THE UNIVERSITY OF WESTERN ONTARIO
FACULTY OF ENGINEERING

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

ECE 9023 – Random Signals, Adaptive and Kalman Filtering (M.Eng. only)

COURSE OUTLINE

OBJECTIVE:

This course will introduce to the students the theoretical and implementation aspects of adaptive and Kalman filters. Students will gain a deeper understanding of random signals and the analysis of linear systems in a stochastic framework. Students will understand the theory behind various adaptive Finite Impulse Response (FIR) filtering techniques such as the Least Mean Square (LMS), Recursive Least Squares (RLS), and Affine Projection Algorithm (APA). In addition, students will grasp the practical aspects of adaptive and Kalman filters through implementation and simulation studies.

INSTRUCTOR:

Dr. Vijay Parsa, P.Eng.
EC 2262E/ACEB 3466, 519-661-2111 ext. 88947/81252,
Email: vparsa@uwo.ca
Consultation hours: Mondays between 9:00 – 11:00 AM EDT (Zoom or Teams), or by appointment.

CONTACT HOURS: 3 lecture hours/week; half course

ANTIREQUISITE: None

PREREQUISITES: ECE 4429 or equivalent. Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you will be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

COURSE DELIVERY WITH RESPECT TO THE COVID-19 PANDEMIC: Although the intent is for this course to be delivered in-person, the changing COVID-19 landscape may necessitate some or all of the course to be delivered online, either synchronously (i.e., at the times indicated in the timetable) or asynchronously (e.g., posted on OWL for students to view at their convenience). The grading scheme will not change. Any assessments affected will be conducted online as determined by the course instructor.

When deemed necessary, tests and examinations in this course will be conducted using a remote proctoring service. By taking this course, you are consenting to the use of this software and

acknowledge that you will be required to provide personal information (including some biometric data) and the session will be recorded. Completion of this course will require you to have a reliable internet connection and a device that meets the technical requirements for this service. More information about this remote proctoring service, including technical requirements, is available on Western's Remote Proctoring website at: https://remoteproctoring.uwo.ca.

COURSE CONTENT:

- Random signals and stochastic processes
- Linear optimum filtering theory
- Method of Steepest Descent
- The Least Mean Square (LMS) algorithm and its analysis
- The Recursive Least Squares (RLS) algorithm and its analysis
- The Affine Projection Algorithm (APA) and its analysis
- Kalman filters
- Other adaptive filters – subband adaptive filters and IIR adaptive filters.

SPECIFIC LEARNING OBJECTIVES:

1) To understand the effects of linear filtering on random signals through the analysis of correlation and power spectral density functions.
2) To understand the conceptual framework of linear optimum filtering theory and the derivation of Wiener-Hopf equations.
3) To understand the theory behind popular adaptive algorithms such as the Least Mean Square (LMS), Recursive Least Squares (RLS), and Affine-Projection Algorithm (APA).
4) To understand Kalman filter theory and its relation to RLS adaptive filters.
5) To understand the convergence and tracking characteristics of the LMS, RLS, and APA adaptive filters.

SPECIFIC LEARNING OUTCOMES:

Degree Level Expectation	Weight	Assessment Tools	Outcomes
Depth and breadth of knowledge	35%	• MATLAB assignments • Quizzes/Problem sets • Project • Midterm	• Understanding of advanced concepts and theories • Awareness of important current problems in the field of study • Understanding of computational and/or empirical methodologies to solve related problems

Research & scholarship	15%	• Project	• Ability to conduct critical evaluation of current advancements in the field of specialization • Ability to conduct coherent and thorough analyses of complex problems using established techniques/principles and judgment
Application of knowledge	30%	• MATLAB assignments • Quizzes/Problem sets • Project • Midterm	• Ability to apply knowledge in a rational way to analyze a particular problem
Professional capacity / autonomy	10%	• Project • Midterm • MATLAB assignments	• Awareness of academic integrity • Ability to implement established procedures and practices in the coursework • Defends own ideas and conclusions • Integrates reflection into his/her learning process
Communication skills	10%	• Project • MATLAB assignments	• Ability to communicate (oral and/or written) ideas, issues, results and conclusions clearly and effectively

TEXTBOOK:

[1] S. Haykin, "*Adaptive Filter Theory*", Pearson Education Inc., Upper Saddle River, New Jersey, USA, 5th edition, 2014.

COURSE PROJECT:

The students in the course will be required to perform a project either using MATLAB or an embedded computing system on an assigned topic related to adaptive filters and submit a report. **Students must successfully demonstrate their project to the instructor or TA prior to the submission of the project report, or a grade of 0 will be assigned to project report.**

The project report is due on April 26, 2023, by 11 pm EST. The last date for the project demo is April 25, 2023, 3 pm EST.

