Introduction to Machine Learning

Samuel Carton (adapted from Marek Petrik)

8/2025

What is machine learning?

Arthur Samuel (1959, IBM, computer checkers):

Field of study that gives computers the ability to learn without being explicitly programmed

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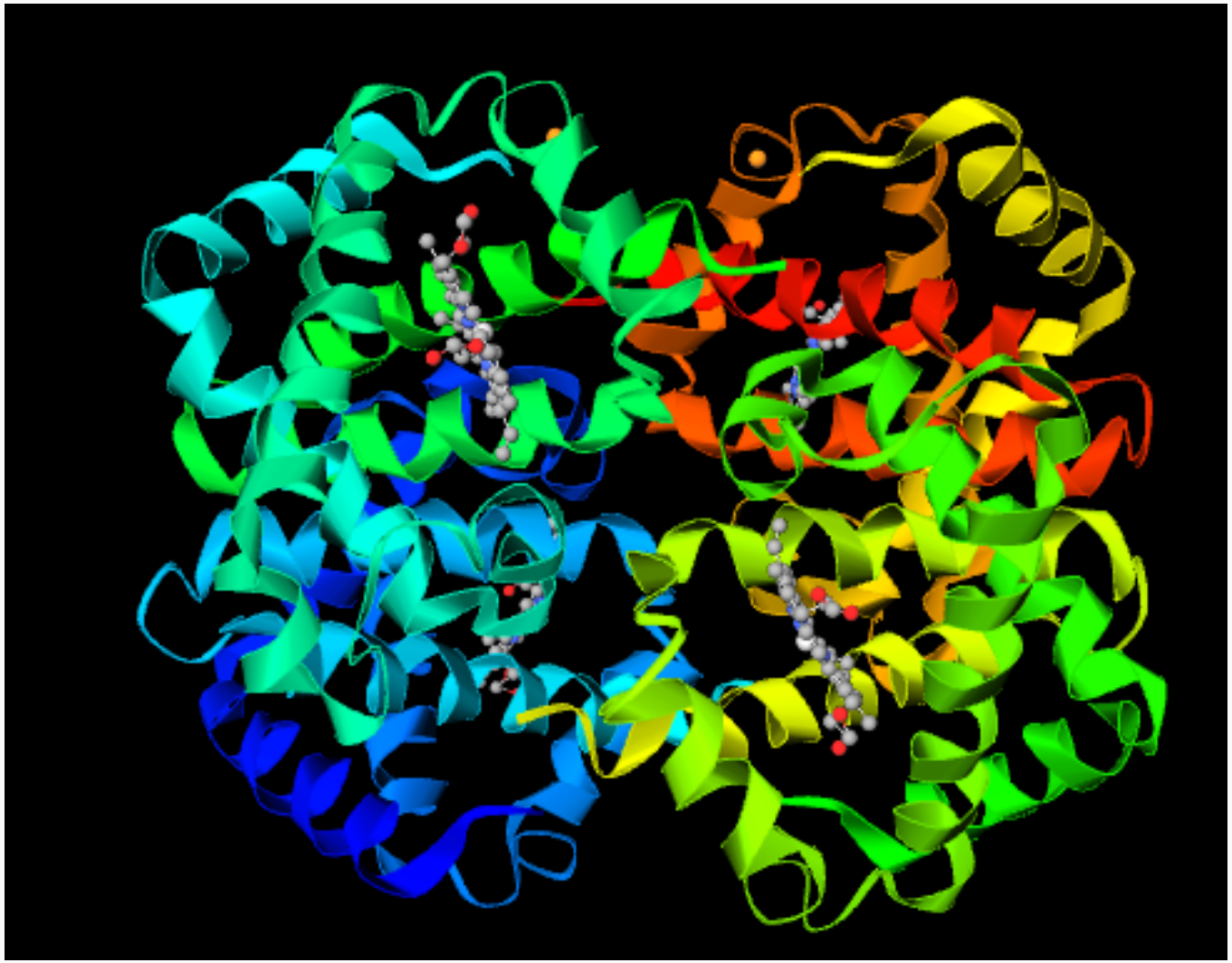
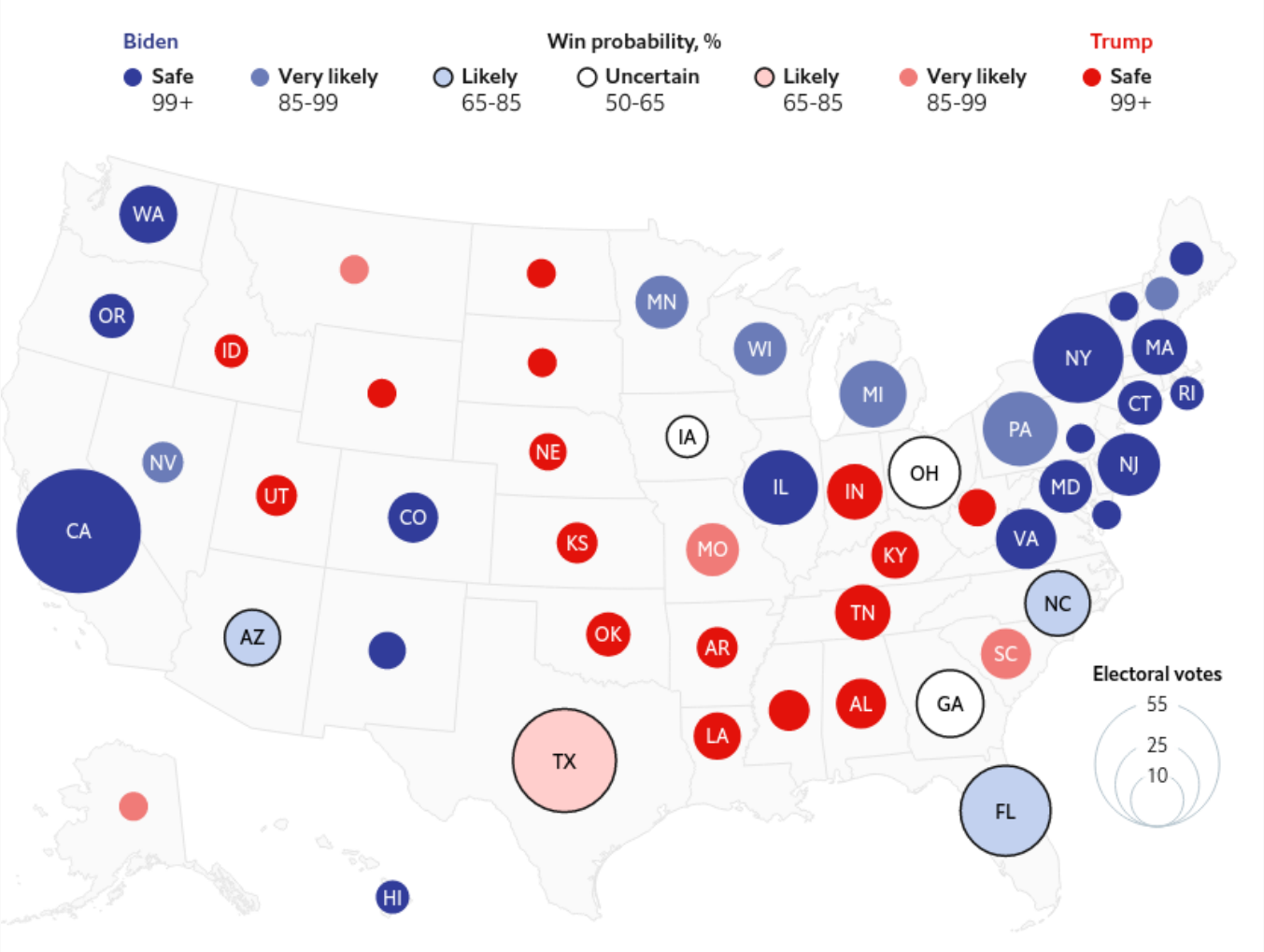
IBM Watson: Computers Beat Humans in Jeopardy

