Machine Learning with Python:
A Hands-On Introduction

https://github.com/cbrownley/2024MLWEEK_MLWITHPYTHON

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Agenda (too much…we'll take our time :)

8:30-8:45 – Setup and Overview

8:45-9:30 – **Data preprocessing**

9:30-10:00 – Hands-on: Data preprocessing

10:00-10:30 – **Cross-validation**

10:30-11:00 – Hands-on: Cross-validation

11:00-11:30 – Hands-on: K-fold cross-validation

11:30-12:00 – **Classification** (breast tumor diagnosis)

12:00-12:30 – Hands-on: Classification

12:30-1:00 – Hands-on: Decision Trees

1:00-1:30 – **Regression** (california housing)

1:30-2:00 – Hands-on: Regression

2:00-2:30 – Hands-on: **Shrinkage methods**

2:30-3:00 – Classification (credit card fraud)

3:00-3:30 – Regression (cycling counts)

3:30-4:00 – Hands-on: Classification (hotel bookings)

Prediction vs Causal Inference

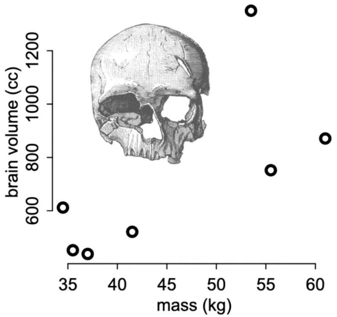
Problems of Prediction

What function describes these points? (fitting, compression)

What function explains these points? (causal inference)

What would happen if we changed a point's mass? (intervention)

What is the next observation from the same process? (prediction)



Good & Bad Controls

"Control" variable: Variable introduced to an analysis so that a causal estimate is possible

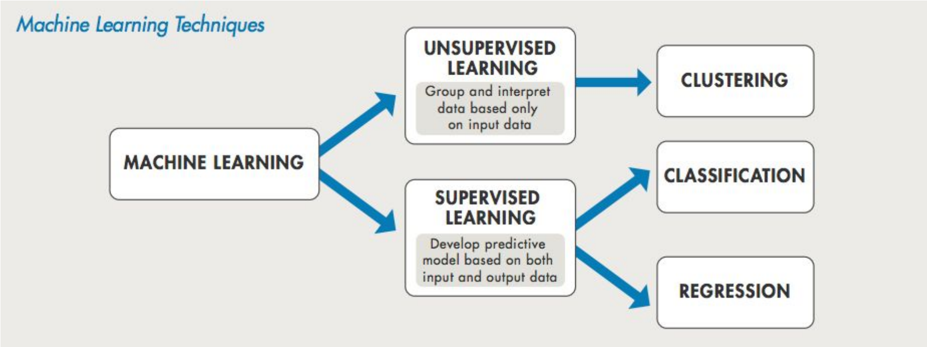
Common **wrong** heuristics for choosing control variables

Anything in the spreadsheet **YOLO**!

Any variables not highly **collinear**

Any **pre-treatment** measurement (baseline)

