INF721

2024/2

UFV

# Deep Learning

## L1: Introduction

# Lecture Outline

- Instructor and students
- Motivation
- Syllabus

# Professor

## Lucas N. Ferreira

Pós-doc at the University of Alberta (Amii)

PhD in Computer Science, University of California, Santa Cruz

## Artificial Intelligence & Criativity

Music Generation, Procedural Content Generation, Game AI

## Contact

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# Students

My name is ...

I am a *[first, second...]* year *[undergrad, masters, phd]* student in *[computer science, physics, ...]*

I am taking this course because ...

Algorithms are traditionally implemented as concrete **functions**

$y = f(x)$

# Problem 1: double a number

$$f(8) = 16$$

$$f(24) = 48$$

Pr ber

**Solution**

$$f(x) = 2 * x$$

# Problem 2: shortest path

f(Viçosa, Belo Horizonte) = Viçosa
Teixeiras
Ponte Nova
Ouro Preto
Belo Horizonte

# Problem 2: shortest path

f(Viçosa, Belo Horizonte) = Viçosa

**Solution**

Dijsktra's Algorithm
Bellman-Ford
Floyd-Warshall

Belo Horizonte

# Problem 3: image classification

f(  ) = Cat

f(  ) = Dog

# Problem 3: image classification

f( 

**Solution**

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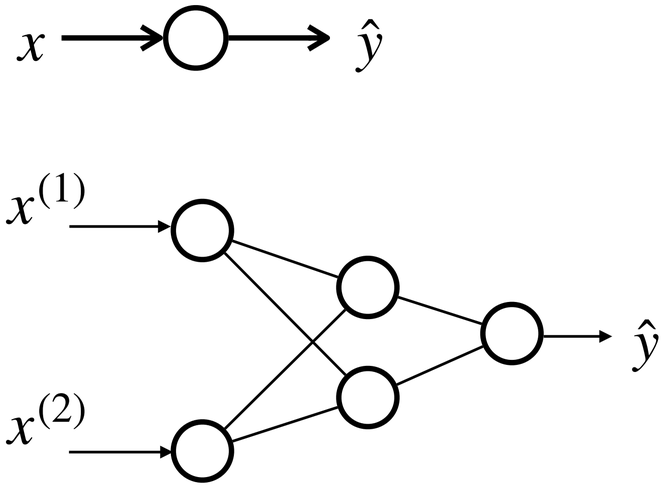
🤔