Fair use, https://en.wikipedia.org/w/index.php?curid=31142331

AlphaFold: Machine Learning for Protein Folding



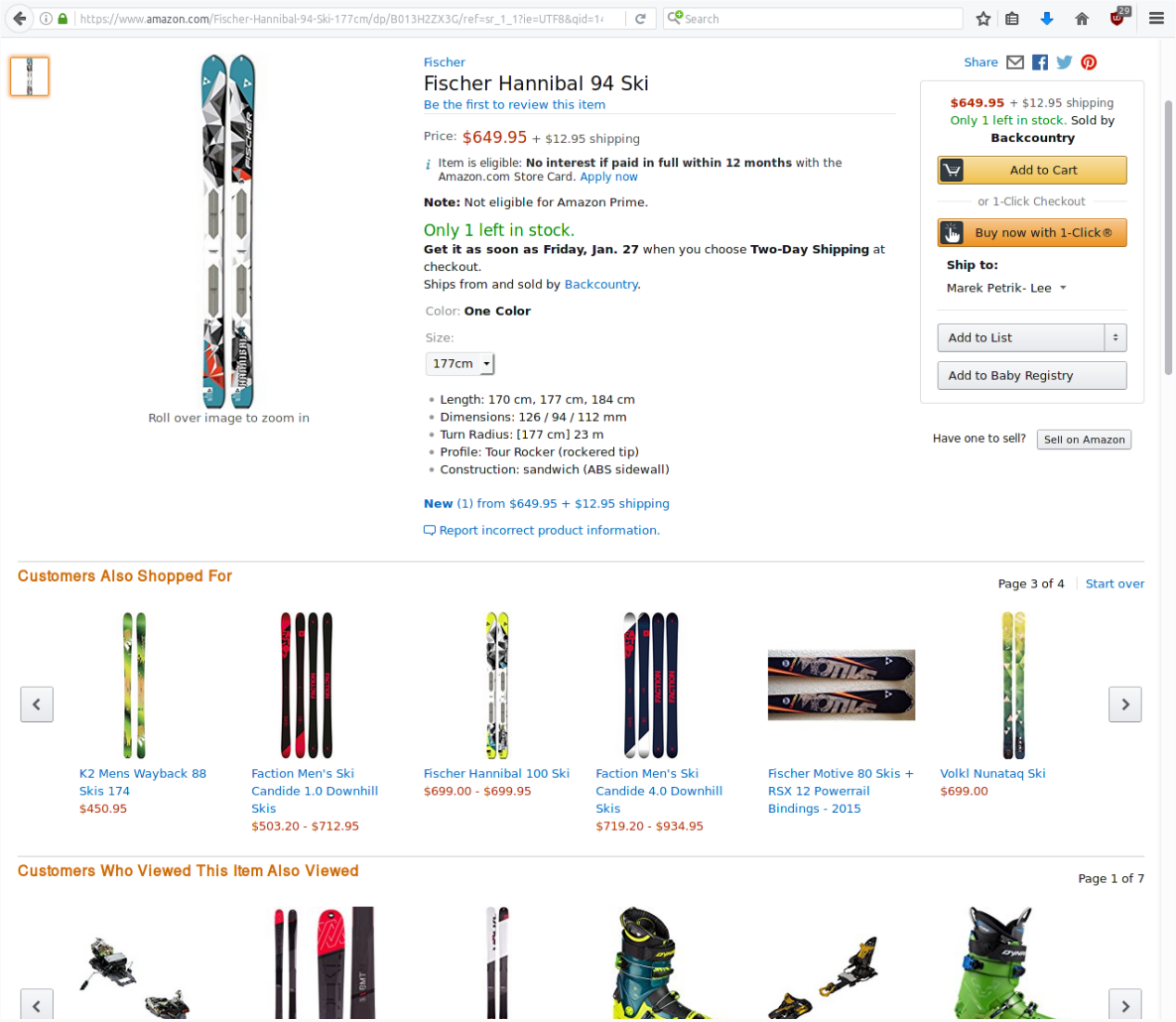
Predicting Elections



https://economist.com

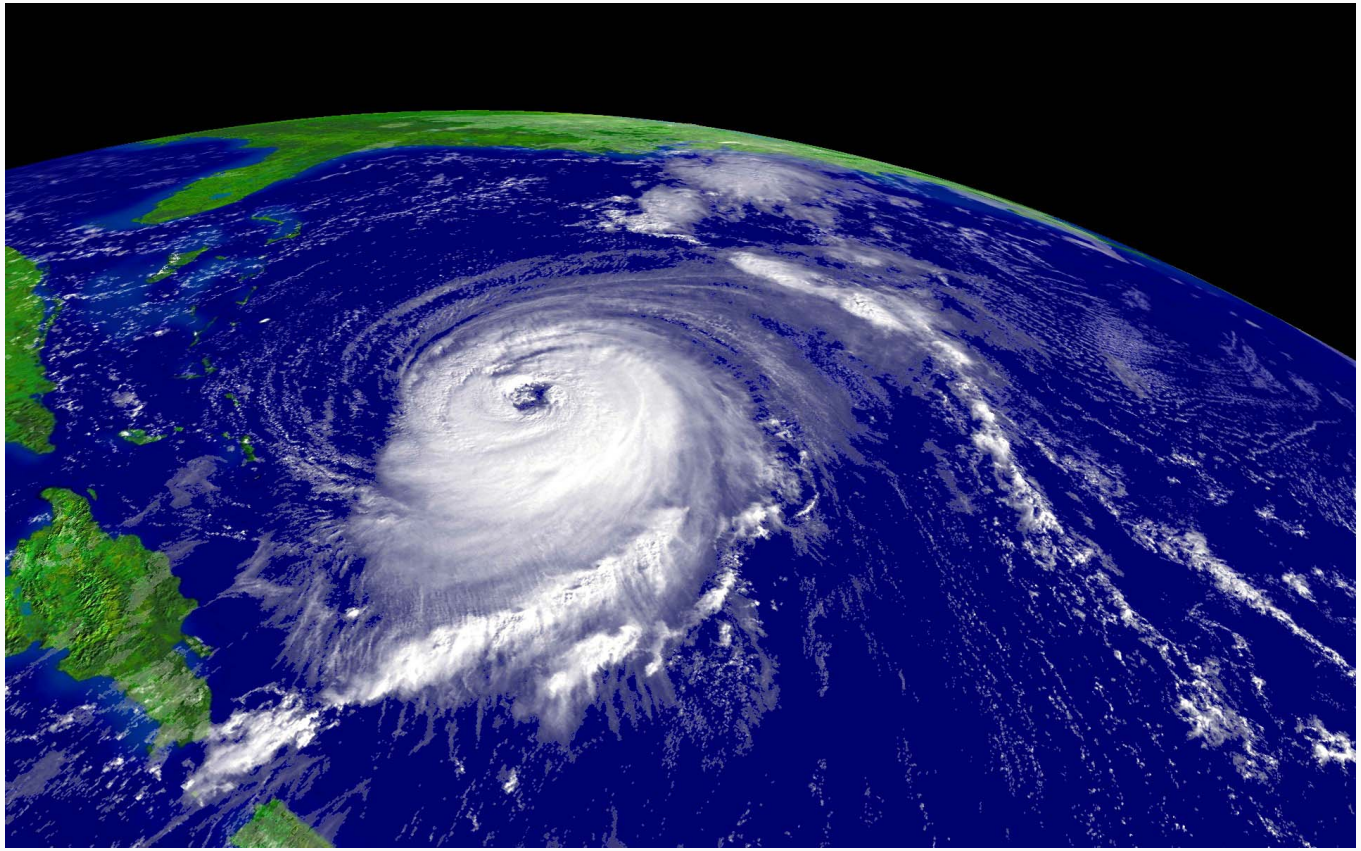
Personalized Product Recommendations

Online retailers mine purchase history to make recommendations



Predicting Strength of Hurricanes

NOAA Models: SHIFOR, SHIPS, DSHIPS, LGEM



Hurricane Isabel, 2003, Source: NOAA.gov

Other Applications

1. Health-care: Identify risks of getting a disease
2. Detect spam in emails
3. Recognize hand-written text
4. Create a fake video (https://www.youtube.com/watch?v=cQ54GDm1eL0)

Any other applications?