Supervised vs Unsupervised



Machine Learning Techniques

MACHINE LEARNING

UNSUPERVISED LEARNING

Group and interpret data based only on input data

CLUSTERING

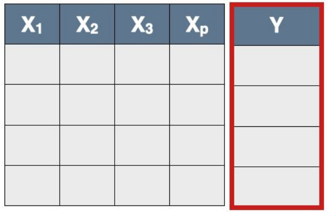
SUPERVISED LEARNING

Develop predictive model based on both input and output data

CLASSIFICATION

REGRESSION

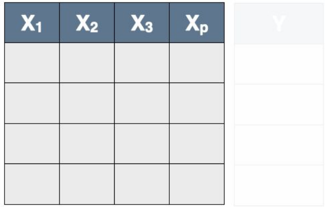
Supervised Learning



X_1	X_2	X_3	X_p	Y

Target

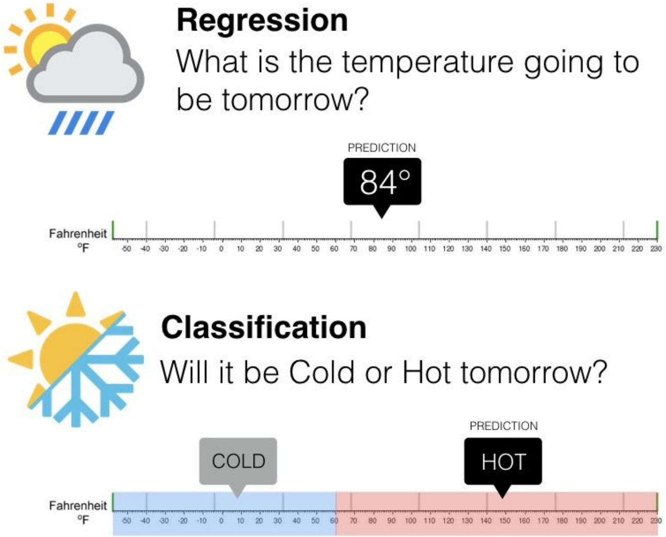
Un-Supervised Learning



X_1	X_2	X_3	X_p	Y

No Target

Regression vs Classification

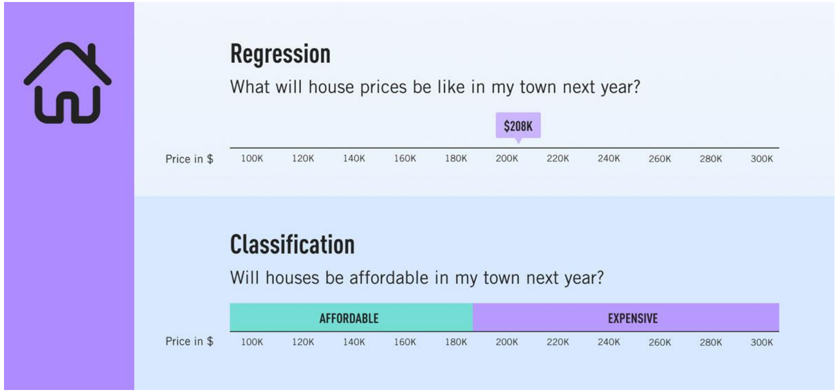


Regression

What is the temperature going to be tomorrow?

Classification

Will it be Cold or Hot tomorrow?



Regression

What will house prices be like in my town next year?

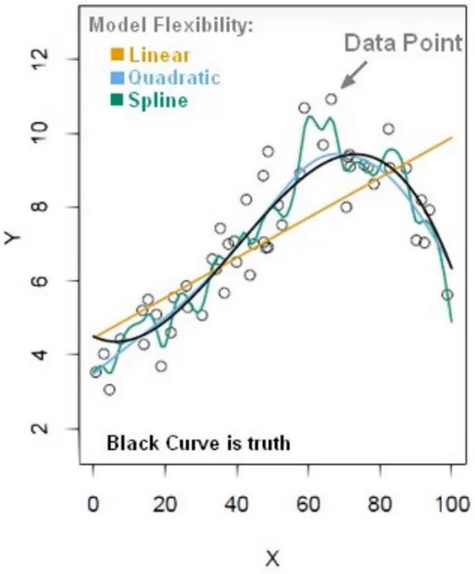
$208K
Price in $
100K 120K 140K 160K 180K 200K 220K 240K 260K 280K 300K

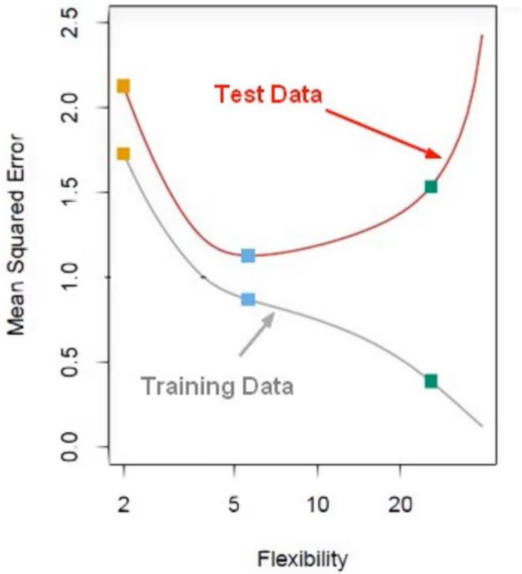
Classification

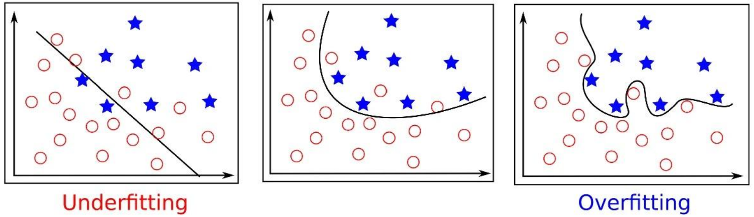
Will houses be affordable in my town next year?

