

Course guide 240AR064 - 240AR064 - Scientific Python for Engineers

Last modified: 16/05/2023

Unit in charge: Teaching unit:	Barcelona School of Indust 707 - ESAII - Department	rial Engineering of Automatic Control.
Degree:	MASTER'S DEGREE IN AUT MASTER'S DEGREE IN IND	OMATIC CONTROL AND ROBOTICS (Syllabus 2012). (Optional subject). USTRIAL ENGINEERING (Syllabus 2014). (Optional subject).
Academic year: 2023	ECTS Credits: 3.0	Languages: English

LECTURER				
Coordinating lecturer:	Perera Lluna, Alexandre			
Others:	Perera Lluna, Alexandre Velasco Garcia, Manuel			

PRIOR SKILLS

Knowledge of a programming language

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Transversal:

CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

TEACHING METHODOLOGY

This class will be structured in three main tasks:

Lectures: the teachers will expose theoretical and practical contents, with the active participation of students. Challenges: Students are exposed to a problem to be solved in a limited time. Competitive projects: Problem solving projects where students are placed on a simulated scenario. In this scenario students program a simulated bot employing machine learning algorithms in python.

Final project defence includes an oral exposition of the developed work jointly with a discussion on the related methodology. In spring semester for the 2019-2020, and responding to the health crisis due to the sars-cov-2 outbreak, the the oral exposition of the developed work jointly with the discussion and related methodology will be carried out through an online meeting to be announced through the online campus.

LEARNING OBJECTIVES OF THE SUBJECT

The goal of the class is to learn skills for scientific programming, focused on the application of advanced machine learning tools on robotics. Students will learn to develop structured and problem solving thinking in a competitive environment.



STUDY LOAD

Туре	Hours	Percentage
Self study	48,0	64.00
Hours large group	27,0	36.00

Total learning time: 75 h

CONTENTS

Scientific Python for Engineering
Description:
Part I
1. Introduction
a. Why python?
b. Python History
c. Installing Python
d. Python resources
2. Working with Python
a. Workflow
b. ipython vs. CLI
c. Text Editors
d. IDEs
e. Notebook
3. Getting started with Python
a. Introduction
b. Getting Help
c. Basic types
d. Mutable and in-mutable
e. Assignment operator
f. Controlling execution flow
g. Exception handling
4. Functions and Object Oriented Programming
a. Defining Functions
b. Decorators
c. Writing Scripts and New Modules
d. Input and Output
e. Standard Library
f. Object-oriented programming
g. Magic Functions
5. Iterators and Generators
a. Iterators
b. Generators
6. Creating Graphic Interfaces (optional)
7. Debugging code
a. Avoiding bugs
b. Debugging workflow
c. Python's debugger
d. Debugging segfaults using gdb
Part II
1. Introduction to NumPy
a. Overview
b. Arrays
c. Operations on arrays
d. Advanced arrays (ndarrays)

- e. Notes on Performance (\%timeit in ipython)
- 2. Matplotlib



- a. Introduction
- b. Figures and Subplots
- c. Axes and Further Control of Figures
- d. Other Plot Types
- e. Animations
- 3. Plotting with Mayavi
- a. Mlab: the scripting interface
- b. Interactive work
- 4. Advanced Numpy
- a. Life of ndarray
- b. Universal functions
- c. Interoperability features
- d. Array siblings: chararray, maskedarray, matrix
- e. Summary
- f. Contributing to Numpy/Scipy

Part III

- 1. Scipy
- a. Introduction
- b. Input/Output
- c. Statistics
- d. Linear Algebra
- e. Fast Fourier Transforms
- f. Optimization
- g. Interpolation
- h. Numerical Integration
- i. Signal Processing
- j. Image Processing
- k. Special Functions
- 2. Sparse Matrices in SciPy
- a. Introduction
- b. Storage Schemes
- c. Linear System Solvers
- d. Others
- 3. Optimizing code
- a. Optimization workflow
- b. Profiling your code
- c. Speeding your code
- 4. Sympy
- a. First Steps with SymPy
- b. Algebraic manipulations
- c. Calculus
- d. Equation solving
- e. Linear Algebra
- Part IV
- 1. Python scikits
- a. Introduction
- b. scikit-timeseries
- c. scikit-audiolab
- 2. scikit-learn
- a. Datasets
- b. Sample generators
- c. Unsupervised Learning
- i. Clustering
- ii. Gaussian Mixture Models
- iii. Novelty/Outliers Detection
- d. Supervised Learning
- i. Linear and Quadratic Discriminant Analysis
- ii. Nearest Neighbors
- iii. Support Vector Machines



- iv. Partial Least Squeares
- e. Feature Selection
- 3. Practical Introduction to Scikit-learn
- a. Solving an eigenfaces problem
- i. Goals
- ii. Data description
- iii. Initial Classes
- iv. Importing data
- b. Unsupervised analysis
- i. Descriptive Statistics
- ii. Principal Component Analysis
- iii. Clustering
- c. Supervised Analysis
- i. k-Nearest Neighbors
- ii. Support Vector Classification
- iii. Cross validation

Full-or-part-time: 30h Theory classes: 15h Laboratory classes: 3h Guided activities: 5h Self study : 7h

GRADING SYSTEM

In spring semester for the 2019-2020, and responding to the health crisis due to the sars-cov-2 outbreak, the class grades will be obtained through a weighted mean comprising a evaluation of the challenges (50%) and the final project (50%).

EXAMINATION RULES.

Depending on the characteristics of the final project complexity, the students can do the competition individually or in teams. Students will prepare a project report describing mathematical strategy, code structure and performance metrics.

BIBLIOGRAPHY

Basic:

- Bressert, Eli. SciPy and NumPy: An Overview for Developers. New York: O'Reilly, 2012. ISBN 978-1449305468.

 - McKinney, Wes. Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython [on line]. 3rd ed. Sebastopol: O'Reilly,

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