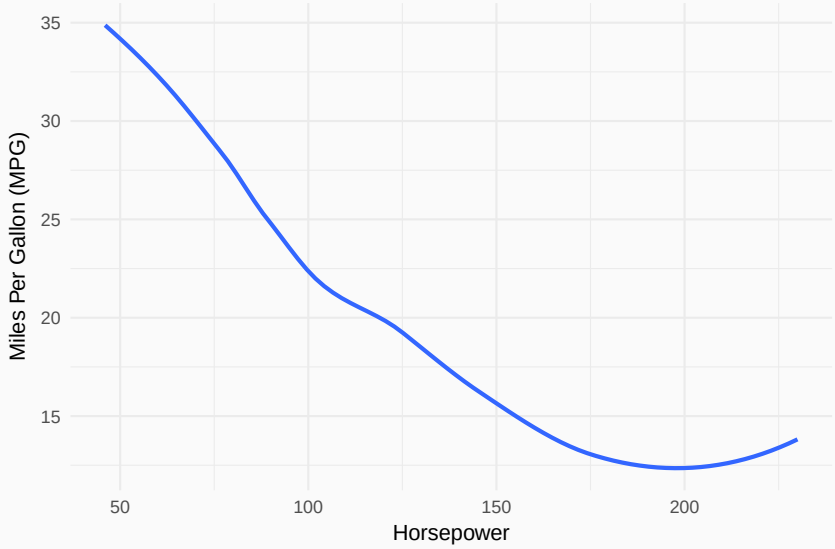
What is Machine Learning

- Discover unknown function f:

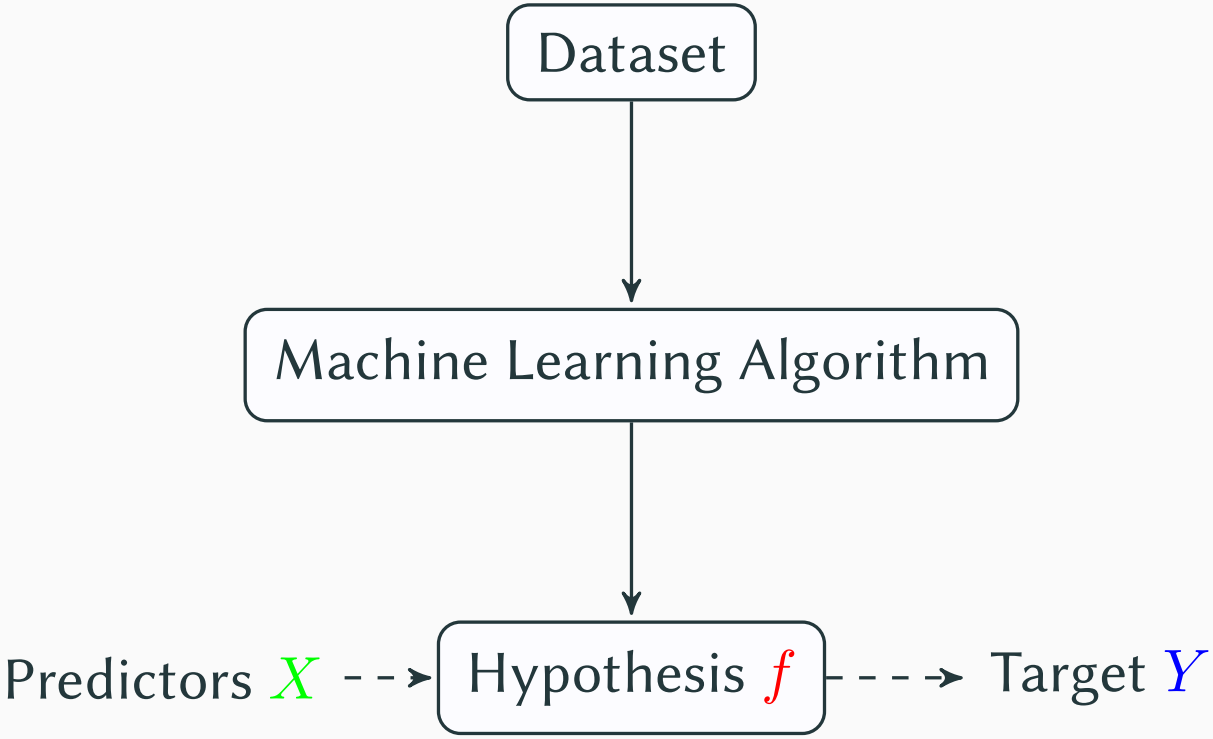
$$Y = f(X)$$

- f = **hypothesis**, or model
- X = **features**, or predictors, or inputs
- Y = **response**, or target