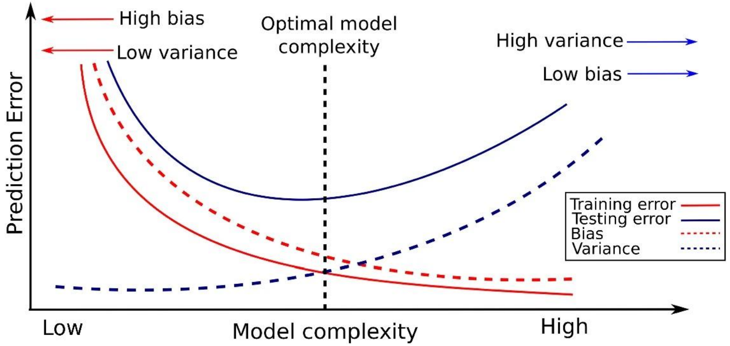
AFFORDABLE
EXPENSIVE
Price in $
100K 120K 140K 160K 180K 200K 220K 240K 260K 280K 300K

The Bias-Variance Trade-off









$$\mathrm{E}\left[\left(y-\hat{f}(x)\right)^2\right] = \mathrm{Bias}\left[\hat{f}(x)\right]^2 + \mathrm{Var}\left[\hat{f}(x)\right] + \sigma^2$$

Where:

$$\mathrm{Bias}\left[\hat{f}(x)\right] = \mathrm{E}\left[\hat{f}(x) - f(x)\right]$$

and

$$\mathrm{Var}\left[\hat{f}(x)\right] = \mathrm{E}[\hat{f}(x)^2] - \mathrm{E}[\hat{f}(x)]^2$$

Flexibility vs Interpretability

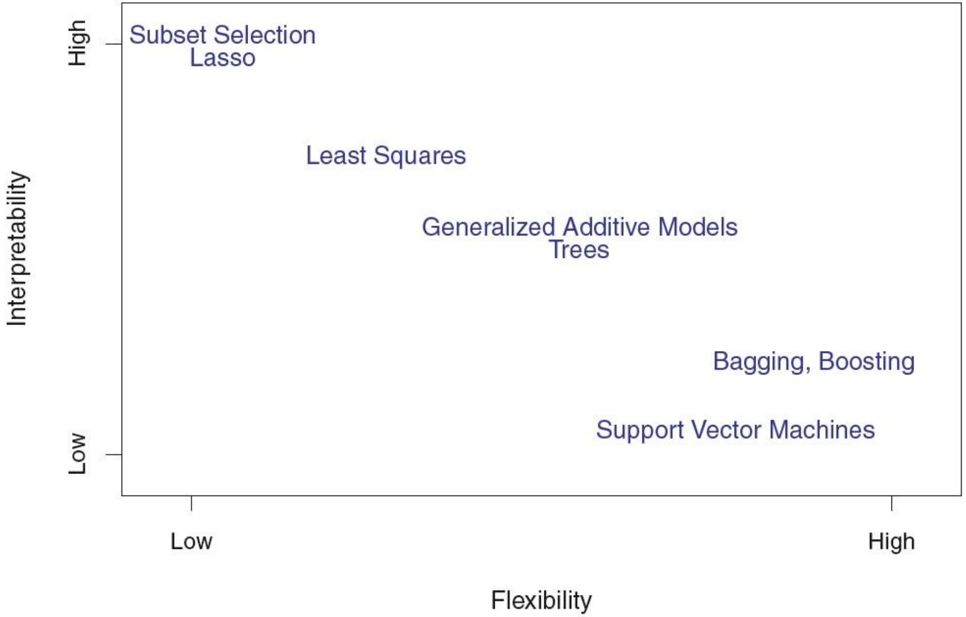


FIGURE 2.7. *A representation of the tradeoff between flexibility and interpretability, using different statistical learning methods. In general, as the flexibility of a method increases, its interpretability decreases.*