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
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

Vision

Cat – 0.92
Dog – 0.95

IMU

DOWN
RIGHT
UP
LEFT

jupyter + CO +  +  +  +  +  
Additional MCU examples

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20a. Motion Classification - ESP32

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24a. Keyword Spotting - ESP32

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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
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
Image Classification Introduction

- **Slides**
  - Not available unless: The activity Quiz 12 is marked complete

- **Video**
  - Not available unless: The activity Slides is marked complete

- **DOKS**
  - Not available unless: The activity Video is marked complete

- **Notebooks**
  - Not available unless: The activity DOKS is marked complete

- **Person Detection (Yolo) - Application**
  - Not available unless: The activity Notebooks is marked complete

- **Lab 4**
  - Not available unless: The activity Person Detection (Yolo) - Application is marked complete
# IESTI01 2023.1 - Course Schedule

<table>
<thead>
<tr>
<th>Date</th>
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<th>Assignment Deadline</th>
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<tbody>
<tr>
<td>15/03/23</td>
<td>1</td>
<td>About the Course and Syllabus</td>
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<td>2</td>
<td>Introduction to TinyML</td>
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<td>22/03/23</td>
<td>3</td>
<td>TinyML - Challenges - Embedded Systems</td>
<td>Pre-Survey / Quiz 1</td>
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<td>TinyML Challenges - Machine Learning</td>
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<td>29/03/23</td>
<td>5</td>
<td>The Machine Learning Paradigm</td>
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<td>6</td>
<td>The Building Blocks of Deep Learning (DL) - Introduction</td>
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<td>05/04/23</td>
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<td>The Building Blocks of DL - Regression with DSS</td>
<td>List 1 / Quiz 3</td>
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<td>The Building Blocks of DL - Classification with DSS</td>
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<td>12/04/23</td>
<td>9</td>
<td>The Building Blocks of DL - DNN Recap, Datasets and Model Metrics</td>
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<td>10</td>
<td>Introducing Convolutions (CNN)</td>
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<td>Image Classification using CNN</td>
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<td>Introduction to Edge Impulse - CNN with Cifar-10</td>
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<td>Preventing Overfitting</td>
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<td>14</td>
<td>Fundamentals wrap-up and Application’s preview</td>
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## Fundamentals

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<tr>
<td>03/05/23</td>
<td>15</td>
<td>ML Applications Overview - AI Lifecycle and ML Workflow</td>
<td>Project Proposal / Quiz 7</td>
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<td>Introduction to TFLite and TFLite-Micro</td>
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<td>Lab 1 - TinyML Kit Overview - HW and SW Installation &amp; Test</td>
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<td>TFLite-Micro Overview &amp; Hello World Code Walkthrough</td>
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<td>17/05/23</td>
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<td>Motion Classification - Introduction</td>
<td>Quiz 9</td>
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<td>24/05/23</td>
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<td>Lab 2 - Motion Classification using MCU (Nano 33)</td>
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<td>21</td>
<td>K-means Clussterging &amp; Anomaly Detection</td>
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<td>22</td>
<td>Lab 2a - Anomaly Detection Hands-On Lab &amp; Post-Processing</td>
<td>Lab 1 / Quiz 10</td>
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<td>31/05/23</td>
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<td>Keyword Spotting - introduction</td>
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<td>Lab 3 - Lab KWS using MCU</td>
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<td>07/06/23</td>
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<td>Image Classification Introduction</td>
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<td>26</td>
<td>Image Classification using Edge Impulse Studio</td>
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<td>Collecting Data - Alternative ways</td>
<td>Lab 3 / Quiz 13</td>
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<td>Responsible AI &amp; Course Wrap-up</td>
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<td>Group Presentations</td>
<td>Lab 4 and Lab 4a</td>
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<td>Group Presentations</td>
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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