EEL 5813 Neural Networks Algorithms and Applications

Florida International University
Department of Electrical and Computer Engineering
Fall 2025

Course Details

Classroom	:	EC-2440
Class Time	:	**TuTh 12:30PM - 1:45PM**
Faculty	:	Dr. Armando Barreto
Office Hours	:	TuTh 11:30PM - 12:30PM
Office	:	10555 W Flagler Street, EC-3981
Phone	:	(305) 348-3711
Email	:	barretoa@fiu.edu
Corequisite	:	N/A
Textbook (Required)	:	**"Neural Network Design (2nd Edition)"**, Martin Hagan, Howard Demuth, Mark Beale, Orlando De Jesus, Copyright Martin Hagan, & Howard Demuth, 2014 ISBN: 978-0-9717321-1-7, 2014.
Textbook (Reference)	:	See Page 4

Catalog Description

Various artificial neural networks and their training algorithms will be introduced. Their applications to electrical and computer engineering fields will also be covered. (3 credits)

Course Objectives

Upon successful completion of this course the student will be to:

1. Describe the basic architectures of Artificial Neural Networks (ANN).
2. Explain fundamental training methods used in ANN systems.
3. Implement ANN models to solve basic engineering problems such as Pattern Detection, Classification and Clustering.
4. Evaluate the performance of ANN-based solutions.

Topics Covered

1. Course Introduction
2. ANN basic architectures – Illustrative example
3. The Perceptron and the Perceptron Learning Rule
4. The single-layer Adaline Network
5. Background (review) on Linear Algebra / Transformations, Vector Spaces
6. Performance Learning
7. Multilayer Perceptron and Backpropagation Training
8. Challenges that appear in networks with "many layers"

Grading Scheme:

Course Requirements	Weight
Exam (in-class)	30%
Project 1 (Individual)	20%
Project 2 (Individual)	30%
Project 3 (Individual)	20%

Grading Scale:

Letter	Range (%)	Letter	Range (%)	Letter	Range (%)
A	96-100	**B-**	80-83.99	**F**	0-59.99
A-	92-95.99	**C+**	74-79.99		
B+	88-91.99	**C**	68-73.99		
B	84-87.99	**D**	60-67.99		

University's Code of Academic Integrity

Florida International University is a community dedicated to generating and imparting knowledge through excellent teaching and research, the rigorous and respectful exchange of ideas, and community service. All students should respect the right of others to have an equitable opportunity to learn and honestly demonstrate the quality of their learning. Therefore, all students are expected to adhere to a standard of academic conduct, that demonstrates respect for themselves, their fellow students, and the educational mission of the University. All students are deemed by the University to understand that if they are found responsible for academic misconduct, they will be subject to the Academic Misconduct procedures and sanctions, as outlined in the Student Handbook. More information can be found at http://academic.fiu.edu/academic_misconduct.html

Regulations Concerning an Incomplete Grade

An incomplete grade (IN) may be given: (1) at the discretion of the instructor for work not completed during the semester and not caused by the student's own negligence, or (2) in matters of alleged academic misconduct per Regulation 2501 Student Conduct and Honor Code.

- Student must contact (e.g., phone, email, Canvas, etc.) the instructor to discuss the possibility of an Incomplete.
- An IN grade may only be awarded to a student when a small portion of the student's work is missing, not to exceed 50% of the course work, and only when the student is otherwise earning a passing grade.
- The instructor determines the timeline to complete the class, but it cannot exceed two consecutive terms (including summer term) after the initial course, or it will automatically default to an F grade.
- Student must make up the incomplete work through the instructor of the course.

University policies on sexual harassment, and religious holidays, and information on services for students with disabilities

- Please visit the following websites: http://academic.fiu.edu/ and http://drc.fiu.edu

Prior Knowledge Requirements:

1. Linear Algebra (Matrix computations, concepts related to vector spaces)
2. Multivariate Calculus (Derivative, identification of extreme points, e.g., maximum, min; multivariable extension, gradient)
3. Working knowledge and availability of a high-level computer language or a computer simulation environment (MATLAB)

Course Policies:

- Preferred communication channel in case of disruption of campus operation: If our in-person lectures cannot take place as regularly scheduled, I will contact you using your FIU email, to arrange for Zoom meetings.
- The instructor reserves the right to change course materials or dates as necessary.

Project Requirements:

- In addition to the standard ("printed") project reports you will be required to submit the software implementation of the Neural Networks in question, as well as the data sets that are required in each case, all of them in a single archive (e.g., zip) file. The executable programs must be in a format that is verifiable by the instructor (e.g., MATLAB ".m" files). If such a format is not possible, the instructor may require a live demonstration of the project.

