

MAP 6197, Spring 2023
Mathematical Introduction to Deep Learning

Instructor, Time and Location

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- **Time & Location:** TuTh 7:30PM - 8:50PM, MSB 0108

This course is offered in the RS (Limited Attendance) modality.

Course Scope and Purpose

The first part of the course contains an overview of deep neural networks, including activation functions, convolutional layers and several architectures such as feed-forward, recurrent networks, ResNets and GANs. The introduction also considers common loss functions and network training with back-propagation and gradient descent.

In the second part of the course, we consider selected mathematical foundations and applications of deep learning, including classical results and contemporary research. Possible areas are:

1. Optimization: classical NP-hardness results, recent work on convergence guarantees for over-parametrized networks and connections of ResNets to optimal control theory.
2. Approximation: Universal function approximation theorems and recent quantitative bounds on the approximation effectiveness for certain function classes.
3. Application of neural networks in scientific computing, e.g. for parametrized PDEs.

The current state of the art evolves quickly and offers connections to multiple areas in mathematics as approximation theory, sparse tensors, optimal control, numerical analysis, random algorithms, etc.

Prerequisite and Co-requisite courses

Scientific Computing or C.I.

Recommended prerequisites

Multi-variable calculus (gradients, chain rule, etc.), linear algebra and basic probability theory. Some knowledge of Python will be helpful.

Course Materials and Resources

Most material will be from scattered online sources and announced during class.

Textbooks

Some textbooks related to the course are:

- Goodfellow, Bengio, Courville: *Deep Learning*, MIT Press, 2016.
- Y. Nesterov: *Lectures on Convex Optimization*, Springer, 2018.
- G. G. Lorentz, M. Golitschek, Y. Makovoz: *Constructive Approximation: Advanced Problems*, Springer-Verlag Berlin Heidelberg, 1996.
- T. M. Cover: *Elements of Information Theory*, 2nd Edition, Wiley-Interscience, 2006.

Research Papers

The course contains results that are not yet available in textbook format. Corresponding research literature will be announced during the course.

Recording Academic Activity

In order not to delay the disbursement of financial aid, we have to record one academic activity in the first week. For this course it is a small assignment in Webcourses that is due on Friday January 13.

Grading Procedures

Homework/Projects

Assignments will be given in an irregular pattern. For the theory part of the course there will be shorter homework assignments. For the more practical parts, the assignments may be longer akin to a project. The assignments will involve coding in Python with the deep learning library Pytorch.

Midterm

The midterm is a take-home exam on March 8, submitted to Webcourses. Details will be provided in class.

Makeup Exams

Make-up examinations will only be given upon prior arrangement with the instructor in those cases that meet the criteria established in University policy for students who are absent while representing the University, while observing a religious holy day, or absent due to court-imposed legal obligations. The student is responsible for contacting the instructor no less than one day after the regular exam date.

Paper Presentation

At the end of the course students will read a research paper and present it in class.

Grading Scheme

The grade will be determined by homework, one midterm and a final project/presentation with the following weights.

	Homework	Midterm	Project
Weight	30%	35%	35%
Day	see	March 8	TBA
Time	announcements	all day	TBA

The grades are determined from the weighted average by the following key:

A	B	C	D	F
100 – 90%	90 – 80%	80 – 70%	70 – 60%	< 60%

Course Description (from Graduate Catalog)

The course covers feed-forward and convolutional neural networks, loss functions, gradient descent optimization and selected topics from the current research literature.

Student Learning Outcomes

1. Students will be able to implement and train simple neural networks.
2. Students will know classical results about neural network theory.
3. Students will obtain some insight into the current state of the art on neural network theory.

