Marine Survey, Acoustics and Sonar Systems (250587)

General Information

School	ETSECCPB
Departments	Departament d'Enginyeria Electrònica (EEL)
Credits	6.0 ECTS
Programs	GRAU EN CIÈNCIES I TECNOLOGIES DEL MAR (pla 2018)
Course	2024/25

Main teaching language at each group

- Group 10EN1 English (Q1)

Faculty

Responsible Faculty: Joaquin Del Rio Fernandez
Faculty: Joaquin Del Rio Fernandez, Enoc Martínez Padró, Daniel Mihai Toma Lesenciuc, Mike Connor Roger Malcolm Van Der Schaar

Objectives of Education

This subject will focus on three fundamental aspects of marine acoustics. On the one hand, it will show the students the basics of marine exploration through acoustic systems, the design of sonar systems, hydrophones and multi-beam echo sounders for bathymetry measurements, currents (by quantifying the Doppler effect) and free surface, to measure waves and meteorological and astronomical tides. In addition, the students will be shown the techniques and instrumentation used in underwater communications and positioning using acoustic techniques. Emphasis will also be placed on the development of applications capable of limiting the effect of anthropogenic noise in the sea and contributing to the sustainable development of maritime activities.

1. Know the transmission mechanisms of acoustic waves in the marine environment used in communication systems or sonar systems
2. Introduction to the modeling of the acoustic channel of propagation, and the effects of non-linealities such as the Doppler or multipath effect.
3. Know how to use and configure equipment for acoustic communication and exploration based on acoustic techniques.

This subject is oriented to the application of technologies of observation, remote perception and automatic exploration of the marine environment, which is essential for the motorization of the coastal water bodies and the obtaining of the necessary data for the control of practically all the activities human resources in the marine environment related to the exploitation of natural and aquacultural resources of the marine and coastal environment.

In this subject the students will learn about underwater acoustics, become familiar with the most commonly used terms, and understand the impact of sound on the environment. They will apply data processing techniques to analyze sound, recognize certain patterns from biological and human sources, and classify acoustic events using Python.

Learning results
Understanding of basic concepts related to underwater acoustics
Understanding the effect of noise on the marine environment, in particular marine fauna

Use of python for data processing and classification tasks

Teaching methodology
The course consists of classroom activity where theoretical concepts will be explained. Laboratory hours will be part instruction to explain topics or guide students through the exercises, but most of the time students will work on the exercises by themselves.

Competencies

Especific

To know and apply the lexicon and concepts of the Marine Sciences and Technologies and other related fields.
Establish a good practice in the integration of common numerical, laboratory and field techniques in the analysis of any problem related to the marine environment.
Apply the state-of-the-art numerical and statisticat techniques in the coastal and marine fields for a correctly interpretation of data. (Specific competence of the Marine Technologies Mention)
Use and apply indicators to assess impacts, both natural and anthropogenic, and propose corrective measures with monitoring and surveillance programs. (Specific competence of the Marine Technologies Mention)
Develop a conceptual framework to address the sustainability of the marine environment and the related socio-economic activities at different scales, explaining the effects of climate change.
Carry out calculations, assessments, surveys and inspections in coastal and marine environments, as well as the corresponding technical documents.

Generic

Apply knowledge and academic experience to the control and monitoring of the marine environment and its coastal boundary, using the state-of-the-art tools in the Marine Sciences and Technologies.
Encompass and teach studies in the different research lines that converge in Marine Sciences and Technologies.
Combining preservation with economic activity within the framework of current legislation promoting the development of a social and environmental awareness.

Total hours of student work

		Hours	Percentage
Supervised Learning	Large group	40.02 h	66.70 %
	Medium group	0.0 h	0.00 %
	Laboratory classes	19.98 h	33.30 %
	Guided Activities	0.0 h	0.00 %
Self Study		90.0 h	

Contents

Basics of bioacoustics

The student will become familiar with the underwater soundscape and some of the technical terms that will be used throughout the course.
Introduction to the acoustic data acquisition chain and the way to analyze and describe sounds in time and frequency dimensions
Programming foundation to be able to work with Python and to put all students at the same minimal level.
Detailed overview of how to measure sound, the EU guidelines for coastal acoustic monitoring, and learning how to interpret Wenz curves and similar graphics.