- Students **may NOT use any neural networks or machine learning pre-programmed packages** (e.g., TensorFlow, Keras, Scikit-learn, PyTorch, FastAI or ANY of the MATLAB TOOLBOXES) for the completion of any of the projects in this course. All projects must be programmed by the student "from scratch", e.g., using matlab without involving any toolbox.
- All project reports must contain a brief introduction and a "conclusions" section.
- If one or more students present work (projects) as theirs but the instructor determines that the work is not truly the product of the student(s) claiming it (that is, in the event of plagiarism or 'copying'), the instructor will assign 0% for the assignment to all parties involved.

Tentative Weekly Schedule

Dates	Contents	Assessments
Week 1 Aug 25 – Aug 31	**I. Introduction** • Scope of the course • What are AI, ML and Neural Networks? How do they relate to each other? • Characterization of Artificial Neural Networks (ANNs) – Biological inspiration • Applications of ANNs • Development of ANNs	
Week 2 Sep 1 – Sep 7	**II. ANN Basic Architectures – Illustrative Example** • Typical elements in ANNs: Weights, Adders, (Transfer/Activation) Functions, Delays • Feedforward Networks • (Preview example of) Competitive Networks: Hamming Network • (Preview example of) Recurrent Networks: Hopfield Network	
Week 3 Sep 8 – Sep 14	**III. The Perceptron and the Perceptron Learning Rule** • Architecture • Perceptron Learning Rule • Convergence • Limitations: Non-linearly separable problems	
Week 4 Sep 15 – Sep 21	**IV. The single-layer Adaline Network** • Single-Layer Adaline Network • Adaline Learning ("Delta Rule") Equation. • Mean Least Squares Reduction	
Week 5 Sep 22 – Sep 28	**V. Background (review) on Linear Algebra / Transformations, Vector Spaces** • Vector Spaces	EXAM 1
Week 6 Sep 29 – Oct 5	• Linear Transformations for Neural Networks	
Week 7 Oct 6 – Oct 12	**VI. Performance Learning** • Performance Surfaces	
Week 8 Oct 13 – Oct 19	• Performance Optimization	PROJECT 1 due (Capital vowel classification – single layer network)

Week 9 Oct 20 – Oct 26	**VII. Multilayer Perceptron and Backpropagation Training** ("Generalized Delta Rule") • The Multilayer Perceptron architecture	
Week 10 Oct 27 – Nov 2	• Derivation of the Backpropagation (BP) Algorithm (basic) • I) Forward propagation of inputs • II) Backpropagation of sensitivities III) Update of weights and biases	
Week 11 Nov 3 – Nov 9	• Implementation of BP for an MLP in Matlab	
Week 12 Nov 10 – Nov 16	Veterans Day (Tue. Nov 11) - No Class • Non-linear Decision Boundaries	PROJECT 2 due (MNIST handwritten digit classif.– Multilayer BP network)
Week 13 Nov 17 – Nov 23	• Backpropagation with Momentum	
Week 14 Nov 24 – Nov 30	• BP Variations and Considerations (How many hidden layers? Nguyen-Widrow Initialization) Thanksgiving (Thu. Nov 27) - No Class	
Week 15 Dec 1 – Dec 6	**VIII. Challenges that appear in networks with "many layers"** • The Vanishing Gradient Problem • Alternative Activation Functions (e.g., Rectified Linear Unit = ReLU) • Increase in the amount of (labeled) samples required to train • Possibility of "overfitting"	PROJECT 3 due (Classification of myocardial infarction patients from EKG features- BP and BP with Momentum)

Reference Textbooks:

1. "Fundamentals of Neural Networks - Architectures, algorithms and applications."
   Laurene Fausett, Prentice-Hall, 1994., ISBN: 0-13-334186-0
2. "Make Your Own Neural Network"
   Tariq Rashid, CreateSpace Independent Publishing Platform; (March 31, 2016)
   ISBN-10: 1530826608, ISBN-13: 978-1530826605
3. "Understanding Neural Networks: Computer Explorations"
   Maureen Caudill and Charles Butler, MIT Press, 1992. ISBN: 0-262-53099-6
4. "Principles of Artificial Neural Networks"
   Daniel Graupe, World Scientific Publishing Company; 2 edition (April 5, 2007)
   ISBN-10: 9812706240, ISBN-13: 978-9812706249
5. "Neural Networks for Applied Sciences and Engineering: From Fundamentals to Complex Pattern Recognition"
   Sandhya Samarasinghe, Auerbach Publications; 1st edition (September 12, 2006)
   ISBN-10: 084933375X, ISBN-13: 978-0849333750
6. "Hands-On Mathematics for Deep Learning: Build a solid mathematical foundation for training efficient deep neural networks"
   Jay Dawani, Packt Publishing (June 12, 2020)
   ISBN-10: 1838647295, ISBN-13: 978-1838647292
7. "Neural Networks: A comprehensive foundation", (3rd edition)
   Simon Haykin, Macmillan, 2008,
   ISBN-10: 0131471392, ISBN-13: 978-0131471399
8. "Neural Networks And Learning Machines"
   Simon Haykin, Pearson Education; Third edition (2016)
   ISBN-10: 9789332570313, ISBN-13: 978-9332570313