Carnegie Mellon University

Learning-based Image Synthesis 16-726

Mondays and Wednesdays 9:30-10:50 am (EST)

Semester: Spring**, Year:** 2023

Units: 12**, Section(s):** A

Instructor information

Name	Jun-Yan Zhu
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Office hours	Tuesday 11:00 am -12:00 pm (EST)

TA Information

TA name	Emily Kim
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Office hours	Wednesday 1:00-2:00 pm (EST)

TA name	Nikos Gkanatsios
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Office location	Office TBD and Zoom link (See Canvas)
Office hours	Thursday noon-1:00 pm (EST)

Course Description

- This course introduces machine learning methods for image and video synthesis. The objectives of synthesis research vary from modeling statistical distributions of visual data, through realistic picture-perfect recreations of the world in graphics, and all the way to providing interactive tools for artistic expression. Key machine learning algorithms will be presented, ranging from classical learning methods (e.g., nearest neighbor, PCA) to deep learning models (e.g., ConvNets, NeRF, deep generative models, including GANs, VAEs, autoregressive models, and diffusion models). Finally, we will discuss image and video forensics methods for

detecting synthetic content. Students will learn to build practical applications and create new visual effects using their own photos and videos.

Course Prerequisites

- This course requires familiarity with basic concepts of computer vision/graphics/image processing (16385 or 15462 or 15463 or 16720 or 18793). Some knowledge of machine learning (10301 or 10315 or 10601 or 10606 or 10607 or 10701) will also be helpful.

- If you would like to register the class but have not taken any of the above courses, please contact the instructor. We will handle your application on a case-by-case basis.

Learning Objectives

- The course aims to familiarize students with the fundamental concepts of machine learning algorithms with a focus on generative models.

- The course helps students understand state-of-the-art methods in image and video synthesis.

- Through the programming assignments and a final project, students have an opportunity to learn how to build practical systems and interactive tools for creating and editing visual content.

Learning Resources

- Resource will include lecture slides, webpages, code, videos, and paper reading list. Additional coding tutorials on PyTorch and ConvNets will be provided.

- There is no official textbook for this course. But you will find the following textbooks useful. They both free online versions.

  "Computer Vision: Algorithms and Applications", Richard Szeliski, 2010

  "Deep Learning", Ian Goodfellow, Yoshua Bengio, and Aaron Courville, 2016

Assessments

The final course grade will be calculated using the following categories:

Assessment	Percentage of Final Grade
Class presentation	10%
Programming assignments (5)	65%
Final project	25%

- For the course presentation (1-2 people per group), students will choose one paper from the suggested readings and present it to the entire class (feel free to reuse the slides available online but please credit it

accordingly). If other students have questions about the paper, the presenters need to answer questions in the Q & A session (live) and on Piazza (online).

- For the programming assignments, students will be allowed a total of five late days per semester; each additional late day will incur a 10% per 24 hours penalty. For each assignment, students need to build a website describing the results and submit the source code to Canvas. The code should be easy to run by TAs.

- For the final project (2-3 people per group), students are required to build a website describing the results and algorithm of the final project. A final project presentation is also needed.

Course Schedule (Tentative)

Date	Topics	Assignments Due
W 01/18	Introduction	
M 01/23	Pointwise Processing and Image Filtering	HW0 out
W 01/25	Image Warping and Retargeting	
M 01/30	Data-driven Graphics	HW1 out
W 02/01	Convolutional Network for Image Synthesis	
M 02/06	Generative Adversarial Networks (part I)	
W 02/08	Generative Adversarial Networks (part 2)	
M 02/13	Generative Models Zoo (Variational Autoencoder, Autoregressive Models)	
W 02/15	Generative Models Zoo (Diffusion Models, Normalizing Flows, etc.)	HW2 out, HW1 due
M 02/20	Generative Models (student presentation)	
W 02/22	Image-to-Image Translation and Conditional Generative Models (part I)	
M 02/27	Image-to-Image Translation and Conditional Generative Models (part II)	
W 03/01	Style and Content, Texture Synthesis	HW3 out, HW2 due
M 03/06	No class (spring break)	
W 03/08	No class (spring break)	
M 03/13	Text-to-Image Synthesis	

W 03/15	Conditional Image Synthesis (student presentation)	
M 03/20	Image Editing with Optimization (classic)	HW4 out, HW3 due
W 03/22	Image Editing with Optimization (deep learning)	
M 03/27	Image Editing with Optimization (Student presentation)	Project proposal due
W 03/29	Face Modeling (classic)	
M 04/03	Face Modeling (deep learning)	HW4 due HW5 out
W 04/05	Face Modeling (student presentation)	
M 04/10	3D-aware Synthesis (part 1)	
W 04/12	3D-aware Synthesis (part 2)	
M 04/17	3D and Video Synthesis (Student presentation)	HW5 due
W 04/19	Visual Forensics (Guest Lecture)	
M 04/24	Video Synthesis and Editing	
W 04/26	Final project presentation	Project Due (05/09)

Course Policies

- **Attendance & Participation**: we encourage you to attend the live sessions, if your time zone permits. If not, please watch the recorded videos (without student Q & A section) on Canvas. Please do not distribute videos outside this class.

- **Academic Integrity & Collaboration**: Students are encouraged to discuss the assignment with peers, but each student must write their own code and submit their own work. If your work benefits from another student's discussion or idea, please credit it on your website/README. You absolutely should not share or copy code. Additionally, you should not use any external code unless explicitly permitted. Plagiarism is strongly prohibited and will lead to failure of this course.

- **Late-work/Make-up work policy**: For the programming assignments, students will be allowed a total of 5 (five) late days per semester; each additional late day will incur a 10% penalty.

- **Accommodations for students with disabilities**: If you have a disability and require accommodations, please contact Catherine Getchell, Director of Disability Resources, 412-268-6121, getchell@cmu.edu. If you have an accommodations letter from the Disability Resources office, I encourage you to discuss your

accommodations and needs with me as early in the semester as possible. I will work with you to ensure that accommodations are provided as appropriate.

- **Statement on student wellness**: As a student, you may experience a range of challenges that can interfere with learning, such as strained relationships, increased anxiety, substance use, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may diminish your academic performance and/or reduce your ability to participate in daily activities. CMU services are available, and treatment does work. You can learn more about confidential mental health services available on campus at: http://www.cmu.edu/counseling/. Support is always available (24/7) from Counseling and Psychological Services: 412-268-2922.

- **Accommodating diversity**: It is my intent that students from all diverse backgrounds and perspectives be well served by this course, that students' learning needs be addressed both in and out of class, and that the diversity that students bring to this class be viewed as a resource, strength and benefit. It is my intent to present materials and activities that are respectful of diversity: gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture. Your suggestions are encouraged and appreciated. Please let me know ways to improve the effectiveness of the course for you personally or for other students or student groups. In addition, if any of our class meetings conflict with your religious events, please let me know so that we can make arrangements for you."