1ο Semester:

COURSE OUTLINE « Advanced Techniques for Signal Processing »

1. GENERAL

SCHOOL	Informatics and Telecommunications		
ACADEMIC UNIT	Informatics and Telecommunications		
LEVEL OF STUDIES	Post graduate		
COURSE CODE	101	**SEMESTER**	2
COURSE TITLE	Advanced Techniques for Signal Processing		

INDEPENDENT TEACHING ACTIVITIES	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures	2	6
Laboratory exercises	1	

COURSE TYPE	Special background
PREREQUISITE COURSES:	
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes (in English)
COURSE WEBSITE (URL)	https://www.dit.uoi.gr/e-class/courses/257/

2. LEARNING OUTCOMES

Learning outcomes

Upon successful completion of the course, students will be able to:

- Explain the basic categories of signals
- Estimate the output of a system by convolving the input signal with the impulse response
- Use the appropriate Fourier transform to analyze signals in frequency domain
- Employ basic functions of known signal processing methods in MATLAB/GNU Octave code
- Understand advanced techniques of frequency analysis and time-frequency analysis.
- Employ basic functions of known image processing methods in MATLAB/GNU Octave code
- Understand the basic architectures of Coherent Neural Networks, and their individual parameters

General Competences

The general competences that are acquired upon completion of the course are:

- Search for, analysis and synthesis of data and information, with the use of the necessary technology
- Production of free, creative and inductive thinking
- Team work

3. SYLLABUS

The course "Advanced Signal Processing Techniques" aims to expand the theoretical background in relation to corresponding courses of undergraduate programs of positive and polytechnic studies, as well as the algorithmic application of one-dimensional and multidimensional signal processing. Initially, a review of signal classes is presented, focusing on computational processing methods and well-known continuous and discrete signal transformations. The theoretical

background is further examined with short-time Fourier transform, time-frequency analysis and wavelet transform techniques, while non-linear techniques are also analyzed. The practical application of well-known algorithms in real applications and signals is carried out by solving laboratory exercises in the laboratory and also by implementing tasks at home. A key component of the course is the extension of processing techniques to multidimensional signals, either one-dimensional multi-channel signals or two-dimensional images, resulting in cutting-edge technologies that utilize artificial intelligence and machine learning methods, such as Convolutional Neural Networks.

Week	Subject title	Bibliography	e-class
1	**Introduction on Signals & Systems:** Basic Concepts, signals & systems, types of signal, continuous and discrete time signals & systems, transformations of independent and dependent variable, examples**.**	[1]	https://www.dit.uoi.gr/e-class/courses/257/
2	**Convolution and Linear Displacement Independent Systems and Convolution:** Linear time - Independent Systems, Properties, Impulse Response, Convolution Properties, Convolution Calculation Techniques, Exercises, programming examples	[1]	https://www.dit.uoi.gr/e-class/courses/257/
3	**Introduction to MATLAB/GNU Octave Programming:** Programming Environment, Basic Functions, Vectors and Arrays, Functions from Specialized Signal and Image Processing Toolkits, and Statistical, Artificial Intelligence	[2]	https://www.dit.uoi.gr/e-class/courses/257/
4	**Fourier Transform** Physical Interpretation, Frequency Domain, Calculation, Fourier Transform of Known Functions, Programming Examples	[1],[3]	https://www.dit.uoi.gr/e-class/courses/257/
5	**Discrete Time Fourier Transform and Discrete Fourier Transform:** Signal transformation methods by case, fast Fourier transform. Exercises, programming examples	[3]	https://www.dit.uoi.gr/e-class/courses/257/

