

IESTI01 – TinyML

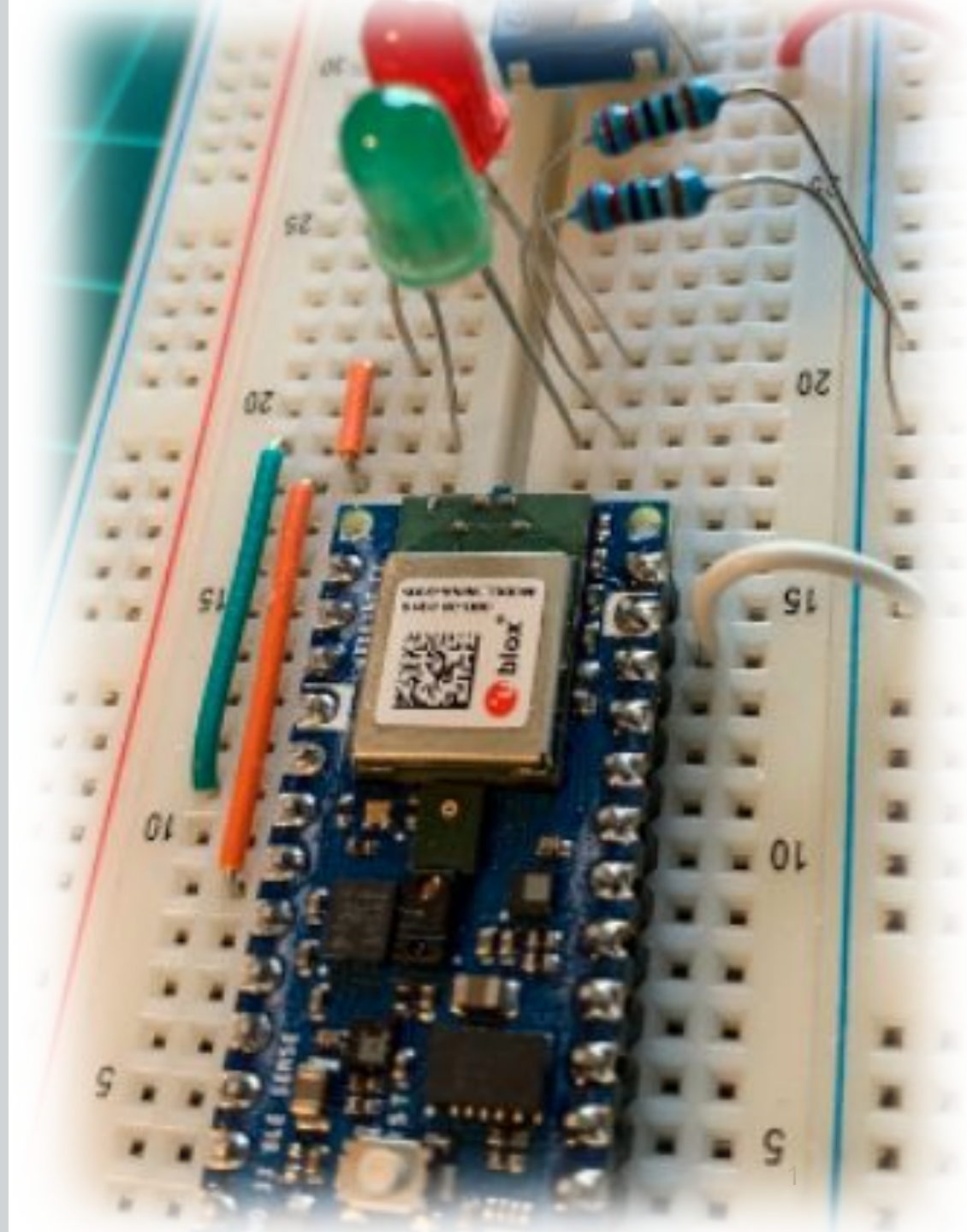
Embedded Machine Learning

Course Overview



Prof. Marcelo Rovai

UNIFEI



IESTI01 – TinyML course Overview

1. **Target:** Undergrad Engineering Students (mid to final semesters)
 - Electronics
 - Computing
 - Control & Automation
2. **Modality:** Hybrid -> Online classes + Self-Paced MOOC course at the platform: **Moodle**
3. **Capacity:** 30 students (Hybrid mode)
4. **Editions:** 4 (previous course editions in 2021 (2x) and 2022 were with online classes every week)
5. **Labs:** Students have the kits in their possession during all semester(*)
6. **Goal:** Course to give the basis, aiming to project development

