ESIROI
ÉCOLE D'INGÉNIEURS
UNIVERSITÉ DE LA RÉUNION

DEPARTMENT : *IT*
SEMESTER : *S7*

IDENTIFICATION

Course code :	ESI-SPI-CI-IN4-S7-UE2-EC4
ECTS :	1

DURATION

Lectures :	4
Tutorial classes :	4
Labs :	8
Total :	16

Project :
Personnal work :

ASSESSMENT

Continuous assessments and lab work evaluation (complete pipeline deployed on target hardware).

TEACHING MATERIALS

Slides, Jupyter notebooks, Edge Impulse platform, ESP32/Arduino Nano 33 BLE Sense boards, practical work sheets.

LANGUAGE

English

CONTACT

Master the complete data analysis pipeline for IoT, from sensor data collection to machine learning model training, deployment, and validation of embedded models on resource constrained devices (edge AI / TinyML).

Modifié le : 14 juillet 2026

UE : UE7-IOT

COURSE : Data Analysis for IoT

SCOPE OF THE COURSE

OBJECTIVES

COMPETENCE AND SKILLS

- Analyze IoT data by integrating edge analytics (edge computing) specificities
- Apply programming and communication paradigms specific to embedded systems and IoT
- Design infrastructures and service solutions tailored for connected objects

PROGRAM

- **Module 1 — IoT Data Collection and Preparation (Lecture : 1h, Tutorial : 1h, Lab : 2h)**
  - Specificities of IoT data : time series, multi-axis sensor data, sampling, noise
  - Collection strategies : on-field labeling, reproducible acquisition protocols
  - Preprocessing : cleaning, normalization, windowing, data augmentation
  - Handling class imbalances and variable field conditions
  - *Lab : Accelerometer/gyroscope data collection on ESP32, labeling and exploration with Python/Pandas*
- **Module 2 — Model Training for Embedded Systems (Lecture : 1.5h, Tutorial : 1.5h, Lab : 2h)**
  - Introduction to TinyML : memory, computation, and energy constraints
  - TensorFlow Lite for Microcontrollers : architecture, quantization (int8, float16), model conversion
  - Edge Impulse Studio : project creation, data import, impulse design (DSP + classification)
  - Suitable architectures : 1D CNN for time series, anomaly detection, lightweight transfer learning
  - Trade-offs : accuracy vs. model size vs. inference latency
  - *Lab : Training a gesture recognition model on Edge Impulse, exporting to TFLite*
- **Module 3 — Embedded Deployment and Inference (Lecture : 1h, Tutorial : 1h, Lab : 2h)**
  - Deploying TFLite models on microcontrollers (ESP32, Arduino Nano 33 BLE)
  - Integration into a real-time loop : acquisition → preprocessing → inference → action
  - Memory optimization : arena sizing, operator resolver, flatbuffer model
  - Measuring embedded performance : latency, RAM/Flash memory consumption, energy consumption

- *Lab : Deploying the model on target hardware, measuring latency and memory consumption*

- **Module 4 — Field Validation and Robustness (Lecture : 0.5h, Tutorial : 0.5h, Lab : 2h)**

  - Robustness challenges in real-world conditions : sensor drift, environmental variations, aging
  - Field validation vs. laboratory validation : test protocols, performance metrics in situ
  - Data drift and concept drift : detection and update strategies (retraining, feedback loop)
  - Field feedback → retraining loop : incremental data collection, data and model versioning
  - Ethical and reliability considerations for automated decisions at the edge
  - *Lab : Validating the model in real-world conditions, analyzing errors, proposing improvements, iterating*

BIBLIOGRAPHY

Pete Warden & Daniel Situnayake — *TinyML : Machine Learning with TensorFlow Lite on Arduino and Ultra-Low-Power Microcontrollers* — O'Reilly, 2020
Vijay Janapa Reddi et al. — *Widening Access to Applied Machine Learning with TinyML* — Harvard, 2021
Edge Impulse Documentation — docs.edgeimpulse.com
TensorFlow Lite for Microcontrollers Documentation — tensorflow.org/lite/microcontro

REQUIREMENTS

- Python and C/C++ programming basics
- Probability and statistics fundamentals (S5-S6)
- IOT701 : Embedded and Real-Time Systems (co-requisite)