Course Schedule

January/February	Introduction to neural networks (feed-forward, convolutional, recurrent), losses (least squares, KL divergence), optimization and some basic architectures (ResNets, GANs)
February/March	PAC learning theory, function approximation with neural network, optimization results, generalization results.
April	Paper presentations

Academic Integrity: Tutoring Services

There is growing evidence of inappropriate use of "tutoring services" in taking course examinations. In response to this evidence, the Department of Mathematics of the University of Central Florida will monitor the use of online tutoring services during both the midterm and final examinations period. Evidence of inappropriate use by students will be forwarded to the university's Division of Student Conduct and Academic Integrity of the Office of Student Rights and Responsibilities for further disciplinary consideration.

UCF Syllabus Statements

UCF Core Syllabus Statements

Academic Integrity

Students should familiarize themselves with UCF's Rules of Conduct at [<http://scai.sdes.ucf.edu/student-rules-of-conduct/>](http://scai.sdes.ucf.edu/student-rules-of-conduct/). According to Section 1, "Academic Misconduct," students are prohibited from engaging in

1. Unauthorized assistance: Using or attempting to use unauthorized materials, information or study aids in any academic exercise unless specifically authorized by the instructor of record. The unauthorized possession of examination or course-related material also constitutes cheating.
2. Communication to another through written, visual, electronic, or oral means: The presentation of material which has not been studied or learned, but rather was obtained through someone else's efforts and used as part of an examination, course assignment, or project.
3. Commercial Use of Academic Material: Selling of course material to another person, student, and/or uploading course material to a third-party vendor without authorization or without the express written permission of the university and the instructor. Course materials include but are not limited to class notes, Instructor's PowerPoints, course syllabi, tests, quizzes, labs, instruction sheets, homework, study guides, handouts, etc.
4. Falsifying or misrepresenting the student's own academic work.
5. Plagiarism: Using or appropriating another's work without any indication of the source, thereby attempting to convey the impression that such work is the student's own.
6. Multiple Submissions: Submitting the same academic work for credit more than once without the express written permission of the instructor.
7. Helping another violate academic behavior standards.
8. Soliciting assistance with academic coursework and/or degree requirements.

Responses to Academic Dishonesty, Plagiarism, or Cheating

Students should also familiarize themselves with the procedures for academic misconduct in UCF's student handbook, *The Golden Rule* [<https://goldenrule.sdes.ucf.edu/>](https://goldenrule.sdes.ucf.edu/). UCF faculty members have a responsibility for students' education and the value of a UCF degree, and so seek to prevent unethical behavior and respond to academic misconduct when necessary. Penalties for violating rules, policies, and instructions within this course can range from a zero on the exercise to an "F" letter grade in the course. In addition, an Academic Misconduct report could be filed with the Office of Student Conduct,

which could lead to disciplinary warning, disciplinary probation, or deferred suspension or separation from the University through suspension, dismissal, or expulsion with the addition of a “Z” designation on one’s transcript.

Being found in violation of academic conduct standards could result in a student having to disclose such behavior on a graduate school application, being removed from a leadership position within a student organization, the recipient of scholarships, participation in University activities such as study abroad, internships, etc.

Let’s avoid all of this by demonstrating values of honesty, trust, and integrity. No grade is worth compromising your integrity and moving your moral compass. Stay true to doing the right thing: take the zero, not a shortcut.

Course Accessibility Statement

The University of Central Florida is committed to providing access and inclusion for all persons with disabilities. Students with disabilities who need access to course content due to course design limitations should contact the professor as soon as possible. Students should also connect with Student Accessibility Services (SAS) <<http://sas.sdes.ucf.edu/>> (Ferrell Commons 185, sas@ucf.edu, phone 407-823-2371). For students connected with SAS, a Course Accessibility Letter may be created and sent to professors, which informs faculty of potential course access and accommodations that might be necessary and reasonable. Determining reasonable access and accommodations requires consideration of the course design, course learning objectives and the individual academic and course barriers experienced by the student. Further conversation with SAS, faculty and the student may be warranted to ensure an accessible course experience.

Campus Safety Statement

Emergencies on campus are rare, but if one should arise during class, everyone needs to work together. Students should be aware of their surroundings and familiar with some basic safety and security concepts.