(*) During Pandemic times, kits were sent to student's homes by mail

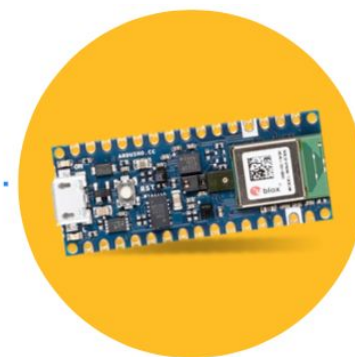
Part 1

Fundamentals
of TinyML

Part 2

Applications
of TinyML

Deploying
TinyML



Background Requirements

Part 1

Fundamentals of TinyML

- Python (own review)
- TensorFlow
- Google Colab
 - Jupyter Notebook

Part 2

Applications of TinyML

- Python
- TensorFlow (Lite)
- Google Colab
- Edge Impulse Studio

Deploying TinyML

- Python
- TensorFlow (Lite-Micro)
- Google Colab
- Edge Impulse Studio
- IDE (as Arduino)
- C/C++

Challenge: The course combines **Computer Science** with **Engineering** (Electronics)

Hands-on Learning

- Software

- Python / C++
- Machine Learning (TensorFlow)
- Programming environments ([Google Colab](#) or Jupyter)
- Edge Impulse Studio

- Hardware

- Arduino Nano 33 BLE Sense
- Seeed Wio Terminal
- ESP / ESP-CAM (Optional)
- Sensors



TinyML Arduino Kit



Wio Terminal Kit



Hands-on Activities

Speech



Okay, Google.

Vision



Cat - 0.92

Dog - 0.95

IMU



+



+



+



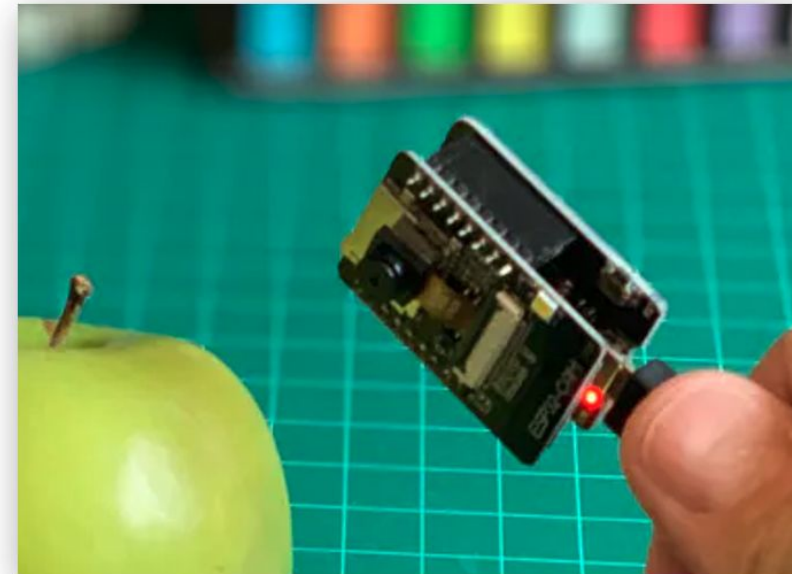
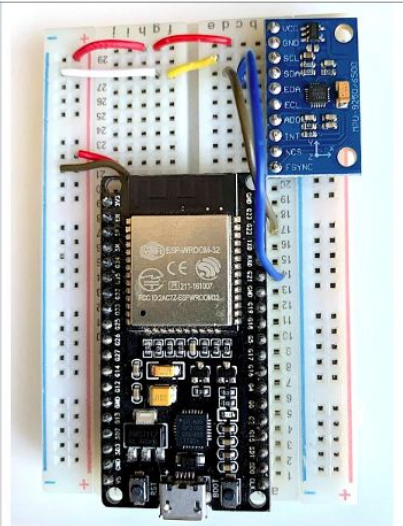
Additional MCU examples

