INSTITUTO POLITÉCNICO NACIONAL

SECRETARÍA ACADÉMICA

DIRECCIÓN DE EDUCACIÓN SUPERIOR

SYNTHESIZED SCHOOL PROGRAM

ACADEMIC UNIT: Escuela Superior de Cómputo

ACADEMIC PROGRAM: Ingeniería en Sistemas Computacionales

LEARNING UNIT: Supervised Neural Networks **LEVEL:** III

AIM OF THE LEARNING UNIT:
The student builds computer systems for pattern recognition and classification, based on the technology of Supervised Learning Neural Networks.

CONTENTS:

I. Fundamentals of Supervised Neural Networks.
II. Single-layer Supervised Neural Networks.
III. Feed forward Multilayer Supervised Neural Networks.
IV. Design & Simulation of Neural Networks.
V. Accelerated Learning Methods on Multilayer Neural Networks.
VI. Implementations of Neural Networks on programmable devices

TEACHING PRINCIPLES:
The teacher will apply a Projects-Based learning process, through inductive and heuristic methods using analysis techniques, technical data, organization charts, cooperative presentation, exercise-solving and the production of the learning evidences. It will encourage teamwork and individual integrity and responsibility to the environment. Moreover, an autonomous learning will be encouraged by the development of a final project.

EVALUATION AND PASSING REQUIREMENTS:
The program will evaluate the students in a continuous formative and summative way, which will lead into the completion of learning portfolio. Some other assessing methods will be used, such as revisions, practical´s, class participation, exercises, learning evidences and a final project.

Unit Learning can also be approved through::

- Evaluation of acknowledges previously acquired, by developing a computer program and a written evidence of learning
- Official recognition by either another IPN Academic Unit of the IPN or by a national or international external academic institution besides IPN with a current cooperation a agreement.

REFERENCES:

- Demouth H., Beale M., Hagan M. (2009). Matlab Neural Network Toolbox 6 User´s Guide. The Matworks, Inc, USA. on line only (16/marzo/2011). www.mathworks.com/access/helpdesk/help/pdf_doc/nnet/nnet.pdf.
- Hagan, M. T. Demuth, H. B. Beale, M. (2002). *Neural Network Design*. USA: PWS Publishing Company. ISBN-13: 978-0534943325.
- Haykin, S. (2009). *Neural Networks and Learning Machines*. (3ª Edition). USA: Prentice Hall. ISBN: 13: 978-0-13-147139-9.
- Ham, F. M. Kostanic, I. (2001). *Principles of Neurocomputing for Science & Engineering*. New York USA: Mc Graw-Hill. ISBN 0-07-025966-6.
- Omondi A. R., Rajapakse J. C. (2006). FPGA Implementation of Neural Networks, Springer, Dordrecht, The Netherlands. ISBN -10: 0-387-28485-0 (HB)

INSTITUTO POLITÉCNICO NACIONAL

SECRETARÍA ACADÉMICA

DIRECCIÓN DE EDUCACIÓN SUPERIOR

ACADEMIC UNIT: Escuela Superior de Cómputo.
ACADEMIC PROGRAM: Ingeniería en Sistemas Computacionales
LATERAL OUTPUT: Analista Programador de Sistemas de Información.
FORMATION AREA: Professional.
MODALITY: Presence.

LEARNING UNIT: Supervised Learnig Neural Networks.
TYPE OF LEARNING UNIT: Theorical - Practical, Optative.
VALIDITY: August, 2011
LEVEL: lll.
CREDITS: 7.5 Tepic, 4.39 SATCA

ACADEMIC AIM

This program contributes to the profile of graduated on Ingeniería en Sistemas Computacionales, to develop the skills to design computer systems based on supervised neural networks for solving computational problems in engineering, the ability to describe and to distinguish the major network architectures, the ability to implement intelligent systems in integrated circuits, ability to design and simulate intelligent systems through the main neural network simulators.

