ECE 8930: Deep Representation Learning

Fall 2024

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Contents

1 Class Information

Class time	Mondays, 4:30-7:00pm
Class location	Riggs Hall 223 (2nd floor) (see Figure 1)
Time to wait	60 minutes
Modality	In-person
Student hours	Monday 10am - 12pm

2 Course Description

The course is designed for graduate students to gain theoretical background, knowledge, and applied skills for developing advanced, domain-specific deep neural network architectures. The course will cover a variety of inter-related theoretical topics centered around the basic concept of learning representations/embeddings form different data modalities. We will apply these theoretical concepts to several applied research problems, such as information propagation on social networks, learning causal structures from biomedical data, and neruo-symbolic reasoning.

Figure 1: Riggs Hall

The course work consists of two main components. First, students will conduct a comprehensive literature survey of state-of-the-art representation learning methods in one of the topics designated by the course instructor. The literature survey shall include standard benchmarks, baseline and state-of-the-art methods, and evaluation protocols and metrics. Topics will be assigned on first-come-first-serve basis. The aim is to gain knowledge of the proven methods in the literature. Students will (1) present a summary of the literature survey to the rest of the class, and (2) submit a complete paper draf in LaTeX (on Overleaf).

The second component is to design, implement (in Python and PyTorch) and evaluate a novel neural architecture and surpass (or at least achieve) state-of-the-art performance on standard benchmarks. Students will (1) give a conference-like 20-minute presentation on the new method and results to the rest of the class and (2) submit a complete paper draft in LaTeX in International Conference on Machine Learning (ICML) format (on Overleaf).

3 Prerequisites

1. Strong Python programming skills
2. Strong linear algebra background
3. Strong Linux background
4. ECE 6420 or 8550, and
5. Instructor approval

4 Learning Objectives and Outcomes

Upon completion of this course, students will have a solid theoretical understanding and applied skills developing advanced representation learning algorithms for various modalities, including im-

age, audio and networked data. Topics covered will include:

- Encoder-decoder architecture
- Diffusion-based models
- Graph neural networks
- Representation invariance and disentanglement
- Causal representation learning, causal structure discovery and counterfactual reasoning
- NeuroSymbolic deep neural network architectures

5   Required Materials

- Overleaf account
- Access to arxiv.com

6   Topical Outline

1. *Monday, August 26, 2024*

    (a) Overview of advanced representation learning
        i. Introduction to deep representation learning
        ii. Generative artificial intelligence
        iii. Graph neural networks
        iv. Representations invariance and disentanglement
        v. Causal representation learning, data-driven causal structure discovery and counterfactual reasoning
        vi. NeuroSymbolic artificial intelligence

2. *Monday, September 2, 2024* (Labor day holiday. Lecture will be recorded and provided no later than Sept. 3, 2024)

    (a) Convolutional architectures
    (b) Transformer-based architectures

3. *Monday, September 9, 2024*

    (a) Research topic presentations

4. *Monday, September 16, 2024*

    (a) Generative Adversarial Networks
    (b) Encoder-decoder architectures

5. *Monday, September 23, 2024*

    (a) Representation invariance and disentanglement
    (b) Causal representation learning, data-driven causal structure discovery and counterfactual reasoning

6. *Monday, September 30, 2024*

(a) Diffusion-based models

    (b) Graph neural networks

7. *Monday, October 7, 2024*

    (a) NeuroSymbolic deep neural network architectures

    (b) Neural estimation of mutual information

8. *Monday, October 14, 2024*

    (a) Fall break

9. *Monday, October 21, 2024*

    (a) Detecting AI-Generated Content

    (b) Watermarking AI-Generated Content

10. *Monday, October 21, 2024*

    (a) Literature survey presentations – survey paper due

11. *Monday, October 28, 2024*

    (a) Problem formulations presentations – first round

12. *Monday, November 4, 2024*

    (a) Problem formulations presentations – second round

13. *Monday, November 11, 2024*

    (a) Invited talk – speaker tentatively confirmed

14. *Monday, November 18, 2024*

    (a) Mid-term progress report presentations and paper drafts due

15. *Monday, November 25, 2024*

    (a) Online (Zoom)