IENTI01 – TinyML Embedded Machine Learning

20a. Motion Classification - ESP32



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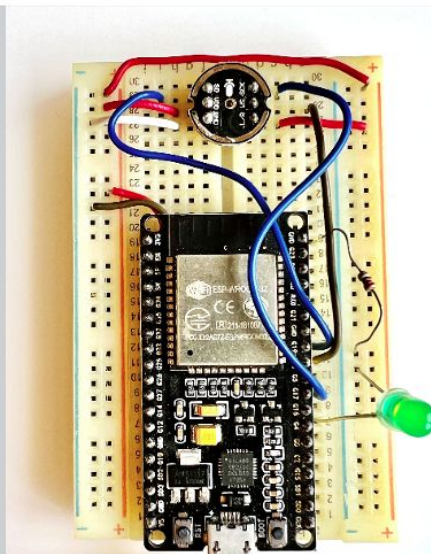


IENTI01 – TinyML Embedded Machine Learning

24a. Keyword Spotting - ESP32

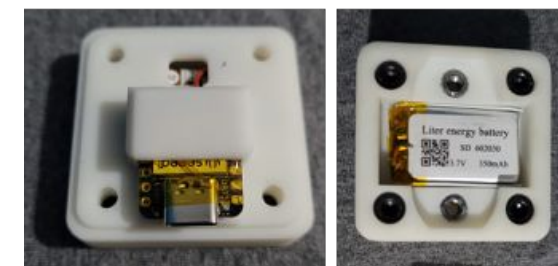
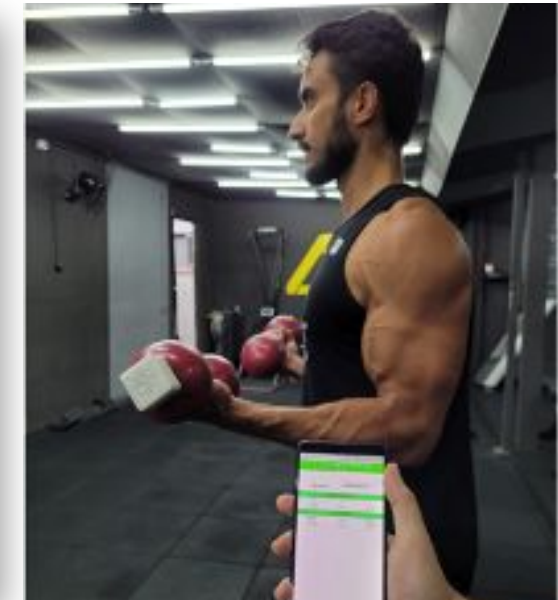
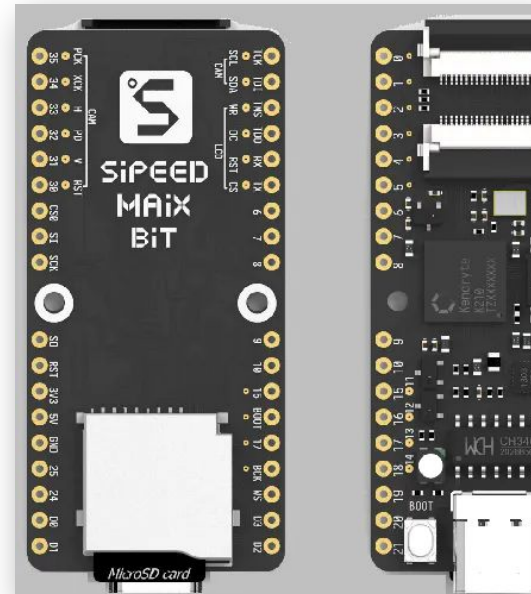
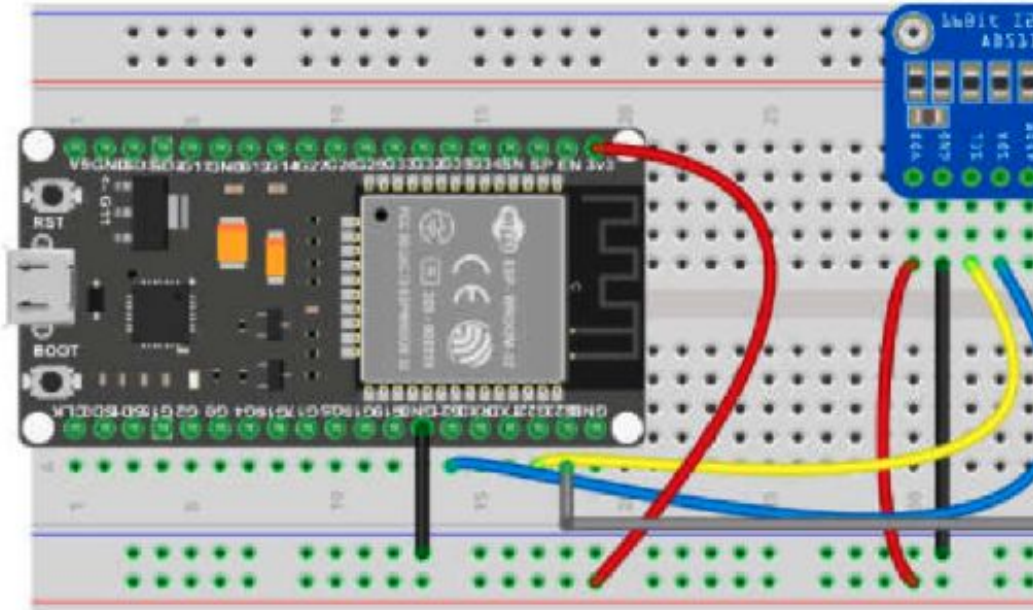


