

Introduction

Statistical Methods for Data Science

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- What is *data*?
- Why do we need to do *data science*?
- Why *statistical methods*?



What is data?

Images of you...



image from <https://en.wikipedia.org/wiki/Pedestrian>



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What is data?

Movies you have watched...

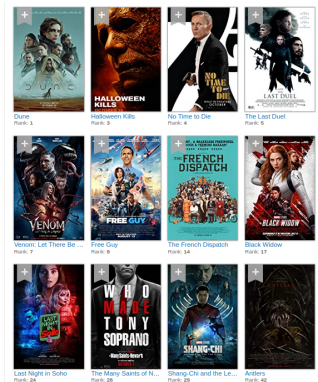


image from <https://www.imdb.com>



What is data?

Places you have been...

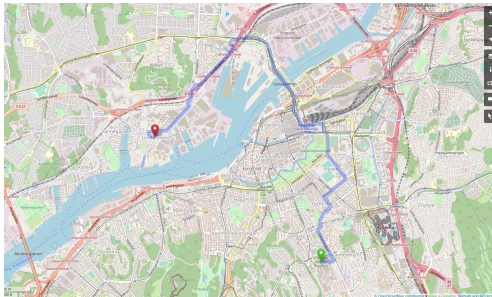


image from <https://www.openstreetmap.org>



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What is data?

- Data is everywhere
- Our personal data is being collected as we speak
- Our behaviors are being **explored**, **modeled** and **predicted** using data
- We are constantly refreshing our social media feed ... and now there is ChatGPT
- We are not in control anymore
- ChatGPT knows you better than you know yourself



Why do we need to do data science?

- Learning what to do with data is to empower yourself
- Taking back control
- Controlling others - don't do that
- Using data for good

Is it even optional?



Why statistical methods?

- Data is random
- We are bad at keeping track of random things
 - What was the temperature *every day* in 2022? 🐱
- We use summaries instead
 - What was the *average* temperature in 2022? 🐱

Statistical methods



What is this course NOT about?

- Hardcore probability theory course

What is σ -algebra?

Definition 1.2 (σ -algebra) A class of sets $\mathcal{A} \subset 2^\Omega$ is called a σ -algebra if it fulfills the following three conditions:

- (i) $\Omega \in \mathcal{A}$.
- (ii) \mathcal{A} is closed under complements.
- (iii) \mathcal{A} is closed under countable unions.



Source: Klenke, Achim. Probability theory: a comprehensive course. Springer Science & Business Media, 2013.

- Introductory statistics course

2. A box contains four black pieces of cloth, two striped pieces, and six dotted pieces. A piece is selected randomly and then placed back in the box. A second piece is selected randomly. What is the probability that:

- a. both pieces are dotted?
- b. the first piece is black and the second piece is dotted?
- c. one piece is black and one piece is striped?



Source: Lee, Yong-Gu, and Sam-Yong Kim. Introduction to statistics. Yulgokbooks, Korea (2008): 342-351.

- Pure machine learning course



Support Vector Machines, Decision Trees,

Convolutional Neural Networks, Transformers



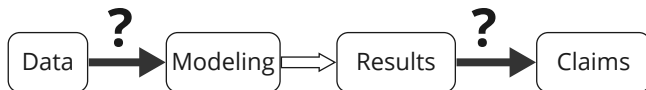
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Two foci:

- What to do with data
- How to regulate your data-related claims



In practice, this course is a mixture of probability, statistics and machine learning

Regulate your data-related claims

- You have 3 ducks at home and they weigh 2kg, 5kg, 0.5kg each
- Oof, absolute units
- You feed them a weight loss drug called “duckiphanamin” for a month and now they weigh 1.2kg, 6kg, 0.48kg each

Question! Can you claim that duckiphanamin works?

- How about feeding duckiphanamin to your other 100 ducks? If they all lose 0.5kg each, can you claim duckiphanamin works then?

You should be able to navigate these questions with confidence



- Data collection and engineering
 - Not to be underestimated!
 - Not covered in the course - we work with structured data!
- Communication is important!
 - You never develop in isolation
 - Learn how to communicate efficiently
- Be patient
 - There is a lot to learn
 - Learning can be painful. Hang in there!
- **Do not hesitate to ask questions!!!**



- Information: Canvas
- Lecturer & TAs: can be found on Canvas
- Communication:
 - Email me
 - Ping me on Discord
- Student representatives:
 - Please send me an email this week if you are interested!
 - Otherwise they will be randomly selected
 - Read more about student representatives [here](#)



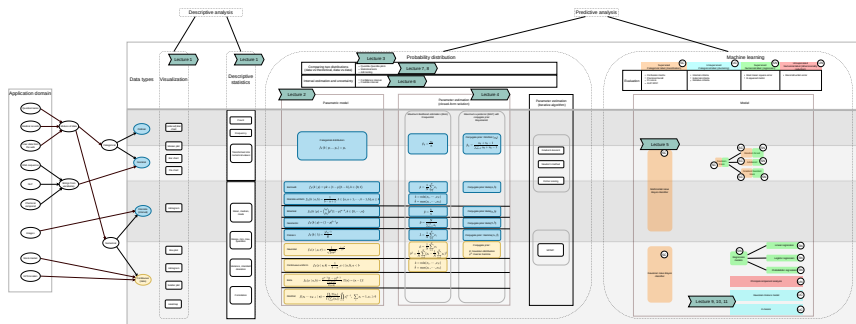
- Composition (100 pts):
 - Homework:
 - 3 assignments (30 pts - 10 pts each)
 - 1 project (10 pts)
 - Exam:
 - 1 oral exam (20 pts)
 - 1 take-home exam (40 pts)
- Grade: U, 3, 4, 5
 - Homework (H):
 - U: if $H < 20$ pts
 - 3: if $20 \text{ pts} \leq H < 30$ pts
 - 4: if $30 \text{ pts} \leq H < 35$ pts
 - 5: if $H \geq 35$ pts
 - Exam (E):
 - U: if $E < 20$ pts
 - 3: if $20 \text{ pts} \leq E < 35$ pts
 - 4: if $35 \text{ pts} \leq E < 50$ pts
 - 5: if $E \geq 50$ pts
 - Final grade: round $((3.5 * \text{grade of H} + 4 * \text{grade of E}) / 7.5)$
- Submission: Canvas

- Homework: group of max. 3 students
- Exam: individual
- Late policy:
 - Homework: 25% penalty for 0-24 hours
 - Exam: strict
- About grouping: try to team up with someone with complementary knowledge and skill sets



- Data types, descriptive statistics, visualization
- Probability distributions
- Modeling, parameter estimation, point estimation, interval estimation
- Hypothesis testing
- Application 1: classification, Naive Bayes classifier
- Application 2: clustering, K-means, Gaussian mixture model

Lecture map to help you keep track of where we are



Programming language and tools

- Programming language: Python
- Interactive environment: Jupyter Notebook



- Libraries
 - Data handling and processing
 - NumPy: efficient mathematical functions
 - Pandas: structured data processing
 - Visualization
 - Matplotlib: plotting library
 - Seaborn: additional statistical plotting functions
 - Statistics
 - SciPy: a Python library for statistics and math in general
 - StatsModels: some more advanced statistical models
 - Machine learning
 - scikit-learn: predictive models and clustering

- Reading materials posted throughout the course



Have fun!

See you on the other s(l)ide(s...)!