$$\text{MPG} = f(\text{Horsepower})$$



Machine Learning

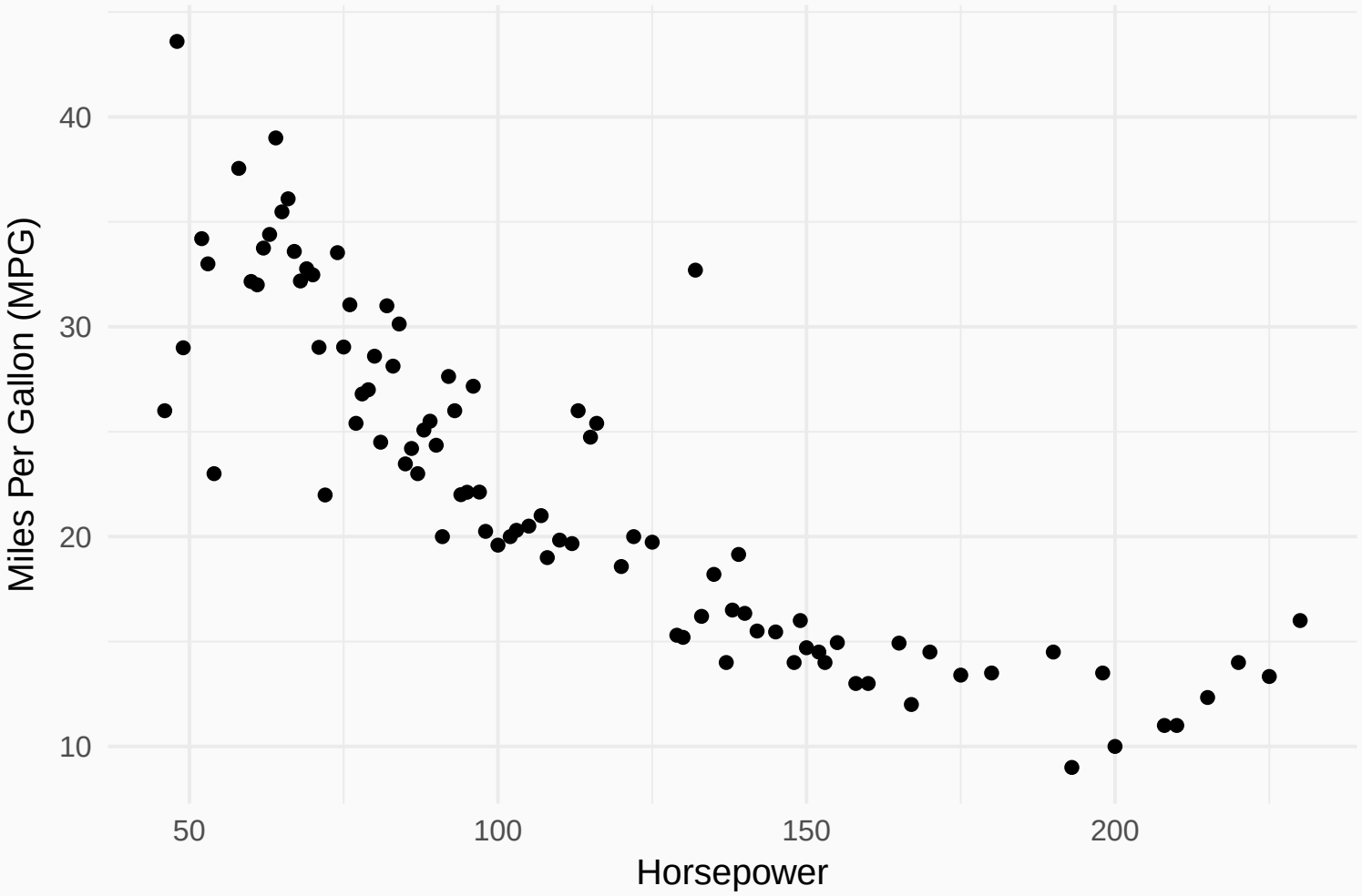


Purpose: Inference or prediction

Auto Dataset

	mpg	horsepower	name
1	18.00	130.00	chevrolet chevelle malibu
2	15.00	165.00	buick skylark 320
3	18.00	150.00	plymouth satellite
4	16.00	150.00	amc rebel sst
5	17.00	140.00	ford torino
6	15.00	198.00	ford galaxie 500
7	14.00	220.00	chevrolet impala
8	14.00	215.00	plymouth fury iii
9	14.00	225.00	pontiac catalina
10	15.00	190.00	amc ambassador dpl
	...	...	...

Auto Dataset



Bayes Classifier

What is the MPG of a car with horsepower = 150?

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Limitation of Bayes Classifier