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```
./dev/cu.usbserial-110
Send
11:11:46.604 -> banana: 0.30859
11:11:46.604 -> potato: 0.02344
11:11:46.918 -> Predictions (DSP: 7 ms., Classification: 171 ms., Anomaly:
11:11:46.918 -> apple: 0.59375
11:11:46.918 -> banana: 0.37500
11:11:46.918 -> potato: 0.03125
11:11:47.236 -> Predictions (DSP: 7 ms., Classification: 171 ms., Anomaly:
11:11:47.236 -> apple: 0.63672
11:11:47.236 -> banana: 0.33984
11:11:47.236 -> potato: 0.02734
11:11:47.523 -> Predictions (DSP: 7 ms., Classification: 171 ms., Anomaly:
11:11:47.523 -> apple: 0.63281
11:11:47.560 -> banana: 0.35156
11:11:47.560 -> potato: 0.01562
11:11:47.849 -> Predictions (DSP: 7 ms., Classification: 171 ms., Anomaly:
11:11:47.849 -> apple: 0.71094
11:11:47.849 -> banana: 0.26562
11:11:47.849 -> potato: 0.02344
Autoscroll Show timestamp Both NL & CR 115200 baud Clear output
```


Goal: Innovative projects using other MCUs

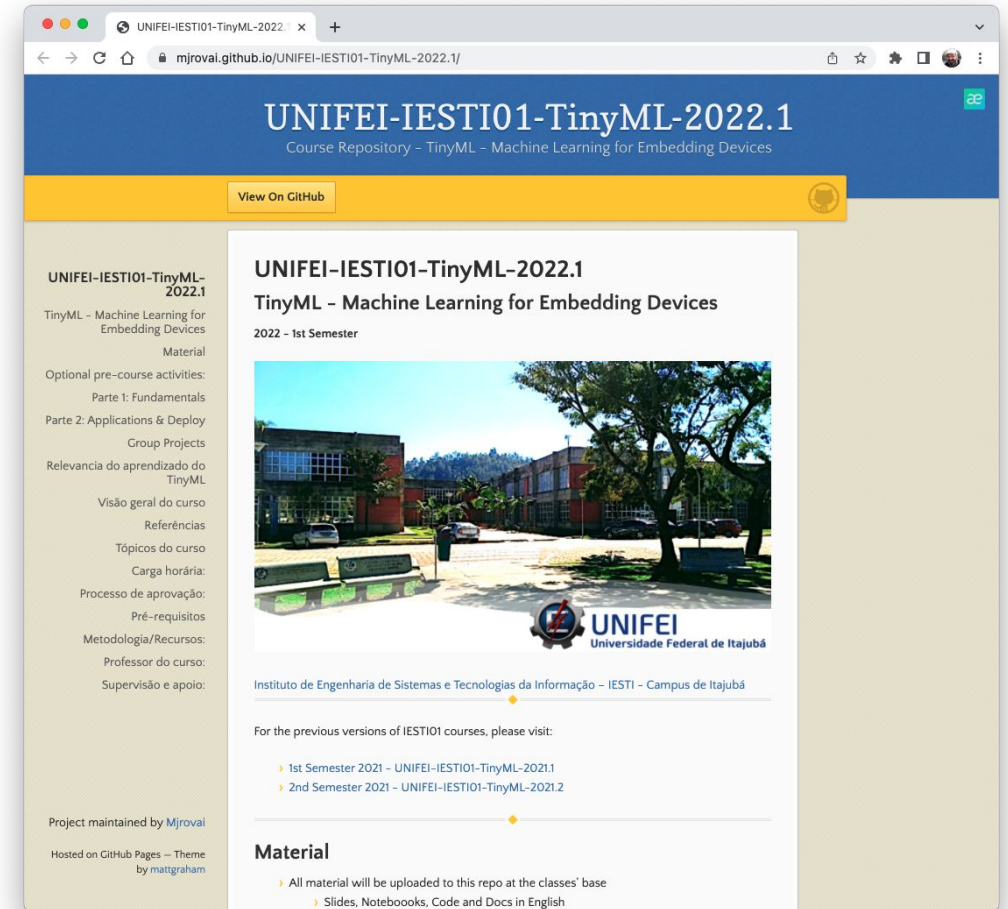


How is the course structured?

Course Structure

- Weekly video-recorded lectures (15 weeks)
 - Slides
 - Hands-on coding (by teacher & students)
- Weekly Additional Readings
- Possible Guest Lecturer (previous *)
- Assignments
 - Quizzes (Weekly)
 - Notebooks with codes (4)
 - Hands-on lab reports (4)
- Final Project (Groups of 3 or 4 students)
 - Report
 - Presentation

(*) IESTI01 2021.1 -> Daniel Situnayaki, Edge Impulse - US
IESTI01 2021.2 -> Dr. Marco Zennaro, ICTP - Italy



[Previous IESTI01 Courses available for consultation](#)

Class planning and approval process

- Minimal suggested Workload (4 hours per week):
 - 30 hours (Weekly recorded classes of about 2h, for 15 weeks)