    (b) Guest speaker – Prof. Amit K. Roy-Chowdhury, University of California, Riverside

    (c) Hands-on research and paper writing

16. *Monday, December 2, 2024*

    (a) In-person

    (b) Hands-on research and paper writing

17. *Monday, December 9, 2024*

    (a) Final presentations

7   Major Assessment and Grading Activities

Task/Milestone	Weight	Due date
Research topic selection	5%	Sep. 3
Research topic presentations and discussions	5%	Sept. 9
Literature survey paper	20%	Oct. 21
Literature survey presentation	10%	Oct. 21
Research problem formulation	10%	Oct. 28
Problem formulation presentation	10%	Nov. 4
Final paper	30%	Dec. 9
Final presentation	10%	Dec. 9

8   Grading System and Late Submission Policy

- Due to the structure and pace of this course, late submissions will not be allowed
- Following is the grading structure of the course

Grad	Range
A	$90 - 100\%$
B	$80 - 89\%$
C	$75 - 79\%$
D	$65 - 74\%$
F	$<65\%$

9   Generative Artificial Intelligence Policies

- The use of generative artificial intelligence (AI) tools (e.g., ChatGPT, etc.) is prohibited
- Suspected violations will be facilitated using the Academic Integrity process outlined in the Graduate School Policies and Procedures Handbook

10   Absences

- Attendance in person is mandatory
- Each unexcused is penalized 5%
- Students will receive and automatic **F** after *four* unexcused absences

11   Inclement Weather and Emergencies

- Any class-event (e.g., presentations) that was scheduled at the time of a class cancellation due to inclement weather will take place at the next class meeting unless I contact you otherwise
- Class cancellation due to inclement weather ***does not*** change due dates of any off-class assignments (e.g., paper submission)
- And any extension or postponement of assignments or exams must be granted by me via email or Canvas within 24 hours of the weather-related cancellation

12 Important Dates

Event	Date
Last day to add course	August 27th, 2024
Drop without record	September 4th, 2024
Drop with a W grade	October 28th, 2024

13 Other class policies

- Food is not allowed
- Beverages and water are allowed
- Cell phone use is not allowed

14 Useful resources

1. Aston Zhang, Zachary C. Lipton, Mu Li and Alexander J. Smola, Dive into Deep Learning

15 About the Instructor

I am a Tenured Full Professor at the Holcombe Department of Electrical and Computer Engineering at Clemson University. From 2013 to 2023, I was a Research Associate Professor at Department of Electrical and Computer Engineering, and a Research Director and Distinguished Principal Scientist with Information Sciences Institute, both are units of University of Southern California (USC) Viterbi School of Engineering. I am the Founding Director of the USC's Visual Intelligence and Multimedia Analytics Laboratory (VIMAL). I received my B.S. in electrical engineering in 1994 and my M.S. in computer engineering in 1997 from Mansoura University in Egypt. I earned a graduate software engineering diploma in 1997 from the Information Technology Institute in Egypt via a scholarship granted to distinguished graduates from Egyptian universities. I obtained my Ph.D. with Distinction from the University of New Mexico in 2003 where I was also awarded the Outstanding Graduate Student award. my research interests include representation learning, debiasing and fair representations, multimedia forensics and visual misinformation identification (such as deepfake and image manipulation detection) and face recognition and biometric anti-spoofing. I lead several multi-institution research efforts, including DARPA's MediFor, GARD and LwLL and IARPA's Janus, Odin and BRIAR. I have over 100 publications in top computer vision, machine learning and biometrics conferences and journals, including CVPR, NeurIPS, ICCV, ECCV, ACM MM, PAMI, TBIOM and ICB. I am the recipient of 2022 and 2019 USC Information Sciences Institute Achievement Award. My research has also been featured in Forbes, Glamour UK, Fox News, Time For Kids and PCMag. For more information about my research and publications, please visit my Google Scholar page.

