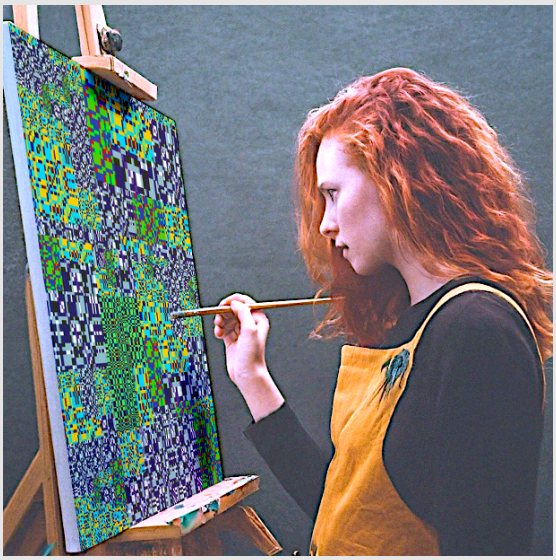
GEORGIA INSTITUTE OF TECHNOLOGY
CIVIL & ENVIRONMENTAL ENGINEERING
SCHOOL OF LITERATURE, MEDIA, AND COMMUNICATION

CEE4803/LMC4813 Art & Generative AI



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Course Description

This interdisciplinary course explores the intersection of AI technology, art, design, and neuroscience to create innovative synthetic, or generative media for artistic expression. Students will learn how to leverage AI algorithms, design principles, and neuroscience insights to generate new forms of visual and auditory art. Through hands-on projects that embrace both artistic materials and technology, they will explore the creative potential of AI, transcending traditional boundaries to produce dynamic and imaginative artwork. The course will be unique as it brings together faculty from engineering as well as humanities and arts.

We will delve into the fascinating intersection of artificial intelligence (AI), art, technology, design, and neuroscience to create new synthetic media to express ideas and feelings beyond traditional visual arts. An art medium is the tools or materials artists use to create their work, allowing them to visually express ideas and emotions through painting, sculpture, photography. Each medium has its unique qualities and allows artists to convey diverse expressions and emotions in their artwork. We will explore AI algorithms, design, and neuroscience principles to create generative, or synthetic art media to create visual or auditory elements, manipulating existing media, or even facilitating interactive experiences. To do so, we will delve in various aspects of design principles and their application in the arts, offering insights into how artists and designers use visual principles and elements to create compelling and impactful works of art. We will also explore various aspects of neuroscience relevant to design, composition, and the arts, offering insights into how the brain processes visual information, perceives space and color, and responds emotionally to artistic stimuli. We will utilize AI-generated media to explore innovative expressions, transcending traditional boundaries and embracing the creative potential of AI technology and produce artwork that is dynamic, unpredictable, and often highly imaginative.

Instructors

The class will be taught by Mark Leibert (IAC, LMC) and Francesco Fedele (CEE). Together these faculty members will introduce both artistic and engineering concepts and practices to model collaborative creative production and provide students with materials and discussion that will merge and represent the crossroads of multiple disciplines. The course will include guest speaker sessions from faculty from the GT school of Psychology to integrate neuroscience and perception into understandings of AI and creative expression. We will also have the support of Dr. Matthew Golden, researcher in the school of Physics, who will provide his expertise in artificial neural networks and AI.

Mark Leibert is a professor of the practice in the School of Literature, Media, and Communication. He has operated at the intersection of Art and Technology for 2 decades. He is an artist, academic, and industry professional. His research and teaching interests include contemporary art, painting, color theory, visual culture, web and graphic design, UX, and artist materials. Leibert co-founded the VIP course Art & AI in 2019. One of their research projects took first place in the Systems, People, and Environment category in the VIP innovation awards.