 - 15 hours of assignments/coding/labs
 - 15 hours in research, individual studies, and final project (in a group)
- Approval process:
 - 1st Evaluation:
 - Individual **Quizzes**: 10%
 - Individual **Exercise Lists** (Notebooks): 25%
 - Group **Project Proposal**: 15%
 - 2nd Evaluation
 - Individual **Quizzes**: 10%
 - Individual **Practical Projects** (Lab reports): 25%
 - Group **Project Presentation (*)** and Final Report: 15%

[UNIFEI IESTI01 2021.1 – Final Projects](#)

[UNIFEI IESTI01 2021.2 – Final Projects](#)

[UNIFEI IESTI01 2022.1 – Final Projects](#)



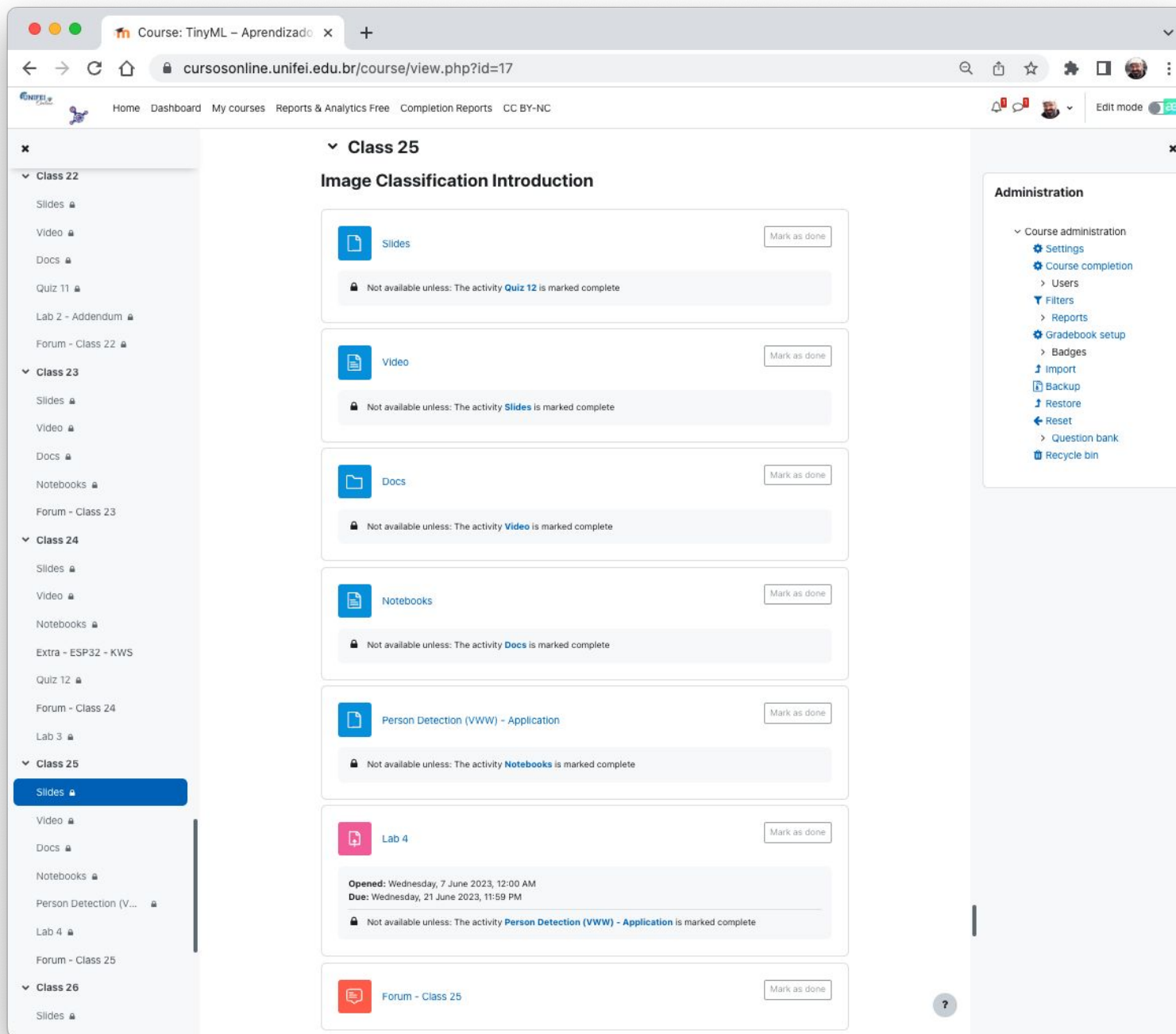
My courses

Course overview

All



TinyML – Aprendizagem de Máquina para ...
Extensão 2023



The screenshot shows a Moodle course page for "Course: TinyML – Aprendizado". The browser address bar shows the URL "cursosonline.unifei.edu.br/course/view.php?id=17". The page has a top navigation bar with links for Home, Dashboard, My courses, Reports & Analytics Free, Completion Reports, and CC BY-NC. A right-hand sidebar contains an "Administration" menu with options like Settings, Course completion, Users, Filters, Reports, Gradebook setup, Badges, Import, Backup, Restore, Reset, Question bank, and Recycle bin.

The main content area is titled "Class 25" and "Image Classification Introduction". It contains a list of activities, each with a "Mark as done" button and a lock icon indicating they are not yet available. The activities are:

- Slides: Not available unless: The activity Quiz 12 is marked complete
- Video: Not available unless: The activity Slides is marked complete
- Docs: Not available unless: The activity Video is marked complete