It also helps to develop generic skills such as strategic thinking, creative thinking, collaborative and participatory work, assertive communication, contributing to their integral development, so The student will be able to perform in different sectors of society, public private research and integrate and manage internal work teams and multidisciplinary with an attitude of leadership, ethics and responsibility. The student is continuously updated to meet the needs of society and sustainable development of the country

It is based on the progrmasof linear algebra, calculus, algorithms and structured programming, analysis and object-oriented design, and software engineering. It is related laterally to pattern recognition, artificial intelligence, genetic algorithms, Fuzzy Systems Engineering, Computational Intelligence in Control Engineering and Unsupervised Artificial Neural Networks. This supports subsequent to the learning units Terminal Work I and II.

AIM OF THE LEARNING UNIT:
The student builds computer systems for pattern recognition and classification, based on the technology of Supervised Learning Neural Networks.

CREDITS HOURS

THEORETICAL CREDITS / WEEK: 3.0

PRACTICAL CREDITS / WEEK: 1.5

THEORETICAL HOURS / SEMESTER: 54

PRACTICAL HOURS / SEMESTER: 27

AUTONOMOUS LEARNING HOURS: 54

CREDITS HOURS / SEMESTER: 81

LEARNING UNIT DESIGNED BY:
Academia de Ingeniería de software.

REVISED BY:
Dr. Flavio Arturo Sánchez Garfias.
Subdirección Académica

APPROVED BY:
Ing. Apolinar Francisco Cruz Lázaro.
Presidente del CTCE

AUTHORIZED BY: Comisión de Programas Académicos del Consejo General Consultivo del IPN

Ing. Rodrigo de Jesús Serrano Domínguez
Secretario Técnico de la Comisión de Programas Académicos

THEMATIC UNIT: I **TITLE:** Fundamentals of Supervised Neural Networks

UNIT OF COMPETENCE

The student classifies supervised learning algorithms based on the architecture of Artificial Neural Networks.

No.	CONTENTS	Teacher led-Instruction HOURS		Autonomous Learning HOURS		REFERENCES KEY
		T	P	T	P	
1.1	Historical framework of artificial neural networks.	3.0	0.0	5.0	3.0	3B, 4B, 7B
1.2	Definitions of neural networks.					
1.3	The biological neuron model.					
1.4	The artificial neural network model.					
1.5	Characteristics of neural networks.					
1.6	Applications of neural networks.					
1.7	Supervised learning algorithms.					
1.8	Supervised neural network architectures					
	Subtotals:	3.0	0.0	5.0	3.0	

TEACHING PRINCIPLES

This thematic unit must start in the frame of the course and team building. Thematic unit will be addressed through the strategy of project-based learning, using the inductive method; This unit uses learning techniques such as concept mapping, cognitive maps, worksheets, presentation of additional issues, development of practice and final project proposal.

LEARNING EVALUATION

Diagnostic Test

Project Portfolio:

Project proposal	10%
Graphic Organizers	5%
Worksheet	5%
Exposure themes	10%
Report of Practical	20%
Self-Evaluation Rubrics	5%
Cooperative-evaluation Rubrics	5%
Written Learning Evidence	40%

THEMATIC UNIT: II **TITLE:** Single-layer Supervised Neural Networks

UNIT OF COMPETENCE

The student solves classification problems of simple patterns, based on learning algorithms and architectures of single-layer supervised neural networks.

No.	CONTENTS	Teacher led-Instruction HOURS		Autonomous Learning HOURS		REFERENCES KEY
		T	P	T	P	
2.1	The Perceptron	1.5	0.5	2.5	1.5	3B, 4B, 7B, 12B
2.1.1	General features of the simple perceptron.					
2.1.2	Simple and multiple perceptron architecture.					
2.1.3	Perceptron learning rule.					
2.1.4	Main Applications.					
2.1.5	Examples and exercises of graphic rating method					
2.1.6	Examples and classification exercises using the perceptron rule.					
2.1.7	Perceptron Simulation in MATLAB / NNT.					
2.2	Adaline network					
2.2.1	General characteristics of Adaline	1.5	0.5	2.5	1.5	
2.2.2	Adaline Architecture					
2.2.3	Learning algorithm (delta rule)					
2.2.4	Main applications					
2.2.5	Examples and exercises in pattern classification					
2.2.6	Examples and exercises of signal processing					
2.2.7	Adaline network simulation in Matlab Neural Network Toolbox (Matlab/NNT).					
	Subtotals:	3.0	1.0	5.0	3.0	

