



Course Syllabus

General Information

Course Number: InIn5555

Course Title: **Introduction to Optimization and Neural Networks**

Credit-Hours: Three

Course Description

Basic concepts of classical optimization techniques. Unconstrained optimization will include multivariate searching techniques without using derivatives, and optimization techniques based on the gradient method. Constrained optimization techniques will be focused in sequential quadratic programming. Application in industrial settings will be introduced. Neural networks will be introduced as a nonlinear technique. Neural networks will cover the perceptron, the adaline, and the backpropagation learning rules. Heuristic backpropagation, conjugate gradient backpropagation and Levenberg-Marquardt backpropagation algorithms. Applications of neural networks in industrial settings will be introduced.

Prerequisites

Students will need to have the following courses:

ININ 4021 – Deterministic Models in Operations Research

ININ 4022 – Probabilistic Models in Operations Research

Mate 3063 - Calculus III

Textbook and References

- ☐ Bazaraa, M.S. Sherali, H.D. and Shetty, C.M. 2006, Nonlinear Programming Theory and Algorithms, Third Edition, John Wiley & Sons, Inc. New York.
- ☐ Hagan, M.T., Demuth, H.B., and Beal, M., 1996, Neural Network Design, PWS Publishing Co, Boston
- ☐ Freeman, J.A., Skapura, D.M., 1992, Neural Networks Algorithms, Applications, and Programming Techniques, Addison-Wesley, Publishing Co., Massachusetts
- ☐ Beal, R. and Jackson, T., 1998, Neural Computing and Introduction, Adam Hilger, New York.
- ☐ Smith, M. 1993, Neural Networks for Statistical Modeling, Van Nostrand Reinhold, New York.
- ☐ Bose, N.K. and Liang, P., 1996, Neural Network Fundamentals with Graphs, Algorithms, and Applications, McGraw-Hill, Inc. New York

Purpose

This course provides the student the sufficient mathematical and computational background to formulate and solve nonlinear optimization problems that involve the application of direct searching techniques, fundamental nonlinear algorithms such as the gradient and the sequential quadratic algorithm. Students will also be prepared to understand the neural network algorithms and their application in solving classification and modeling problems.

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Course Goals

After completing the course, the student will be able to:

- ☐ Understand the fundamental concepts of nonlinear optimization.
- ☐ Develop an appropriate model for a given nonlinear optimization problem.
- ☐ Identify the appropriate algorithm for solving a given nonlinear problem.
- ☐ Learn the uses of computer packages to solve nonlinear optimization problems.
- ☐ Understand the capabilities and limitations of neural networks.
- ☐ Develop a computer program to solve prediction and control problems.

Requirements

All students are expected to come to class on time, and prepared; do all assigned readings and related homework; actively participate in class discussions; and satisfy all assessment criteria to receive credit for the course.

Department and Campus Policies

Class attendance: Class attendance is compulsory. The University of Puerto Rico, Mayagüez Campus, reserves the right to deal at any time with individual cases of non-attendance. Professors are expected to record the absences of their students. Frequent absences affect the final grade, and may even result in total loss of credits. Arranging to make up work missed because of legitimate class absence is the responsibility of the student. (Bulletin of Information Undergraduate Studies).

Absence from examinations: Students are required to attend all required examinations. If a student is absent from an examination for a justifiable reason acceptable to the professor, he or she will be given a special examination. Otherwise, he or she will receive a grade of zero or "F" in the examination missed. (Bulletin of Information Undergraduate Studies)

Final examinations: Final written examinations must be given in all courses unless, in the judgment of the Dean, the nature of the subject makes it impracticable. Final examinations scheduled by arrangements must be given during the examination period prescribed in the Academic Calendar, including Saturdays. (See Bulletin of Information Undergraduate Studies).

Partial withdrawals: A student may withdraw from individual courses at any time during the term, but before the deadline established in the University Academic Calendar. (See Bulletin of Information Undergraduate Studies).

Complete withdrawals: A student may completely withdraw from the University of Puerto Rico, Mayagüez Campus, at any time up to the last day of classes. (See Bulletin of Information Undergraduate Studies).