Much of his practice is a poetic engagement with algorithms and artificial intelligence. This digital practice is rooted in a deep understanding and practice in oil painting and photography. Leibert's

design and digital experience includes projects with the High Museum of Art, The Papers of George Washington, the Carter Center, Task Force for Global Health, and many others. His artwork, which includes painting, photography, and digital installations, is in private and corporate collections, including the High Museum of Art, Capital One, Ritz Carlton, among others. He is co-founder of Day and Night projects, an Atlanta artist-run gallery, and his work is represented by Sander Hudson Gallery. He has taught at James Madison University, Anderson Ranch Arts Center, SCAD, Georgia State University, and Georgia Tech.

Dr. Francesco Fedele is an associate professor in the School of Civil and Environmental Engineering. In 2016, following a serious injury, his path to recovery led him to self-taught art therapy through drawing and painting. Rediscovering Pablo Picasso's cubism during this transformative period inspired his early artworks. As art became an integral part of his life, he envisioned sharing this experience with his engineering students, aiming to create ways to integrate Arts into the GT curriculum and broaden students' perspective on science and engineering through the lens of an artist. He created the course "Arts and Geometry," which introduces engineering students to manifold geometry, exploring shapes from cylinders to crumpled paper. It delves into how these concepts influenced Picasso's cubism and Einstein's relativity, emphasizing a new way of seeing and thinking. In our fast-paced world with breakthroughs in AI, quantum computing, and understanding the universe, traditional engineering teaching based on the 17th century calculus of Newton and Leibniz often overlooks 20th-century mathematical tools by geniuses like Elie Cartan and Einstein. The course is integrated with weekly art labs taught over the years by Atlanta professional artists. The artists teach students the fundamentals of several art mediums: pencil and charcoal drawing, printmaking, oil painting and sculptures. Co-teaching with an artist at Georgia Tech exemplifies a model to integrate arts into STEM, fostering innovation at the crossroads of art, science, and technology. In 2021, together with Artist Rachel Grant, Dr. Fedele received ***the Class of 1934 CIOS Honor Roll Award*** course. In 2022, they also received the ***CEE Senior Faculty Teaching Award***. In 2024, Dr. Fedele received the ***CETL Curriculum Innovation Award***. The course is summarized in an article of the The Conversation: This engineering course has students use their brainwaves to create performing art.

GT highlights about the VIP course on Art and AI and the "Art and Geometry" course

exploring-art-and-ai-georgia-techs-school-literature-media-and-communication I

exploring-art-and-ai-georgia-techs-school-literature-media-and-communication II

visiting-artist-mark-leibert-experiments-generative-ai-imagery-painting-design-installation

this-engineering-course-has-students-use-their-brainwaves-to-create-performing-art

announcing-the-2024-ctl-faculty-teaching-award-winners

PREREQUISITES: This is an interdisciplinary course and we welcome students from different backgrounds. We don't require any prior experience in Arts. We also don't require any background in Python programming. Students will gain familiarity with using Python to learn AI concepts and make Art.

COURSE MATERIAL:

- Book: Deep Learning, MIT Press (https://www.deeplearningbook.org/)
- Design Basics, David Lauer & Stephen Pentak, Cengage Learning, 2011
- Various handouts and lecture notes
- Online articles, research papers, and case studies relevant to each topic.
- The Coding Train

SOFTWARE:

- Photoshop
- Illustrator
- Midjourney, Dall E, or Stable Diffusion
- Google Colab notebook
- Anaconda, Python, Jupyter notebook
- Processing, https://processing.org/

Course Objectives

- Understand the fundamentals of AI technologies and creating synthetic media using design principles.
- Explore the creative potential of AI algorithms for generating new media to create art, music, and narratives.
- Develop practical skills in using AI tools and platforms for artistic expression and media production.
- Critically analyze the societal impacts and ethical considerations of AI-driven media.

Learning Outcomes

By the end of the course, students will be able to:

- **Explaining AI Fundamentals:** Students should explain in their own words the fundamental concepts and principles of Artificial Neural Networks (ANNs) at a beginner level.