- In case of an emergency, dial 911 for assistance.
- Every UCF classroom contains an emergency procedure guide posted on a wall near the door. Students should make a note of the guide’s physical location and review the online version at <http://emergency.ucf.edu/emergency_guide.html>.
- Students should know the evacuation routes from each of their classrooms and have a plan for finding safety in case of an emergency.
- If there is a medical emergency during class, students may need to access a first-aid kit or AED (Automated External Defibrillator). To learn where those are located, see <<https://ehs.ucf.edu/automated-external-defibrillator-aed-locations>>.

- To stay informed about emergency situations, students can sign up to receive UCF text alerts by going to <<https://my.ucf.edu>> and logging in. Click on “Student Self Service” located on the left side of the screen in the toolbar, scroll down to the blue “Personal Information” heading on the Student Center screen, click on “UCF Alert”, fill out the information, including e-mail address, cell phone number, and cell phone provider, click “Apply” to save the changes, and then click “OK.”
- Students with special needs related to emergency situations should speak with their instructors outside of class.
- To learn about how to manage an active-shooter situation on campus or elsewhere, consider viewing this video (<<https://youtu.be/NIKYajEx4pk>>).

Campus Safety Statement for Students in Online-Only Courses

Though most emergency situations are primarily relevant to courses that meet in person, such incidents can also impact online students, either when they are on or near campus to participate in other courses or activities or when their course work is affected by off-campus emergencies. The following policies apply to courses in online modalities.

- To stay informed about emergency situations, students can sign up to receive UCF text alerts by going to <<https://my.ucf.edu>> and logging in. Click on “Student Self Service” located on the left side of the screen in the toolbar, scroll down to the blue “Personal Information” heading on the Student Center screen, click on “UCF Alert”, fill out the information, including e-mail address, cell phone number, and cell phone provider, click “Apply” to save the changes, and then click “OK.”
- Students with special needs related to emergency situations should speak with their instructors outside of class.

Deployed Active Duty Military Students

Students who are deployed active duty military and/or National Guard personnel and require accommodation should contact their instructors as soon as possible after the semester begins and/or after they receive notification of deployment to make related arrangements.

Make-Up Assignments for Authorized University Events or Co-curricular Activities

Students who represent the university in an authorized event or activity (for example, student-athletes) and who are unable to meet a course deadline due to a conflict with that event must provide the instructor with documentation in advance to arrange a make-up. No penalty will be applied. For more information, see the UCF policy at <<https://policies.ucf.edu/documents/4-401.pdf>>

Religious Observances

Students must notify their instructor in advance if they intend to miss class for a religious observance. For more information, see the UCF policy at <<http://regulations.ucf.edu/chapter5/documents/5.020ReligiousObservancesFINALJan19.pdf>>.

COVID-19 Statements

Students are asked to follow the official CDC guidelines.

Other Statements

UCF Creed

Integrity, scholarship, community, creativity, and excellence are the core values that guide our conduct, performance, and decisions.

Integrity

I will practice and defend academic and personal honesty.

Scholarship

I will cherish and honor learning as a fundamental purpose of my membership in the UCF community.

Community

I will promote an open and supportive campus environment by respecting the rights and contributions of every individual.

Creativity

I will use my talents to enrich the human experience.

Excellence

I will strive toward the highest standards of performance in any endeavor I undertake.

Ethics

An ethics statement shows the guidelines by which your class will be run. This statement discusses plagiarism, cheating, honor, and what is expected of students with respect to these aspects. The following two sample statements may be displayed:

UCF faculty support the UCF Creed. Integrity – practicing and defending academic and personal honesty – is the first tenet of the UCF Creed. This is in part a reflection of the second tenet, Scholarship: – I will cherish and honor learning as a fundamental purpose of membership in the UCF community. – Course assignments and tests are designed to have educational value; the process of preparing for and completing these exercises will help improve your skills and knowledge. Material presented to satisfy course requirements is therefore expected to be the result of your own original scholarly efforts.

