University of South Carolina
College of Engineering and Computing

CSCE 790: Neural Networks and Their Applications
Fall 2024
Section: 007 Location: Swearingen Engr Ctr 2A24

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Course Syllabus

COURSE DESCRIPTION:
This course covers the fundamentals, mechanisms, and methodologies employed in constructing learning algorithms through artificial neural networks. Key topics encompass various neural network topologies, neural network learning paradigms, training rules, and applications across supervised, unsupervised, and reinforcement learning tasks.

COURSE OVERVIEW:
This course provides a comprehensive introduction to artificial neural networks, covering a range of topics from fundamental network topologies (e.g., multi-layer perceptron, deep networks, convolution neural networks) to advanced structures (e.g., recurrent neural networks, long short-term memory networks, reservoir networks, graph neural networks, and transformers). We delve into neural network learning paradigms and training rules (e.g., backpropagation), with a focus on practical applications in supervised, unsupervised, and reinforcement learning tasks.

Throughout the course, students will gain a solid understanding of the background, mechanisms, and techniques essential for building effective learning algorithms using artificial neural networks. The students will learn and practice methods and techniques to use artificial neural networks in applications including classification, regression, and decision-making tasks.

LEARNING OUTCOMES:
As a result of successful participation in this course, students will be able to:

1. Explain the properties and applications of feedforward neural networks
2. Explain and implement backpropagation-based training for feedforward neural networks
3. Design neural network for classification and regression
4. Design neural networks for estimation and system identification

PREREQUISITES:
Background in linear algebra and basic calculus, or, equivalently, MATH 141 and MATH 344 are desirable. Students should have familiarity with a programming language, e.g., MATLAB or Python.

TEXTBOOK AND REFERENCES:

1. I. Goodfellow, Y. Bengio, and A. Courville, Deep Learning, MIT Press, Cambridge, 2016. (Primary text)
2. S. Haykin, Neural Networks: A Comprehensive Foundation, Prentice-Hall, NJ, 1999.
3. Martin T. Hagan, Howard B. Demuth and Mark Beale, Neural Network Design, PWS Publishing Company, 1995.
4. F.L. Lewis, S. Jagannathan, and A. Yesilderik, Neural Network Control of Robot Manipulators and Nonlinear Systems, Taylor and Francis, UK, 1999.
5. Relevant material (e.g., link to research papers, supplementary book references) will be provided to the students via Blackboard.

ATTENDANCE POLICY:

You are expected to attend class lectures and **participate in class discussions**. If you expect to miss a class for any reason, you should contact the instructor by email as soon as possible. You are responsible for all the material covered during the lectures whether you are present or not.

Lecture presentations assume that you have read the assigned material before coming to class and are prepared to ask questions during class. **If you do not ask questions, then I will assume that you understand the material**. If there is a topic you do not understand, it is your responsibility to seek clarification from me during lectures or during office hours, or from other students.

TIME COMMITMENT AND PLANNING:

Any university course requires a large amount of work outside of lecture. I assume that when you register for this course you will allocate an average of at least six to ten (6-10) hours per week, in addition to lectures, to read the papers, complete the course project, assignments, and prepare for exams. It is your responsibility to manage your workload.

CLASSROOM BEHAVIOR:

Cell phones, personal digital assistants (PDAs), music players and other electronic devices that can distract you and other students must not be used in the classroom. Please remember to turn off the audio ringer on your cell phones before entering the classroom. Under no circumstances should you use a phone or PDA while class is in session. If your cell phone rings during class or you are involved in any other form of disruptive behavior that creates a disturbance in class (such as reading a newspaper, sleeping, texting, or having extended conversations), you may be asked to leave the classroom.

Similarly, while you may use your laptop computer during class to take notes, using your laptop in a way that distracts other students around you or otherwise disrupts the class (e.g., surfing the web, reading email, or playing audio/video recordings) is not permitted, and may result in you being asked to leave the classroom. You should plan to arrive before class begins and not leave until after class ends. This is an issue of respect for everyone involved – not just for the instructor, but also the students whom you disturb with your late entry and/or early departure. If you arrive late to (or must leave early from) a lecture please sit near an exit in the back of the classroom.

