COURSE DETAILS

"SENSOR DATA FUSION AND MEASUREMENT UNCERTAINTY MANAGEMENT"

SSD ING-IND/12

DEGREE PROGRAMME: AUTONOMOUS VEHICLE ENGINEERING (MOVE)

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

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GENERAL INFORMATION ABOUT THE COURSE

INTEGRATED COURSE: SENSOR DATA FUSION AND MEASUREMENT UNCERTAINTY MANAGEMENT
MODULE: SMART SENSOR DATA FUSION
SSD OF THE MODULE: ING-INF/12
YEAR OF THE DEGREE PROGRAMME: I
SEMESTER: II
CFU: 6

REQUIRED PRELIMINARY COURSES

NONE

PREREQUISITES

Basic knowledge about C++ and Matlab programming are required.

LEARNING GOALS

The course is intended to present, from both theoretical and experimental point of view, methods and algorithms for acquired data processing. Moreover, particular attention will be paid to the real-time data transmission and processing from the smart sensor realized by means of an embedded system and an external high-performance computational unit, such as digital signal processor or personal computer. This way, it will be possible for the students to accomplish the main objective of the course, i.e. the definition, implementation and metrological characterization of an integrated measurement system involving IMU, GNSS and radar.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

The student needs to show ability to know and understand methodological tools for the selection of the best strategy for data fusion. Such tools will allow the student to solve more complex problems such as realizing the integration of measures provided by different sensors sources.

Applying knowledge and understanding

The student needs to show ability to solve problems regarding the design and implementation of integrated navigation systems based on inertial measurement units and global navigation systems.

COURSE CONTENT/SYLLABUS

- *Theoretical fundamentals of multi-sensors data fusion procedure*
  - *Data fusion Models*
  - *Kalman filter*
  - *Extended Kalman filter*
  - *Unscented Kalman filter*
  - *Particle filter*
  - *Basics of heuristic approaches*
  - *Basics of machine and deep learning approaches*
- *Fundamentals of radio and radar systems*
  - *Main elements of a general radiocommunication system*
  - *Antennas and budget equation*
  - *Typical long/medium/short range communication protocols*
  - *Main elements of a general radar system*
  - *Radar operating principle*
  - *Radar operating frequencies*
- *Implementation on embedded systems*
  - *Data acquisition from external sensors*
    - *Sensors daughter boards*
    - *MEMS inertial measurement unit*
    - *Global navigation satellite system*
  - *Multi-sensors data fusion*
    - *Data integration among IMU, GNSS and radar*
    - *Examples of Kalman filter implementation*
    - *Examples of Extended Kalman filter implementation*
    - *Examples of Unscented Kalman filter implementation*
  - *Measurement uncertainty estimation*

- *A-type and B-type estimation of uncertainty of raw data*
- *Measurement uncertainty estimation of filter outputs*

READINGS/BIBLIOGRAPHY

Slides, lecture notes, technical papers. Textbooks:
Jitendra R. Raol, Multi-sensor data fusion with Matlab, CRCPress, Boca Raton FL, USA, 2010
H.B. Mitchell, Multi-Sensor Data Fusion – An Introduction, Springer, 2007
P. Groves, Principles of GNSS, Inertial, and Multisensor Integrated Navigation Systems, Artech House, 2008
John P. Bentley, Principles of Measurement Systems, Pearson Education Limited, Edinburgh, 2005
S.C. Mukhopadhyay, K. P. Jayasundera, O.A. Postolache - Modern Sensing Technologies, Springer, 2019
Microcontroller, sensors, GNSS and radar datasheets, user and reference manuals.

TEACHING METHODS

Lectures for approx..60 % of total hours, interactive tutorials for approx..10 % of total hours, laboratory activities for approx..20 % of total hours and exercises for approx..10 % of total hours.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam type	
written and oral	X
only written	
only oral	
project discussion	X
other	X

In case of a written exam, questions refer to: (*)	Multiple choice answers	
	Open answers	X
	Numerical exercises	X

(*) multiple options are possible

b) Evaluation pattern:

The final mark will be weighted on CFU of each module and therefore will be made ub of:

Module Smart Sensors and Measurement Uncertainty – 6 CFU 50% consisting of Open answer, Numerical exercise and microcontroller programming.

Module Sensor data fusion – 6 CFU 50% consisting of Open answer and project discussion.