Fundamentals of Artificial Neural Networks

ECH 6937 Section TGY7 (Class Number 28652)

Class Periods: M Periods 8-9 (3:00 – 4:55 PM) and W Periods 9 (4:05 – 4:55 PM)

Location: Weimer 1084

Academic Term: Spring 2024

Instructor: Spyros A. Svoronos

Phone: 352-392-9101 (O), 352-378-1342 (H landline), I do not carry a cell phone

E-mail: svoronos@ufl.edu

Office Hours: T 4:30-6:00 PM in my office and via Zoom

W 5:10-6:15 PM in my office and via Zoom

F 5:10-6:15 PM in my office and via Zoom

Zoom: https://ufl.zoom.us/j/6379945549 with passcode: 0

Masking policy: I am considered high risk, as I will be turning 70 this year and have certain health issues. To protect myself I will be wearing a mask consistently. I believe that this precautionary measure is ample to safeguard my health. It's important for me to clarify that my decision to wear a mask should not be misconstrued as a solicitation for you to do the same. My choice to wear a mask should not influence your own decision regarding mask usage.

Teaching Assistant: None

Course Description

(3 credits) Introduction to the fundamental aspects of artificial neural networks and deep learning, including chemical engineering examples. Python coding of neural networks, first from scratch including object-oriented programming, and later using the Keras API.

Course Pre-Requisites / Co-Requisites

Chemical Engineering student with programming ability in at least one programming language (not necessarily Python)

Course Objectives

The course will teach many of the core concepts behind artificial neural networks (ANNs) and deep learning. Important concepts, such as the backpropagation algorithm, will be mathematically derived. To reinforce understanding, the concepts will be put to practice with Python code written by the students. The code will be applied to chemical engineering problems as well as to the problem of handwritten number recognition utilizing 70,000 28x28-pixel grey-scale images (the MNIST set). By the end of this course, students will be able to:

- Understand the principles behind ANN algorithms
- Write Python code from scratch and develop their own ANN libraries
- Use the Keras API

- Understand the challenges and pitfalls of deep learning and potential remedies
- Understand and design Convolutional Neural Networks (CNNs)

Materials and Supply Fees

N/A

Required Textbooks and Software

- *Neural Networks and Deep Learning* by Michael Nielsen,
  http://neuralnetworksanddeeplearning.com/
  Cost: Free, a $5 donation is suggested
- *Python in easy steps* by Mike McGrath
  https://www.amazon.com/s?k=python+in+easy+steps&ref=nb_sb_noss_1
  Cost: $10.69 - $15.99
- *Automate the Boring Stuff with Python* by Al Sweigart, no starch press
  https://automatetheboringstuff.com/
  Cost: Can read on-line for free, $24.99 for paperback printing

Software: Laptop computer running Windows and Excel is **required**

Recommended Materials

N/A

Course Topics:

1. Introduction to artificial neural networks (ANNs) and deep learning
2. The beginning: Perceptrons
3. Sigmoid neurons
4. The basic structure of ANNs
5. Gradient descent
6. Fitting and overfitting
7. Lessons in Python developing part of the code to be used later (several weeks)
8. The first ANN program without explanation of backpropagation
9. The backpropagation algorithm and its coding
10. Introduction to Keras
11. The cross-entropy cost function
12. Regularization methods
13. Initializing weights

14. Heuristics for hyper-parameter tuning
15. The vanishing gradient problem and deep learning
16. Deep convolutional networks

Attendance Policy:

Attendance is required. Excused absences must be consistent with university policies in the undergraduate catalog (https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx) and require appropriate documentation. Unexcused absences will significantly impact the class participation grade (see below).

Course Assessment:

1. A midterm exam weighing 30% of the grade.
   Date: Monday March 4 (3:00 PM - ?)
2. A final take home exam weighing 35%.
   Handed out: Saturday April 27
   Due: Wednesday May 1 at 8:00 PM
3. Homework weighing 30%. Each homework problem will be graded in a scale from 0 to 3 with a 3 earned only for perfect answers.
4. Class participation weighing 5%.

Detailed Explanation of Grading:

1. For each student, Overall points are calculated as follows:

Overall Points = 0.30*MidtermGrade +0.35*FinalGrade+
+0.30*HomeworkGrade+0.05*ClassParticipationGrade

where

- Exam grades are 0-100
- Homework/Classwork Grade = (Total homework points earned)/(maximum possible points) *100
- Class participation grade:
  Students will receive an 85 if they attend all classes (aside from university excused absences) but do not contribute to class discussions, or ask questions, or correct lecture errors, something encouraged and appreciated. Then the grade is reduced according to the frequency of unexcused class absences and raised according to how active a participant they are.

2. Grades are then decided as follows:

Division between A and A- : The division between the lowest A and the highest A- occurs in students who averaged overall score 85 +/- 2.5. As it is undesirable to have a student with 84.99 obtain a different grade from a student with 85.01, instead of having a hard boundary at 85, the students are first sorted in decreasing order of overall points and the division occurs at the largest gap (difference). So, if there are five students with overall points 87.1, 85.9, 84.8, 82.7, and 82.6, 84.8 is assigned the lowest A and 82.7 the highest A-.

Divisions between lower grades are decided in the same manner, with one exception. A minimum of 50% overall points is required for a student to earn a C.

Division between A- and B+ : 80 +/- 2.5
Division between B+ and B : 75 +/- 2.5
Division between B and B- : 65 +/- 2.5
Division between B- and C+ : 60 +/- 2.5
Division between C+ and C : 55 +/- 2.5
Division between C and C- : 50+/- 2.5
Division between C- and D+ : 37.5 +/- 2.5
Division between D+ and D : 30 +/- 2.5
Division between D and D- : 25 +/- 2.5
Division between D- and E : 20

The class participation grade is designed so that students who attend class regularly will not have an A grade lowered even if they never speak. It helps attending students with lower overall points.

ADDITIONAL INFORMATION

Students Requiring Accommodations

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting https://disability.ufl.edu/students/get-started/. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

In-Class Recording

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same

class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

University Honesty Policy

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Conduct Code (https://sccr.dso.ufl.edu/process/student-conduct-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: https://registrar.ufl.edu/ferpa.html

Campus Resources:

Health and Wellness

U Matter, We Care:
Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: https://counseling.ufl.edu, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence
If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)
Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/.

Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling; https://career.ufl.edu.

Library Support, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. https://teachingcenter.ufl.edu/.

Writing Studio, 302 Tigert Hall*,* 846-1138. Help brainstorming, formatting, and writing papers. https://writing.ufl.edu/writing-studio/.

Student Complaints Campus*:* https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/;https://care.dso.ufl.edu.

On-Line Students Complaints*:* http://www.distance.ufl.edu/student-complaint-process.