Rensselaer

Course Information:

ECSE 4964/6964: COMPUTATIONAL CREATIVITY

(3 Credits)

- 2023_Fall Term
- Elect, Comp & Syst Enginr
- School of Engineering

Course Schedule:

2023_Fall Term [202309]
Term Start Date: Monday, 28-Aug-2023 **Term End Date:** Friday, 2-Feb-2024
ADD TO CALENDAR

Location and Schedule:
CRN: 64494/64495

JEC 4104
Mondays and Thursdays, 4:00-5:20 PM

LMS Information:

The main website for the course is https://richradke.github.io/computationalcreativity/; you are responsible for knowing any information that appears there. RPI's LMS will not be used; all grades will be available on Gradescope. See the section below for more information about online tools used in the class.

Prerequisites or Other Requirements:

A first course in machine learning (ECSE-4840 or ECSE-4850 or CSCI-4100 or equivalent). Having taken such a course implies an understanding of calculus, probability, and programming (e.g., the content in MATH-2010, ECSE-2500, and CSCI-1200). Additionally, a creative/artistic mindset and curiosity/enthusiasm for making fun images and videos is required!

Course Websites:

This course will use a variety of online resources to share and collect course content. These include:

- Github: the hub for all our classroom materials is https://richradke.github.io/computationalcreativity/.
- Discord: the invite link for our Discord channel is https://discord.gg/k9EwtdFVX. To get my attention, ping me @epipolar.
- Gradescope: all homework/project reports will be submitted and graded here.
- Box: almost every assignment will be accompanied by a digital component (images, videos, code, behind-the-scenes info) that you will share with me and others in the class.
- Google Forms: after every assignment is submitted you will do a self-assessment of your team's performance, as well as a peer assessment of several other teams' work.
- Webex Teams: when we have a remote speaker, we will use Webex Teams to host them.
- Mediasite and Youtube: recorded lectures will be uploaded to both these sites.

I will add you to these various sites using your RCS email before the start of class, and you should download the various apps for your phone and other devices. If you can't get access to any of these online resources, please send me an email as soon as possible. By taking this class, you acknowledge the use of various third-party software and tools (Gradescope, Google Forms, Discord, Colab, OpenAI, etc.) that may require you to disclose personal information outside of the RPI network.

Course Instructor:

Prof. Rich Radke

Office: JEC 7002

Office Phone: 518 276 6483

Email: rjradke@ecse.rpi.edu

Office Hours: Tuesdays 3:30-5:30 PM

Course Description:

Creative applications of generative artificial intelligence have exploded in the past year, including image generation tools like Stable Diffusion and DALLE-2 and text generation tools like Chat-GPT. This course will survey the theoretical foundations of these tools, focusing on generative models and self-supervised learning, as well as explore the historical and ethical considerations involving the procedural generation of art. Students will apply cutting-edge tools for generating creative content and critique each other's work.

Textbook:

We will cover most of *Generative Deep Learning: Teaching Machines To Paint, Write, Compose, and Play, 2nd Edition* by David Foster, O'Reilly Media, June 2023.

We will also discuss research papers from the recent academic literature that will be linked from the course webpage.

Course Content:

The course website https://richradke.github.io/computationalcreativity contains a complete list of topics, split into 8 modules:

1. Introduction and Background
2. Variational auto-encoders
3. Generative Adversarial Networks
4. Additional generative models
5. Language models
6. Diffusion models for image generation
7. Multimedia generation
8. Neural rendering fields

Student Learning Outcomes:

- Describe and apply algorithms for generating images using variational autoencoders, generative adversarial networks, and diffusion models
- Describe and apply algorithms for language modeling
- Describe and apply algorithms for multimedia generation from text prompts
- Discuss and compare the development and history of generative AI techniques
- Identify ethical issues involving generative AI applications
- [6000 level] Demonstrate a graduate-level understanding of specific generative machine learning algorithms and tools, based on short technical reports and code demonstrations.

The outcomes will be assessed based on homework assignments, a culminating class project, class participation, and for the graduate level of the class, reaction reports to recent research papers. For a detailed breakdown, see the Grading Criteria section below.

Grading Criteria:

At the 4000 level, the grade will be based on reading and participation (worth 20%), a final project (worth 30%), and the average homework grade (worth 50%).

