ENGG*4430 Neuro-Fuzzy and Soft Computing Systems

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Winter 2024
Section(s): C01

School of Engineering
Credit Weight: 0.50
Version 1.00 - January 24, 2024

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1 Course Details

1.1 Calendar Description

This course covers the basics of fuzzy systems, neural networks and neuro-fuzzy systems. The main focus is the concepts and algorithms of fuzzy sets, rules, and reasoning, as well as neural network structures, supervised learning and unsupervised learning of neural networks, and hybrid neuro-fuzzy systems. The applications of neural networks and fuzzy systems to control systems, signal processing, systems modeling and systems identification will be presented through examples.

Pre-Requisites:	ENGG*3410
Restrictions:	Non-BENG students may take a maximum of 4.00 ENGG credits.

1.2 Course Description

This course is an introductory course in neuro-fuzzy and soft computing systems, which is a basic course in most electrical and computer engineering programs. The main goals of the course are (1) to teach students the fundamental concepts in neuro-fuzzy and soft computing systems, and (2) to illustrate clearly how the neuro-fuzzy algorithms would provide intelligent solutions to various problems.

1.3 Timetable

Lectures

Monday, 7:00 - 9:50 pm, ALEX 309

1.4 Final Exam

Friday, April 12, 8:30 - 10:30 am

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2 Instructional Support

2.1 Instructional Support Team

Instructor: Simon Yang Ph.D., P.Eng.
Email: syang@uoguelph.ca
Telephone: +13594295669
Office: RICHS 2513

2.2 Teaching Assistants

Teaching Assistant (GTA): Nicholas Smith
Email: nsmith27@uoguelph.ca

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3 Learning Resources

3.1 Required Resources

Course Website (Website)
Course material, news and announcements will be regularly posted at the ENGG*4430 Courselink.

3.2 Recommended Resources

No specific textbooks will be assigned. Follow lecture notes and use the following references:

- *Soft Computing & Intelligent Systems Design*, by Karray & De Silva, Addison-Wesley, 2005.
- *Neuro-fuzzy and Soft Computing,* by Jang, Sun & Mizutani, Prentice Hall, 1997.
- *An Introduction to Fuzzy Sets,* by Pedrycz & Gomide, MIT Press, 1998.
- *Reinforcement Learning: An Introduction*, by Sutton & Barto, MIT Press, 2018.
- *Evolutionary Computing*, by Dumitrescu et al., CRC, 2000.

3.2 Additional Resources

Lecture Information: Students should take their own notes during lectures.

Assignments: The assignments will be posted at the Courselink before the assignments start. Assignment solutions are submitted at Dropbox of Courselink by its due time.

Miscellaneous Information: Other information related to this course are also posted at the Courselink.

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4 Learning Outcomes

4.1 Course Learning Outcomes

By the end of this course, you should be able to:

1. Have a general understanding of soft computing methodologies, including artificial neural networks, fuzzy sets and fuzzy logic systems, and hybrid neuro-fuzzy systems.
2. Develop computational neural network models for some simple engineering systems.
3. Develop fuzzy models for engineering systems, particularly for control systems.
4. Combine neural networks and fuzzy systems to design neuro-fuzzy control and inference systems.
5. Appreciate the pros and cons of intelligent control systems and compare their performance to that of classical control systems.

4.2 Engineers Canada - Graduate Attributes (2018)

Successfully completing this course will contribute to the following:

#	Outcome	Learning Outcome
1	Knowledge Base	1, 2, 3, 4, 5
1.1	Recall, describe and apply fundamental mathematical principles and concepts	1, 2, 3, 4, 5
1.2	Recall, describe and apply fundamental principles and concepts in natural science	1, 2, 3, 4, 5
1.3	Recall, describe and apply fundamental engineering principles and concepts	1, 2, 3, 4, 5
1.4	Recall, describe and apply program-specific engineering principles and concepts	1, 2, 3, 4, 5
2	Problem Analysis	2, 3, 4
2.1	Formulate a problem statement in engineering and non-engineering terminology	2, 3, 4
2.2	Identify, organize and justify appropriate information, including assumptions	2, 3, 4

