UFMG/ICEx/DCC
Information Theory
1st semester of 2024

Prof: Mário S. Alvim

**Instructions Regarding the Seminar**

**General goals**

- All students have to investigate a new topic on Information Theory, or explore more deeply a topic on Information Theory covered in the course, understanding its fundamentals and possible applications, and communicating their discoveries to their colleagues in class.
- **Graduate students** are encouraged, when possible, to apply the knowledge obtained in the course to some aspect of their research, be it directly related to their thesis/dissertation or not.
- Everyone should have some fun investigating new and intriguing subjects! ☺

**Organization and evaluation**

- Seminars will be presented by groups as follows:
  - **Graduate students** will work groups of 1 student each (i.e., they will work individually).
  - **Undergraduate students** must form groups of 2 or 3 students.
- The seminar is worth 25 marks distributed as follows:
  1. A **written report**, in the format of a short paper with **at most 4 pages** (excuding bibliographic references), **single column**, **font size of 11pt**. You are **strongly encouraged to use LaTeX**, and if you do so, **use the SBC template for papers available here**: `http://www.sbc.org.br/documentos-da-sbc/summary/169-templates-para-artigos-e-capitulos-de-livros/878-modelosparapublicaodeartigos`. **(7 marks)**
  2. An **lightning oral presentation** in class, with duration of at most 8 minutes, followed by 5 minutes dedicated to questions and discussion (time constraints may vary depending on the number of students enrolled for the seminar). **(18 marks)**
- Both the written report and the lightning oral presentation will be evaluated according to:
  1. depth and relevance of the students' coverage of the topic,
  2. clarity and conciseness, and
  3. ability to communicate to your peers the knowledge you acquired.
- Important remarks:
  - In the written report the students must use **their own words** to explain the topics studied. Any plagiarism detected will be severely punished. ChatGPT and similar AI tools are not allowed.
  - All students must be present at every other students' presentations. Students who skip a colleague's presentation without a valid justification will have their grade reduced.

**Suggested topics**

- **Graduate students** are encouraged to apply the knowledge obtained in the course to a problem in their research area. A great seminar would ideally lead to a formal modeling or to a solution in terms of information theory of some problem in the student's thesis/dissertation.
- If you cannot directly apply Information Theory to your research problem quite yet (or if you are not a Graduate student with a research problem to begin with), an alternative is to choose relevant papers on your area of interest that use Information Theory and understand why and how they do it, explaining the advantages and shortcomings of their approach.

  E.g.: How is Information Theory used in Machine Learning, Security and Privacy, Pattern Recognition, Robotics, Artificial Intelligence, etc.? What information measures are used? Do the measures chosen really capture the intuitive notion of "information" in that specific problem? Is the concept of a information-theoretic channel used in their modeling? Etc...
- If you believe that what you need from Information Theory to apply to your area of interested was not yet covered in this course (the course will still go on for a couple of months), an option for your seminar is study a topic on Information Theory and report on it. Table 1 contains a list of suggestions for topics. **This list is not exhaustive:** you may propose your own topic!

**Important dates**

| Task | Due date | Observations |
|---|---|---|
| **Inform the professor about chosen groups and topics** | **Before 10:00 AM of May 06th 2024** | • One member per group must fill in the form<br>https://forms.gle/ya9s45j39UnrEH8E9,<br>before the deadline, informing:<br>a) the group members (E.g.: Ana Alves, Breno Brito, Clara Campos);<br>b) in case the group wants to choose from the table of suggested topics, inform a list of priorities ordered from the most preferable topic to the least preferable one: (E.g.: B A D E C G I H J F).<br>• Ties, if any, will be broken using the group's grades so far in this course. |
| **Discussions about topics** | **May 09th 2024 in my office at DCC or via online meetings / June 25th 2024 in class** | • This is the time for groups to discuss their topics with the professor.<br>• In this day the order of presentation among groups will be defined. |
| **Submission of written report** | **Before 10:00 PM of July 21st 2024** | • One member per group must submit the report in PDF format via Moodle. |
| **Lightning oral presentations** | **July 16th, 18th, 23rd, and 25th 2024 during class** | • Presentation days will be defined randomly.<br>• After you present we'll have some time for some questions & answers. |

| MacKay's book | |
|---|---|
| **Chapter 10** | The Noisy-Channel Coding Theorem |
| **Chapter 11** | Error-Correcting codes and Real Channels |
| **Chapter 12** | Hash Codes: Codes for Effcient Information Retrieval |
| **Chapter 13** | Binary Codes |
| **Chapter 14** | Very Good Linear Codes Exist |
| **Chapter 16** | Message Passing |
| **Chapter 17** | Communication over Constrained Noiseless Channels |
| **Chapter 18** | Crosswords and Codebreaking |
| **Chapter 19** | Why have Sex? Information Acquisition and Evolution |
| **Chapter 28** | Model Comparison and Occam's Razor |
| **Chapter 41** | Learning as Inference |
| **Chapter 47** | Sparse Graph Codes: Low-Density Parity-Check Codes |
| **Chapter 48** | Sparse Graph Codes: Convolutional Codes and Turbo Codes |
| **Chapter 49** | Sparse Graph Codes: Repeat-Accumulate Codes |
| **Chapter 50** | Sparse Graph Codes: Digital Fountain Codes |
| **Cover & Thomas** | |
| **Chapter 04** | Entropy Rates of a Stochastic Process (Markov Chains, Entropy rate of a random walk on a Weighted Graph, Second Law of Thermodynamics, etc.) |
| **Chapter 05** | Gambling and Data Compression (Gambling and Side Information, The Entropy of English, etc.) |
| **Chapter 14** | Kolmogorov Complexity (The number $\Omega$, Universal Gambling, Occam's Razor, Universal Probability, the Minimum Description Length Principle, etc.) |
| **Chapter 16** | Information Theory and Portfolio Theory (The Stock Market, Investiment in Stationary Markets, etc.) |

Table 1: Suggested topics for the seminar. This list is not exhaustive: you may propose your own topic of interest.