The homeworks and course project can be done in groups of at least two and up to three; all members of the group will get the same grade on the assignments. In general, each homework will involve a reasonable amount of programming, either from scratch or by integrating existing software tools/libraries and Google Colab notebooks. Homework is due at the start of class on the date indicated. Late submissions will not be accepted since the grading process also involves your assessment of others' work.

Tentatively, the assignments will address:

1. Dataset selection/curation, variational autoencoders, and project proposal (due 9/21, 10% of grade)
2. GANs and diffusion models (due 10/12, 10% of grade)
3. Large language models (due 11/2, 10% of grade)
4. Text to image and video (due 11/16, 10% of grade)
5. Neural rendering fields (NeRF) (due 11/30, 10% of grade)

The 6000 level of the class has two additional requirements. First, each homework will include an additional problem involving a critical 2-page review (not just a summary) of 2 recent papers from CVPR, SIGGRAPH, NeurIPS, etc. that pertains

to the material for that homework. Second, the 6000-level students will also be expected to incorporate more research-level/hand-written code into their assignments and final projects.

Each assignment will include a peer evaluation component distributed via Google Forms; the final grade for each assignment will be a weighted average of 90% the instructor's assessment and 10% the average peer assessment.

The participation grade (20% of the course grade) will be made up of 50% instructor assessment of student engagement/contribution, 25% within-group peer assessments, and 25% frequency of peer assessment submissions. Within-group assessments will be monitored per assignment to assess any imbalances that should affect the participation grade.

The final project of the students' own design should be a creative product that leverages at least three of the concepts from the class. Students will provide one progress report during the semester, and a final written report and source code on the last day of class. The overall project grade will be computed as 10% proposal, 20% progress report, 35% final report, and 35% project evaluation. All projects will be presented and discussed in the last week of class.

The details of the grading policy are provided below.

Grading policy for 4964

- Homework assignments 50% (10% each)
- Class participation 20%
- Final project 30% (broken down as above)

Grading policy for 6964

- Homework assignments 50% (10% each)
- Class participation 15%
- Final project 25% (broken down as above)
- Reaction reports to research papers 10%

Attendance Policy:

Attendance is expected in every class period, unless previously discussed with the instructor, and if necessary, officially documented by the Student Experience office (4th floor, Academy Hall). We will cover a lot of ground in this course, so attendance is important. Note that a percentage of your course grade also depends on your participation and engagement during class.

You are expected to approach the instructor with any issue that may affect your performance in class ahead of time. This includes absence from important class meetings, late assignments, inability to perform an assigned task, the need for extra time on assignments, etc. You should be prepared to provide sufficient proof of any circumstances based on which you are making a special request as outlined in the Rensselaer Handbook of Student Rights and Responsibilities.

Grade appeals on an assignment should be made in Gradescope within 72 hours of its return to the class. Letter grades will not be assigned until the end of the class, after the final project report has been graded. Any letter grade assignment posted before the end of the class should be regarded as tentative and subject to change.

Students acknowledge the use of various third-party software and tools (Piazza, Gradescope, Google Forms, Discord, Colab, OpenAI, etc.) that may require them to disclose personal information outside of the RPI network

Academic Policies:

- Academic Integrity

  Student-teacher relationships are built on trust. For example, students must trust that teachers have made appropriate decisions about the structure and content of the courses they teach, and teachers must trust that the assignments that students turn in are their own. Acts that violate this trust undermine the educational process. The Rensselaer Handbook of Student Rights and Responsibilities and The Graduate Student Supplement define various forms of Academic Dishonesty and you should make yourself familiar with these. In this class, all assignments that are turned in for a grade must represent the student's own work. In cases where help was received, or teamwork was allowed, a notation on the assignment should indicate your collaboration.

  Violations of academic integrity may also be reported to the appropriate Dean (Dean of Students for undergraduate students or the Dean of Graduate Education for graduate students, respectively).

If you have any question concerning this policy before submitting an assignment, please ask for clarification. In addition, you can visit the following site for more information on our Academic Integrity Policy: Students Rights, Responsibilities, and Judicial Affairs.

- Disability Services

  Rensselaer Polytechnic Institute strives to make all learning experiences as accessible as possible. If you anticipate or experience academic barriers based on a disability, please let me know immediately so that we can discuss your options. To establish reasonable accommodations, please register with The Office of Disability Services for Students. After registration, make arrangements with the Director of Disability Services as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion. DSS contact information: dss@rpi.edu; +1-518-276-8197; 4226 Academy Hall.

