Introduction to Statistical Learning

Eltecon Data Science Course by Emarsys

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About me

- Eltecon BSc
- University of Amsterdam MSc in Economics
- Last 6+ years working with data
  - 2.5 year @ Emarsys as a Data Scientist
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Goal of the lesson

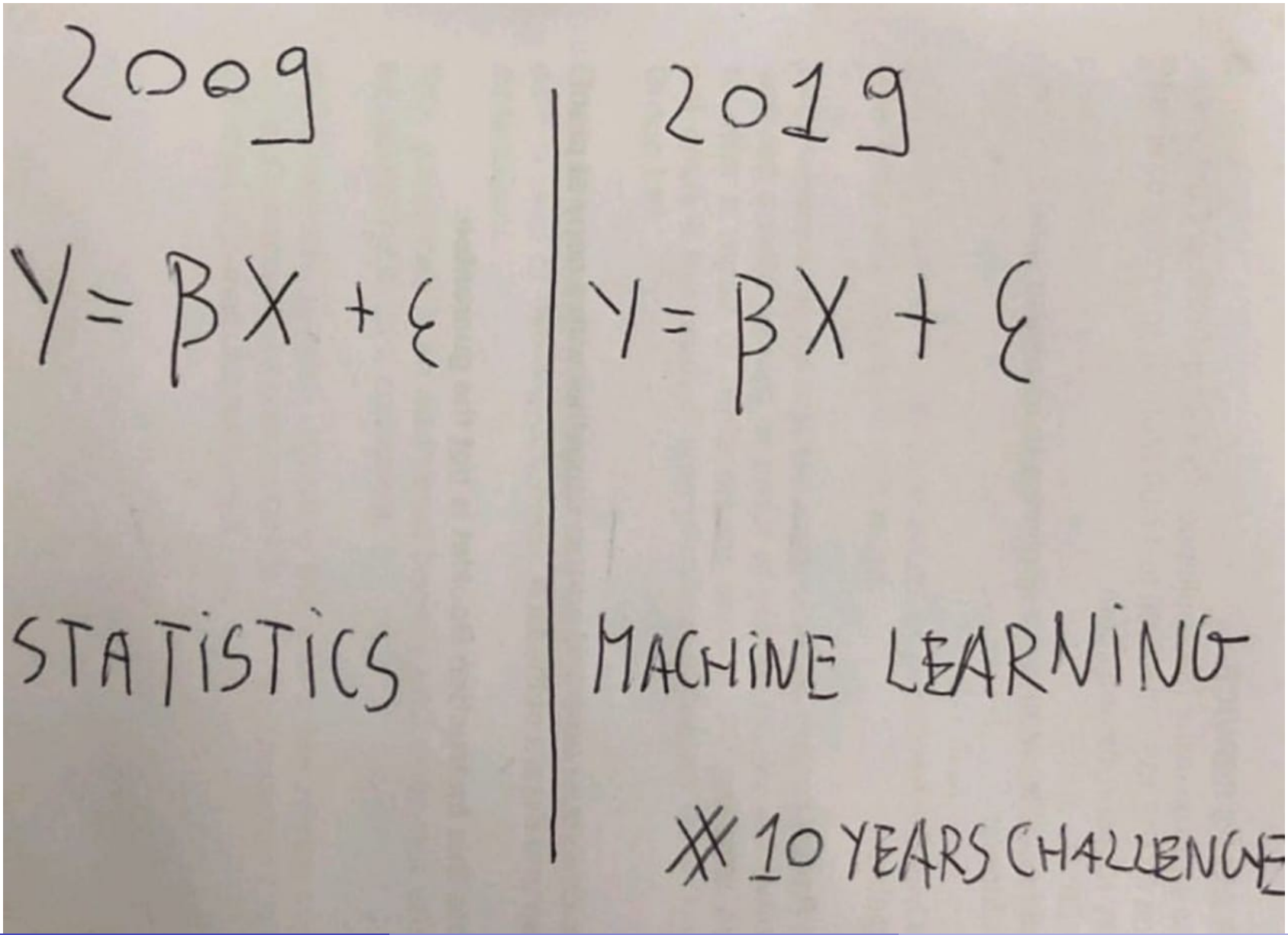
Section 1

Statistical Learning in General

Introduction to Statistical Learning

- tell about the book and what chapters are covered

What is Statistical Learning



What is Statistical Learning

*"**Machine learning** is all about results, it is likely working in a company where your worth is characterized solely by your performance. Whereas, **statistical modeling** is more about finding relationships between variables and the significance of those relationships, whilst also catering for prediction"*

source

What is Statistical Learning

Assumption:

$$Y = f(X) + \epsilon$$

- We **assume** a systematic relationship between X and Y
- f is generally unknown
- **Statistical Learning refers to a set of approaches for estimating f based on the available observations (X)**

What is Statistical Learning

Assumption:

$$Y = f(X) + \epsilon$$

- ϵ is assumed to have mean 0
- ϵ is assumed to be independent of X
  $\Rightarrow$ **otherwise** could be modeled through f

Why estimate f?