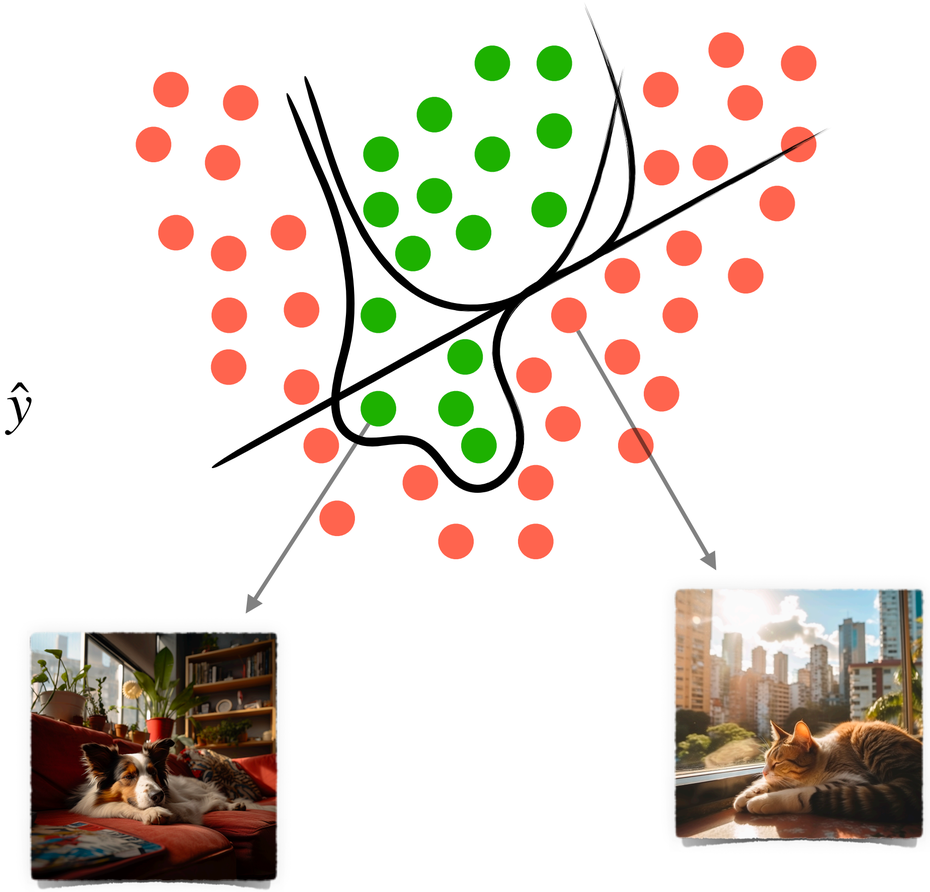
f(  ) = Dog

The goal of **Machine Learning** is to find a function from experience (data) to perform a particular task

