EEE 598 – Deep Learning: Foundations and Applications

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Course Catalogue Description:
This course is concerned with understanding the mathematical and signal processing foundations and fundamentals of deep learning using neural networks with applications to the classification, processing, restoration, compression, and generation of multimedia. Examples of multimedia include image, video, text, speech, and audio with a particular emphasis on sensor data commonly found in electrical engineering applications. Topics include the basics of artificial neural networks, training and backpropagation, initialization and regularization, convolutional neural networks, generative adversarial neural networks, transformers, self-supervised/weakly-supervised/unsupervised learning, variational autoencoders and diffusion models. Course content will be delivered via lectures, written and programming assignments, laboratory sessions to learn about programming in a high performance computing environment with GPUs, and a final cumulative design/research project.

Course Credit Hours or Units: 4

Enrollment Requirements:
Fulton Electrical, Computer and Energy Engineering (ECEE) graduate student or POLY, SBHSE, SCAI, SEMTE or SSEBE graduate student.

Recommended prior coursework: EEE 350 Random Signal Analysis or equivalent & {EEE 404 Real-Time Digital Signal Processing OR EEE 407 Digital Signal Processing OR EEE 508 Digital Image and Video Processing} or equivalent. If you are unsure about your background, please contact Dr. Jayasuriya about attending this course.

Course Objectives:
This course introduces students to the fundamentals behind the design, training, and testing of deep neural networks for various types of multimedia input including images/video, text, speech, and audio. Students learn how to implement these networks in a modern computing environment leveraging high performance computing via GPUs. Students will learn from traditional lectures as well as a separate laboratory section to learn new tools and programming skills and will be assessed via written and programming assignments. The final cumulative design/research project will be conducted by students to architect and realize a modern deep learning solution for a problem of the students' interest.

Expected Learning Outcomes:
At the end of this course, students should be able to do the following:

- Explain the basics of a modern deep learning neural architecture and when to utilize it for a given application.
- Design and implement a deep learning solution for a given application leveraging modern deep learning APIs.
- Understand the mechanics of training deep neural networks including familiarity with high-performance computing with GPUs.

Assignments/Exams:
Biweekly written and programming assignments will be given that involve numerical calculations, derivations/proofs as well as short design/implementation exercises written in a modern computing language (e.g. Python). In addition, lab assignments will be given that utilize the high performance computing environment available through ASU Research Computing. A final cumulative project will feature a project proposal, interim update, and a final report and presentation due by the end of the class. Late assignments will lose 10% each day unless given special permission in advance by the instructor.

Homework and Lab Assignments 50%
Final Project and Demo 40%
Class Participation 10%

Readings, Activities, Special Materials:
No required textbooks, relevant materials and resources will be distributed on Canvas to the class.

Grade Policies:

Only given for exceptional final projects as determined by instructor	A+
93-100	A
90-92	A-
88-89	B+
83-87	B
80-82	B-
78-79	C+
70-77	C
60-69	D
0-59	E

Course Itinerary (Tentative, subject to change):
The course will meet weekly via lectures as well as an additional lab session, and assignments will be roughly assigned every two weeks. A tentative schedule is presented below

Thurs 8/22	Lecture 1: Deep Learning	Assignment 1 assigned
Fri 8/23	Lab - Intro to Sol and Pytorch	
Tues 8/27	Lecture 2: Perceptrons and MLPs	
Thurs 8/29	Lecture 3: Backpropagation	Assignment 1 due before class Paper Reading: Read KAN paper and annotate it
Fri 8/30	Lab - ANNs	Assignment 2 assigned
Tues 9/3	Lecture 4: CNNs	KAN paper assignment due
Thurs 9/5	Lecture 5: ResNets	
Fri 9/6	Lab - CNNs	Assignment 2 due Assignment 3 assigned
Tues 9/10	Lecture 6: Loss Functions, Normalization, and Initialization	
Thurs 9/12	Lecture 7: Sequence modeling	
Fri 9/13	Lab - CNN/Resnet	
Tues 9/17	Lecture 8: Audio	
Thurs 9/19	Lecture 9: 3D Data	
Fri 9/20	Lab - Sequential Modeling (RNN/LSTMs)	Assignment 3 due Assignment 4 assigned Project Proposal assigned
Tues 9/24	Lecture 10: Positional encoding and Transformers	
Thurs 9/26	Lecture 11: Transformers in Vision	
Fri 9/27	Lecture 12: Graph Neural Networks	Project Proposal due
Tues 10/1	Lab - RNN/LSTMs	Project Proposal revisions assigned
Thurs 10/3	Guest Lecture: Research topic in deep learning	

