CSCI699 -
Representation Learning: Theory and Practice

Units: 4
Fall—MW—10-12:

Location: LVL 13, website TBD

Instructors: Aram Galstyan and Greg Ver Steeg
Office Hours: TBD
Contact Info: galstyan@isi.edu, gregv@isi.edu

Teaching Assistant: Sami Abu-El-Haija
Office: Physical or virtual address
Office Hours: 2 – 3:20 PM, MW
Contact Info: haija@isi.edu

IT Help: Group to contact for technological services, if applicable.
Hours of Service:
Contact Info: Email, phone number (office, cell), Skype, etc.

Note: this is a new course and the syllabus may change several times. Please check for updates on the course listing or course webpage. The course is intended for research-oriented PhD students. Enrollment of exceptional master's students will be considered on a case by case basis.

This version: August 16, 2019

Course Description

The course is designed for students wishing to gain theoretical and applied skills in Inference, Machine Learning, Information Theory, and Deep Learning. We will cover the necessary background in Mathematics (Linear Algebra, Matrix Calculus, Information Theory) and Programming (Numpy, Computational Graphs, TensorFlow). We will cover a variety of inter-related theoretical topics including Deep Learning, Graphical Models, Variational Methods, Embeddings, and others. We will extensively be applying the theoretical topics on applications (Natural Language Processing, Computer Vision, Graph Theory). The majority of the grade is hands-on: specifically, by implementing programs which require the student to thoroughly understand both the theory and the application domain. Our goal is to show students that most of the applications require a similar set of theoretical skills, which we will teach in the course.

Learning Objectives and Outcomes

The course prepares students and equips them with theoretical and practical skills for conducting state-of-the-art research in Artifical Intelligence and Machine Learning. The assignments will be open-ended, and we hope that some/most of the submissions will become scientific papers at top-tier conferences and journals.

Prerequisite(s): Python Programming, Linear Algebra (knowing how to multiply two matrices), Calculus (knowing the chain rule).
Co-Requisite(s): None
Concurrent Enrollment: None
Recommended Preparation: None

Course Notes

Letter Grade only (Audits and pass/fail are not allowed)

Technological Proficiency and Hardware/Software Required

You are expected to know how to use Linux. TensorFlow can work on Windows, but if you choose to go that way, we will not be able to help you debugging any installation issues.

Required Readings and Supplementary Materials

Deep Learning Textbook: https://www.deeplearningbook.org/, but we will not cover the entire textbook. We will provide a detailed breakdown a month before the course begins. Nonetheless, students are encouraged to read the entire textbook on their own.
Otherwise, we will be using (free) online notes written by other universities, published scientific papers, as well as handouts we will create for the course.

Description and Assessment of Assignments

Assignments are to be completed individually. Students are allowed to only discuss ideas (e.g. on a whiteboard and/or a piece of paper), but are not allowed to share code.

Grading Breakdown

Component	% of Grade
Assignment 1	8
Assignment 2	16
Assignment 3	14
Assignment 4	14
Assingment 5	14
Beyond Assignment 3, 4, or 5	10
Test [multiple choice]	14
Participation [in class, piazza]	10
TOTAL	**100**

Grading Scale

Course final grades will be determined using the following scale

A	85-100
A-	75-84
B+	70-74
B	64-69
B-	60-63
C+	57-59
C	53-56
C-	50-52
F	50 and below

Assignment Submission Policy

Assignments 1, 2, 3, 4 & 5 must be submitted individually, online through Vocareum. The "Beyond Assignment" must be submitted as a PDF, which is expected to be 2-to-4 pages long (max 4, though 3 is ideal).

Grading Timeline

The majority of the assignment grade will be obtained by the students as soon as they submit the assignment on vocareum. A portion of the assignment grade, however, such as model visualizations, will be submitted in PDF and manually graded, and should be available a week after submission. The grade for participation is to encourage students to ask questions, and to answer each other (in-class and on Piazza).

Additional Policies

Each student has 7 late days total, for submitting the assignments. Student cannot use more than 3 late days on any given assignment. Weekend days count as regular days. Assignments submitted after 3 late days will automatically receive a grade of 0. If a student exceeds the 7 late days, he/she will lose 25% of the assignment grade, for every late day.