COURSE FORMAT:

The class will include a mixture of lectures, discussions, and student presentations. The lectures are expected to be highly interactive in nature, so **students are expected and encouraged to come to class prepared to discuss readings**.

Homework Assignment	30%
Midterm Exam (No final exam)	30%
Final Project	40%

ASSESSMENTS:

Your overall final course letter grade will be determined by your grades on the following assessments.

Your final grade is based on the total points you have earned over the semester. The percentage scores are translated to letter grades as follows: A = $[90\% - 100\%]$, B+ = $[87\% - 89.99\%]$, B = $[80\% - 86.99\%]$, C+ = $[77\% - 79.99\%]$, C = $[70\% - 76.99\%]$, D+ = $[67\% - 69.99\%]$, D = $[60\% - 66.99\%]$, F = $[0\% - 59.99\%]$

IMPORTANT NOTE REGARDING GRADE APPEALS:

Grade appeals for any assessment must be requested (either in writing or via email to me) within one (1) week of my posting the grade to Blackboard.

SUMMARY OF ASSESSMENTS:

- **Homework Assignments:** You will be required to turn in assignments/reports on time. They will typically involve reading research papers, reporting critiques, design, development, and implementation of codes on MATLAB/Python.
- **Presentation:** Each of you will be required to prepare an in-class presentations (20 minutes each) on recent papers (this will be either independently or in groups). The grading will be based on how well you present the motivation for the project/research you are presenting, problem definition, ideas, techniques, and limitations of the work. Critical thinking and deep insights into the research work are important to get a good grade.
- **Exam:** There will be a Midterm exam and a final project. For the final project, topics shall be decided after discussing with the instructor. You will be expected to turn in a project report by the end of the course ($\approx$ in the middle of the semeseter), which will contribute 30% toward your final grade.

REQUEST FOR ACCOMMODATIONS:

The University of South Carolina is committed to providing access to programs and services for qualified students with disabilities. If you are a student with a disability and require accommodation to participate and complete requirements for this class, notify me immediately and contact the Office of Student Disability Services (http://www.sa.sc.edu/sds, 1523 Greene Street, LeConte College Room 112A, 803-777-6142, sasds@mailbox.sc.edu) for verification of eligibility and determination of specific accommodations. In addition, please provide me the required accommodation letter from the Office of Student Disability Services. All course materials are available in alternative format upon request.

ACADEMIC INTEGRITY:

The faculty takes violations of the University Honor Code (http:// www.housing.sc.edu/ academicintegrity/ honorcode.html) seriously. Students are encouraged to review the Honor Code and to understand the consequences of any action that is proven to be a violation of the code.

You are expected to practice the highest possible standards of academic integrity. Any deviation from this expectation will result in a minimum academic penalty of your failing the assignment. In addition, an honor code violation will be subject to the sanctions described in the USC Community Handbook and Policy Guide. Violations of the University Honor Code include, but are not limited to, improper citation of sources, using another student's work, and any other form of academic misrepresentation. For more information, please see the University Honor Code.

In reference to this course, students are expected to do their own work when assignments and exams require individual work. For example, students are encouraged to discuss with peers while working on assignments and projects, but they may not copy the work of others, either manually or electronically,

under these conditions. Further, students who allow their work to be copied by others risk violation of the University Honor Code.

COURSE SCHEDULE:

The schedule is tentative and is subject to change.

- Week 01: Overview of the course and background (ML basics)
- Week 02: Review of basic mathematical concepts (Linear algebra, Functions)
- Week 03: Feedforward neural networks (Multi-layer perceptrons, McCulloch-Pitts Model)
- Week 04: Neural networks – Learning paradigms (Supervised, Unsupervised, RL)
- Week 05: Classification problems (and clustering) - Decision boundaries
- Week 06: Background on optimization (Gradients and gradient descent, regularization)
- Week 07: Backpropagation
- Week 08: Sequence Modeling
- Week 09: Background on dynamical systems and Recurrent neural networks
- Week 10: Deep learning and vanishing gradients
- Week 11: Long-Short Term Memory Networks and Reservoir computing
- Week 12: Autoencoders
- Week 13: Convolutional networks
- Week 14: Advanced neural networks (Transformers and GNNs)
- Subject to availability of time - Neural network for robotic systems