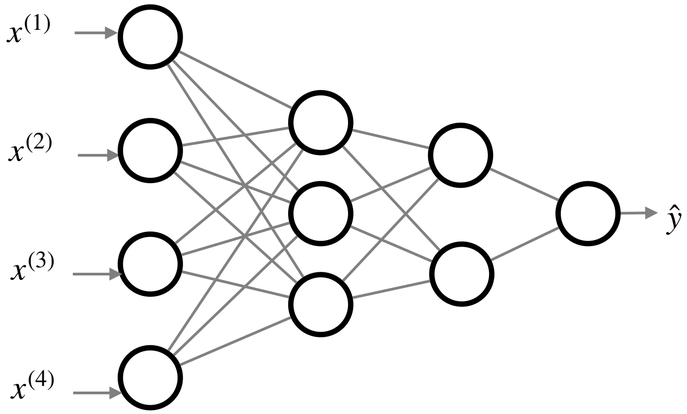
# Neural Networks

## Shallow Networks



## Deep Neural Networks

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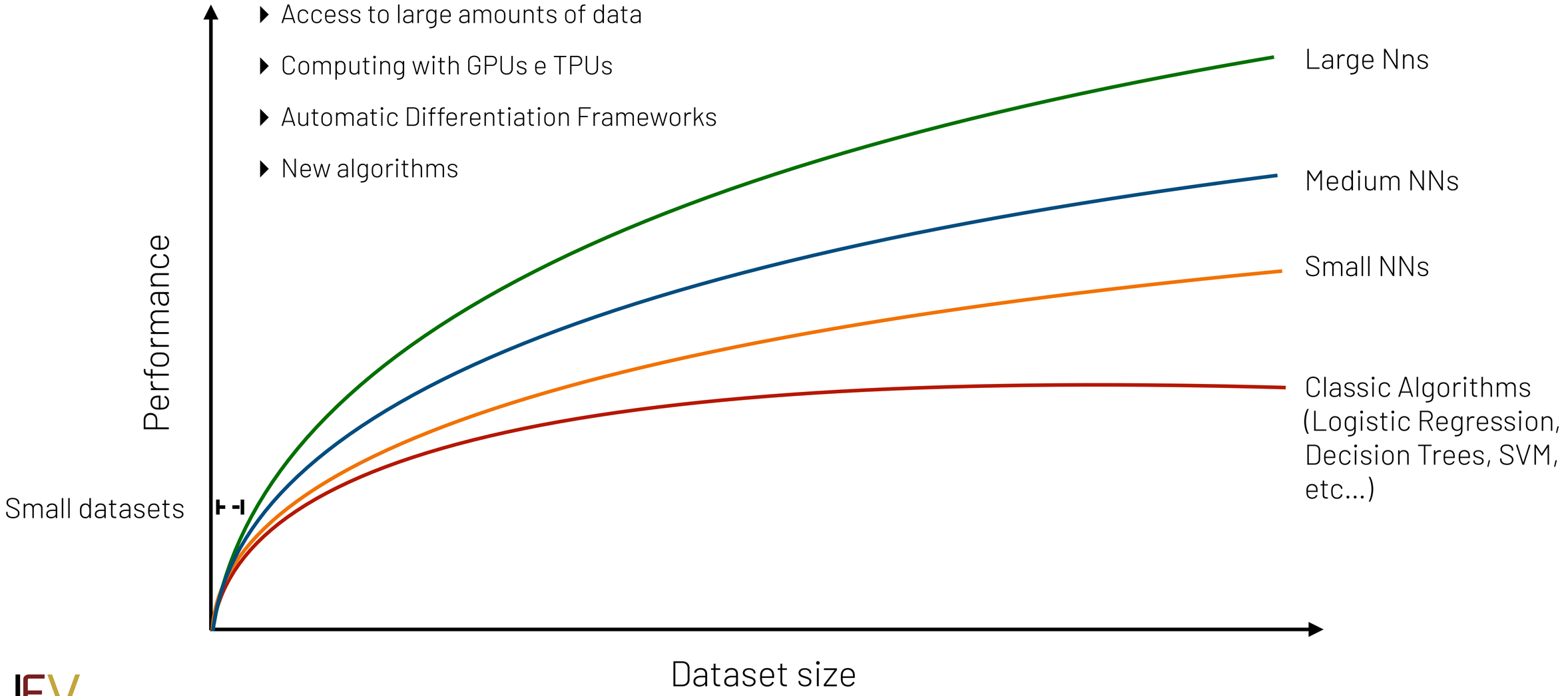
# The Neural Networks (NNs) success



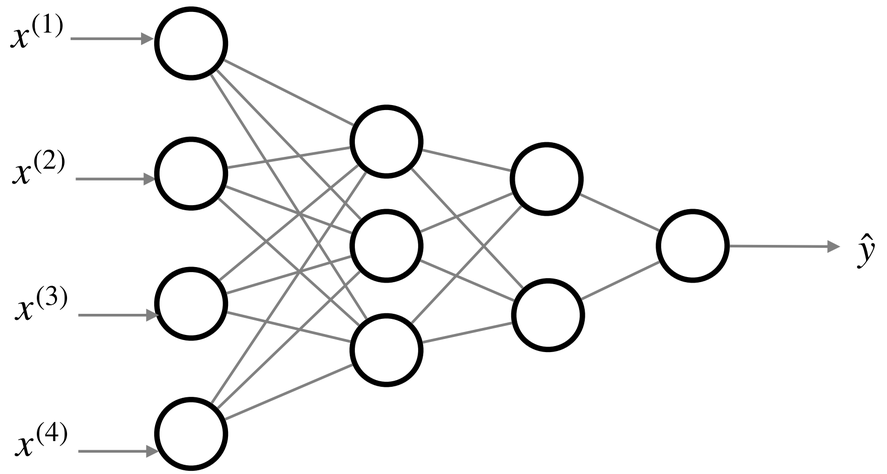
# This course

*This course introduces students to the fundamentals and modern techniques of Deep Learning, aiming at enabling students to design and implement deep neural networks for classification, regression, and generation of unstructured data.*