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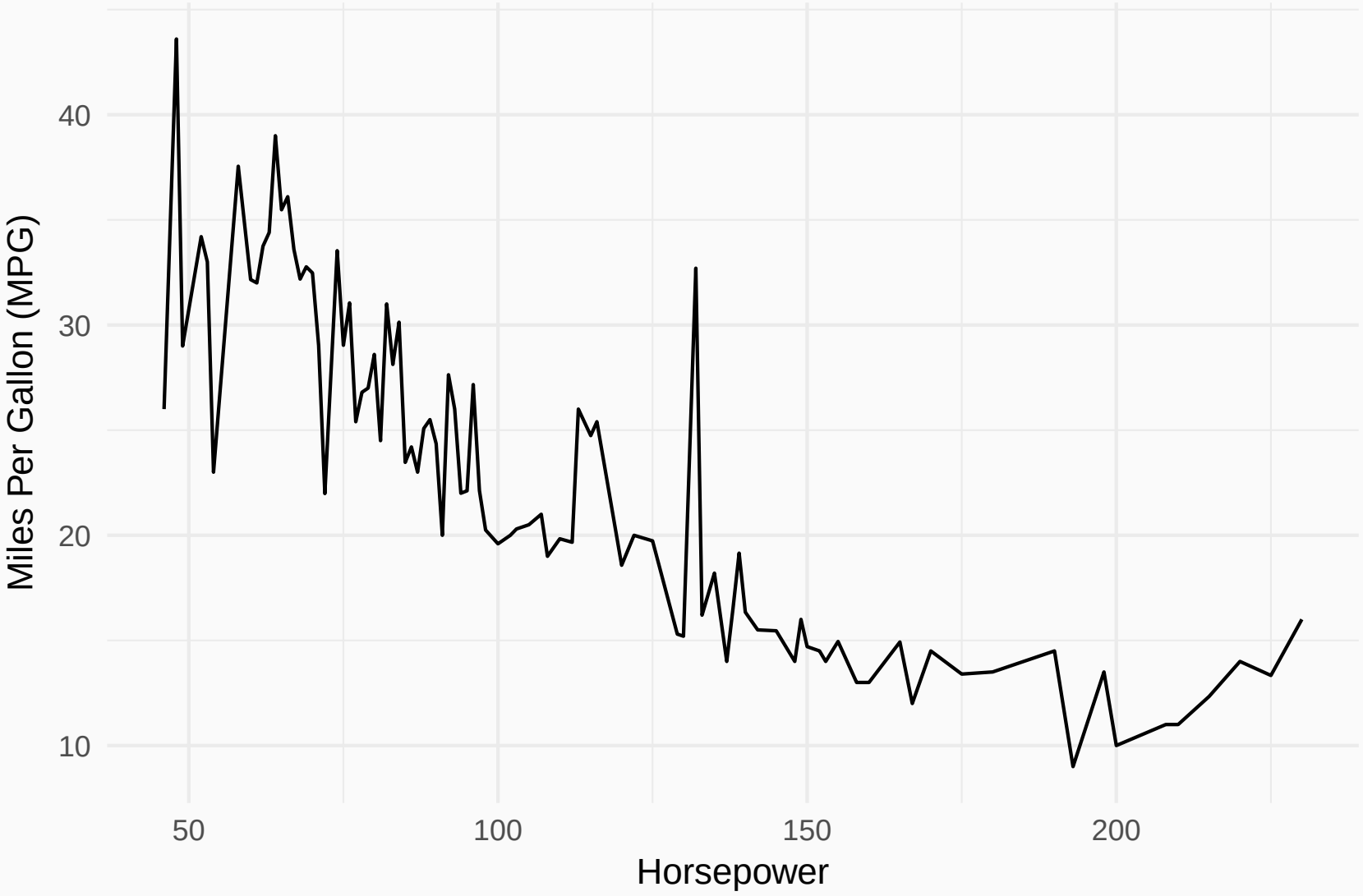
Return the **nearest neighbor**.

Nearest Neighbor Hypothesis



Errors in Machine Learning

Must allow for errors ϵ:

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

1. World is too complex to model precisely
2. Many features are not captured in data sets
3. Datasets are limited

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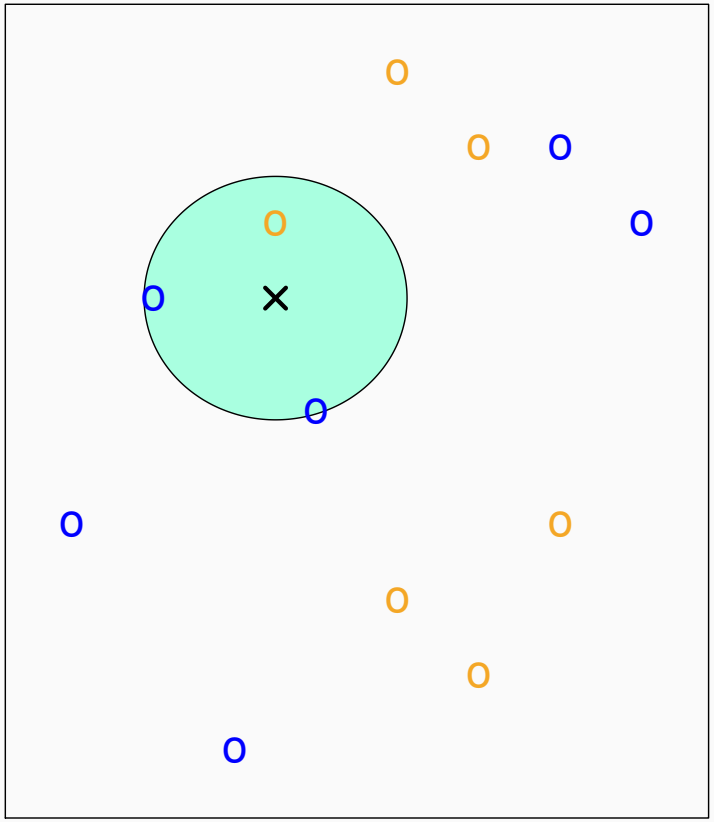
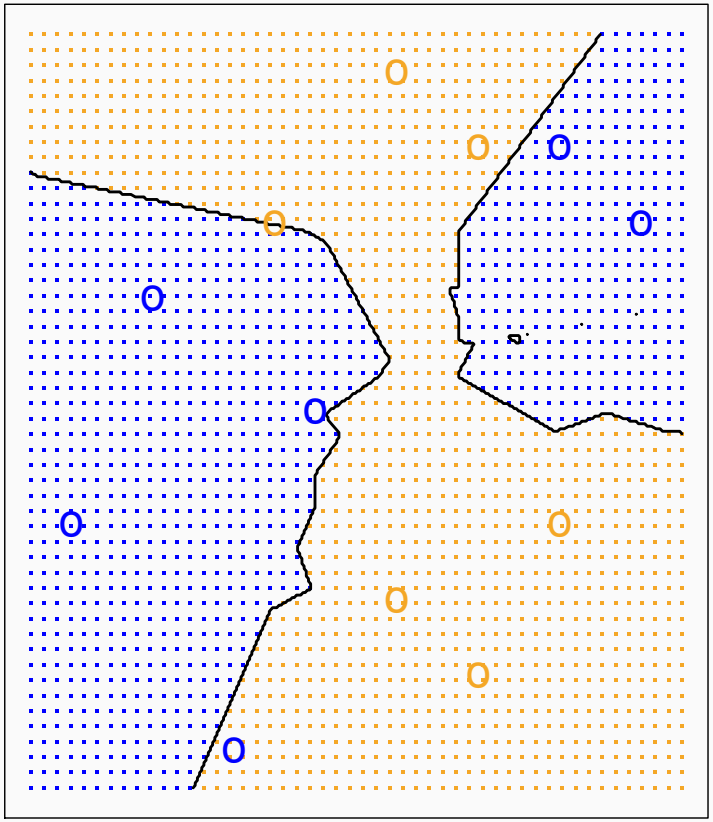
How to reduce prediction errors?

