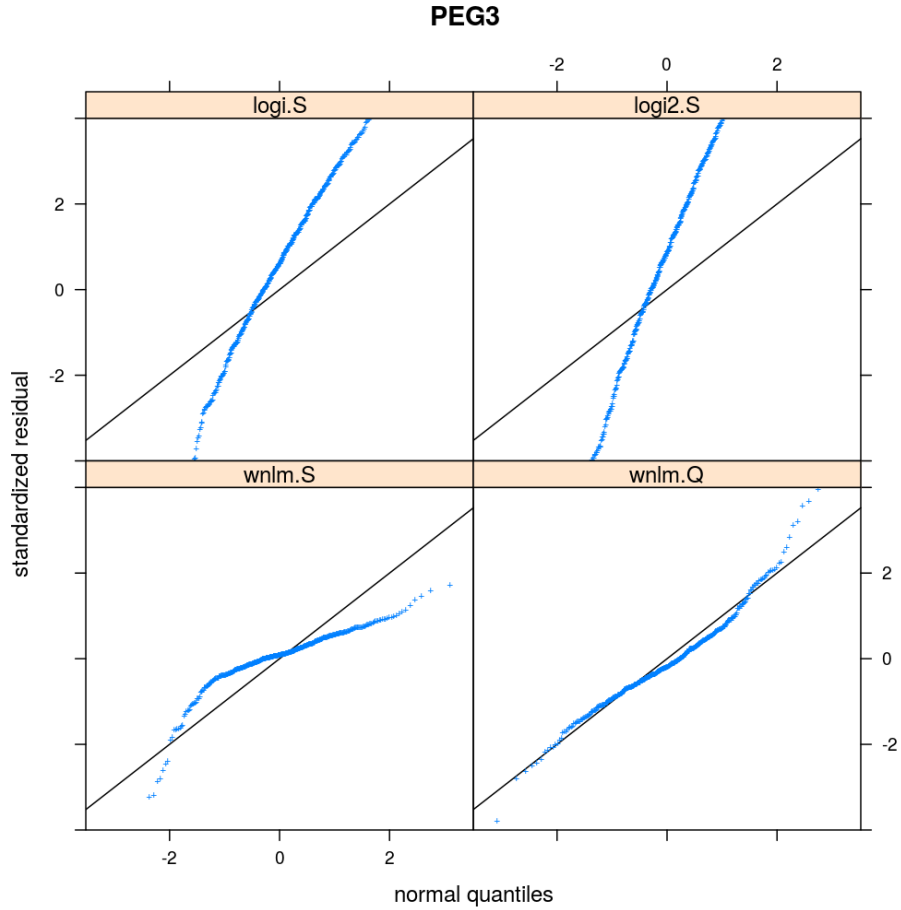
Which Model to Select? The One That Fits the Best![5]

Information theory, optimality, model ensemble

subjective evaluation



diagnostics



[5] should also be: simple, interpretable, fast to fit,...

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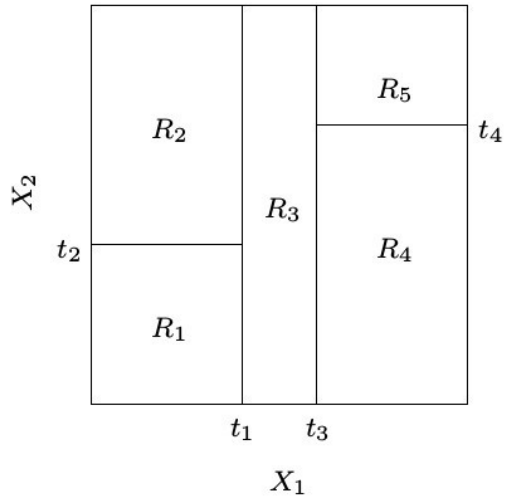
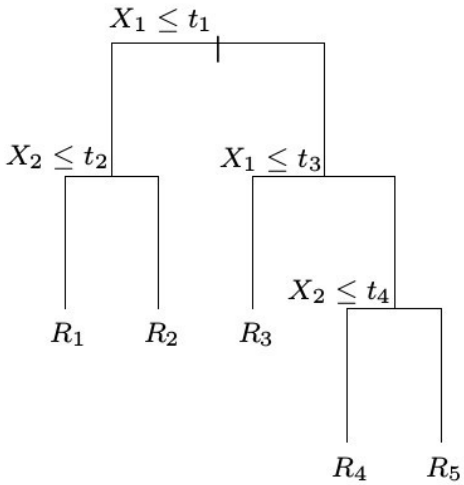
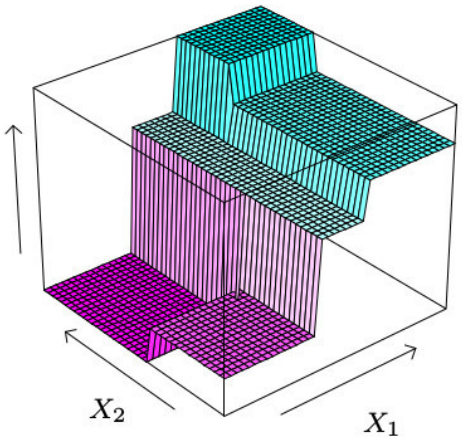
Decision Tree is Ideal for Demo