16 Accessibility statement

Clemson University values the diversity of our student body as a strength and a critical component of our dynamic community. Students with disabilities or temporary injuries/conditions may require

accommodations due to barriers in the structure of facilities, Students who experience a barrier to full access to this class should let the instructor know and are encouraged to request accommodations through SAS (Student Accessibility Services) as soon as possible. To request accommodations through SAS, please see this link. You can also reach out to SAS with questions by calling 864-656-6848, email CUSAS@clemson.edu or visiting SAS at the ASC Suite 239. Contact the office for the most updated drop-in schedule if you would prefer not to schedule an appointment.

17 Title IX statement

Clemson University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, sexual orientation, gender, pregnancy or related conditions (including pregnancy, childbirth, termination of pregnancy, lactation, recovery from the foregoing, or medical conditions related to the foregoing), national origin, age, disability, veteran's status, genetic information or protected activity in employment, educational programs and activities, admissions and financial aid. This includes a prohibition against sex discrimination (including sex-based harassment and sexual violence) as mandated by Title IX of the Education Amendments of 1972. This Title IX policy is located on the Access Compliance and Education website. Ms. Alesia Smith is the Clemson University Title IX Coordinator, and the Assistant Vice President of Equity Compliance. Her office is located at 223 Brackett Hall, 864-656-3181 and her email address is alesias@clemson.edu. Remember, email is not a fully secured method of communication and should not be used to discuss Title IX issues.

18 Academic Integrity statement

As members of the Clemson University community, we have inherited Thomas Green Clemson's vision of this institution as a "high seminary of learning." Fundamental to this vision is a mutual commitment to truthfulness, honor, and responsibility, without which we cannot earn the trust and respect of others. Furthermore, we recognize that academic dishonesty detracts from the value of a Clemson degree. Therefore, we shall not tolerate lying, cheating, or stealing in any form. All infractions of academic dishonesty by undergraduates must be reported to Undergraduate Learning for resolution through that office. In cases of plagiarism instructors may use the Plagiarism Resolution Form. Additionally, for undergraduate classes: Plagiarism, which includes the intentional or unintentional copying of language, structure, or ideas of another and attributing the work to one's own efforts. Graded works generated by artificial intelligence or ghostwritten (either paid or free) are expressly forbidden. See the Undergraduate Academic Integrity Policy website for additional information and the current catalog ("Academic Regulations" section) for the policy. Send questions to UGSintegrity@clemson.edu. For graduate students, see the current graduate student handbook for all policies.

19 Emergency preparedness statement

Emergency & Safety Procedures have been posted in all buildings and on elevators. Students should be reminded to review these procedures for their own safety. All students and employees should be familiar with guidelines from Clemson University Public Safety. Clemson University is committed to providing a safe campus environment for students, faculty, staff, and visitors. As members of the community, we encourage you to take the following actions to be better prepared in case of an emergency:

1. Ensure you are signed up for emergency alerts (CU Alerts). Alerts are only sent when there is a potential threat to safety, a major disruption to campus services, and for once- monthly tests.

2. Familiarize yourself with all possible exits, safer locations, and other key information on the emergency evacuation maps in this building and those that you visit regularly.

3. Make a plan for how you would Run, Hide, and Fight in case of an active threat in this building and those that you visit regularly.

   - Run: What are all the possible exits in this building, and the routes to them?
   - Hide: What are the potential hiding locations in this room and building that are out

   of sight of doors and windows, how do you lock the door(s), how would you barricade the door(s) and windows, and where do you turn off the lights?

   - Fight: What tools are available in this room and building, should you have to fight?

4. Learn what you can do to prepare yourself for the hazards that affect our locations (`https://www.clemson.edu/cusafety/emergency-management/emergency-` procedures/index.html).

   - Download the Rave Guardian app to your phone

   (`https://www.clemson.edu/cusafety/cupd/rave-guardian/`).