KNN: K-Nearest Neighbors

Idea: Use several similar training points when making predictions. Errors will average out.

Example with 2 features (horsepower, model year)



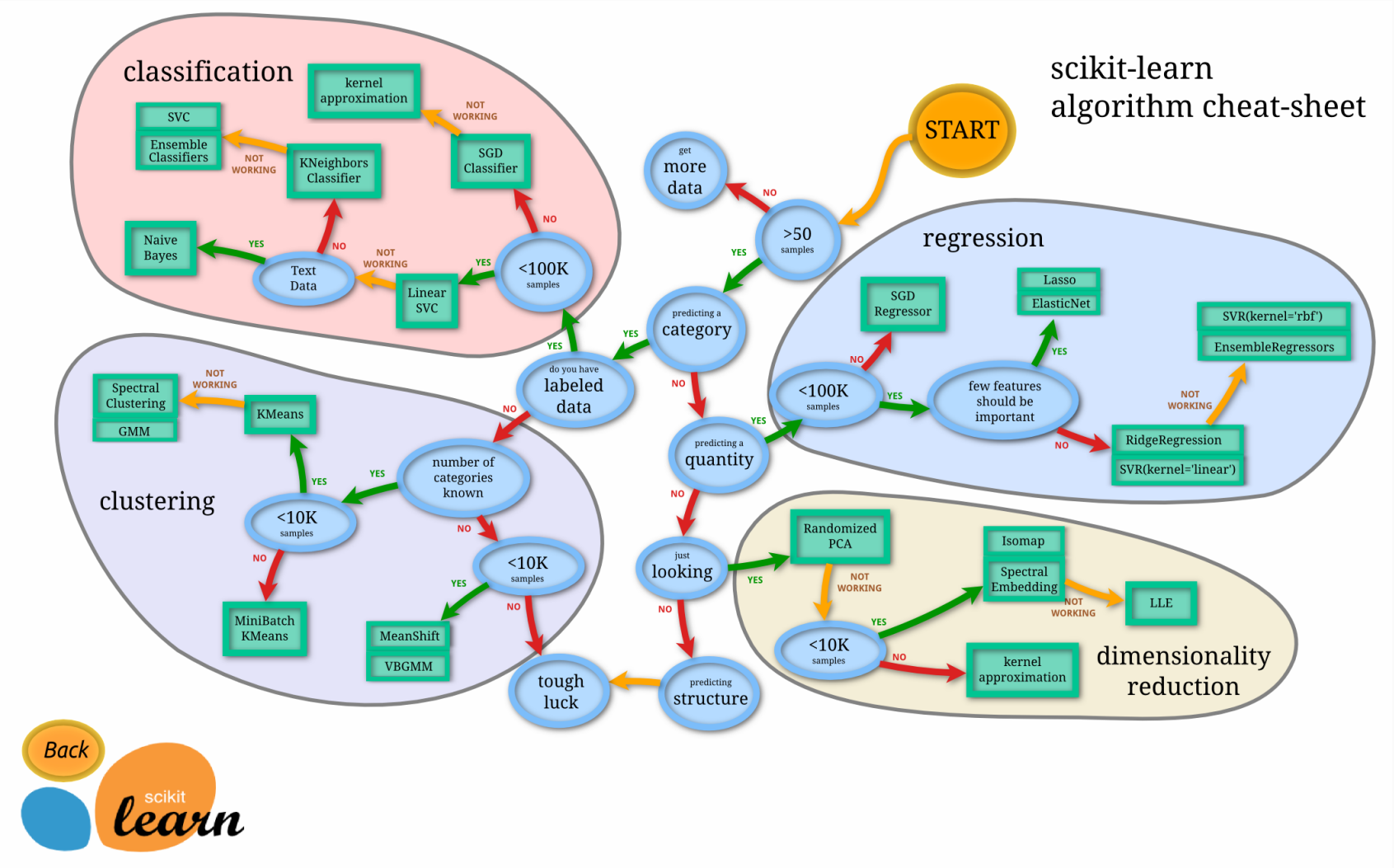


KNN: Effect of different k

Questions ...

- How to choose k?
- Are there better methods?

Machine Learning Choices ...