Tree Grows as We Partition Recursively







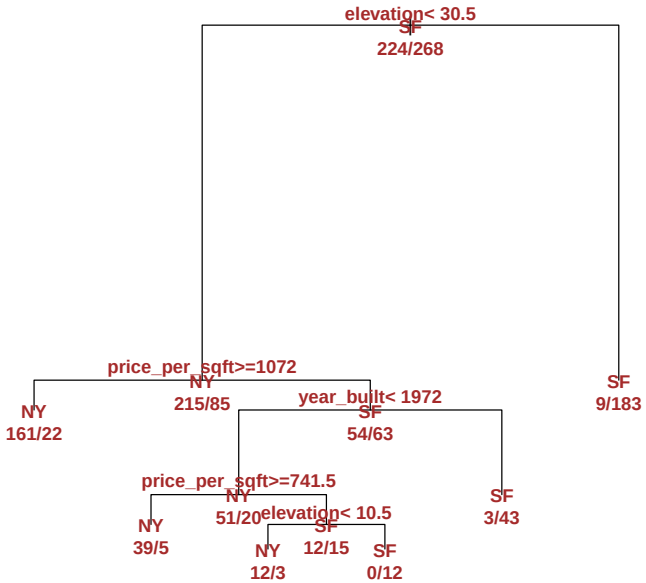
Why R?

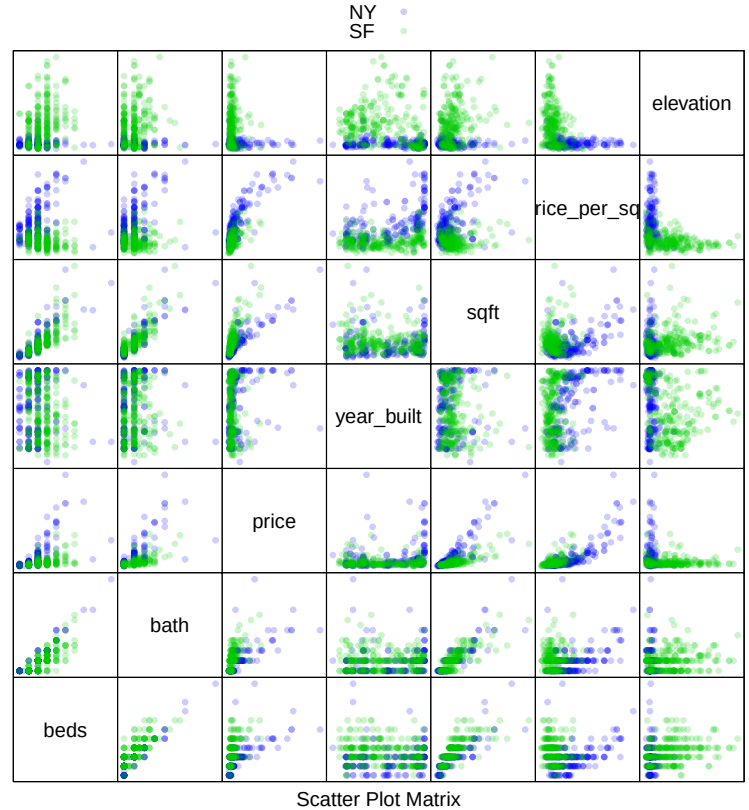
- created by and for biostatisticians
- functional programming paradigm
- open source
- mature
- lots of machine learning packages
- R2D3[6]

