King Fahd University of Petroleum and Minerals

Electrical Engineering Department

Center for Energy and Geo-Processing (CeGP)

EE499 Special Topics

Term 151

EE Undergraduate Research

Guidelines to Students

KFUPM- Georgia Tech

Important Disclaimer

This version is a draft and not approved yet. It cannot be used for any legal action and the institutions are not responsible for the content. It is only meant to provide early information. Your feedback and questions are welcomed at **muqaibel@kfupm.edu.sa**

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Introduction

The skills that students acquire during their academic years play an important role in their future success. The growing adoption of undergraduate research (UR) has changed education in the USA over the past twenty years. Rather than simply attending lectures and taking notes, undergraduate students at leading Universities like Georgia Tech (GT) have the option to spend part of their academic learning hours conducting research with one or more of the faculty members.

There are a few factors that define an undergraduate research experience. To distinguish undergraduate research from other project-based experience, students are expected to gain literature review skills; read conference and journal papers and understand the scientific publication terms; identify research methodologies: statistical, theoretical, experimental or simulation; and generate results, critically compare and analyze them.

Why would I join Undergraduate Research?

For undergraduate students, the research experience is motivated by the following: it gives them a chance to find their passion and identify their areas of interest. Usually such research experience leads to ideas for senior design projects, master theses, or PhD dissertation topics. Successful cases will lead to journal publications and hence an enhanced application to a graduate program. Other students would like to add undergraduate research to their resumes while others are simply fulfilling their credit hours while gaining different experience. Other than regular HW, quizzes, exams …class room experience.

For the proposed Global Research Experience for Undergraduates (GREU) program between KFUPM and GT, students will be further motivated by gaining international experience; exposure to different culture and school; students will have a chance to prove themselves for higher study admission. This is the case for students at both institutions.

The maximum number of undergraduate researchers in the course is limited. Students with research interest , and high academic high performance are encouraged to join.

Course Description

This course provides a practical introduction to research methodologies, and research community. Students in the course learn about the nature of applied research and the iterative process of research writing. The course teaches students how to work in a mentor-mentee relationship with a KFUPM faculty advisor, post graduate fellows, and graduate students. The course helps students to identify a study

topic, organize a literature review, and select appropriate research methodologies. By the end of the course, students will complete a technical paper that includes an introduction, problem statement (significance of study), literature review, methods section, results and analysis and references findings, discussion, conclusions, and references. Students will be encourage to participate in conferences and present their work.

Course Objectives

- To familiarize the students with the concept of research and its components.
- To discuss the different research methodologies: statistical, theoretical, experimental or simulation.
- To understand the structure of technical proposal: problem statement, deliverables and plan the time for executing the research.
- To critically evaluate the findings of the research and reach at conclusions.

Course Learning Outcomes

After successfully completing the course, the students will be able to

1. Read and understand conference and journal papers and their scientific terminology.
2. Identify the main contributions of a scientific research paper.
3. Write literate review for a given research problem.
4. Identify the appropriate research methodology: statistical, theoretical, experimental or simulation
5. Critically compare and analyze results
6. Identify the different means to disseminate research results through journals, magazines, conference and technical congregations and conferences to present his findings.

Course Material

Most of the reading material will be related to the specific research problem. Blackboard contains will contain additional course readings. Course readings are selected chapters from some of the latest introductory research methodology textbooks, research journal articles, and specialized research training guidebooks.

Textbook:

References will be provided through the mentor.

Other useful references and material:

- Gina Wisker, The Undergraduate Research Handbook (Palgrave Study Skills), ISBN-13: 978-0230520974, 2009

- Colin Robson, How to do a Research Project: A Guide for Undergraduate Students, 1st Edition, Blackwell Publishing 2007, ISBN-13: 978-1405114905
- Paul D. Leedy and Jeanne Ellis Ormrod (Author): Practical Research: Planning and Design (11th Edition), ISBN-13: 978-0133741322
- Wayne C. Booth, Gregory G. Colomb , and Joseph M. Williams. The Craft of Research, Third Edition (Chicago Guides to Writing, Editing, and Publishing), ISBN-13: 978-0226065663
- John W. Creswell, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 4th Edition, ISBN-13: 978-1452226101

Instructor for term 151

Dr. Ali Muqaibel, Electrical Engineering (EE) Department, KFUPM

Other involved faculty: Dr. Samir Alghadhban, EE, KFUPM

Prerequisites: Consent of the Instructor

Tentative Grading Policy:

Item	Equivalent to	Points
Weekly Progress Report	HWS	15
Selected Readings (Quizzes)	Quizzes	10
Literature Review Report	Exam 1	15
Reproducing results in pre-selected or pre-assigned paper or two	Exam 2	15
Term paper	Term Project	25
Presentation	Final	20

The term paper will bring new ideas to improve the current research. Before the final grade, the paper must be submitted to conference or a journal and the student is expected to go through the submission process.

1.6 Breakdown of Course Contents

One meeting per week with graduate mentor and one meeting per week with the Professor. There will be some self-reading material and students will be quizzed on the material. The material will come from selected sources. The student will gain and apply knowledge to a specific research problem related to the field of the instructor. Possible research areas: robotics and automation, distributed compression, autonomous vehicles and fusion of sensors, devices and sensors for healthcare Power load distribution in Saudi Arabia…etc. Specific research problems will be identified to clearly have a research nature and distinguish the course from other senior design problems.

Week	Module	Topic
1-2	1	Overview of the course, student expectations, & introductions Problem Statement, Significance of Study, Proposal, Methodology, References, & Timeline
3-4	2	Literature Review
5-7	3	Research Methods: Statistical, Experimental, Analytical, Simulation
8-10	4	Discussion and Analysis of Results
11-12	5	Writing Technical Papers
13-14	6	Presentation
15	Term Paper Presentations & Final Paper submission	

Specific topics for term 151

Our Undergraduate Researchers (scholars) will be provided seating whenever possible in an associated research center or lab. The student is expected to spend a minimum number of hours in the lab to interact with the research fellows.