Source: `http://scikit-learn.org/stable/tutorial/machinelearningmap/index.html`

End of the semester: Know what, when, and why to use, know

This Course: First Steps in Machine Learning

1. **Foundations**: Mathematics necessary to use and understand ML algoirhtms

2. **Algorithms**: Use common ML algorithms

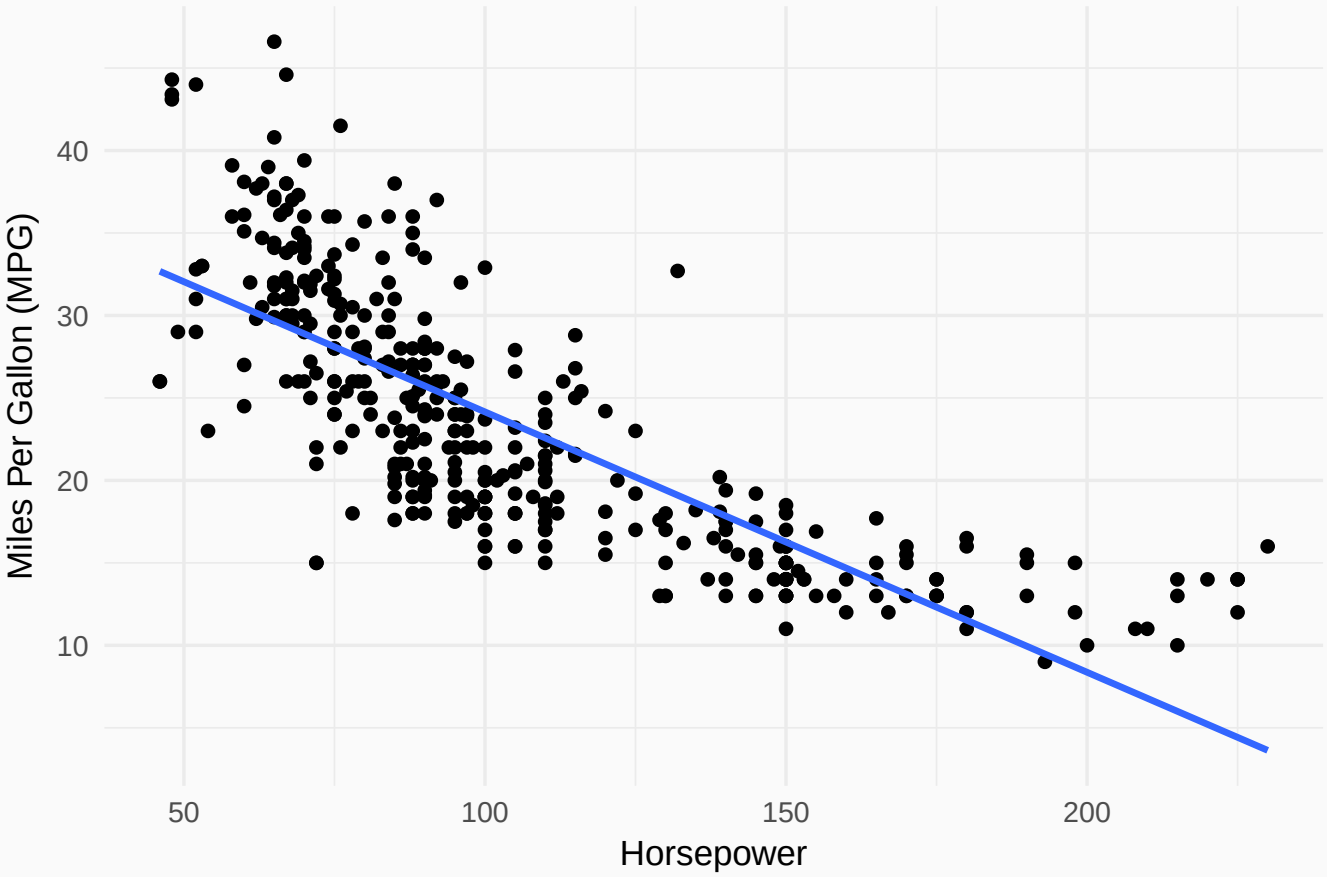
3. **Principles**: Understand when different algorithms are appropriate

4.

Parametric Prediction Methods

Linear regression:

$$\text{MPG} = f(\text{horsepower}) = \beta_0 + \beta_1 \times \text{horsepower}$$



R Language

- Download and install R: `http://cran.r-project.prg`
- Try using RStudio as an R IDE
- *See class website for more info*
- All my R code is in the class git repo
- You can use Python or another language, but at your own risk

Why R (vs Python)

1. Language syntax particularly suitable for manipulating tabular data
2. Better-quality packages at `cran.r-project.org` than `pypi.org`
3. Excellent data manipulation and visualization tools: dplyr, ggplot, tidyverse, better than python versions like pandas, matplotlib
4. R-notebooks more flexible and git-friendly than Jupyter
5. Shiny: a neat web framework to create simple web data interface
6. Rcpp: convenient interface with C++
7. Easier to install and use particularly on Windows/Mac

Why Python (vs R)

1. It is popular
2. Better general programming language, good support for data structures
3. Better support for numerical algebra: numpy, scipy,
4. Much better support for deep learning: tensor flow, keras
5. Clean syntax

Logistics

- **Website**: (get there through mycourses) `https://gitlab.cs.unh.edu/carton/ml-fall2025`
- **Grading**: See website
- **Assignments**: posted on myCourses at least a week in advance
- **Questions**: myCourses Discussion
- **Programming language**: R, Python