Fri 10/4	Lab - Transformers	Assignment 4 due Assignment 5 assigned
Tues 10/8	Guest Lecture: Research topic in deep learning	
Thurs 10/10	Lab - Transformers continued	
Fri 10/11	Lecture 13: Generative Adversarial Networks	Revised Project Proposal due Literature Review assigned
Tues 10/15	FALL BREAK	
Thurs 10/17	Guest Lecture	
Fri 10/18	Lab - GANs	Assignment 5 due Assignment 6 assigned
Tues 10/22	Lecture 14: Variational Autoencoders	Literature Review due
Thurs 10/24	Lecture 15: Diffusion I	
Fri 10/25	Lab - Diffusion	Midterm update assigned
Tues 10/29	Lecture 16: Diffusion II	
Thurs 10/31	Lecture 17: LLMs	
Fri 11/1	Lecture 18: Fine-tuning LLMs	Assignment 6 due Assignment 7
Tues 11/5	Lab - Finetuning LLMs	
Thurs 11/7	Lecture 19: Differentiable Programming and CUDA	
Fri 11/8	Lab - CUDA	Midterm update due
Tues 11/12	Lecture 20: Differentiable Programming and CUDA II	
Thurs 11/14	Lecture 21: Network Compression and TinyML	
Fri 11/15	Lab - CUDA II	Assignment 7 due
Tues 11/19	Lecture 22: Explainability and Uncertainty Estimation	

Thurs 11/21	**Lecture 23: Deep Learning and Neuroscience**	
Fri 11/22	**Lab - Final Project Working session**	**Peer reviews due**
Tues 11/26 [Suren out of town]	**Lab - Final Project Working session**	
Thurs 11/28	**Thanksgiving**	
Fri 11/29	**Thanksgiving**	
Tues 12/3	**Lecture (deep RL)/Final Presentations**	
Thurs 12/5	**Lecture (Physics-based ML)/Final Presentations**	
Fri 12/6	**Lecture (Frontiers)/Final Presentations**	
Friday 12/13	**Final Reports due by 5pm**	

Absence Policy:
Students are expected to attend all classes. Unexcused absences beyond three will result in a reduction in the student's final grade by one letter grade for every two absences. Tardiness over 10 minutes will be considered an unexcused absence. Attendance will be taken every class, starting the second week of class to allow for new students. If you anticipate having a problem attending class for whatever reason, you are urged to contact the instructor in advance of your expected absence. Absences beyond 6 classes without informing the instructor would result in you being dropped from the course according to ASU rules. Assigned work can be made up in contact with the instructor.

Excused absences related to religious observances/practices in accord with ACD 304–04, "Accommodation for Religious Practices." Students may be excused for the observance of religious holidays. Students should notify the instructor at the beginning of the semester about the need to be absent from class due to religious observances. Students will be responsible for materials covered during their absence and should consult with the instructor to arrange reasonable accommodation for missed exams or other required assignments.

Excused absences related to university sanctioned activities in accord with ACD 304–02, "Missed Classes Due to University-Sanctioned Activities." Students required to miss classes due to university sanctioned activities will not be counted absent. However, absence from class or examinations due to university-sanctioned activities does not relieve students from responsibility for any part of the course work required during the period of the absence. Students should inform the instructor early in the semester of upcoming scheduled absences and immediately upon learning of unscheduled required class absences. Reasonable

accommodation to make up missed exams or other required assignments will be made. Consult the instructor BEFORE the absence to arrange for this accommodation.
Line-of-duty absence and missed assignment policy: A student who is a member of the National Guard, Reserve, or other U.S. Armed Forces branch who misses classes, assignments or examininations due to line-of-duty responsibilitites, shall have the opportunity to make up the coursework in accordance with SSM 20-18 Accommodating Active Duty Military Personnel. This accommodation also applies to spouses who are the guardian of minor children during line-of - duty activities. This policy does not excuse students from course responsibilities during their absence. Students should first notify the Pat Tillman Veterans Center of their activation and then the instructor to discuss options.

Instructor Absence Policy:
Students should wait for an absent instructor 15 minutes in class sessions of 90 minutes or less, and 30 minutes for those lasting more than 90 minutes, unless directed otherwise by someone from the academic unit.