Plagiarism and cheating – presenting another’s ideas, arguments, words or images as your own, using unauthorized material, or giving or accepting unauthorized help on assignments or tests – contradict the educational value of these exercises. Students who attempt to obtain unearned academic credentials that do not reflect their skills and knowledge can also undermine the value of the UCF degrees earned by their more honest peers.

Copyright

This course may contain copyright protected materials such as audio or video clips, images, text materials, etc. These items are being used with regard to the Fair Use doctrine in order to enhance the learning environment. Please do not copy, duplicate, download or distribute these items. The use of these materials

is strictly reserved for this online classroom environment and your use only. All copyright materials are credited to the copyright holder.

Unauthorized Use of Websites and Internet Resources

There are many websites claiming to offer study aids to students, but in using such websites, students could find themselves in violation of academic conduct guidelines. These websites include (but are not limited to) Quizlet, Course Hero, Chegg Study, and Clutch Prep. UCF does not endorse the use of these products in an unethical manner, which could lead to a violation of our University's Rules of Conduct. They encourage students to upload course materials, such as test questions, individual assignments, and examples of graded material. Such materials are the intellectual property of instructors, the university, or publishers and may not be distributed without prior authorization. Students who engage in such activity could be found in violation of academic conduct standards and could face course and/or University penalties. Please let me know if you are uncertain about the use of a website so I can determine its legitimacy.

Unauthorized Use of Technology for Graded Work

If you were in a classroom setting taking a quiz, would you ask the student sitting next to you for an answer to a quiz or test question? The answer should be no. This also applies to graded homework, quizzes, tests, etc.

Students are not allowed to use GroupMe, WhatsApp, or any other form of technology to exchange course material associated with a graded assignment, quiz, test, etc. when opened on Webcourses.

The completion of graded work in an online course should be considered a formal process: Just because you are not in a formal classroom setting being proctored while taking a quiz or test does not mean that the completion of graded work in an online course should not be treated with integrity.

The following is not all inclusive of what is considered academic misconduct. These examples show how the use of technology can be considered academic misconduct and could result in the same penalties as cheating in a face-to-face class:

- Taking a screen shot of an online quiz or test question, posting it to GroupMe or WhatsApp, and asking for assistance is considered academic misconduct.
- Answering an online quiz or test question posted to GroupMe or WhatsApp is considered academic misconduct. Giving advice, assistance, or suggestions on how to complete a question associated with an online assignment, quiz, or test is considered academic misconduct.
- The use of outside assistance from another student or by searching the internet, Googling for answers, use of websites such as Quizlet, Course Hero, Chegg Study, etc. is considered academic misconduct.

- Gathering to take an online quiz or test with others and sharing answers in the process is considered academic misconduct.

If a student or group of students are found to be exchanging material associated with a graded assignment, quiz, or test through any form of technology (GroupMe, WhatsApp, etc.), or use outside assistance (Googling answers, use of websites such as Quizlet, Course Hero, Chegg Study, etc.), they could receive anywhere from a zero grade on the exercise to an “F” in the course depending on the act.

In-Class Recording

Students may, without prior notice, record video or audio of a class lecture for a class in which the student is enrolled for their own personal educational use. A class lecture is defined as a formal or methodical oral presentation as part of a university course intended to present information or teach students about a particular subject. Recording classroom activities other than class lectures, including but not limited to lab sessions, student presentations (whether individually or part of a group), class discussion (except when incidental to and incorporated within a class lecture), clinical presentations such as patient history, academic exercises involving student participation, test or examination administrations, field trips, and private conversations is prohibited. Recordings may not be used as a substitute for class participation and class attendance, and may not be published or shared without the written consent of the faculty member. Failure to adhere to these requirements may constitute a violation of the University’s Student Code of Conduct as described in the Golden Rule.