- Causality/Inference (more in Econ, e.g. What drives unemployment?)
- Prediction (more in Business, e.g. How much Happy Socks are we selling next month?)

Prediction: Reducible error/Irreducible error

$$Y = f(X) + \epsilon$$

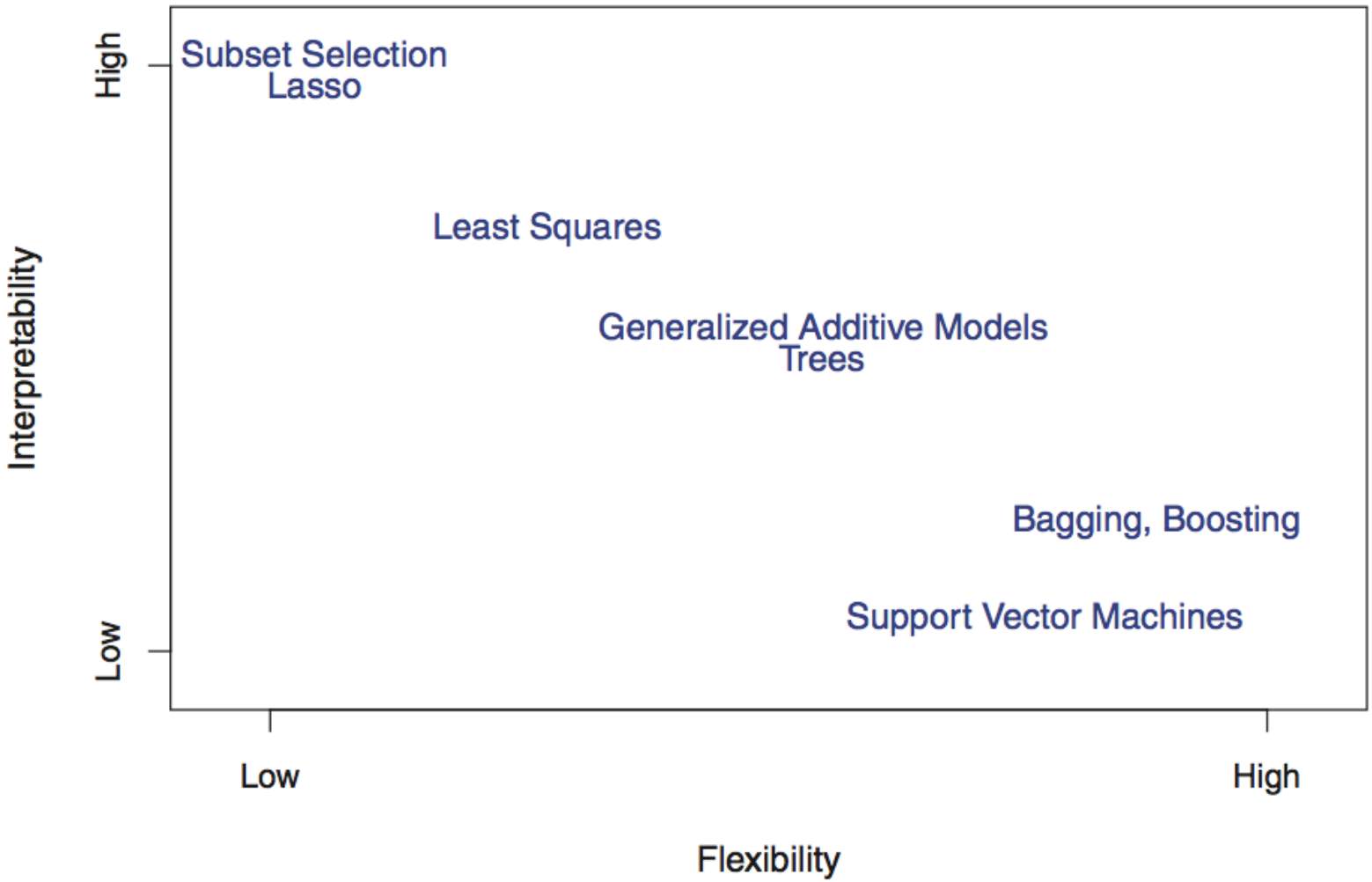
$$\begin{aligned} E(Y - \hat{Y}) &= E[f(X) + \epsilon - \hat{f}(X)]^2 \\ &= \underbrace{[f(X) - \hat{f}(X)]^2}_{\text{reducible error}} + \underbrace{Var(\epsilon)}_{\text{irreducible error}} \end{aligned}$$

- the aim is to estimate f by reducing the reducible error
- What about the irreducible error? Can't do anything about that.
  - Didn't measure :(
  - Can't measure: e.g. mood of a buyer on the day she's buying the house

How to estimate f?