#	Outcome	Learning Outcome
2.3	Construct a conceptual framework and select an appropriate solution approach	2, 3, 4
2.4	Execute an engineering solution	2, 3, 4
2.5	Critique and appraise solution approach and results	2, 3, 4
3	Investigation	2, 3, 4, 5
3.1	Propose a working hypothesis	2, 3, 4, 5
3.2	Design and apply an experimental plan/investigative approach (for example, to characterize, test or troubleshoot a system)	2, 3, 4, 5
3.3	Analyze and interpret experimental data	2, 3, 4, 5
3.4	Assess validity of conclusions within limitations of data and methodologies	2, 3, 4, 5
4	Design	2, 3, 4, 5
4.1	Describe design process used to develop design solution	2, 3, 4, 5
4.2	Construct design-specific problem statements including the definition of criteria and constraints	2, 3, 4, 5
4.3	Create a variety of engineering design solutions	2, 3, 4, 5
4.4	Evaluate alternative design solutions based on problem definition	2, 3, 4, 5
4.5	Develop and refine an engineering design solution, through techniques such as iteration, simulation and/or prototyping	2, 3, 4, 5
5	Use of Engineering Tools	2, 3, 4
5.1	Select appropriate engineering tools from various alternatives	2, 3, 4
5.2	Demonstrate proficiency in the application of selected engineering tools	2, 3, 4
5.3	Recognize limitations of selected engineering tools	2, 3, 4

5 Teaching and Learning Activities

5.1 Lecture

Topics: Tentative Schedule

Weeks	Lecture Topics
1	General Introduction to Intelligent Systems
2-3	Basic Concepts and Models of ANN
4-6	Biological Neural Networks
7-8	Recurrent NN and Unsupervised Learning
9-10	Fuzzy Logic and Fuzzy Sets
11-12	Neuro-fuzzy Systems

5.2 Other Important Dates

- Tuesday, January 8: First day of classes
- Monday, February 19 - Friday, February 23: Winter Break
- Friday, April 5: Last day of for regularly scheduled classes

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6 Assessments

6.1 Assessment Details

Assignments (10%)
Assignment 1: Monday, Jan. 29
Assignment 2: Monday, Feb. 12
Assignment 3: Monday, Mar. 4
Assignment 4: Monday, Mar. 25

Project (45%)
Interim Report (10%): Monday, Feb. 26
Presentation (10%): Monday, Apr. 1
Final Report (25%): Monday, Apr. 8

Midterm (20%)
Date: Mon, Feb 26, 7:00 PM - 9:00 PM

Final Exam (25%)
Date: Fri, Apr 12, 8:30 AM - 10:30 AM

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7 Course Statements

7.1 Course Grading Policies

Missed Assessments: If you are unable to meet an in-course requirement due to medical, psychological, or compassionate reasons, please email the course instructor. See the

undergraduate calendar for information on regulations and procedures for Academic Consideration:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Accommodation of Religious Obligations: If you are unable to meet an in-course requirement due to religious obligations, please email the course instructor within two weeks of the start of the semester to make alternate arrangements. See the undergraduate calendar for information on regulations and procedures for Academic Accommodation of Religious Obligations:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-accomrelig.shtml

Project Reports: Late submissions of project interim report and final report will not be accepted.

7.2 Relationships with other Courses

Previous Courses:

ENGG*1500: Solving systems of linear equations, matrix algebra, complex numbers
MATH*1200 & MATH*1210: Limits, differentiation, integration, series expansion
MATH*2270: Differential equations
ENGG*2400: Foundations of engineering system analysis
ENGG*2450: Foundations of electric circuits, circuit analysis, ideal operational amplifiers
ENGG*3390: Foundations of signal processing
ENGG*3410: Foundations of control systems
ENGG*3700: Foundations of optimization for Engineers

Follow-on Courses:

ENGG*6570: Advanced topics on neuro-fuzzy systems and soft computing systems, genetic algorithms
ENGG*6580: Advanced control systems; nonlinear control; intelligent control

8 School of Engineering Statements

8.1 Instructor's Role and Responsibility to Students

The instructor’s role is to develop and deliver course material in ways that facilitate learning for a variety of students. Selected lecture notes will be made available to students on Courselink but these are not intended to be stand-alone course notes. Some written lecture notes will be presented only in class. During lectures, the instructor will expand and explain the content of notes and provide example problems that supplement posted notes. Scheduled classes will be the principal venue to provide information and feedback for tests and labs.