# Content

## 1. Neural Network Fundamentals

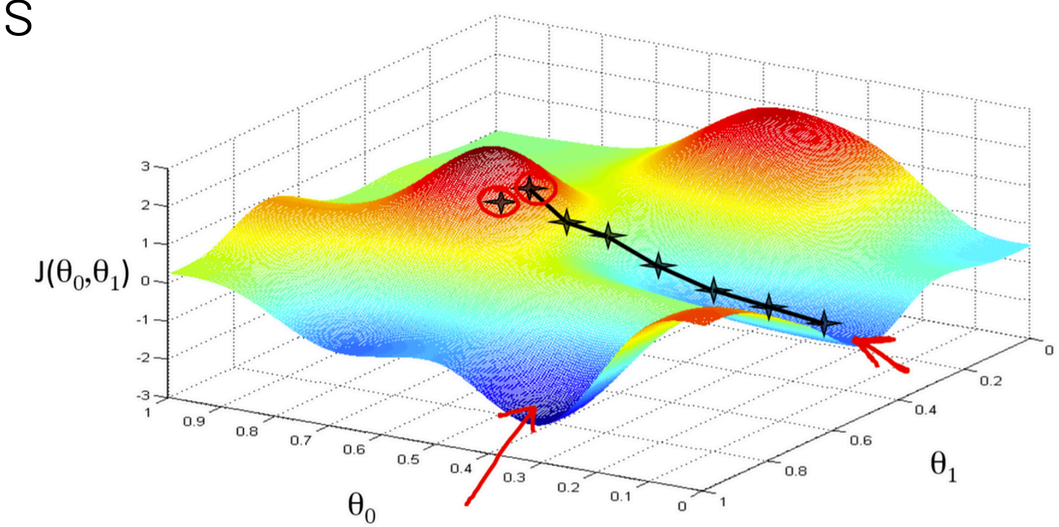
- Machine Learning
- Linear Models
- Gradient Descent
- Multilayer Perceptron (MLP)
- Backpropagation
- Numpy implementations



# Content

## 2. Improving Neural Networks Performance

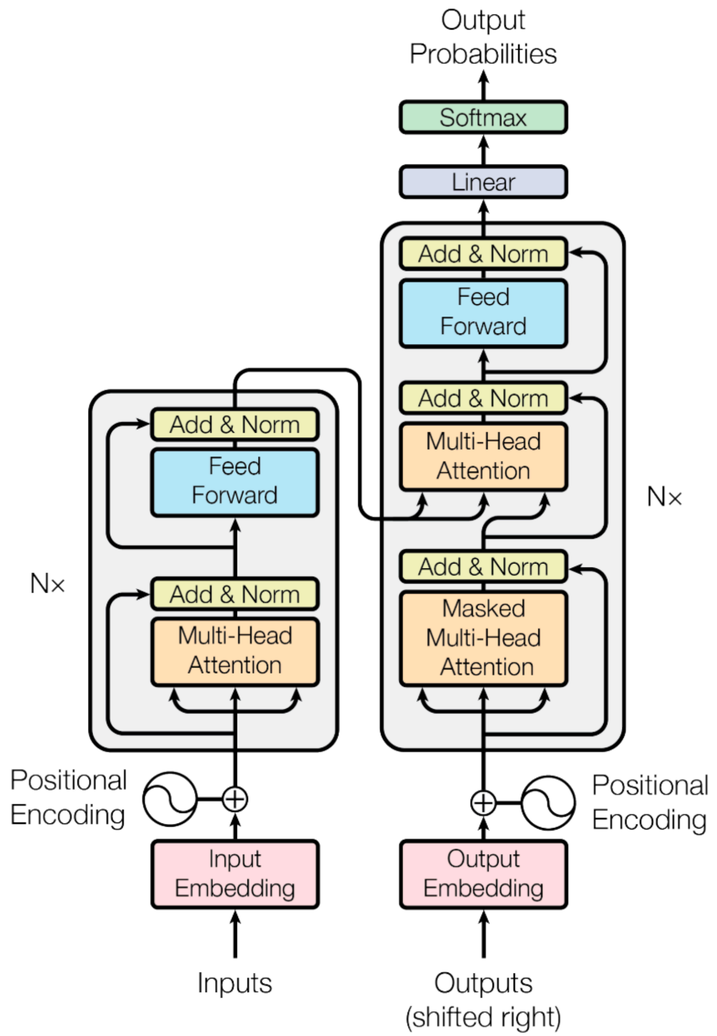
- Regularization
- Normalization
- Advanced Optimization Algorithms
- Hyperparamenters Tunning
- Autograd