- Notebooks: Not available unless: The activity Docs is marked complete
- Person Detection (VWW) - Application: Not available unless: The activity Notebooks is marked complete
- Lab 4: Opened: Wednesday, 7 June 2023, 12:00 AM; Due: Wednesday, 21 June 2023, 11:59 PM; Not available unless: The activity Person Detection (VWW) - Application is marked complete
- Forum - Class 25

A left-hand sidebar shows a navigation menu for classes 22 through 26, with "Class 25" and "Slides" currently selected.

IESTI01 2023.1 - Course Schedule

	Date	Class	Content	Assignment Deadline
Fundamentals	15/03/23	1	About the Course and Syllabus	
		2	Introduction to TinyML	
	22/03/23	3	TinyML - Challenges - Embedded Systems	Pre-Survey / Quiz 1
		4	TinyML Challenges - Machine Learning	
	29/03/23	5	The Machine Learning Paradigm	Quiz 2
		6	The Building Blocks of Deep Learning (DL) - Introduction	
	05/04/23	7	The Building Blocks of DL - Regression with DSS	List 1 / Quiz 3
		8	The Building Blocks of DL - Classification with DSS	
	12/04/23	9	The Building Blocks of DL - DNN Recap, Datasets and Model Metrics	List 2 / Quiz 4
		10	Introducing Convolutions (CNN)	
	19/04/23	11	Image Classification using CNN	List 3 / Quiz 5
		12	Introduction to Edge Impulse – CNN with Cifar-10	
	26/04/23	13	Preventing Overfitting	List 4 / Quiz 6
		14	Fundamentals wrap-up and Application's preview	
Application & Deploy	03/05/23	15	ML Applications Overview - AI Lifecycle and ML Workflow	Project Proposal / Quiz 7
		16	Introduction to TFLite and TFLite-Micro	
	10/05/23	17	Lab 1 - TinyML Kit Overview - HW and SW Installation & Test	Quiz 8
		18	TFLite-Micro Overview & Hello World Code Walkthrough	
	17/05/23	19	Motion Classification - Introduction	Quiz 9