Disabilities: After introducing and identifying himself/herself to the instructor and the institution as a student with disability, the student will receive reasonable accommodations in his/her courses and evaluations. For additional information you can, contact Services to Students with Disabilities at the office of the Dean of students (Q-019), 787 – 265 – 3862 ó 787 – 832 – 4040 exts. 3250, 3258.

Ethics: Any academic fraud is subject to the disciplinary sanctions described in Chapter VI of the revised General Student Bylaws of the University of Puerto Rico of the Board of Trustees. The professor will follow the norms established in articles 2.6 to 2.14 of the Bylaws.

(http://www.uprm.edu/procuraduria/documentos_oficiales.html)

Campus Resources

General Library and University Computer Center is available to obtain professor's reference materials. The University's Counseling Office has a tutorial program for students who need extra help.

Course Syllabus

General Topics		
Lecture	Topic	Reading
	UNCONSTRAINED OPTIMIZATION	
1	Introduction	T1: 4.1-4.2
2	The Simplex Search Method	T1: 8.5
3	The Hooke & Jeeves Method	T1: 8.5
4-5	Powell 's Conjugate Direction Method	T1: 8.8
6	Steepest Descent Method	T1: 8.6
7	Newton 's Method	T1: 8.7
8	Marquardt Method	T1: 8.7
9-10	Conjugate Gradient Method	T1: 8.8
11-12	Quasi-Newton Method	T1: 8.8
	CONSTRAINED OPTIMIZATION	
13-14	Quadratic Programming	T1: 11.2
15-16	Sequential Quadratic Programming	T1: 10.4
	Applications (Case Study)	
17	Maximizing Storage Capacity	
18	Production Planning with Nonlinear Costs	
	NEURAL NETWORKS	
19	Perceptron Architecture	T2: 4.1-4.8
20-21	Perceptron Learning Rules	T2: 4.8-4.13
22-23	Adaline Learning Rules	T2: 11.1- 11.4
24	Multilayer Perceptron	T2: 11.1 – 11.4
25-27	Backpropagation Algorithm	T2: 11.7 – 11.24
28-30	Heuristic Backpropagation	T2:12.1 – 12.12
31-32	Conjugate Gradient BP	T2: 12.14
33-35	Levenberg- Marquardt BP	T2: 12.19
	APPLICATIONS	
36	Control of the pH of erythromycin	
37	Minimization Disposal Costs	
38	Delay Detection in Extraction Process	
39	Control Dissolved Oxygen Limitations	
40	Prediction of Erythromycin Concentrations	

*Legend:

T1: Bazaraa, Sherali and Shetty, 1993

T2: Hagan, Demuth and Beal, 1996

Coordinator: Dr. Nazario Ramírez

Additional Policies

Meeting time and Place

- Tuesday and Thursday 9:00 am – 10:15 am
- II 201

Lecturer

- Mauricio Cabrera-Ríos, PhD
- Office: OFICINAS 342
- E-mail: mauricio.cabrera1@upr.edu, mauricio.cabrera@gmail.com
- Office Hours: Monday and Wednesday 9:00 am to 12:00 pm or BY APPOINTMENT

Examinations

- Two midterm exams
- Be on time, no make-up time will be provided for those arriving late
- **If for any reason you are absent in a scheduled exam: NOTIFY THE LECTURER the same day of the scheduled exam the reason of your absence. There is no exception to this rule, it has to be on the same day of the scheduled exam through any possible means.**
- Any request for an early or late exam requires a formal justification from a third-party that will be verified by the instructor. **Upon verification, the instructor will decide if the right to take the exam will be granted. The exam will be scheduled to be taken within a week of the original exam date.**

Mini-projects

- Up to six group mini-projects in the course. MUST achieve at least 90% in all of them.
- Mini-projects will be graded in a 100 pt. scale.
- A report of at most 5 pages will be turned on each case in addition of any especial requirement.

Academic Misconduct

- Copied assignments and identical printouts will be subject to Academic Misconduct.
- DO NOT do anything good that looks bad to the lecturer.
- When in doubt, ask the lecturer.

Grading

The student's final course score will be a weighted average with the following weights:

- Midterm 1 10%
- Midterm 2 10%
- Mini-Projects 60%
- Attendance 10%