- parametric models + less parameters to learn (needs less training data) - can erroneously assume f
- non-parametric models + more flexible - more parameters to learn (needs more training data) - can overfit the data

Prediction Accuracy vs. Model Interpretability



source: ISLR, p.25.

Supervised vs. Unsupervised Learning

- Supervised: has response variable (Y)
  - linear reg., logistic reg., GAM, SVC
- Unsupervised: no supervisor response variable
  - cluster analysis

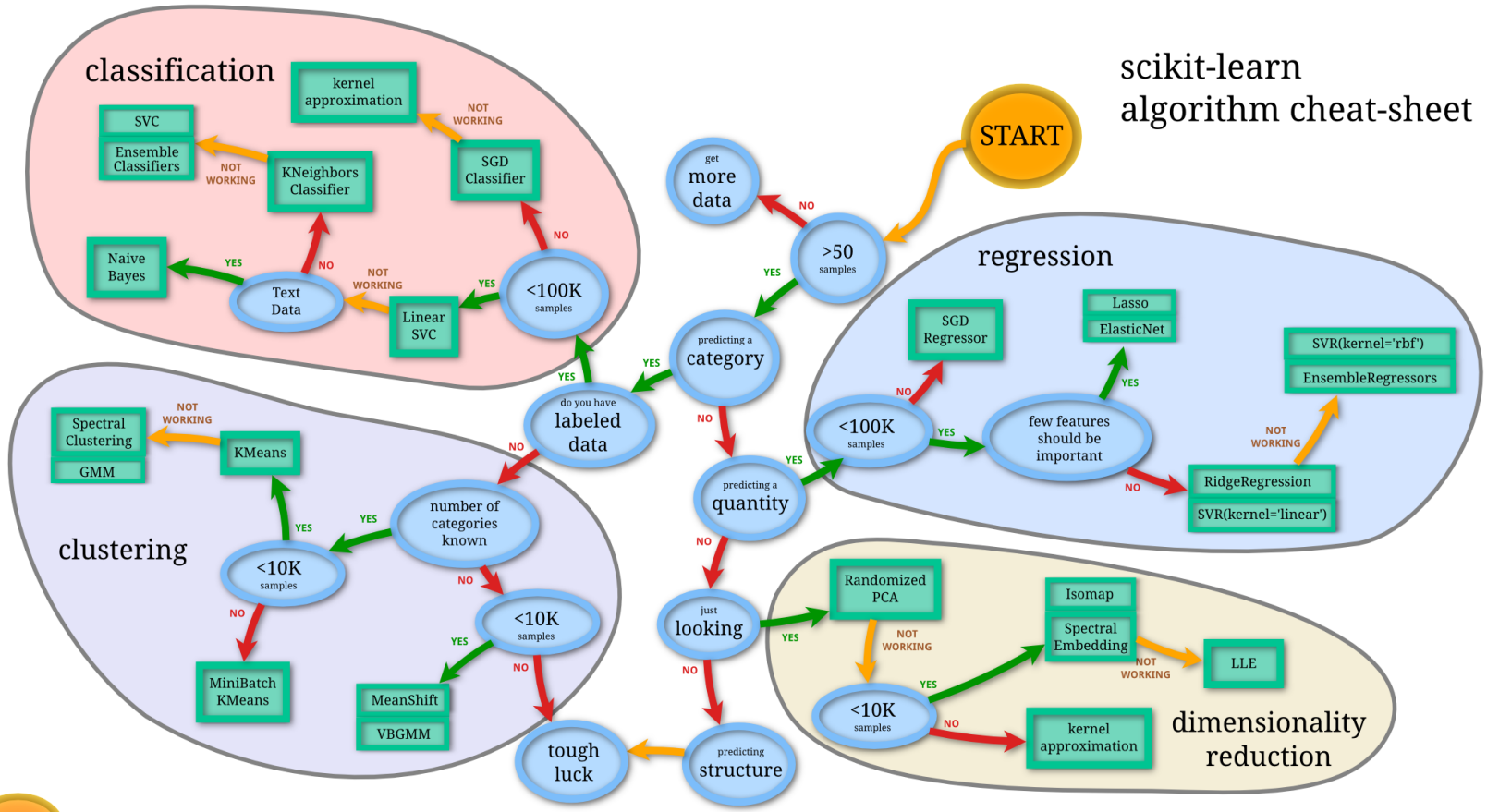
Regression vs. Classification

- Regression: quantitative response (e.g. market price prediction)
- Classification: qualitative response (e.g. male/female based on purchase patterns)

