

## ML Week 0x01a Introduction

Some preliminaries

- English
- This is an introduction. There's so much more.
- None of this gives quick fixes. Some is quicker than others.
- The goal is to play with data.
- It's important to see examples.

What is ML?

1. Some algorithms we know how to write
  - (a) Sort numbers
  - (b) Fly a plane
2. Some algorithms we don't know how to write (example: drive a car)
  - (a) Drive a car
  - (b) Read addresses on envelopes
  - (c) Detect spam
3. Maybe we can write programs to write programs when we can't
4. Some things we used to say
  - Artificial intelligence
  - Expert systems

Types of ML

1. Supervised
  - (a) Training data: input and correct responses
  - (b) Regression (continuous) (example: home prices)
  - (c) Classification (discrete) (example: medical outcome (alive/dead))

2. Unsupervised

- (a) Clustering
- (b) Deep neural networks
- (c) Associative (example: human experience, e.g. from a career)
- (d) Dimensionality reduction

3. Reinforcement

- (a) Make a choice, get feedback
- (b) Online
- (c) Can be stochastic (example: predicting weather from local clues)

Curse of Dimensionality

- 1. *Fléau (ou : malédiction) de la dimension*
- 2. Volume of unit cube  $\pm \epsilon$
- 3. Distance from  $(0, 0, \dots, 0)$  to  $(1, 1, \dots, 1)$
- 4. Physics:  $1/r^{d-1}$
- 5. It's easy to get lost...
- 6. Richard Ernest Bellman, Dynamic programming, Princeton University Press, 1957.

Probability

- 1. Event
- 2. Complement of an event
- 3. Disjoint (mutually exclusive)
- 4. Independent events — knowing one outcome gives no information about other
- 5. addition ( $\times 2$ ), multiplication ( $\times 2$ )
- 6. Conditional probability
- 7. Marginal probability
- 8. Joint probability

## Statistics

1. Goal for a bit: think like a statistician
2. What is statistics? ( $\times 3$ )
3. Said differently: goal is to compare reality to a model
4. Or to find a model and then compare.
5. Good statistical models are often relatively simple.
6. What is data science ( $\times 5$ )

## Study design

1. Anecdote
2. Study types ( $\times 2$ )
3. Observational studies can't conclude causality
4. Observational studies can be
  - prospective: identify individuals, collect information
  - retrospective
  - we can combine them
5. Experimental studies
  - We do stuff
  - Can conclude causation if properly designed
    - controlling: hold other variables constant (e.g., drink pill with full glass of water even if we don't care)
    - randomization: cancel out effects we can't control
    - replication: enough participants
6. Study types example
  - Sunscreen use correlated to skin cancer rates.
  - Confounding variable
7. Random sampling hazards
  - Not actually random

- Convenience sample
- Non-response bias

## Statistical concepts

### 1. Variable types

- Input: Features
- Input variables measure: Explanatory variable
- Output: Response variable
- Training set
- Test set (tune parameters) (compare model parameters)
- Validation set (tune hyperparameters) (measure performance of model)
- Cross validation
- Bias - same errors regardless of input (inflexible)
- Variance - different errors with same input (too flexible)

### 2. Population statistics ( $\times 6$ )

- sample mean vs population mean ( $\times 7$ )
- Sample standard deviation and variance: divide by  $n - 1$

### 3. Distributions

- Important: pdf (pmf), cdf, ppf ( $\times 5$ )
  - pdf = densité de probabilité
  - pmf = fonction de masse
  - cdf = fonction de répartition
  - ppf = ?
- The rest: just so you've heard of them
- Boxplot ( $\times 2$ )

### 4. Normal distributions ( $\times 2$ )

- Sample mean vs population mean
- How close are they?
- Point estimate: if you have to guess, this is it
- Correction: if I want to be on average weighted right as much possible

5. Sampling distributions ( $\times 3$ )

- Sampling mean is unimodal and approximately symmetric
- It is centred at population mean.
- The standard deviation of the sample mean tells us how far a point sample's mean is likely to be from the population mean. In other words, how much error we are likely to have in the point estimate's mean. **Standard error.**
- TODO: Generate uniform population, sample, and plot sampling distribution
- TODO Generate highly skewed population, sample, and plot sampling distribution
- In real life, we don't have access to the population parameters. We have to *estimate* them from samples. So we can't *know* the standard error (erreur type).

6. Confidence intervals ( $\times 3$ )

- Sampling is usually expensive.
- Reminder: Independent random samples!
- Correct language: "We are 95% confident that the population parameter is between. . ."
- Incorrect language: describe the confidence interval as capturing the population parameter with a certain probability.
- This is one of the most common errors: while it might be useful to think of it as a probability, the confidence level only quantifies how plausible it is that the parameter is in the interval.
- Another especially important consideration of confidence intervals is that they only try to capture the population parameter. Our intervals say *nothing* about the confidence of
  - capturing individual observations
  - a proportion of the observations
  - about capturing point estimates

Confidence intervals only attempt to capture population parameters.