The University of Texas at Tyler
Department of Electrical Engineering

EENG 5340: Advanced Topics in EE (Elective)

Adaptive Filters

Syllabus

Catalog Description:

> Introduction to discrete-time signal processing, Impulse response, z-transform, FIR, IIR filters, Stochastic Processes, Correlation functions and power spectral density, Wiener Filters, Introduction to gradient search algorithms, steepest-descent algorithm, LMS algorithm, Recursive Least Squares algorithm, Introduction to Noise Cancelation and Echo Cancelation.

Prerequisites: EENG 4311 – Signals and Systems, EENG 4312 – Communication Theory

Credits: (3 hours lecture)

Text(s):   Behrouz Farhang-Boroujeny, Adaptive Filters: Theory and Applications, 2nd Edition, ISBN: 978-1-119-97954-8

Additional Material: Lecture Handouts, MATLAB

Course Coordinator: Ali Ghorshi, PhD

Topics Covered: (paragraph of topics separated by semicolons)

> Introduction to discrete-time signal processing, Impulse response, z-transform, FIR, IIR filters, Stochastic Processes, Correlation functions and power spectral density, Wiener Filters, Introduction to gradient search algorithms, steepest-descent algorithm, LMS algorithm, Recursive Least Squares algorithm.

Evaluation Methods: (only items in dark print apply):

1. Examinations / Quizzes
2. Homework
3. Report
4. Computer Programming
5. Project
6. Presentation
7. Course Participation
8. Peer Review

Course Learning Outcomes[1]: By the end of this course students will be able to:

1. Introduction to Adaptive Filtering: a historical perspective; a state-of-the-art perspective.
2. Introduction to discrete-time signal processing.
3. Statistical Signal Processing Revision: correlation; ergodicity; means, variances; stationarity; wide sense stationarity; periodogramme; frequency response vs. power spectrum.
4. Explain the Wiener Filter Theory: normal equations; error performance surfaces; orthogonality; minimum mean square errors.
5. Explain the Least Mean Squares (LMS) algorithm: formulation; convergence; stability criteria.
6. Explain the Recursive LMS-IIR Algorithms: output error formulation; equation error formulation; full gradient, simplified gradient.
7. Explain Frequency Domain Adaptive LMS: Architectures, advantages, and disadvantages.
8. Explain Recursive Least Squares (RLS) algorithm: RLS formulation; forgetting factors; practical implementations; QR based RLS; numerical stability and integrity issues.
9. Comparative Analysis: Wiener; LMS-FIR, LMS-IIR. RLS.
10. Applications of adaptive filters: System identification; room acoustics, control systems; inverse system modeling; modems, telecommunications adaptive equalization, echo cancelation; adaptive beamforming (radar, sonar, hearing aids, listening devices); active noise cancelation systems in cars, airplanes, medical systems, communication systems.

1Numbers in brackets refer to method(s) used to evaluate the course learning outcome.

Relationship to Student Outcomes (only items in dark print apply)[2]: This course supports the following Electrical Engineering Student Outcomes, which state that our students will possess:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics [1-7, 9, 11, 12]
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors [8, 10]
3. an ability to communicate effectively with a range of audiences [16]
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts [13]
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions [14, 15]
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

2Numbers in brackets refer to course learning outcome(s) that address the Program Outcome.

Contribution to Meeting Professional Component: (in semester hours)

Mathematics and Basic Sciences:		hours
Engineering Sciences and Design:	3	hours
General Education Component:		hours

Prepared By:	Ali Ghorshi, PhD	Date:	18 August 2019
Edited By:			21 April 2020
			26 December 2020

The University of Texas at Tyler
Department of Electrical Engineering

EENG 5340 Advanced Topics in EE (Adaptive Filters)

