

ENV-548

**Sensor orientation**

Skaloud Jan

Cursus	Sem.	Type
Environmental Sciences and Engineering	MA2, MA4	Opt.
Robotics, Control and Intelligent Systems		Opt.
Robotics	MA2, MA4	Opt.
Space Technologies minor	E	Opt.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	During the semester
Workload	120h
Weeks	14
<b>Hours</b>	<b>4 weekly</b>
Courses	2 weekly
Exercises	1 weekly
Lab	1 weekly
<b>Number of positions</b>	

**Summary**

Determination of spatial orientation (i.e. position, velocity, attitude) via integration of inertial sensors with satellite positioning. Prerequisite for applications related to remote sensing, environmental monitoring, mobile mapping, robotics, space exploration, smart-phone navigation, etc.

**Content****Lectures**

- Concept and principles.
- Inertial and other reference frames.
- Gyroscope and accelerometer technology.
- Attitude parameterization and modeling.
- Strapdown mechanization.
- Initial alignment.
- Random processes and noise models.
- Bayes and Kalman Filters.
- External aiding  
INS/GNSS integration and reliability.
- Application to mobile mapping and remote sensing

**Labs**

- Estimating and characterizing sensor errors in synthetic and real data (practical lab / real instruments)
- Determining trajectory from ideal and realistic inertial data
- Witnessing inertial physics (practical lab / real instruments)
- Performing Kalman Filtering with different motion models
- Setting up loosely coupled INS/GNSS integration

**Keywords**

Inertial sensors, platform orientation, sensor integration, Kalman Filtering, estimation, INS/GNSS, navigation

**Learning Prerequisites****Recommended courses**

Advanced satellite positioning, statistics, adjustment of observations

### **Important concepts to start the course**

basic signal processing, random processes, programming in Matlab

### **Learning Outcomes**

By the end of the course, the student must be able to:

- Manipulate precise as well as low-cost inertial instruments.
- Compute initial orientation from a real data.
- Integrate inertial signals via simulations.
- Predict orientation performance via covariance propagation.
- Construct a model for a gyroscope or accelerometer.
- Develop dynamic models for a particular scenario.
- Implement Kalman Filter.

### **Transversal skills**

- Collect data.
- Make an oral presentation.
- Use both general and domain specific IT resources and tools

### **Teaching methods**

Ex cathedra, exercises (part. in computer room), demonstrations

### **Expected student activities**

Active participation in the course and lab assignments, programming of algorithms and self-control (debugging), study and presentation of one inertial-sensor technology .

### **Assessment methods**

- During the semester (50%)
  - Midterm (20%)
  - Graded ex. (30%)
- In session :
  - Oral exam (50%)

### **Supervision**

Office hours                      No

### **Resources**

#### **Bibliography**

Recommended literature via Moodle.

#### **Ressources en bibliothèque**

- [Find the reference at the Library](#)

**Notes/Handbook**

Sensor orientation (polycop., ~100 pages), slides via Moodle.

**Moodle Link**

- <https://go.epfl.ch/ENV-548>