8.2 Students' Learning Responsibilities

Students are expected to take advantage of the learning opportunities provided during lectures and lab sessions. Students, especially those having difficulty with the course content, should also make use of other resources recommended by the instructor. Students who do (or may) fall behind due to illness, work, or extra-curricular activities are advised to keep the instructor informed. This will allow the instructor to recommend extra resources in a timely manner and/or provide consideration if appropriate.

8.3 Lab Safety

Safety is critically important to the School and is the responsibility of all members of the School: faculty, staff and students. As a student in a lab course you are responsible for taking all reasonable safety precautions and following the lab safety rules specific to the lab you are working in. In addition, you are responsible for reporting all safety issues to the laboratory supervisor, GTA or faculty responsible.

9 University Statements

9.1 Email Communication

As per university regulations, all students are required to check their e-mail account regularly: e-mail is the official route of communication between the University and its students.

9.2 When You Cannot Meet a Course Requirement

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons please advise the course instructor (or designated person, such as a teaching assistant) in writing, with your name, id#, and e-mail contact. The grounds for Academic Consideration are detailed in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Academic Consideration and Appeals
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Graduate Calendar - Grounds for Academic Consideration
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

Associate Diploma Calendar - Academic Consideration, Appeals and Petitions
https://www.uoguelph.ca/registrar/calendars/diploma/current/index.shtml

9.3 Drop Date

Students will have until the last day of classes to drop courses without academic penalty. The deadline to drop two-semester courses will be the last day of classes in the second semester. This applies to all students (undergraduate, graduate and diploma) except for Doctor of Veterinary Medicine and Associate Diploma in Veterinary Technology (conventional and alternative delivery) students. The regulations and procedures for course registration are available in their respective Academic Calendars.

Undergraduate Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml

Graduate Calendar - Registration Changes
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/genreg-reg-regchg.shtml

Associate Diploma Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/diploma/current/c08/c08-drop.shtml

9.4 Copies of Out-of-class Assignments

Keep paper and/or other reliable back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time.

9.5 Accessibility

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student.

When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is required; however, interim accommodations may be possible while that process is underway.

Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability.

Use of the SAS Exam Centre requires students to make a booking at least 14 days in advance, and no later than November 1 (fall), March 1 (winter) or July 1 (summer). Similarly, new or changed accommodations for online quizzes, tests and exams must be approved at least a week ahead of time.

For Guelph students, information can be found on the SAS website
https://www.uoguelph.ca/sas

For Ridgetown students, information can be found on the Ridgetown SAS website
https://www.ridgetownc.com/services/accessibilityservices.cfm

9.6 Academic Integrity

The University of Guelph is committed to upholding the highest standards of academic integrity, and it is the responsibility of all members of the University community-faculty, staff, and students-to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff, and students have the responsibility of supporting an environment that encourages academic integrity. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Please note: Whether or not a student intended to commit academic misconduct is not

relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

Undergraduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml

Graduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

9.7 Recording of Materials

Presentations that are made in relation to course work - including lectures - cannot be recorded or copied without the permission of the presenter, whether the instructor, a student, or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

9.8 Resources

The Academic Calendars are the source of information about the University of Guelph's procedures, policies, and regulations that apply to undergraduate, graduate, and diploma programs.

Academic Calendars
https://www.uoguelph.ca/academics/calendars

9.9 Illness

Medical notes will not normally be required for singular instances of academic consideration, although students may be required to provide supporting documentation for multiple missed assessments or when involving a large part of a course (e.g.. final exam or major assignment).