TEACHING PRINCIPLES

This unit will be addressed through the strategy of project-based learning, using the inductive method also will be added concept mapping techniques, cognitive maps, exercises-solving, exposure of issues, development of practical programming algorithms, and advance final project.

LEARNING EVALUATION

Project Portfolio:

Graphic Organizers	5%
Exercise delivery	5%
Exposure themes	5%
Report of Practical	20%
Program delivery	10%
Advance of the Project	5%
Self-Evaluation Rubrics	5%
Cooperative-evaluation Rubrics	5%
Written Learning Evidence	40%

THEMATIC UNIT: III **TITLE:** Feed forward Multilayer Supervised Neural Networks

UNIT OF COMPETENCE

The student solves problems of complex pattern classification, based on learning algorithms and architectures of supervised multilayer neural networks.

No.	CONTENTS	Teacher led-Instruction HOURS		Autonomous Learning HOURS		REFERENCES KEY
		T	P	T	P	
3.1	Multilayer Perceptrons	1.5	1.0	3.0	1.5	3B, 4B, 7B, 12B
3.1.1	General Features					
3.1.2	Multilayer network architecture.					
3.1.3	Examples of pattern classification with Graphical Method					
3.1.4	Generalized Delta Rule (Backpropagation)					
3.1.5	Main applications.					
3.1.6	Examples and exercises in functions approximation.					
3.1.7	Examples and exercises in pattern classification					
3.1.8	Multilayer network simulation in Matlab / NNT					
3.2	Radial Basis Function Neural Networks (RBFN)					
3.2.1	General Features.	1.5	0.5	3.0	1.5	
3.2.2	Architecture.					
3.2.3	Learning algorithm.					
3.2.4	Main applications.					
3.2.5	Examples and exercises of function approximation and pattern classification					
3.2.6	Simulations in MATLAB/NNT.					
	Subtotals:	3.0	1.5	6.0	3.0	

TEACHING PRINCIPLES

This unit will be addressed through the strategy of project-based learning, using the inductive method also will be added concept mapping techniques, cognitive maps, exercises-solving, exposure of issues, development of practical, programming algorithms, and advance final project.

LEARNING EVALUATION

Project Portfolio:

Graphic Organizers	5%
Exercise delivery	5%
Exposure themes	10%
Report of Practical	20%
Program delivery	15%
Advance of the Project	5%
Self-Evaluation Rubrics	5%
Cooperative-evaluation Rubrics	5%
Written Learning Evidence	30%

THEMATIC UNIT: IV **TITLE:** Design & Simulation of Neural Networks

UNIT OF COMPETENCE

The student designs systems of complex pattern classification based on heuristics and simulation tools of supervised multilayer neural networks.

No.	CONTENTS	Teacher led-Instruction HOURS		Autonomous Learning HOURS		REFERENCES KEY
		T	P	T	P	
4.1	Multilayer Network Design (Feedforward).	1.0		1.5		1C, 2C, 10C, 11C, 13C
4.1.1	Overview of neural network design.					
4.1.2	Number of input and output neurons.					
4.1.3	Number of hidden layers.					
4.1.4	Number of neurons in hidden layers					
4.1.5	Sets standards for training and testing.					
4.1.6	Training methodology.					
4.1.7	Unwanted effects during training:					
4.1.8	Correction methods underfitting and overfitting					
4.2	MATLAB: Neural Network Toolbox.	1.0	0.5	1.5	1.0	
4.2.1	Introduction.					
4.2.2	General Features					
4.2.3	Construction of neural networks					
4.2.4	Simulation of supervised artificial neural networks.					
4.3	NeuroSolutions.	1.0	0.5	1.5	1.0	
4.3.1	Introduction.					
4.3.2	General Features					
4.3.3	Construction of neural networks					
4.3.4	Supervised Neural Network Simulation					
4.4	Stuttgart Neural Network Simulator (SNNS).	1.0	0.5	1.5	1.0	
4.4.1	Introduction.					
4.4.2	General Features.					
4.4.3	Neural network construction.					
4.4.4	Supervised Neural Network Simulation					
	Subtotals:	4.0	1.5	6.0	3.0	

