

ECE 598LV — Representation of Information

Spring 2024

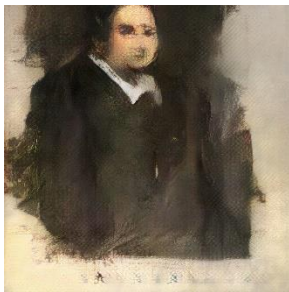
Lecturer: Prof. Lav R. Varshney, varshney@illinois.edu
Office Hours: T 12:30-1:30, 314 CSL and by appointment

Teaching Assistant: TBD
Office Hours: TBD

Lecture: TR 11:00-12:20am, 3017 Electrical & Computer Engineering Building
[When necessary, Zoom with recording on MediaSpace]

Course Webpage: <http://courses.grainger.illinois.edu/ece598lv2/sp2024/>

Course Goals



Portrait of Edmond Belamy (Oblivious)



Kenyan Brussels Sprouts Gratin (Chef Watson)



www.thispersondoesnotexist.com
(StyleGAN2)

- Provide an introduction to advanced topics in information theory, to understand fundamental limits of representing information
- Provide an introduction to emerging techniques in generative artificial intelligence that are based on learning representations
- Explore the interaction between information and intelligence

In this class, we aim to address these topics, both theoretically and practically, keeping a variety of application domains such as visual art, music, culinary, text, and materials in mind.

Brief Technical Description

Learning representations are critical in many branches of artificial intelligence, especially in recent applications of generative AI. At the same time, there are several information-theoretic principles that are foundational to representation of information. This course covers relevant information-theoretic topics in multiterminal source coding, multiterminal channel coding, universal prediction, and associative memories, as well as mathematical and computational foundations of learning representations arising in generative AI models that include variational autoencoders, autoregressive models such as Transformers, normalizing flow models, information lattice learning, invariant risk minimization, and diffusion models. Emerging connections between information theory and AI will be discussed throughout. Governance and social responsibility in generative AI will also be briefly discussed.

Suggested Prerequisites

ECE 563. ECE 544 or its equivalent.

Requirements

- Weekly homework (25%)
- Midterm exam [take-home] (20%)
- Final exam [take-home] (15%)
- Individual project (35%)
- Social responsibility essay (5%)

Textbook

- T. M. Cover and J. A. Thomas, *Elements of Information Theory*, 2nd ed., Wiley, 2006.
- Further readings and lecture notes from conference tutorials, the research literature, and written by the instructor provided through the course website.

Detailed Course Schedule (Tentative)

Date	Topic
1/16	Introduction to Learning Representations
1/18	Review of Lossless Source Coding
1/23	Review of Rate-Distortion Theory
1/25	Source Coding with Coded Side Information
1/30	Source Coding with Coded Side Information
2/1	Information Bottleneck Method
2/6	Multiple Access Channel
2/8	Multiple Access Channel
2/13	Invariant Risk Minimization
2/15	Invariant Risk Minimization
2/20	Associative Memories
2/22	Associative Memories
2/27	Normalizing Flow Models
2/29	Normalizing Flow Models
3/5	Variational Autoencoders
3/7	Variational Autoencoders
3/19	Autoregressive Models
3/21	Autoregressive Models
3/26	Universal Prediction
3/28	Universal Prediction
4/2	Transformers
4/4	Transformers
4/9	Neural Text Decoding and Prompt Programming
4/11	Diffusion Models
4/16	Diffusion Models
4/18	Lattice Theory of Information and Information Lattice Learning
4/23	Lattice Theory of Information and Information Lattice Learning
4/25	Governance and Social Responsibility
4/30	Emerging Topics / Closing / Student Presentations

Emergency Response Recommendations

Emergency response recommendations can be found at the following website:

<http://police.illinois.edu/emergency-preparedness/>. I encourage you to review this website and the campus building floor plans website within the first 10 days of class.

<http://police.illinois.edu/emergency-preparedness/building-emergency-action-plans/>.

Inclusivity Statement

The Grainger College of Engineering is committed to the creation of an anti-racist, inclusive community that welcomes diversity along a number of dimensions, including, but not limited to, race, ethnicity and national origins, gender and gender identity, sexuality, disability status, class, age, or religious beliefs.

The College recognizes that we are learning together in the midst of the Black Lives Matter movement, that Black, Hispanic, and Indigenous voices and contributions have largely either been excluded from, or not recognized in, science and engineering, and that both overt racism and micro-aggressions threaten the well-being of our students and our university community.

The effectiveness of this course is dependent upon each of us to create a safe and encouraging learning environment that allows for the open exchange of ideas while also ensuring equitable opportunities and respect for all of us. Everyone is expected to help establish and maintain an environment where students, staff, and faculty can contribute without fear of personal ridicule, or intolerant or offensive language. If you witness or experience racism, discrimination, micro-aggressions, or other offensive behavior, you are encouraged to bring this to the attention of the course director if you feel comfortable. You can also report these behaviors to the Bias Assessment and Response Team (BART) (<https://bart.illinois.edu/>). Based on your report, BART members will follow up and reach out to students to make sure they have the support they need to be healthy and safe. If the reported behavior also violates university policy, staff in the Office for Student Conflict Resolution may respond as well and will take appropriate action.