# Content

## 3. Advanced Arquitectures

- Convolutional Neural Networks
- Recurrent Neural Networks
- Transformers
- Case Studies
- Transfer Learning
- Pytorch Implementation



# Content

## 4. Generative AI

- Generative Adversarial Networks
- Autoregressive Models
- Variational Autoencoders
- Difusion Models

"Realistic photo of a dog sleeping on the couch in an apartment; books and plants in the background.", **Midjourney**

# Prerequisites

**INF213: Data Structures**

- Python programming
- Basic data structures and their associated algorithms

**MAT135: Analytic Geometry and Linear Algebra**

- Basic operations with vectors and matrices

**MAT140: Calculus I**

- Derivatives of composite and multivariate functions

# Grading

- Exams (40%)
- Programming Assignments (40%)
- Final Project (20%)

# Exams

A list of (mostly multiple choice) questions taken **individually** in the classroom with a duration of 1:40h

- Midterm Exam 1
- Midterm Exam 2

**Make up exams**

- If you can’t take an exam for any personal reason, let the instructor know in advance so we can schedule a make up exam

# Programming Assignments

Implementing neural networks in Python and Jupyter Notebook using pre-defined classic datasets, with a duration of 1.5 weeks.

- P1: Logistic Regression
- P2: Multilayer Perceptron
- P3: Convolutional Neural Networks
- P4: Recurrent Neural Networks

**Late Policy**

- 15% penalization for each day late
- Max of 2 days late per assing

# Final Project

Proposal, implementation, and evaluation of a transformer model for a learning problem of interest to the students, conducted individually or in pairs, with an approximate duration of 4 weeks.

- FP1: Project Proposal
- FP2: Project Implementation
- FP3: Project Presentation

# Schedule

| Week | Date | Lecture | Programming Assignment |
|---|---|---|---|
| 1 | 09/09 | 1. Introdution | |
| | 11/09 | 2. Linear Models | |
| 2 | 16/09 | 3. Gradient Descent | **PA1: Logistic Regression** |
| | 18/09 | 4. Evaluting Neural Networks | |
| 3 | 23/09 | 5. MLP I | |
| | 25/09 | 6. MLP II | **PA2: Multilayer Perceptron** |
| 4 | 30/09 | 7. Advanced Optimization Algorithms | |
| | 02/10 | 8. Regularization and Normalization | |
| 5 | 07/10 | 9: Hyperparameter Tunning | |
| | 09/10 | **Midterm Exam I** | |
| 6 | 14/10 | 10. CNNs I | **PA3: Convolutional Neural Networks** |
| | 16/10 | 11. CNNs II | |
| 7 | 21/10 | 12. RNNs I | |
| | 23/10 | 13. RNNs II | |

# Schedule

| Week | Date | Lecture | Programming Assignment |
|---|---|---|---|
| 8 | 28/10 | 14. Word Embeddings | **PA4: Recurrent Neural Networks** |
| | 30/10 | **Holyday (Dia da Cidade)** | |
| 9 | 04/11 | 15. Attention | **FP2: Project Implementation** |
| | 06/11 | 16. Transformer I | |
| 10 | 11/11 | 17. Transformers II | |
| | 13/11 | 18. Transfer Learning | |
| 11 | 18/11 | **Midterm Exam II** | |
| | 20/11 | 19. GANs | |
| 12 | 25/11 | 20. Variational Autoencoders | |
| | 27/11 | 21. Diffusion Models | |
| 13 | 02/12 | 22. Multimodal Learning | |
| | 04/12 | 23. Conclusion | |
| 14 | 09/12 | **Final Project Presentation I** | |
| | 11/12 | **Final Project Presentation II** | |