Statistical Learning Dimensions Summarized

- Goal: inference vs. prediction
- Model interpretability vs. Prediction Accuracy
- Supervised vs. Unsupervised
- Regression vs. Classification

Other model selection decision points



Back

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Section 2

Linear Regression

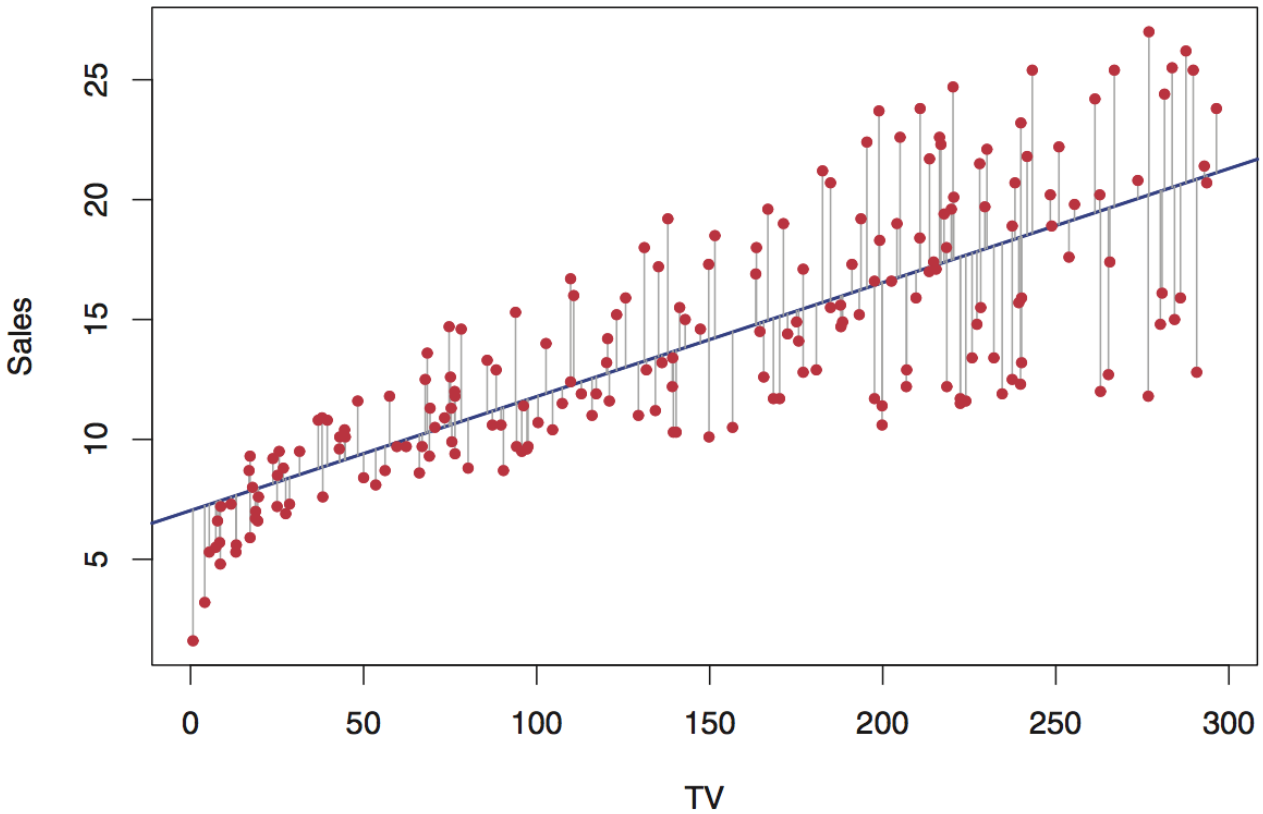
Simple Linear Regression Formula

- assumes an approximate linear relationship between X and Y

$$Y \approx \beta_0 + \beta_1 X$$

Estimating Coefficients

We want to find the coefficients so that the resulting line is as "close" to the observations as possible.