6	**Short-time Fourier Transform and Time-Frequency Analysis:** Fundamentals, applications and implementations in real signals. Exercises, programming examples	[1]	https://www.dit.uoi.gr/e-class/courses/257/
7	**Wavelet Transform:** Basic principles of transformation, Separation of signals into respective frequency bands, wavelet visualization, exercises, programming examples	[2]	https://www.dit.uoi.gr/e-class/courses/257/
8	**Nonlinear Analysis:** Fractals, Chaotic Behavior.	[1]	https://www.dit.uoi.gr/e-class/courses/257/
9	**Multichannel Signal Processing:** Processing of multichannel signal instances. Implementation. Biomedical Technology applications, programming examples	[4]	https://www.dit.uoi.gr/e-class/courses/257/
10	**Multidimensional Signals and Image Processing:** Review of Classical Image Processing Techniques, Histogram Thresholding, Morphological Approaches	[5], [6]	https://www.dit.uoi.gr/e-class/courses/257/
11	**Image Processing Using Machine Learning:** Feature Extraction from Images Clustering Applications in Image, Classification Applications in Image, Introduction to Machine Vision, Programming Examples	[5], [6]	https://www.dit.uoi.gr/e-class/courses/257/
12	**Convolutional Neural Networks (CNNs):** Levels of Convolutional Networks, Parameterization of Convolutional Levels known architectures of pre-trained networks with transfer learning (Transfer Learningn). programming examples	[5]	https://www.dit.uoi.gr/e-class/courses/257/
13	**Project Presentation:** Presentation of students' theoretical and programming work and recap.		https://www.dit.uoi.gr/e-class/courses/257/

4. TEACHING and LEARNING METHODS - EVALUATION

DELIVERY	Face to face.
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY	☒ Use of electronic presentations, posted in the e-class ☒ Using Software on the Computer during the lecture. ☒ Use of specialized software ☒ Availability of educational material through e-class. ☒ Management of tasks/exercises through a website. ☒ Communication with students via e-mail. ☐ Online chat room for teachers and students.
TEACHING METHODS	

Activity	***Semester workload***
Lectures	26 h
Laboratory practice	13 h
Homeworks	31 h
Project implementation	40 h
Non – directed study	70 h
Course total	**180 h**

ΑΞΙΟΛΟΓΗΣΗ ΦΟΙΤΗΤΩΝ	The evaluation of the course will result from the combination of individual performance for: • Homeworks which will contain exercises and programming tasks (40/100). • Project which students will implemented in groups of two people (60/100). The proper Solution methodology (50/100), the understanding of functions (30/100), the correct numerical solution and extraction of results (20/100) will be evaluated. For all of the above, there will be corresponding material posted on the course website, many similar examples of equal difficulty, also indicative examples of written assignments and laboratory exercises.

5. ATTACHED BIBLIOGRAPHY

- *Suggested bibliography:*

1. Διαμαντάρας Κωνσταντίνος~Μπότσης Δημήτρης Α., Μηχανική μάθηση, Αθήνα, Ελλάς, Εκδόσεις Κλειδάριθμος, 2019.
2. Κ. Διαμαντάρας, Τεχνητά Νευρωνικά Δίκτυα. Αθήνα, Ελλάς: Κλειδάριθμος, 2007
3. S. Haykin, Neural Networks: A Comprehensive Foundation. Prentice-Hall, Upper Saddle River, New Jersey, 1999
4. Lance Chambers, The practical handbook of genetic algorithms applications, Volume I, CHAPMAN & HALL/CRC, United States of America, 2001.
5. Maurice Clerc, Particle Swarm Optimization, Wiley Online Library, United States of America, 2006.
6. Σπυρίδων Λυκοθανάσης, Γενετικοί Αλγόριθμοι και Εφαρμογές, Ελληνικό Ανοικτό Πανεπιστήμιο, Πάτρα, Ελλάδα, 2001.
7. Ιωάννης Μαρινάκης, Μαγδαληνή Μαρινάκη, Νικόλαος Φ. Ματσατσίνης, Κωνσταντίνος Ζουπουνίδης, Μεθευρετικοί και εξελικτικοί αλγόριθμοι σε προβλήματα διοικητικής επιστήμης, Αθήνα, Ελλάδα, Εκδόσεις Κλειδάριθμος, 2011.

8. Δούνιας, Γεώργιος, Τσάκωνας, Αθανάσιος, Εξελικτικός υπολογισμός και εξόρυξη δεδομένων, Αθήνα, Ελλάδα, Εκδόσεις Κλειδάριθμος, 2009.
9. Ιωάννης Γ. Τσούλος, Καθολική βελτιστοποίηση: μέθοδοι, λογισμικό και εφαρμογές, Διδακτορική διατριβή, διαθέσιμη από Εθνικό αρχείο διδακτορικών διατριβών, https://www.didaktorika.gr/eadd/handle/10442/14148