Course Outline

Course Description:	Introduction to discrete-time signal processing, Impulse response, z-transform, FIR, IIR filters, Stochastic Processes, Correlation functions and power spectral density, Wiener Filters, Introduction to gradient search algorithms, steepest-descent algorithm, LMS algorithm, Recursive Least Squares algorithm, Introduction to Noise Cancelation and Echo Cancelation.
Course credit:	3 hours
Prerequisites	EENG 4311 – Signals and Systems, EENG 4312 – Communication Theory
Class Meeting Days and Location:	TBA 11:00 AM-12:20 PM TR
Instructor(s):	**Course coordinator**
	Dr. Ali Ghorshi, Electrical Engineering Office: A215 Phone: 903-566-6137 E-mail: aghorshi@uttyler.edu Office hours: TBA Zoom ID: 972 7118 6298, Passcode: 787382
Required Materials	Behrouz Farhang-Boroujeny, Adaptive Filters: Theory and Applications, 2nd Edition, ISBN: 978-1-119-97954-8
Recommended Materials:	Simon O. Haykin, Adaptive Filter Theory, 5th Edition, ISBN: 978-0-132-67149-1
Course Student Learning Objectives (SLOs)	1. Introduction to Adaptive Filtering: a historical perspective; a state-of-the-art perspective. 2. Introduction to discrete-time signal processing. 3. Statistical Signal Processing Revision: correlation; ergodicity; means, variances; stationarity; wide sense stationarity; periodogramme; frequency response vs. power spectrum. 4. Wiener Filter Theory: normal equations; error performance surfaces; orthogonality; minimum mean square errors. 5. The Least Mean Squares (LMS) algorithm: formulation; convergence; stability criteria. 6. Recursive LMS-IIR Algorithms: output error formulation; equation error formulation; full gradient, simplified gradient. 7. Frequency Domain Adaptive LMS: Architectures, advantages, and disadvantages. 8. Recursive Least Squares (RLS) algorithm: RLS formulation; forgetting factors; practical implementations; QR based RLS; numerical stability and integrity issues. 9. Comparative Analysis: Wiener; LMS-FIR, LMS-IIR. RLS. 10. Applications of adaptive filters: System identification; room acoustics, control systems; inverse system modeling; modems, telecommunications adaptive equalization, echo cancelation; adaptive beamforming (radar, sonar, hearing aids, listening devices); active noise cancelation systems in cars, airplanes, medical systems, communication systems.

EENG 5340 Advanced Topics in EE Spring 2021 Outline.docx   1
12/26/2020

	WEEK	TOPICS COVERED	
Course Schedule/Content	1	Introduction to Adaptive Filters and Discrete-Time Signal Processing	
	2	Statistical Signal Processing Revision	
	3	Wiener Filter	
	4	Wiener Filter (Cont.)	
	5	Gradient Search Algorithm	
	6	Steepest-descent Algorithm	
	7	LMS Algorithm	
	8	Midterm Exam	
	9	SPRING BREAK	
	10	Recursive Least Square Algorithm	
	11	Comparative Analysis of Wiener Filter, LMS, RLS	
	12	IIR Adaptive Filter	
	13	IIR Adaptive Filter (Cont.)	
	14	Introduction to Noise Cancelation and Echo Cancelation	
	15	Introduction to Noise Cancelation and Echo Cancelation (Cont.)	
	16	FINAL EXAM	

