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 SENSORS AND MEASUREMENT UNCERTAINTY
SSD OF THE MODULE: ING-INF/12
YEAR OF THE DEGREE PROGRAMME: I
SEMESTER: I
CFU: 6

REQUIRED PRELIMINARY COURSES

NONE

PREREQUISITES

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

LEARNING GOALS

The course is intended to provide the general knowledge about measurement systems and sensors as well as their metrological characteristics, both static and dynamic in order to point out the main specifications needed to define the best solution according to the required target. Moreover, uncertainty estimation in direct and indirect measurements according to the current recommendation has to be mastered by the students. Finally, embedded systems and microcontroller will be presented along with the main integrated development environments for the implementation of firmware

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

The student needs to show ability to know and understand methodological tools for the estimation of the measurement uncertainty and the designing and development of smart sensors. Such tools will allow the student to solve more complex problems such as realizing data acquisition systems based on embedded system.

Applying knowledge and understanding

The student needs to show ability to solve problems regarding the design of data acquisition systems and to choose the most suitable embedded solution for solving a practical problem.

COURSE CONTENT/SYLLABUS

- *General principles [0.5 CFU]*
  - *General measurement system*
  - *Static characteristics of measurement system elements*
  - *Accuracy of measurement systems in the steady state*
  - *Dynamic characteristics of measurement systems elements*
- *• Measurement uncertainty estimation according to GUM [1.5 CFU]*
  - *Fundamentals of statistics and probability*
  - *A-type and B-type estimation of uncertainty in direct measurements*
  - *Measurement uncertainty estimation in indirect measurements according to JCGM 100:2008*
  - *Propagation of distributions using a Monte Carlo method according to JCGM 101:2008*
  - *Extension to any number of output quantities according to JCGM 102:2011*
- *• Basic models and operating principle of main sensors [1.5 CFU]*
  - *Temperature sensors*
  - *Pressure sensors*
  - *Accelerometers*
  - *Gyroscopes*
  - *Magnetometers*
  - *Linear and angular encoders*
  - *MEMS technology for measurement sensors*
- *• Implementation on embedded systems [2.5 CFU]*
  - *Overview on embedded systems*
  - *Overview on main microcontrollers architectures*
  - *Register level programming of ARM-based microcontrollers*
    - *General input/output ports;*
    - *Timers;*
    - *Analog to digital converters*
    - *Digital to analog converters*

- *Short range communication protocols*
  - *Universal Synchronous-Asynchronous Receiver/Transmitter*
  - *Inter Integrated Circuit*
  - *Serial Peripheral Interface*
- *Direct memory access*

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.