COURSE OUTLINE

(1) GENERAL

SCHOOL	Engineering			
DEPARTMENT	Electrical and Computer Engineering			
LEVEL OF STUDY	Undergraduate			
COURSE UNIT CODE	8.015	**SEMESTER**	8	
COURSE TITLE	Neural Networks			
COURSEWORK BREAKDOWN			**TEACHING WEEKLY HOURS**	**ECTS Credits**
Theory (Lectures)			2	2
Laboratory			1	1
Tutorial/Exercises			1	1
TOTAL			**4**	**4**
COURSE UNIT TYPE	Specialized general knowledge/Skills development			
PREREQUISITES				
LANGUAGE OF INSTRUCTION/EXAMS	Greek and English			
COURSE DELIVERED TO ERASMUS STUDENTS	YES			
WEB PAGE (URL)				

(2) LEARNING OUTCOMES

Learning Outcomes

This course introduces students to the fundamental techniques and applications of neural networks. By the end of the course, students will be able to assess the applicability of neural networks for a given task, select an appropriate neural network paradigm, and build a working neural network model for the task. Through lectures, homework, and laboratory experiments, students should be able to do the following upon completion of this course:

- Understand and explore Neural Network applications.
- Describe the differences between a computer and a Neural Network.
- Understand the basic operation of the neurons in the brain.
- Describe the basic elements of an artificial neuron.
- Understand the various learning methods and Neural Network architectures.
- Design and computer the parameters of perceptron neural network.
- Design and computer the parameters of adaline and madaline neural networks.
- Design and computer the parameters of a multilayer neural network with the backpropagation algorithm.
- Understand the various parameters and options involved in the implementation of a multilayer neural network.
- Understand the main factors involved in learning and generalization in neural networks.
- Design and computer the parameters of a Kohonen Self-Organising Map neural network.
- Understand the fundamentals of deep learning.
- To know the main techniques in deep learning and the main research in this field.
- Identify the deep learning algorithms which are more appropriate for various types of learning tasks in various domains.
- Access practical issues concerning the application on neural networks to real world problems of identification and forecasting.
- Design and implement perceptron neural network with Python.
- Design and implement multilayer neural network with the backpropagation algorithm with Python.
- Design and implement a Kohonen Self-Organising Map neural network with Python.
- Design and implement deep learning algorithms and solve real-world problems.

General Skills
• Autonomous work • Teamwork • Search, analysis and synthesis of data and information, using the necessary technologies • Decision making • Promoting liberal, creative and inductive/deductive thinking • Work in an interdisciplinary environment

(3) SYLLABUS

Description:

The course introduces the theory and practice of neural computation. It provides the principles of neurocomputing with artificial neural networks widely used for addressing real-world problems such as classification, regression, system identification, pattern recognition, data mining, time-series prediction, etc. Artificial neural network models are inspired by biological neural networks. The course begins with an overview of information processing principles in biological systems. The core of the course consists of the theory and properties of major neural network algorithms and architectures. Two main topics are covered: learning linear models by perceptrons, and learning non-linear models by probabilistic neural networks, multilayer perceptrons with backpropagation, and Kohonen neural networks. Finally, Convolution Neural Networks and Deep learning is introduced. The students will have a chance to implement and try out several of these models on practical problems.

Outline:

1. **Introduction:**
   Introduction and motivation for using neural computing, History of neural networks, Neural Networks applications.
2. **Fundamentals of Artificial Neural Networks:**
   Biological prototype, General model for ANN analysis, .Single layer, multilayer and recurrent architectures, Supervised learning, Unsupervised learning, Learning algorithms.
3. **Single Layer Networks:**
   Perceptron model, Linear classification, Geometrical interpretation of layers, Adaline and madalines.
4. **Multilayer Feedforward Networks – Supervised learning:**
   Error backpropagation algorithm, Delta rule, Examples, Convergence, Other Neural Networks learning rules for adaptive multilayer networks.
5. **Neural Networks Applications:**
   Neural Networks applications development methodology, Selected application analysis.
6. **Unsupervised learning:**
   Kohonen Self Organizing feature maps, Learning vector Quantization, Adaptive Resonance Theory (ART).
7. **Deep Learning:**
   Motivation for Deep Architectures, Convolution Nets, Description of Network Architectures, Applications.

(4) TEACHING METHODS - ASSESSMENT

MODE OF DELIVERY	In-Class Face-to-Face, Laboratory exercises
USE OF INFORMATION AND COMMUNICATION TECHNOLOGY	▪ Use of ICTs power point lectures ▪ Use of ICTs for the communication with students via the e-class platform

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- Use of ICTs for laboratory exercises with Python
- Use of ICTs for videotaping the lectures and be available to students

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<tr><td>TEACHING ORGANIZATION</td><td>

<table>
<tr><th>Method description/Activity</th><th>Semester Workload</th></tr>
<tr><td>Lectures</td><td>52</td></tr>
<tr><td>Laboratory</td><td>26</td></tr>
<tr><td>Laboratory Exercises</td><td>26</td></tr>
<tr><td>Non-guided personal study</td><td>16</td></tr>
<tr><td>Total Contact Hours</td><td>120</td></tr>
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<tr><td>ASSESSMENT METHODS</td><td>

- Theory 50%
  - 10% Assignments
  - 20% Project
  - 70% Final
- Laboratory 50%
  - 20% Assignments
  - 20% Overall performance in class
  - 70% Final Project

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(5) RECOMMENDED BIBLIOGRAPHY

-Recommended Bibliography:

- *Artificial Neural Networks, K. Diamantaras, Klidarithmos, 2007. (Greek)*
- *Neural Networks and Learning Machines, Third Edition, Simon Haykin, Prentice-Hall, 2009.*
- *Neural Networks and Deep Learning, Charu C. Aggarwal, Springer, 2018.*
- *Neural Networks and Deep Learning, Michael Nielsen, Determination Press, 2015.*
- *Artificial Intelligence for Humans, Volume 3: Neural Networks and Deep Learning, Jeff Heaton, Heaton Research, 2015.*

Relevant Scientific Journals:

- *Neural Networks, Elsevier*
- *Journal of Artificial Neural Networks*
- *IEEE Transactions on Neural Networks and Learning Systems*
- *International Journal of Neural Systems*
- *Neurocomputing*
- *Neural Computation*