Class Withdrawal	The withdrawal policy outlined by the Registrar will be strictly followed. The policy may be found at the following website: http://www.uttyler.edu/registrar/registration/withdrawals.php The last day to withdraw from courses is listed in the Academic Calendar.
Grading Policy and Criteria to Determine Final Grade	Homework and project reports will be due in Canvas one week after assignment. Project reports should be written as per the guidelines provided. A 25% penalty will be assessed for missing the submission deadline and an additional 25% penalty will apply per week for late project reports and homework. Any deviation from this rule will be at the sole discretion of the instructor. All submissions are required to be in Microsoft Word format with machine readable text and not images or other representations of text. This rule will be applied to all sections of the report including the appendices and program code with comments. All flowcharts and diagrams must be prepared using Microsoft Office and not by hand. Any attempts to defeat the plagiarism checking software by submission of documents that include images instead of body text or any other mechanism will result in a grade of zero. The instructor or responsible grader reserves all rights to make this judgement and reject a project report if the above rules are not followed. Any violations may result in ACADEMIC DISHONESTY charges to be filed against the student. Student waives all rights to a make-up exam if they miss a scheduled testing date. Any make-up testing will be at the sole discretion of the instructor. Students should be aware that absolute academic integrity is expected of every student in all undertakings at The University of Texas at Tyler. Failure to comply can result in strong university-imposed penalties. All lab reports and assignments will be verified using plagiarism checking software and violations will result in a grade of zero for the lab report or assignment at a minimum, and

	possibly stronger penalties such as a failing grade in the course and a scholastic dishonesty report submitted to the university.
	Grades will be assigned based on the total score as per the distribution below and the following scale out of a 100 total: A: >90, B: >80, C: >70, D: >60, F: <60 Any deviation from the above policy such as scaling or curving to calculate the individual item or final scores will be at the sole discretion of the instructor and performed by the instructor uniformly for all students in the class section.
Examination and/or Major Assessment Policies and Procedures	Homeworks/Quizzes/Assignments 30% Midterm Examination 30% Final Examination 40%
Attendance and Make-up Policy	The progressive nature of the class means that perfect attendance is recommended if a good grade is desired. Makeup quizzes, exams or projects will only be provided for valid absences and at the sole discretion of the instructor.
Computer Equipment Policy	In order to take this class, integrated laboratory sessions and quizzes/exams, you will need the following items as specified below: • Windows 10 Computer or Mac running Windows virtualization software • High-speed Internet connection • Webcam (internal or external) • MATLAB
Proctoring	The assessments in this online course will be proctored using ProctorU or two-way interactive Zoom sessions. Beyond the cost of initial equipment needed (e.g. a camera for your computer), there will not be any additional cost for proctoring. You will need to create a ProctorU account and install the ProctorU extension before attempting any assessment. To create a ProctorU account, follow the ProctorU tool within Canvas. Please make sure you are using the current version of Chrome or Firefox and download the ProctorU extension available at http://bit.ly/proctoruchrome or https://www.proctoru.com/firefox. In order to use ProctorU, you will need the following: • High-speed Internet connection • Webcam (internal or external) • Windows, Mac, or Chrome Operating System • Up-to-date Chrome or Firefox browser and ProctorU extension installed • Valid photo ID • Quiet environment to take your assessment You can visit the Test Taker Resource Page for additional information at https://bit.ly/ProctorMe