TEACHING PRINCIPLES

This unit will be addressed through the strategy of project-based learning, using the inductive method also will be added concept mapping techniques, cognitive maps, exercises-solving, exposure of issues, development of practical, programming algorithms, and advance final project.

LEARNING EVALUATION

Project Portfolio:

Graphic Organizers	5%
Exercise delivery	5%
Exposure themes	10%
Report of Practical	20%
Program delivery	15%
Advance of the Project	5%
Self-Evaluation Rubrics	5%
Cooperative-evaluation Rubrics	5%
Written Learning Evidence	30%

THEMATIC UNIT: V **TITLE:** Accelerated Learning Methods on Multilayer Neural Networks

UNIT OF COMPETENCE

The student simulates multilayer supervised neural networks based on advanced heuristics and numerical methods.

No.	CONTENTS	Teacher led-Instruction HOURS		Autonomous Learning HOURS		REFERENCES KEY
		T	P	T	P	
5.1	Variable learning rate	0.5		1.0	0.5	3B, 4B, 7B,
5.1.1	General Features					
5.1.2	Learning algorithm.					
5.1.3	Exercises.					
5.1.4	Simulation in Matlab / NNT.					
5.2	Momentum Method.	0.5		0.5	0.5	
5.2.1	General Features					
5.2.2	Learning algorithm.					
5.2.3	Exercises.					
5.2.4	Simulation in Matlab / NNT					
5.3	Variable and momentum learning.	1.0	0.5	1.5	1.0	
5.3.1	General characteristics					
5.3.2	Learning algorithm.					
5.3.3	Exercises.					
5.3.4	Simulation in Matlab / NNT.					
5.4	Conjugate Gradient Method.	1.0	0.5	1.5	1.0	
5.4.1	General Features.					
5.4.2	Learning algorithm.					
5.4.3	Exercises.					
5.4.4	Simulation in Matlab / NNT.					
5.5	Levenberg Marquardt Algorithm.	1.0	0.5	1.5	1.0	
5.5.1	General characteristics.					
5.5.2	Learning algorithm.					
5.5.3	Exercises					
5.5.4	Simulation in Matlab / NNT					
	Subtotals:	4.0	1.5	6.0	4.0	

TEACHING PRINCIPLES

This unit will be addressed through the strategy of project-based learning, using the inductive method also will be added concept mapping techniques, cognitive maps, exercises-solving, exposure of issues, development of practical, programming algorithms, and advance final project.

LEARNING EVALUATION

Project Portfolio:

Graphic Organizers	5%
Exercise delivery	5%
Exposure themes	10%
Report of Practical	20%
Program delivery	20%
Advance of the Project	15%
Self-Evaluation Rubrics	5%
Cooperative-evaluation Rubrics	5%
Written Learning Evidence	15%

THEMATIC UNIT: VI **TITLE:** Implementations of Neural Networks on programmable devices

UNIT OF COMPETENCE

The student designs supervised neural network based on programmable devices.