# Communication

**Google Spaces — Prefered!**

- Questions about course content and logistics (~30 minutes latency)

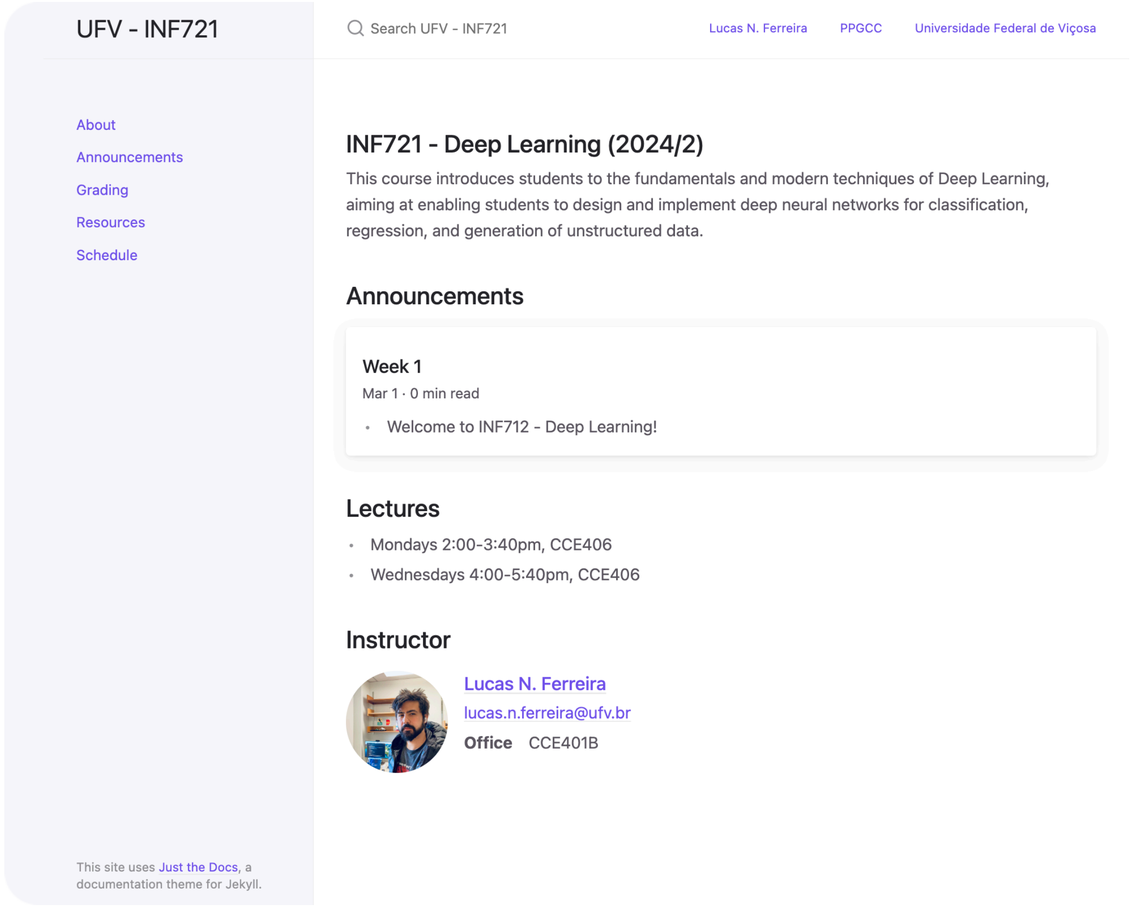
**Email**

- Personal matters, such as grading and attendance (~2 days latency)

**Appointments**

- Email, direct message, or talk to me after class to schedule an appointment

# Course Website




Moodle will be used only for posting grades and managing submissions.

All relevant information can be found on the course webpage:

**https://ufv-inf721-2024-2.lucasnferreira.com**

# Next lecture

**L2: Machine Learning**

- Present an introduction to machine learning and it’s different types of problems;
- Formalize supervised learning.