Course Schedule: A Weekly Breakdown

Week	Monday	Wednesday
	Refresher	
1	Welcome; Syllabus Overview; Course Goals; Logistics; Overview of Learning Paradigms; Matrix Calculus; Backpropagation Algorithm; Reading: Linear Algebra **[Assignment 1 out: Basics]**	Probability Theory and Information Theory (part 1) Reading: DL#3; numpy refresher [basics, io, broadcasting, shared memory, advanced indexing, boolean ops, concatenation & stacking];
2	***Labor Day Holiday [no class]***	Probability Theory and Information Theory (part 2); TensorFlow (part 1): Graphs, Sessions, Auto-Gradients; Time-permitting: Supervised Learning; Linear Regression; Regularization; Gradient Descent (DL#8.3); Recommended Reading: (DL#5)
	Supervised (Deep) Learning: P(Y|X)	
3	Deep Learning; Training (Adaptive Gradient Methods (DL#8.5)); Tricks (Dropout (DL#7.12), BatchNorm)) **Assignment 1 due [midnight]** Reading (DL#6 except 6.1 and 6.5)	Euclidean Convolution (DL#9 up to 9.3); Sequence Models (DL#10 up to 10.4); TensorFlow (part 2): Assign Ops, Devices, Variables, Losses, Training Loop. **Assignment 2 out: Image Segmentation and Sequence Modeling using Convolutional and Recurrent Nets**
4	Information Bottlenecks Reading: physics paper and deep learning paper	Graph Neural Networks; Graph Convolution; Graph Regularization
	Unsupervised (Representation) Learning: P(X)	
5	Autoregressive Models; WaveNet; PixelCNN	Autoencoders; Variational Auto Encoders (DL#20) **Assignment 2 due [on Friday]**
6	Probabilistic Graph Models (PGM): Belief Propagation and Variational Inference Reading: Graphical Models in a Nutshell **Assignment 3 out: Autoregressive Models**	PGM (continue) Basic concepts in Statistical Physics
7	Energy Models: Restriced Boltzmann Machines; Ising Model & phase-transitions.	Guest Lecturer: TBA Presentations by top-performing students on Assignment 2 (for bonus credits)
8	VAEs: Information Theoretic Derivation	Generative Adversarial Networks (GANs) (DL#20) **Assignment 3 due [on Friday]**
9	GANs (continued) (DL#20); Normalizing Flows **Assignment 4 out: Flow Models**	Normalizing Flows (continue); Glow paper (link)
10	Discrete Latent Variable Models	Disentangled Representations; Invariant Representations
	Embedding Learning	
11	Word Embeddings; Graph Embeddings. **Assignment 4 due [on Friday]** **Assignment 5 out: Semi-supervised Embeddings**	Guest Lecturer: TBA Attention Models for Embeddings
	Program Induction	
12	Program Synthesis	Visual Question Answering using Program Synthesis. **[Assignment 5 due]**
	Misc Topics [/ to be finalized with students, based on demand]	
13	Sequence-to-Sequence Models	Meta-Learning
14	Catastrophic Forgetting **[Beyond Assignment due]**	Deep Learning on Videos
15	Geometric Deep Learning	In class test (multiple choice) on Misc topics; Farewell; Advice for the future.
	The End	

Academic Conduct:

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, "Behavior Violating University Standards" policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, policy.usc.edu/scientific-misconduct.

Support Systems:

Student Health Counseling Services - (213) 740-7711 – 24/7 on call
engemannshc.usc.edu/counseling
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call
suicidepreventionlifeline.org
Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-4900 – 24/7 on call
engemannshc.usc.edu/rsvp
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) | Title IX - (213) 740-5086
equity.usc.edu, titleix.usc.edu
Information about how to get help or help a survivor of harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following protected characteristics: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations.

Bias Assessment Response and Support - (213) 740-2421
studentaffairs.usc.edu/bias-assessment-response-support
Avenue to report incidents of bias, hate crimes, and microaggressions for appropriate investigation and response.

The Office of Disability Services and Programs - (213) 740-0776
dsp.usc.edu
Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Support and Advocacy - (213) 821-4710
studentaffairs.usc.edu/ssa

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC - (213) 740-2101

diversity.usc.edu

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call

dps.usc.edu, emergency.usc.edu

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call

dps.usc.edu

Non-emergency assistance or information.