Community of Care

As members of the Illinois community, we each have a responsibility to express care and concern for one another. If you come across a classmate whose behavior concerns you, whether in regards to their well-being or yours, we encourage you to refer this behavior to the Student Assistance Center (217-333-0050 or <http://odos.illinois.edu/community-of-care/referral/>). Based on your report, the staff in the Student Assistance Center reaches out to students to make sure they have the support they need to be healthy and safe.

Further, we understand the impact that struggles with mental health can have on your experience at Illinois. Significant stress, strained relationships, anxiety, excessive worry, alcohol/drug problems, a loss of motivation, or problems with eating and/or sleeping can all interfere with optimal academic performance. We encourage all students to reach out to talk with someone, and we want to make sure you are aware that you can access mental health support at McKinley Health Center (<https://mckinley.illinois.edu/>). Or the Counseling Center (<https://counselingcenter.illinois.edu/>). For urgent matters during business hours, no appointment is needed to contact the Counseling Center. For mental health emergencies, you can call 911.

Disruptive Behavior

Behavior that persistently or grossly interferes with classroom activities is considered disruptive behavior and may be subject to disciplinary action. Such behavior inhibits other students' ability to learn and an instructor's ability to teach. A student responsible for disruptive behavior may be required to

leave class pending discussion and resolution of the problem and may be reported to the Office for Student Conflict Resolution (<https://conflictresolution.illinois.edu>; conflictresolution@illinois.edu; 333-3680) for disciplinary action.

Academic Integrity

Academic integrity and discipline will be based on the standards set forth by the College of Engineering and the University of Illinois. The University has the responsibility for maintaining academic integrity so as to protect the quality of education and research on our campus and to protect those who depend upon our integrity. It is the responsibility of the student to refrain from infractions of academic integrity, from conduct that may lead to suspicion of such infractions, and from conduct that aids others in such infractions.

Examples of Infractions of Academic Integrity

A. Cheating -- Using or attempting to use in any academic exercise materials, information, study aids, or electronic data that the student knows or should know is unauthorized. During examinations, students should assume that external assistance (e.g., books, notes, calculators, conversation with others) is prohibited unless specifically authorized by the instructor. Substantial portions of the same academic work may not be submitted for credit more than once or by more than one student without authorization.

B. Fabrication -- Unauthorized falsification or invention of any information or citation in an academic endeavor. Fabrication also includes altering the answers given for an exam after the examination has been graded. Fabrication also includes submitting false documents for the purpose of being excused from a scheduled examination or other academic assignment.

C. Facilitating Infractions of Academic Integrity -- Helping or attempting to help another to commit an infraction of academic integrity, where one knows or should know that through one's acts or omissions such an infraction may be facilitated. Examples include: 1) allowing another to copy from one's work during an examination, 2) taking an exam by proxy for someone else, and 3) unauthorized removal of an examination or quiz from a classroom, faculty office, or other facility (such as the proctor's office) would be committing a breach of academic integrity.

A complete listing of Infractions of Academy Integrity and University Policy can be found at this web site: http://admin.illinois.edu/policy/code/article1_part4_1-401.html

Family Educational Rights and Privacy Act (FERPA)

Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See <https://registrar.illinois.edu/academic-records/ferpa/> for more information on FERPA.

Mental Health

Significant stress, mood changes, excessive worry, substance/alcohol misuse or interferences in eating or sleep can have an impact on academic performance, social development, and emotional wellbeing. The University of Illinois offers a variety of confidential services including individual and group counseling, crisis intervention, psychiatric services, and specialized screenings which are covered through the Student Health Fee. If you or someone you know experiences any of the above mental health concerns, it is strongly encouraged to contact or visit any of the University's resources provided

below. Getting help is a smart and courageous thing to do for yourself and for those who care about you.

Counseling Center (217) 333-3704

McKinley Health Center (217) 333-2700

National Suicide Prevention Lifeline (800) 273-8255

Rosecrance Crisis Line (217) 359-4141 (available 24/7, 365 days a year)

If you are in immediate danger, call 911

Religious Observances

Students should complete the Request for Accommodation for Religious Observances form should any instructors require an absence letter in order to manage the absence. In order to best facilitate planning and communication between students and faculty, we request that students make requests for absence letters as early as possible in the semester in which the request applies.

Sexual Misconduct Reporting Obligation

The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University's Title IX and Disability Office. In turn, an individual with the Title IX and Disability Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options.

A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here: wecare.illinois.edu/resources/students/#confidential.

Other information about resources and reporting is available here: wecare.illinois.edu.

Students with Disabilities

To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the as soon as possible. To ensure that disability-related concerns are properly addressed from the beginning, students with disabilities who require assistance to participate in this class should contact Disability Resources and Educational Services (DRES) and see the instructor as soon as possible. If you need accommodations for any sort of disability, please speak to me after class, or make an appointment to see me or see me during my office hours. DRES provides students with academic accommodations, access, and support services. To contact DRES you may visit 1207 S. Oak St., Champaign, call 333-4603 (V/TDD), or e-mail disability@illinois.edu. <http://www.disability.illinois.edu/>.