University of Manitoba

Department of Electrical & Computer Engineering

Graduate Course Outline

Winter 2022

ECE 7210 – Fractal and Chaos Engineering

COURSE DESCRIPTION

This course presents foundations of fractal (polyscale) and chaos fundamentals, with applications to engineering. A unified approach to fractal dimensions provides tools for polyscale analysis of time series, images, video, and other objects. The new polyscale analysis is a critical extension of the standard mono-scale and multi-scale analyses. Other topics include analysis and synthesis of mono- and multifractal noise, stability analysis of chaotic systems, characterization of chaos using Lyapunov exponents, and reconstruction of strange attractors from experimental data.

COURSE OBJECTIVES

- To master techniques of polyscale analysis and synthesis;
- To understand techniques of dynamical systems, together with chaos analysis and synthesis; and
- To apply those techniques in engineering.

PRE-REQUISITES

Undergraduate level of :

- Differential and difference equations
- Signal processing
- Linear time-invariant systems
- Foundation of nonlinear systems

CONTACT HOURS

3-hours per week

COURSE CONTENT

The following topics will be discussed:

1. Introduction to nonlinear systems;
2. Overview of fractals and chaos;
3. Fractal dimensions (generalization to Rényi metrics);
4. Noise and spectral power laws;
5. Fractional Brownian noise;
6. Foundations of chaotic dynamics (Stability analysis in 1D with Lyapunov metrics; Reconstructing chaos from data); and
7. Applications (throughout the course).

HOMEWORK

Homework will consist of one mini-project (written report), one project (written proposal, written report, oral preparation in class).

REFERENCES

[1] Witold Kinsner, *Fractal and Chaos Engineering: Monoscale, Multiscale and Polyscale Analyses*. Winnipeg, MB: OCO Research, February 2020, 1106 pages. {ISBN: 978-0-9939347-2-8, eBook}

[2] Steven H. Strogatz, *Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering*. Cambridge MA: Westview / Perseus Books Group, 1994, 498 pp. {ISBN 0-7382-0453-6 pbk}.

GRADE ANNOUNCEMENTS

Grades for this course will be announced by May 2022

EVALUATION:

Your final course grade is determined by your performance in the components list below in the Evaluation Table (mini-project, project, and a final examination). Students must receive a minimum of 50% on the final examination and must complete and pass all components in the course in order to be eligible to receive a passing grade.

Each component is weighted as follows:

COMPONENT	NO	VALUE %	TOTAL VALUE	DETAILS / ADDITIONAL INFO
Mini-project	1	15%	15	
Project	1	45%	45	
Final Examination	1	40%	40	
TOTAL			100	

GRADE SCALE

LETTER	MARK	LETTER	MARK	LETTER	MARK	LETTER	MARK
A+	95-100	B+	80-84	C+	65-69	D	45-54
A	85-94	B	70-79	C	55-64	F	<45

INSTRUCTOR INFO

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Office Hours:..... By appointment

VOLUNTARY WITHDRAW:

March 23rd, 2022
Note that limited feedback will be provided prior to the withdrawal deadline.

REQUIREMENTS/REGULATIONS

Student Responsibilities: It is the responsibility of each student to contact the instructor if he/she is uncertain about his/her standing in the course and his/her potential for receiving a failing grade. Students should also familiarize themselves with Sections 4 and 6 of the Regulations dealing with, among others, incomplete term work, deferred examinations, attendance and withdrawal, etc..

Lectures: Attendance at lectures is essential for successful completion of this course. Students must satisfy each evaluation component in the course.

ACADEMIC INTEGRITY

Students are expected to conduct themselves in accordance with the highest ethical standards of the Profession of Engineering and evince academic integrity in all their pursuits and activities at the university. As such, in accordance with the General Academic Regulations and Requirements of the University of Manitoba, Section 7.1, students are reminded that plagiarism* or any other form of cheating is subject to serious academic penalty (e.g. suspension or expulsion from the faculty or university) regardless of media

- Examinations;
- Assignments;
- Laboratory reports; and
- Term exams.

A student found guilty of contributing to cheating in examinations or term assignments is also subject to serious academic penalty.

Please refer any questions regarding Academic Integrity to your course instructor.

***Plagiarism:** to steal and pass off (the ideas or words of another) as one's own; use (another's production) without crediting the source