  Disability Services for Students

- Support Services

  RPInfo - contains various resource links for students, academic resources, support services, and safety & emergency preparedness.

Academic Assistance	ALACâ€"Advising and Learning Assistance Center	518.276.6269	https://info.rpi.edu/advising-learning-assistance/
Student Health and Wellness	Counseling Center	518.276.6479	https://studenthealth.rpi.edu/list-services/counseling-center
	Student Health Center	518.276.6287	https://studenthealth.rpi.edu/list-services/student-health-center
Student Support Services	Class Deans, Undergraduate Dean, Graduate Experience	518.276.8022	https://success.studentlife.rpi.edu/
	Dean, Student Success Dean, First Year Experience		
RPI Info	Central Information Hub for the campus		https://info.rpi.edu
DOTCIO	Help Desk	518.276.7777	

(IT Services)	Submit a ticket to IT Services and Support Center		https://itssc.rpi.edu/hc/en-us

Additional Academic Integrity Course Policy and Penalty Information:

Student-teacher relationships are built on trust. For example, students must trust that teachers have made appropriate decisions about the structure and content of the courses they teach, and teachers must trust that the assignments that students turn in are their own. Acts that violate this trust undermine the educational process. The Rensselaer Handbook of Student Rights and Responsibilities and The Graduate Student Supplement define various forms of Academic Dishonesty and you should make yourself familiar with these. In this class, all assignments that are turned in for a grade must represent the student's own work. In cases where help was received, or teamwork was allowed, a notation on the assignment should indicate your collaboration.

Collaboration between teammates is allowed and encouraged on the homeworks and project, but collaboration with others within or outside RPI is prohibited. Submission of any assignment that is in violation of the collaboration policies will result in a penalty of an F in the class, and may be subject to further disciplinary action.

Day	Date	Topic	HW due dates (tentative)
Monday	28-Aug	Introduction to generative modeling	
Thursday	31-Aug	Algorithms for making art (1960-2010)	
Monday	4-Sep	No class (Labor Day)	
Tuesday	5-Sep	Probability and machine learning review (Monday schedule)	
Thursday	7-Sep	Deep learning crash course	
Monday	11-Sep	Variational auto-encoders (VAEs)	
Thursday	14-Sep	VQ-VAEs and image quality metrics	
Monday	18-Sep	Generative adversarial networks (GANs)	
Thursday	21-Sep	Advanced GANs (e.g., ProGAN, StyleGAN, GANSpace)	HW1: deciding on datasets, creating VAE, project proposal
Monday	25-Sep	Image-to-Image GANs (e.g., CycleGAN, pix2pix); GAN artists	
Thursday	28-Sep	No class (Radke out of town)	
Monday	2-Oct	Denoising diffusion models	
Thursday	5-Oct	Neural style transfer; Deepdream	
Monday	9-Oct	No class (Columbus Day)	
Thursday	12-Oct	Guest Aaron Hertzmann: Can Computers Create Art?	HW2: GANs and basic diffusion models
Monday	16-Oct	Normalizing flow models	
Thursday	19-Oct	Neural language models and word embeddings	
Monday	23-Oct	Word2vec and attention	Project progress report
Thursday	26-Oct	Large language models and their implications	
Monday	30-Oct	Guest Pamela Samuelson: Legal Challenges to Generative AI	
Thursday	2-Nov	CLIP and its applications	HW3: Large language models
Monday	6-Nov	DALL-E 2 and Stable Diffusion	
Thursday	9-Nov	Diffusion developments (inpainting, DreamBooth, ControlNet)	
Monday	13-Nov	Text to 3D (Dreamfusion, Point-E)	
Thursday	16-Nov	Music generation (MuseGAN, Magenta, Jukebox, Riffusion)	HW4: Text to image and video
Monday	20-Nov	Graphic design layout generation and other extensions	
Thursday	23-Nov	No class (Thanksgiving)	
Monday	27-Nov	Neural rendering fields (NeRF) 1	
Thursday	30-Nov	Neural rendering fields (NeRF) 2	HW5: Neural rendering fields
Monday	4-Dec	Student project presentations	
Thursday	7-Dec	Student project presentations	
			Final project report