#	Title	Center	Mentor	Maximum # of students	Related Team from Georgia Tech
1	In-Field Processing for Seismic Data Acquisition	CeGP*	Dr. Bo Liu	2	
2	Application of Advanced Signal Processing techniques to enhance the Signal to Noise Ration and Localization of Micro Seismic Events	CeGP*	Dr. Naveed Iqbal	2	
3	Data Acquisition for through Wall Imaging	CeGP*	Mr. Mohammed Tamim Al-Khoadary	2	
4	Direction of Arrival Estimation	TRL*	Mr. Saleh Al-Awsh	1	
5	Aspect Dependence for through the wall radar imaging	TRL*	Mr. Abdi	1	
6					
7					
8					

CeGP: Center of Energy and Geo-Processing.

TRL: Telecommunication Research Laboratory.

Research Description

1. In-Field Processing for Seismic Data Acquisition:

This research proposes to apply some intelligent processing capabilities in the field to meet the challenges of the large scale seismic acquisition systems. In particular, lossless compression techniques will be used at the sensors that will attempt to remove redundancy from data and reduce the amount of data transfer.

It is expected that the undergraduate students in this project will review the seismic data acquisition techniques, have a comprehensive understanding of the mathematical concepts and methods relating to the signal compression, then apply the methods on synthetic and real data and finally propose a scheme to improve the efficiency of the existing algorithm.

The detailed expected achievements are listed as follows:

a. Application background knowledge: Seismic data acquisition techniques.
b. Methodology: Karhunen-Loeve Transform (KLT), Principal Component Analysis (PCA), Machine Learning, Wavelet Analysis, etc.
c. Tools: Matlab or C.
d. Training: apply signal compression methods on synthetic and real seismic data.
e. Innovation: explore a scheme to enhance the existing methods.

2. Application of Advanced Signal Processing techniques to enhance the Signal to Noise Ration and Localization of Micro Seismic Events

Continuous recording of passive microseismic activity has recently been used in various applications, such as reservoir fluid-injection monitoring, hydraulic-fracture monitoring, and fault-movement monitoring, to name a few. The ability to accurately detect and analyze passive microseismic events (PME) generated by these activities is valuable in monitoring them. However, PME usually have very low signal-to-noise (SNR) especially if monitoring sensors (receivers) are located at the surface where interfering surface waves are overwhelming due to nearby surface sources.

In this study, we propose the use of advanced signal processing techniques to solve this PME detection problem. The goal is two-fold:

1. Enhancing the PME picking, which is a major problem in processing surface microseismic data.
2. Determining the PME source direction and possibly the location.

Following tools/knowledge is required for this project:

- Matlab.
- Background knowledge of probability and statistics.
- Familiarity with transforms like Fourier transform (and wavelet transform).
- Knowledge of linear algebra tools like Singular value decomposition.

3. Data Acquisition for through Wall Imaging

Through the Wall Radar Imaging (TWRI), is a technology that utilizes the penetration property of the radar signal to image a scene from behind an obscured obstacle. TWRI, is a relatively emerged technology encountered with several practical challenges. Researchers proposed several theoretical solutions to overcome these challenges, but with limited practical validation for their solutions or propositions, due to the lack of practical data. That being said, the availability of raw TWRI data will add practical validation for researchers and scholars to evaluate and assess their solution/algorithm upon realistic data.

In this course, students will work together to build an acquisition system and model an environment with well-defined parameters that will eventually generate a bank of raw date to be used and evaluated upon in research papers. The designed environment will take into account different sources of error, e.g. multipath, wall reverberation… etc.

At the end of this course, students will have the ability to model a practical problem for research purposes. They will also learn how to write a research paper/report to be used as a reference by others.

Students Requirements:

- Competent experience to work in MATLAB environment
- EE 207, EE 370

4. Direction of Arrival Estimation

There are numerous methods for determining the location of a signal emitter using diverse types of direction finding (DF) techniques. One of the most widely used techniques is the direction of arrival (DOA) technique that estimates the angle from which the signal arrives. Generally, the received signal is corrupted by different impairments as it propagates through the communication channel. These impairments include noise, multipath, narrowband/wideband interference, etc. Therefore, a robust technique is needed to estimate the DOA of the received signal.

In practical mobile applications, DOA estimation is restricted by the small size of the devices. Thus, the practical implementation of DOA technique in handheld wireless devices has two main limitations. First, limited number of antennas and second, limited spacing between these antennas. This research aims to find a promising solution to estimate the DOA in multiple-input-multiple-output (MIMO) systems for future handsets. We want to design an array configuration and novel sparse DOA estimation technique which works under limited number of elements and limited inter-element spacing. For successful consideration of the problem stated above, a full comparative understanding of sparse DOA estimation algorithms in MIMO systems is needed. Based on this understanding, a novel antenna array will be adopted and the signal processing part will be optimized.

5. Aspect Dependence for through the wall radar imaging

The main challenge of through-the-wall imaging (TWRI) is the multipath ghosts during image reconstruction which affect image interpretation. We investigate efficient and feasible ghost suppression methods for both point-like and extended targets exploiting aspect dependence feature of the multipath ghosts. The research involves designing sparse arrays with multipath rejection capabilities. Further, the research intend to design sparsity promoting sensing matrices for populated scene.

Frequently Asked Questions (FAQ)

This is to be populated by your questions and their answers. Please send your question to Dr. Ali Muqaibel (muqaibel@kfupm.edu.sa)