No.	CONTENTS	Teacher led-Instruction HOURS		Autonomous Learning HOURS		REFERENCES KEY
		T	P	T	P	
6.1	Fundamentals of programmable devices.	0.5		1.0		1C, 9C, 8C,
6.1.1	Introduction.					
6.1.2	General Features					
6.1.3	Classification					
6.1.4	Overview of design and simulation tools.					
6.2	Fundamentals of embedded systems.	0.5		1.0		
6.2.1	Introduction.					
6.2.2	Definition.					
6.2.3	Features					
6.2.4	Examples of embedded systems					
6.3	Main architectures for the construction of neural	1.0		2.0	2.0	
6.3.1	networks.					
6.3.2	Introduction.					
6.3.3	General Features.					
6.3.4	Neural network construction.					
6.4	Supervised Neural Network Simulation	1.0	1.5	2.0	2.0	
6.4.1	Supervised Neural Network Implementation of Programmable Devices.					
6.4.2	Design and simulation of Supervised Neural Networks in programmable devices					
6.4.3	Dedicated design implementation. Soft-core implementation					
	Subtotals:	3.0	1.5	6.0	4.0	

TEACHING PRINCIPLES

This unit will be addressed through the strategy of project-based learning, using the inductive method also will be added concept mapping techniques, cognitive maps, exercises-solving, exposure of issues, development of practical, programming algorithms, and final project.

LEARNING EVALUATION

Project Portfolio:

Exercise delivery	5%
Exposure themes	5%
Report of Practical	20%
Program delivery	15%
Final project	30%
Self-Evaluation Rubrics	5%
Cooperative-evaluation Rubrics	5%
Written Learning Evidence	15%

RECORD OF PRACTICALS

No.	NAME OF THE PRACTICAL	THEMATIC UNITS	DURATION	ACCOMPLISHMENT LOCATION
1	Simple neural models.	I	3.0	Computer Labs.
2	The Perceptron.	II	2.0	
3	Adaline.	II	2.0	
4	Multilayer Perceptron.	III	3.0	
5	Radial Basis Networks.	III	1.5	
6	RNA Simulators	IV	4.5	
7	Methods to accelerate the training of multilayer networks.	V	5.5	
8	Supervised Neural Network Implementation on Programmable devices.	VI	5.5	
		TOTAL OF HOURS	27.0	

EVALUATION AND PASSING REQUIREMENTS:

The practical are considered mandatory to pass this unit of learning.
The practical mean 20% in each thematic unit.
The practices contribute 20% of the final grade.

PERÍOD	UNIT	EVALUATION TERMS
1 2 3	I, II III, IV V, VI	Continuous evaluation 60% and written learning evidence 40% Continuous evaluation 70% and written learning evidence 30% Continuous evaluation 85% and written learning evidence 15% The Learning unit I is 15% worth of the final score The Learning unit II is 15% worth of the final score The Learning unit III is 15% worth of the final score The Learning unit IV is 15% worth of the final score The Learning unit V is 15% worth of the final score The Learning unit VI is 25% worth of the final score Learning unit can also be approved through:: • Evaluation of acknowledges previously acquired, by developing a computer program and a written evidence of learning • Official recognition by either another IPN Academic Unit of the IPN or by a national or international external academic institution besides IPN agreement which has. If accredited by Special Assessment or a certificate of proficiency, this will include a practical part which contribute 50% of the grade and a theoretical part that will provide the remaining 50%, based on guidelines established by the academy.