UT Tyler Honor Code	Every member of the UT Tyler community joins together to embrace: Honor and integrity that will not allow me to lie, cheat, or steal, nor to accept the actions of those who do.
Students' Rights and Responsibilities	To know and understand the policies that affect your rights and responsibilities as a student at UT Tyler, please follow this link: http://www.uttyler.edu/wellness/rightsresponsibilities.php. Students are responsible for reviewing the syllabus and abiding by all that is within. Students are encouraged to seek clarification within the first week of the course.
Campus Carry	We respect the right and privacy of students 21 and over who are duly licensed to carry concealed weapons in this class. License holders are expected to behave responsibly and keep a handgun secure and concealed. More information is available at http://www.uttyler.edu/about/campus-carry/index.php
UT Tyler a Tobacco-Free University	All forms of tobacco will not be permitted on the UT Tyler main campus, branch campuses, and any property owned by UT Tyler. This applies to all members of the University community, including students, faculty, staff, University affiliates, contractors, and visitors. Forms of tobacco not permitted include cigarettes, cigars, pipes, water pipes (hookah), bidis, kreteks, electronic cigarettes, smokeless tobacco, snuff, chewing tobacco, and all other tobacco products. There are several cessation programs available to students looking to quit smoking, including counseling, quitlines, and group support. For more information on cessation programs please visit www.uttyler.edu/tobacco-free.
Grade Replacement/Forgiveness and Census Date Policies	Students repeating a course for grade forgiveness (grade replacement) must file a Grade Replacement Contract with the Enrollment Services Center (ADM 230) on or before the Census Date of the semester in which the course will be repeated. Grade Replacement Contracts are available in the Enrollment Services Center or at http://www.uttyler.edu/registrar. Each semester's Census Date can be found on the Contract itself, on the Academic Calendar, or in the information pamphlets published each semester by the Office of the Registrar. Failure to file a Grade Replacement Contract will result in both the original and repeated grade being used to calculate your overall grade point average. Undergraduates are eligible to exercise grade replacement for only three course repeats during their career at UT Tyler; graduates are eligible for two grade replacements. Full policy details are printed on each Grade Replacement Contract. The Census Date is the deadline for many forms and enrollment actions of which students need to be aware. These include: • Submitting Grade Replacement Contracts, Transient Forms, requests to withhold directory information, approvals for taking courses as Audit, Pass/Fail or Credit/No Credit. • Receiving 100% refunds for partial withdrawals. (There is no refund for these after the Census Date) • Schedule adjustments (section changes, adding a new class, dropping without a "W" grade) • Being reinstated or re-enrolled in classes after being dropped for non-payment

	• Completing the process for tuition exemptions or waivers through Financial Aid
State-Mandated Course Drop Policy	Texas law prohibits a student who began college for the first time in Fall 2007 or thereafter from dropping more than six courses during their entire undergraduate career. This includes courses dropped at another 2-year or 4-year Texas public college or university. For purposes of this rule, a dropped course is any course that is dropped after the census date (See Academic Calendar for the specific date). Exceptions to the 6-drop rule may be found in the catalog. Petitions for exemptions must be submitted to the Enrollment Services Center and must be accompanied by documentation of the extenuating circumstance. Please contact the Enrollment Services Center if you have any questions.
Student Accessibility and Resources	In accordance with Section 504 of the Rehabilitation Act, Americans with Disabilities Act (ADA) and the ADA Amendments Act (ADAAA) the University of Texas at Tyler offers accommodations to students with learning, physical and/or psychological disabilities. If you have a disability, including a non-visible diagnosis such as a learning disorder, chronic illness, TBI, PTSD, ADHD, or you have a history of modifications or accommodations in a previous educational environment, you are encouraged to visit https://hood.accessiblelearning.com/UTTyler and fill out the New Student application. The Student Accessibility and Resources (SAR) office will contact you when your application has been submitted and an appointment with Cynthia Lowery, Assistant Director of Student Services/ADA Coordinator. For more information, including filling out an application for services, please visit the SAR webpage at http://www.uttyler.edu/disabilityservices, the SAR office located in the University Center, # 3150 or call 903.566.7079.
Student Absence due to Religious Observance	Students who anticipate being absent from class due to a religious observance are requested to inform the instructor of such absences by the second class meeting of the semester.
Student Absence for University-Sponsored Events and Activities	If you intend to be absent for a university-sponsored event or activity, you (or the event sponsor) must notify the instructor at least two weeks prior to the date of the planned absence. At that time the instructor will set a date and time when make-up assignments will be completed.
Social Security and FERPA Statement	It is the policy of The University of Texas at Tyler to protect the confidential nature of social security numbers. The University has changed its computer programming so that all students have an identification number. The electronic transmission of grades (e.g., via e-mail) risks violation of the Family Educational Rights and Privacy Act; grades will not be transmitted electronically.
Emergency Exits and Evacuation	Everyone is required to exit the building when a fire alarm goes off. Follow your instructor's directions regarding the appropriate exit. If you require assistance during an evacuation, inform your instructor in the first week of class. Do not re-enter the building unless given permission by University Police, Fire department, or Fire Prevention Services.
Student	Disciplinary proceedings may be initiated against any student who engages in scholastic dishonesty, including, but not limited to,

