Projects proposition - Winter Semester 2026

1 Muffin or Chihuahua ?

Supervisors: Francesca Pistolato, Luís Maia

Description: Nowadays, deep learning models can solve difficult tasks that would normally require a lot of time for human beings. In this project, we will study the basics of neural networks and implement a model capable of distinguishing between a muffin and a chihuahua.

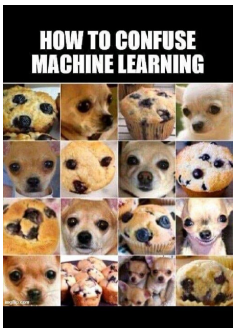

Figure 1: Can you distinguish all of them?

Prerequisites: some Python knowledge
Material:

- "Deep Learning", Chapter 10, from G. James et al., An Introduction to Statistical Learning, with Applications in Python, Springer Texts in Statistics
- Kaggle page "Muffin or Chihuahua"

2 Mathematical Modeling of Voting Systems

Supervisors: Francesca Pistolato, Luís Maia

Description: Study the basics about Theory of Voting. After that, focus on two apportionment method for allocating seats in a parliament and study their characteristics and differences. In the next step, both methods will be implemented computationally. Finally, simulations will be used to compare their proportionality and to explore how outcomes change under different voting system characteristics (varying number of seats, legal thresholds, comparing two-party versus multi-party systems,...)

Prerequisites: some Python (or other programming language) knowledge
Material:

- `https://www.cambridge.org/files/5015/1077/0783/9781107060432AR_final3.pdf`, Chapter 2
- `https://www.youtube.com/watch?v=sJcqNEyTUwg`
- `https://en.wikipedia.org/wiki/Mathematics_of_apportionment`

3 Simulation of Gaussian Random Functions

Supervisors: Felix Benning, Francesca Pistolato, Luís Maia

Description: We want to simulate random functions and plot random functions from $\mathbb{R}^2$ to $\mathbb{R}$ as random landscapes. A random function from domain X into $\mathbb{R}$ is a collection of random variables $(f(x))_{x \in X}$ in $\mathbb{R}$. A Gaussian random function assumes every finite collection of these function values is multivariate Gaussian. Given a covariance function we will implement a simulation of centered Gaussian random functions and compare different approaches.

Prerequisites: Multivariate Gaussian distribution, some Python (numpy+plotting) knowledge.

Material:

- Gaussian vector sampling (from covariance matrix) `https://epubs.siam.org/doi/abs/10.1137/20M1371026`
- Turning band method (Section 4): `https://www.cambridge.org/core/journals/advances-in-applied-probab article/intrinsic-random-functions-and-their-applications/F73CA4908E19CFBAA2026ED1F1E17304`
- Karhunen–Loève (if time allows, theory e.g. in Adler/Taylor 2007)