KEY	B	C	REFERENCES
1		X	Chu, P. P. (2008). *FPGA Prototyping by VHDL Examples Xilinx Spartan-3 version*. USA: Wiley-Interscience. ISBN 10:-0470185317.
2		X	Demouth H., Beale M., Hagan M. (2009). *Matlab Neural Network Toolbox 6 User´s Guide*. The Matworks, Inc, USA. on line only (19/Nov/2009). *www.mathworks.com/access/helpdesk/help/pdf_doc/nnet/nnet.pdf*
3	X		Hagan M. T., Demuth H. B., Beale M. (2002) *Neural Network Design.* PWS Publishing Company. USA. 1-665. ISBN-10: 0971732108
4	X		Ham F. M., Kostanic I. (2001). *Principles of Neurocomputing for Science & Engineering.* Mc Graw-Hill, New York USA. 1-642. ISBN 0-07-025966-6.
5		X	Heaton J., (2008). *Introduction to Neural Networks for C#*, 2nd Edition, Heaton Research Inc. USA, 1-428. ISBN-10: 1604390093.
6		X	Heaton J., (2008) *Introductions of Neural Networks for Java*, 2nd Edition, Heaton Research Inc. USA, 1-440. ISBN-10: 1604390085
7	X		Haykin S. (2009). *Neural Networks and Learning Machines*; 3ª Edition. Prentice Hall, USA. 1-936. ISBN-10: -0-13-147139-2.
8		X	Omondi A. R., Rajapakse J. C. (2006). *FPGA Implementation of Neural Networks*, Springer, Dordrecht, The Netherlands, 1- 360. ISBN -10: 0-387-28485-0 (HB).
9		X	Pedroni V. A. (2004). *Circuit Design with VHDL*, MIT Press, Massachusetts USA, 1-363. ISBN 0-262-16224-5.
10		X	Principe J., Euliano N. R. Lefebvre C. W. (1999). *Neural and Adaptive Systems: Fundamentals through Simulations*, Wiley & Sons, USA 1-672. ISBN-10: 0471351679.
11		X	Principe J., Lefebvre C., Lynn G, Fancourt C., Wooten D..; *Neurosolutions Getting Started Manual version 5*, NeuroDimension, Inc, USA 2006, on line (19/Nov/2009). *http://www.neurosolutions.com/downloads/documentation.html*
12	X		Reed R. D., Marks II R. J., (1999). *Neural Smithing: Supervised Learning in Feedforward Artificial Neural Networks*, The MIT Press, USA, 1-352. ISBN-10: 0262181908
13		X	Zell A., Mamier G., Vogt M. et all; (1995). *Stuttgart Neural Network Simulator User Manual, version 4.2*; University of Stuttgart, Germany, , 1-350. on line (19/Nov/2009). http://www.ra.cs.uni-tuebingen.de/SNNS/UserManual/UserManual.html.

INSTITUTO POLITÉCNICO NACIONAL

SECRETARÍA ACADÉMICA

DIRECCIÓN DE EDUCACIÓN SUPERIOR

TEACHER EDUCATIONAL PROFILE PER LEARNING UNIT

1. GENERAL INFORMATION

ACADEMIC UNIT: Escuela Superior de Cómputo.

ACADEMIC PROGRAM: Ingeniería en Sistemas Computacionales. **LEVEL** III

FORMATION AREA:

Institutional	Basic Scientific	Professional	Terminal and Integration

ACADEMY: Ingeniería de software. **LEARNING UNIT:** Supervised Neural Networks.

SPECIALTY AND ACADEMIC REQUIRED LEVEL: Master or PhD in Computer Science or Electrical Engineering

2. AIM OF THE LEARNING UNIT:

The student builds computer systems for pattern recognition and classification, based on the technology of Supervised Learning Neural Networks.

3. PROFFESSOR EDUCATIONAL PROFILE:

KNOWLEDGE	PROFESSIONAL EXPERIENCE	ABILITIES	APTITUDES
• Concepts and learning algorithms of neural networks. • Techniques for design and simulation of neural networks. • Settlement Pattern classification problems. • Function approximation using neural networks • Knowledge of the Institutional Educational Model. • English.	• One year experience in the design of systems based on neural networks • Two years experience in handling groups and collaborative work • A year experience in the Institutional Educational Model.	• Analysis and synthesis. • Leadership. • Decision making. • Conflict Management. • Group management. • Verbal fluency of ideas. • Teaching Skills • Applications of Institutional Educational Model.	• Responsible. • Tolerant. • Honest. • Respectful. • Collaborative. • Participative. • Interested to learning. • Assertive.

DESIGNED BY	REVISED BY	AUTHORIZED BY
M en C. José Luis Calderón Osorno COORDINATING PROFESOR	Dr. Flavio Arturo Sánchez Garfias Subdirector Académico	Ing. Apolinar Francisco Cruz Lázaro Director
M en C. Edmundo René Durán Camarillo DR. Luz Noé Oliva Moreno M en C. Víctor Hugo García Ortega. COLLABORATING PROFESSORS		

Date: 2011