Standards of Academic Conduct	cheating, plagiarism, collusion, the submission for credit of any work or materials that are attributable in whole or in part to another person, taking an examination for another person, any act designed to give unfair advantage to a student or the attempt to commit such acts.
	i. "Cheating" includes, but is not limited to:
	• copying from another student's test paper;
	• using, during a test, materials not authorized by the person giving the test;
	• failure to comply with instructions given by the person administering the test;
	• possession during a test of materials which are not authorized by the person giving the test, such as class notes or specifically designed "crib notes". The presence of textbooks constitutes a violation if they have been specifically prohibited by the person administering the test;
	• using, buying, stealing, transporting, or soliciting in whole or part the contents of an unadministered test, test key, homework solution, or computer program;
	• collaborating with or seeking aid from another student during a test or other assignment without authority;
	• discussing the contents of an examination with another student who will take the examination;
	• divulging the contents of an examination, for the purpose of preserving questions for use by another, when the instructors has designated that the examination is not to be removed from the examination room or not to be returned or to be kept by the student;
	• substituting for another person, or permitting another person to substitute for oneself to take a course, a test, or any course-related assignment;
	• paying or offering money or other valuable thing to, or coercing another person to obtain an unadministered test, test key, homework solution, or computer program or information about an unadministered test, test key, home solution or computer program;
	• falsifying research data, laboratory reports, and/or other academic work offered for credit;
	• taking, keeping, misplacing, or damaging the property of The University of Texas at Tyler, or of another, if the student knows or reasonably should know that an unfair academic advantage would be gained by such conduct; and
	• misrepresenting facts, including providing false grades or resumes, for the purpose of obtaining an academic or financial benefit or injuring another student academically or financially.
	ii. "Plagiarism" includes, but is not limited to, the appropriation, buying, receiving as a gift, or obtaining by any means another's work and the submission of it as one's own academic work offered for credit.
	iii. "Collusion" includes, but is not limited to, the unauthorized collaboration with another person in preparing academic assignments offered for credit or collaboration with

	another person to commit a violation of any section of the rules on scholastic dishonesty. iv. All written work that is submitted will be subject to review by Unicheck™, available on Canvas
UT Tyler Resources for Students	• UT Tyler Writing Center (903.565.5995), writingcenter@uttyler.edu • UT Tyler Tutoring Center (903.565.5964), tutoring@uttyler.edu • The Mathematics Learning Center, RBN 4021, this is the open access computer lab for math students, with tutors on duty to assist students who are enrolled in early-career courses. • UT Tyler Counseling Center (903.566.7254)
Recording of Class Sessions	Class sessions may be recorded by the instructor for use by students enrolled in this course. Recordings that contain personally identifiable information or other information subject to FERPA shall not be shared with individuals not enrolled in this course unless appropriate consent is obtained from all relevant students. Class recordings are reserved only for the use of students enrolled in the course and only for educational purposes. Course recordings should not be shared outside of the course in any form without express permission.
Important Covid-19 Information for Classrooms and Laboratories	Students are required to wear face masks covering their nose and mouth, and follow social distancing guidelines, at all times in public settings (including classrooms and laboratories), as specified by Procedures for Fall 2020 Return to Normal Operations. The UT Tyler community of Patriots views adoption of these practices consistent with its Honor Code and a sign of good citizenship and respectful care of fellow classmates, faculty, and staff. Students who are feeling ill or experiencing symptoms such as sneezing, coughing, or a higher than normal temperature will be excused from class and should stay at home and may join the class remotely. Students who have difficulty adhering to the Covid-19 safety policies for health reasons are also encouraged to join the class remotely. Students needing additional accommodations may contact the Office of Student Accessibility and Resources at University Center 3150, or call (903) 566-7079 or email saroffice@uttyler.edu.