Gaining knowledge to use the most fundamental Python modules that will be used during the course.
A brief description of underwater sound propagation with direct applications to noise pollution.

All the Python knowledge that has been gained will be applied here to process wave files, correctly calculate various acoustic statistics, plot PSD curves, etc.

Specific Objectives

Understanding the underwater soundscape and the environmental consequences of sound pollution.
Understanding of sound acquisition
Gaining a basic programming foundation in Python
Becoming familiar with sound measurement procedures and terms.
Process a wave file
Being able to apply the basic sonar equation and estimating transmission ranges
Being able to process acoustic data

Cetacean classification

Introduction to machine learning concepts and if possible connect to what students have already learned during previous courses.
Python exercises to become familiar with machine learning toolboxes (in particular under SciPy)
Understanding how to evaluate model performance through the different common measures, FP/TP rates, ROC, AUC, precision/recall, average precision, etc.

Overview of regression modelling as a building of training neural networks.

Introduction to ensemble learning and the random forest classifier. This is already a very powerful tool in machine learning and classification.
Becoming familiar with the tensorflow toolbox; the focus will be on the use of the CPU to train and execute models, not the GPU.
Overview of perceptron classifiers in order to be able to move to DNN
Learning to make use of pretrained models that are available on-line and adapting them as needed.
Learning to use data augmentation to improve the quality/versatility of the data set.
Overview of the building blocks of a CNN and related architectures.
The students will receive audio files containing different whale or doplhin species and will try to classify them through the techniques learned throughout the course.

Management of communications with hydrophones: data, metadata and registration

Hidrophone communications

Evaluations

Activities

Calibration / Characterization of hydrophones

Visit to the LAB, Laboratory of Biocoustic Applications where there is a pool where you can perform the characterization / calibration of the parameters of a hydrophone as its sensitivity depending on the frequency.

Dedication

6h

Teaching Methodology

The subject consists of 4 hours a week of face-to-face classes.

They dedicate 2 hours to theoretical classes, in which the teachers expose the basic concepts and materials of the subject, present examples and carry out exercises.

They spend 2 hours solving problems with greater interaction with students. Practical programming exercises are carried out in order to consolidate the general and specific learning objectives.

The rest of the weekly hours are devoted to laboratory practices.

Support material is used in the format of a detailed teaching plan through the ATENEA virtual campus: contents, programming of assessment and guided learning activities and bibliography.

Although most of the sessions will be given in the language indicated, sessions supported by other occasional guest experts may be held in other languages.

Grading Rules

(*) The evaluation calendar and grading rules will be approved before the start of the course.

The grade for the course is obtained from the grades from the partial and final evaluation tests, from the follow-up and continuous assessment grades, and from the grades corresponding to the activities in the laboratory and in the field. Continuous assessment consists of doing different activities, both individual and group, of an additive and formative nature, carried out during the course (within the classroom and outside of it). The laboratory grade is the average of the activities of this type. The evaluation tests consist of a part with questions about concepts associated with the learning objectives of the subject in terms of knowledge or understanding, and a set of application exercises. NF = 50% Theory mark + 15% Follow-up marks + 35% Laboratory mark Theory mark: evaluation tests Follow-up marks: exercises and work presented during the course Laboratory mark: previous studies and reports on laboratory and field practices. Grading and admission criteria for reevaluation: Students suspended in the ordinary evaluation who have regularly taken the evaluation tests of the suspended subject and have attended and passed 50% of the corresponding subject, field activities, laboratory and follow-up, they will have the option to take a reevaluation test in the period set in the academic calendar. Students who have already passed it, students classified as not presented, or those who have not passed laboratory / field activities, will not be able to take the re-evaluation test for a subject. The maximum grade in the case of taking the reevaluation exam will be five (5.0). The non-attendance of a student summoned to the reevaluation test, held in the set period, may not lead to the completion of another test with a later date. Extraordinary evaluations will be carried out for those students who, due to accredited force majeure, have not been able to take any of the continuous evaluation tests. These tests must be authorized by the corresponding head of studies, at the request of the professor responsible for the subject, and will be carried out within the corresponding academic period.

Bibliography

Basic

- Géron, A. Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow: concepts, tools, and techniques to build intelligent systems. 3rd ed. Sebastopol, CA: O'Reilly, 2023. ISBN 9781098125974.