Course Name: Do-it-yourself sensors for environmental research – advanced course
Lecturer: Elad Levintal (*Fall semester (001.2.5075) / Spring semester (001.2.5076)*

Course Description:
The objective of this advanced course is to progress from simple integration of do-it-yourself (DIY) hardware (e.g., microcontrollers and sensors) to building complex sensor systems for environmental research. **The first part** of this yearly course will be dedicated to classes on advanced hardware features, such as wireless communication, data logging options, and system power optimization. **The second part** will be dedicated to exploring potential projects and literature review; this part will end with each student choosing one sensor project as the basis of this course. **The third part** will be dedicated to developing the sensor project individually. Project development will also include sensor calibration/validation and field/lab tests. Successful projects could be submitted to peer-reviewed journals as technical notes. Emphasizing hands-on system design, integration, and deployment, students will learn to interface with a wide range of sensors for applications in environmental research, focusing on air, soil, water, ecological, and agricultural monitoring. In addition, students will gain practical experience in building and troubleshooting sensor systems while engaging with the broader open-source hardware community.
This course is for students with previous experience working with DIY hardware who are interested in expanding their knowledge in this field.

Credits:
Three points – yearly course during fall and spring semesters. Each week, we will meet for two hours, combining class and hands-on lab work. There will be one sensor-related field trip.

Course Language:
English

Prerequisites:
Course 001-2-5074 (Envirotech – do-it-yourself sensors for environmental research) or proven experience working with microcontrollers (e.g., Arduino)

Evaluation (% of final grade):
- 10% - Presence
- 30% - First-semester report (individual)
    - 20% - report
    - 10% - presentation in class
- 60% - Final project (individual)
    - 40% - final report (can be written as a manuscript draft)
    - 20% - project presentation in class

Attendance regulation:
80% presence is required (10% of final grade)

Reading list:
- Online, open-access resources
- 001-2-5074 presentations

Detailed description of the course:

Fall semester (001.2.5075)

1. Introduction
- Course overview
- Reading resources (001-2-5074 course presentations)
- DIY research labs and groups around the world
- Lab visit and safety issues!

2. Project development
- What is a research-oriented DIY sensor system
- Project flowchart
- Project documentation (Github, proper use of comments, Fritzing, taking pictures, etc.)
- Real-life projects examples
- Main system components (RTC, relay, ADC, MUX, screen, SD card, solar/battery module)

3. Data logging options
- Simple loggers
- Advanced loggers
- EEFROM
- Logger tests in the lab

4. Power optimization
- Solar systems
- Battery types
- Power monitoring tools
- Power optimization methods – hardware vs. software

5. Wireless communications
- Wireless communication methods
- WiFi (ESP32)
- LoRa
- Modems
- Presenting the main course project guidelines (individual)

6. AI and microcontrollers
- AI and microcontrollers
- TinyML
- Soft sensors

7. Literature review for the course project
- How to conduct a systematic sensor-related literature review
- Project brainstorming using manuscripts and online repositories

8. System enclosures
- Simple types
- 3D printable enclosures
- Project development – literature review

9. Spectral sensors
- Types of open-source spectral sensors
- Combining spectral sensors and TinyML

- Spectral sensor tests in the lab

10. Troubleshooting
11. Project development
12. Guest speaker
13. Project development
14. Project development

Spring semester (001.2.5076)

1. First-semester report presentation in class
2. Sensor calibration and validation
    - Main concepts
    - Deciding on the calibration/validation for each project

3. Project development
4. Project development
5. Project development
6. Data analysis – time-series
7. Data analysis – online tools
8. Project development
9. Project development
10. Project development
11. Project development
12. Sensor-related field trip
13. Project development
14. Final project presentations in class