[6] http://www.r2d3.us/visual-intro-to-machine-learning-part-1/

Fitting and Interpreting Decision Tree

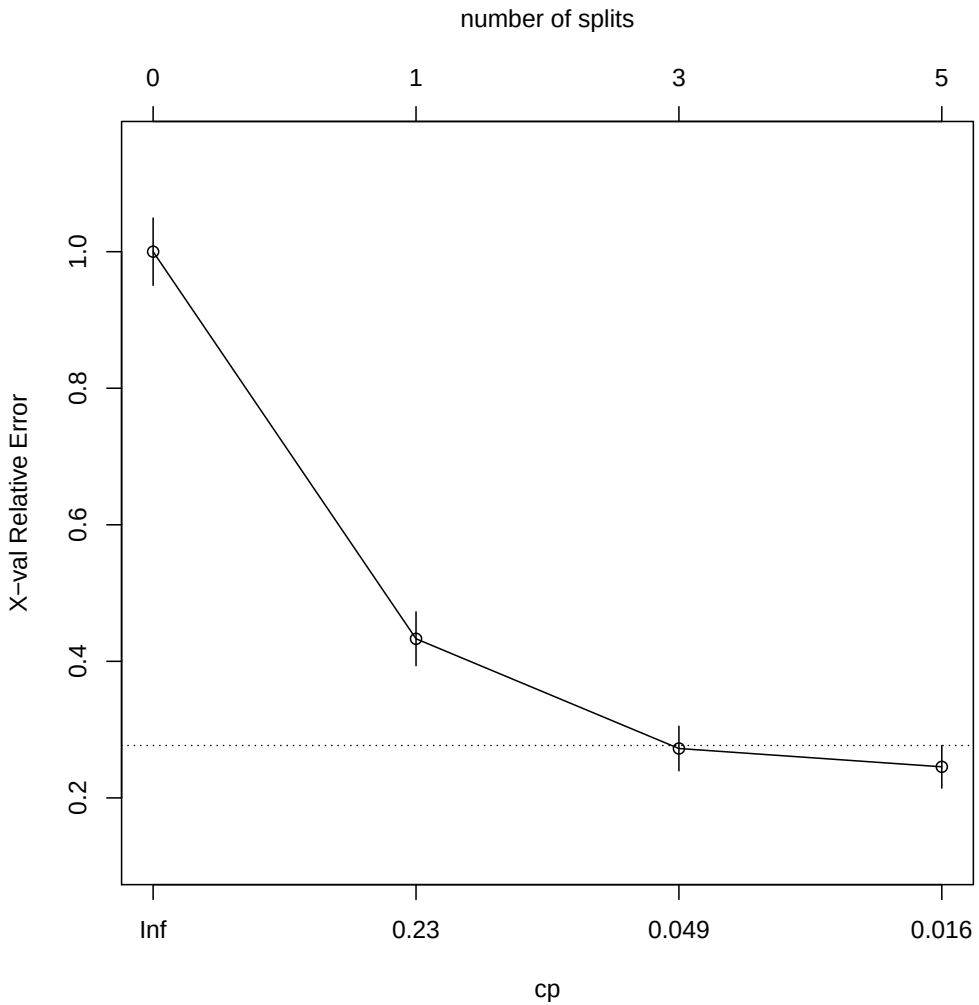
Using the `rpart` R library





Scatter Plot Matrix

Optimality Criteria



Prediction

What We Sidestepped Here

- real World task
- data collection/engineering
- model selection
- validation, performance

Machine Learning and You

- doing it
  - `Hello World!` is easy but useless
  - obtaining skills takes years
  - rewarding
- understanding it
  - learn concepts not cooking
  - collaboration, interpretation