Expected Classroom Behavior:
ASU adheres to a university-wide Student Code of Conduct. The philosophy behind this policy states: The aim of education is the intellectual, personal, social, and ethical development of the individual. The educational process is ideally conducted in an environment that encourages reasoned discourse, intellectual honesty, openness to constructive change and respect for the rights of all individuals. Self-discipline and a respect for the rights of others in the university community are necessary for the fulfillment of such goals. The Student Code of Conduct is designed to promote this environment at each of the state universities. You are expected to treat your instructor and your fellow classmates with respect and kindness. In all correspondence and in Discussion Board postings, you should show respect for the viewpoints of others who may disagree with you or see things from a different perspective. Criticizing, ridiculing, insulting, or belittling others will not be accepted. Keep in mind that electronic communications do not have the advantage of nonverbal cues that are so much a part of interpersonal communication. Humor or satire can sometimes be misinterpreted in strictly electronic communication forums.

Disruptive, Threatening, or Violent Behavior
In the classroom and out, students are required to conduct themselves in a manner that promotes an environment that is safe and conducive to learning and conducting other university-related business. All incidents and allegations of violent or threatening conduct by an ASU student will be reported to the ASU Police Department (ASU PD) and the Office of the Dean of Students. Such incidents will be dealt with in accordance with the policies and procedures described in Section 104-02 of the Student Services Manual, available at http://www.asu.edu/aad/manuals/ssm/ssm104-02.html

Classroom Behavior (Technology Usage):
It is encouraged that you bring technology (cell phones, tablets and laptops) to class to help you take notes and do research, however please turn off cell phone ringers and do not use your phone to make personal calls in class or use any technology to use social media in class. Do not answer your phone in class. If you believe you are receiving an emergency call, please step outside to take it.

Accommodation for Religious Practices

The university community should, in all its activities, be sensitive to the religious practices of the various religious faiths represented in its student body and employees. Faculty are asked to recognize the obligations of their students who may be participating in the observance of religious holidays. Students should notify faculty at the beginning of the semester about the need to be absent from class due to religious observances. For more information, visit http://www.asu.edu/aad/manuals/acd/acd304-04.html

Missed Classes Due to University-Sanctioned Activities
Students who participate in university-sanctioned activities that require classes to be missed, shall be given opportunities to make up examinations and other graded in-class work. Normally, the made-up work will be due on the class day after the immediately after the absence. Absence from class or examinations due to university-sanctioned activities does not relieve students from responsibility for any part of the course work required during the period of the absence. For more information, visit http://www.asu.edu/aad/manuals/acd/acd304-02.html

Academic Integrity/Anti-Plagiarism Policy
Plagiarism of any kind will not be tolerated. Students must take the exams independently without assistance from other students. Students may not submit papers written by persons other than themselves. Students must submit original work for this course and may not submit papers previously submitted to (an)other class(es). The ASU student academic integrity policy lists violations in detail. These violations fall into five broad areas that include but are not limited to: (1) Cheating on an academic evaluation or assignment; (2) Plagiarizing; (3) Academic deceit, such as fabricating data or information; (4) Aiding academic integrity policy violations and inappropriately collaborating; (5) Falsifying academic records. See https://provost.asu.edu/academic-integrity

Disability Accommodations
If you are a student with a disability and have need of assistance or special accommodations, contact Student Accessibility and Inclusive Learning Services (SAILS) https://eoss.asu.edu/accessibility. Students requesting accommodations for a disability must register with SAILS, and must submit appropriate documentation to the instructor from SAILS. For more information, please review the policy at http://www.asu.edu/aad/manuals/ssm/index.html#700

Copyright
Students must refrain from uploading to any course shell, discussion board, or website used by the course instructor or other course forum, material that is not the student's original work, unless the students first comply with all applicable copyright laws; faculty members reserve the right to delete materials on the grounds of suspected copyright infringement. For more information, see the Computer, Internet, & Electronic Communications Policy at http://www.asu.edu/aad/manuals/acd/acd125.html

Prohibition Against Discrimination, Harassment, and Retaliation

Title IX is a federal law that provides that no person be excluded on the basis of sex from participation in, be denied benefits of, or be subjected to discrimination under any education program or activity. Both Title IX and university policy make clear that sexual violence and harassment based on sex is prohibited. An individual who believes they have been subjected to sexual violence or harassed on the basis of sex can seek support, including counseling and academic support, from the university. If you or someone you know has been harassed on the basis of sex or sexually assaulted, you can find information and resources at http://sexualviolenceprevention.asu.edu/faqs

As a mandated reporter, I am obligated to report any information I become aware of regarding alleged acts of sexual discrimination, including sexual violence and dating violence. ASU Counseling Services, https://eoss.asu.edu/counseling, is available if you wish to discuss any concerns confidentially and privately.