EVALUATION:

For the purpose of evaluation, the course is divided into four components, namely

a) MATLAB assignments
b) In-class quizzes/problem sets
c) mid-term
d) project

The in-class problem sets will focus on analytical evaluation of adaptive filtering algorithms. The assignments will focus on practical implementation of the adaptive filtering algorithms using MATLAB. It is assumed that students have the ability to program in MATLAB.

The midterm will be a take home open book examination that will be released on March 6, 2023, 11:00 AM EST and will be due on March 6, 2023, at 2:30 PM EST.

In order to pass the course, a student must obtain a passing grade in each component. A student who fails one of the components shall receive a final grade not greater than 58%. The weighting of each of these components will be as follows:

		Maximum Penalties*	
Component	**Value**	**English**	**Presentation**
Project Report	40%	10%	10%
In-class quizzes/problem sets	15%	10%	10%
Midterm	30%	10%	10%
MATLAB assignments	15%	10%	10%

*In accordance with the policy of the University, the grade assigned to all written and oral work presented in English shall take into account syntax, diction, grammar and spelling. In the professional life of an engineer, the manner in which oral and written communications are presented is extremely important. An engineering student must develop these skills as an integral part of the undergraduate program. To encourage the student to do so, the grades assigned to all written and oral work will take into account all aspects of presentation including conciseness, organization, neatness, use of headings, and the preparation and use of tables and figures.

All work will be marked first for content after which a penalty not to exceed the maximum shown above may be applied for lack of proficiency in English and/or presentation.

ATTENDANCE:

Any student, who in the opinion of the instructor is absent too frequently from class in this course, will be reported to the Dean (after due warning has been given). On the recommendation of the Department concerned, and with the permission of the Dean, the student will be debarred from taking the regular examination in the course.

COURSE CONTENT:

The lecture notes and online lecture videos are copyrighted to the instructor and legally protected. Do not post these videos and lecture notes on any other website or online forums. The recording of the live/synchronous sessions of the course without the permission from the instructor is prohibited. The illegal posting and sharing of the copyrighted course content could be subjected to legal actions.

CHEATING, PLAGIARISM/ACADEMIC OFFENCES:

Academic integrity is an essential component of learning activities. Students must have a clear understanding of the course activities in which they are expected to work alone (and what working alone implies) and the activities in which they can collaborate or seek help; see information above under “Assessments” and ask instructor for clarification if needed. Any unauthorized forms of help-seeking or collaboration will be considered an academic offense.

University policy states that cheating is an academic offence. If you are caught cheating, there will be no second warning. Students must write their essays and assignments in their own words. Whenever students take an idea or a passage of text from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. Plagiarism is a major academic offence. Academic offences are taken seriously and attended by academic penalties which may include expulsion from the program. Students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence (see Western's scholastic discipline regulations for graduate students).

SYNCHRONOUS LEARNING ACTIVITIES:

Students are expected to participate in synchronous learning activities as outlined in the course syllabus and/or described by the instructor. If you have issues that will impede your ability to participate in synchronous activities, please discuss with the course instructor at the beginning of the course.

CONDUCT:

Students are expected to follow proper etiquette during synchronous and asynchronous activities to maintain an appropriate and respectful academic environment. Any student who, in the opinion of the instructor, is not appropriately participating in the synchronous and asynchronous learning activities and/or is not following the rules and responsibilities associated with the online learning activities, will be reported to the Associate Dean (Graduate) (after due warning has been given). On the recommendation of the Department concerned, and with the permission of the Associate Dean (Graduate), the student could be debarred from completing the assessment activities in the course as appropriate.

HEALTH/WELLNESS:

As part of a successful graduate student experience at Western, we encourage students to make their health and wellness a priority. Western provides several health and wellness related services (remotely accessible) to help you achieve optimum health and engage in healthy living while pursuing your graduate degree. Information regarding health- and wellness-related services available to students may be found at http://www.health.uwo.ca/.

Students seeking help regarding mental health concerns are advised to speak to someone they feel comfortable confiding in, such as their faculty supervisor, their program director (graduate chair), or other relevant administrators in their unit. Campus mental health resources may be found at http://www.health.uwo.ca/mental_health/resources.html https://www.uwo.ca/health/psych/index.html

SICKNESS:

Students should immediately consult with the Instructor (for a particular course) or Associate Chair (Graduate) (for a range of courses) if they have problems that could affect their performance. The student should seek advice from the Instructor or Associate Chair

(Graduate) regarding how best to deal with the problem. Failure to notify the Instructor or the Associate Chair (Graduate) immediately (or as soon as possible thereafter) will have a negative effect on any appeal. Obtaining appropriate documentation (e.g., a note from the doctor) is valuable when asking for accommodation due to illness.

ACCESSIBLITY:

Please contact the course instructor if you require material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Accessible Education at 661-2111 x 82147 or http://academicsupport.uwo.ca/accessible_education/index.html, for any specific question regarding an accommodation.