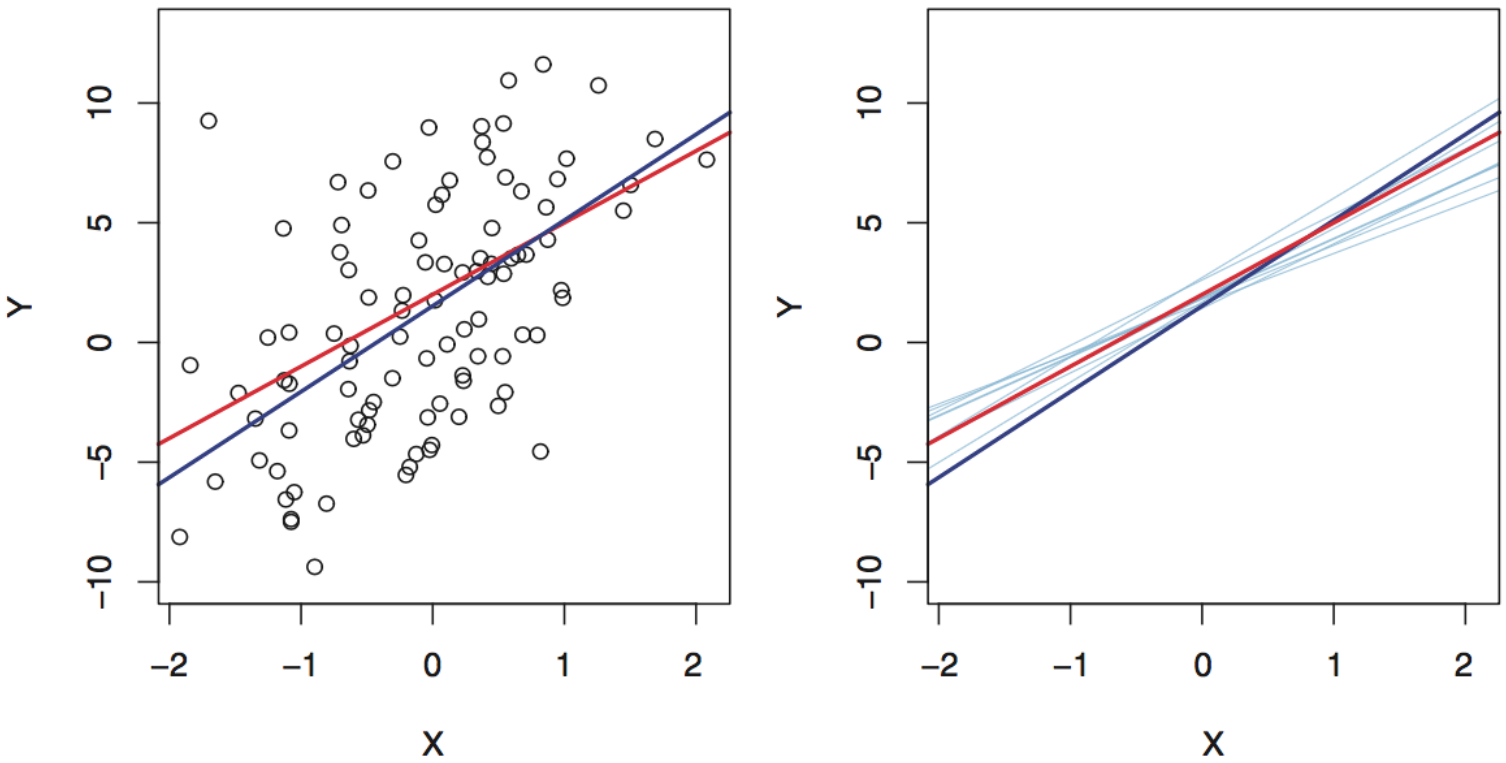
source: ISLR, p.62.

Estimating Coefficients: Least Squares

- Minimize the *Residual Sum of Squares* (*RSS*)

$$RSS = (y_1 - \hat{\beta}_0 - \hat{\beta}_1 x_1)^2 + (y_2 - \hat{\beta}_0 - \hat{\beta}_2 x_2)^2 + ... + (y_n - \hat{\beta}_0 - \hat{\beta}_n x_n)^2$$

Assessing the Coefficient Estimation Accuracy



source: ISLR, p.64.

- Data Generated: $f(X) = 2 + 3X + \epsilon$
- Population regression line (red): $f(X) = 2 + 3X$
- Least Squares regression line (blue)

Section 3

Binary Classification

Section 4

Hands on Exercises

Section 5

Great resources