		20	Lab 2 - Motion Classification using MCU (Nano 33)	
	24/05/23	21	K-means Clustering & Anomaly Detection	Lab 1 / Quiz 10
		22	Lab 2a - Anomaly Detection Hands-On Lab & Pos-Processing	
	31/05/23	23	Keyword Spotting - Introduction	Lab 2 / Quiz 11
		24	Lab 3 - Lab KWS using MCU	
	07/06/23	25	Image Classification Introduction	Quiz 12
		26	Image Classification using Edge Impulse Studio	
	14/06/23	27	Collecting Data - Alternative ways	Lab 3 / Quiz 13
28		Responsible AI & Course Wrap-up		
21/06/23	29	Group Presentations	Lab 4 and Lab 4a	
	30	Group Presentations		

Main references

- [Harvard School of Engineering and Applied Sciences - CS249r: Tiny Machine Learning](#)
- [Professional Certificate in Tiny Machine Learning \(TinyML\) – edX/Harvard](#)
- [Introduction to Embedded Machine Learning - Coursera/Edge Impulse](#)
- [Computer Vision with Embedded Machine Learning - Coursera/Edge Impulse](#)
- Fundamentals textbook: [“Deep Learning with Python” by François Chollet](#)
- Applications & Deploy textbook: [“TinyML” by Pete Warden, Daniel Situnayake](#)
- Deploy textbook [“TinyML Cookbook” by Gian Marco Iodice](#)
- Deploy textbook "AI at the Edge" book by Daniel Situnayake, Jenny Plunkett

I want to thank [Shawn Hymel](#) and Edge Impulse, [Pete Warden](#) and [Laurence Moroney](#) from Google, Professor [Vijay Janapa Reddi](#) and [Brian Plancher](#) from Harvard, and the rest of the [TinyMLedu](#) team for preparing the excellent material on TinyML that is the basis of this course at UNIFEI.

The IESTI01 course is part of the [TinyML4D](#), an initiative to make TinyML education available to everyone globally.

Thanks



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