- **Exploring Arts using AI**: use design principles to generate creative expressions using AI technology.
- **Collaboration and Teamwork:** The capacity to collaborate effectively with interdisciplinary teams, as many real-world applications involve working with experts from various domains.

LECTURES & LABS

Learn AI by Doing

"You don't learn to paint, you paint to learn", *David Laffel (Artist and Professor Emeritus at the Art Students League of New York)*

This is an interdisciplinary course and we welcome students from different backgrounds. We don't require any prior experience in Arts. We also don't require any background in Python programming. Students will gain familiarity with using Python to learn AI concepts and make Art.

One of our objectives is to expose undergraduate students to the fundamentals of AI at a beginner level. Learning some fundamentals will give students more confidence in using the wide range of AI software available. Students will learn by doing, applying practical experience to grasp key concepts.

The primary programming language for AI is Python due to its numerous and efficient libraries. In this course, students will work with pre-made Python scripts, modifying them slightly to understand how different AI algorithms function. This course is not about learning how to code in Python from scratch, but rather about using/adapting existing Python scripts to explore simple AI concepts and their applications to Arts.

Week 1 Course intro Overview of the course objectives and structure. Historical context: art through the ages. Introduction to key AI concepts and techniques relevant to art. Art history: from the caveman to our times	**Lab 1 Skill Assessment, Introductory Exercises** Class introductions Art material review Exercise: Still life drawing Exercise: opposite hand Exercise: Upside-down line drawing Exercise: Continuous line drawing Introduction to photographing your artwork
Week 2 Elements & Principles of Design I Art history: from the caveman to our times Principles of Design: emphasis, balance, contrast, repetition, movement, unity Elements of Design: line, shape, form, value (brightness), color, texture Contrast and Gestalt in Shaping Visual Perception and Organization Assignment: shoe drawing, graphite gradient scales light on a shoe	**Lab 2 Elements & Principles of Design I** Black and white, grayscale: graphite, charcoal and ink Viewfinder Value and shading with graphite Introduction into Value, Shading and Chiaroscuro Exercise: Gradient scale with charcoal Introduction to shading techniques: hatching, cross hatching, stippling, and blending Exercise: 4 graphite gradient scales Light on a sphere

Week 3 Elements & Principles of Design II Harmony and Proportion in Achieving Visual Balance and Cohesion Negative Spaces in Composition and Visual Communication Visual Hierarchy to Guide Viewer Attention and Convey Information Effectively Symmetry and Asymmetry, Rhythm and Pattern Assignment: identify negative and positive spaces of real objects.	**Lab 3 Elements & Principles of Design II** Exercise: Contour Line Drawings Exercise: negative space drawing with charcoal Introduction into critique. Exercise: critique artist work Exercise: critique negative space exercise.
Week 4 Elements & Principles of Design III Creative Coding basics Examples of how to apply to traditional media and digital art. Assignment: use premade creative coding to create a digital artwork	**Lab 4 Elements & Principles of Design III** Coding creative projects using AI and machine learning libraries Exploring the Principle of Proximity using shape primitives in Processing. Use generative AI to expand on Theme & Variation implementation of creative coding.
Week 5 Fundamentals of Machine Learning and Artificial Neural Networks I Artificial Neural Networks as thermodynamic systems in equilibrium: the ISING Model Linear Perceptron: use premade Python codes to learn how AND and OR Boolean gates are modeled by a perceptron Assignment: use premade Python script to explore patterns generated by the 2D Ising model Adapt premade Python script to model a NAND Boolean gate using a perceptron	**Lab 5 Fundamentals of Arts, Traditional media I** Color theory: Hue, Saturation, and Value, color Wheel and Color Relationships and harmony Oil painting: Introduction to Materials, Surfaces, and Basic Techniques Exploring Color Mixing: Understanding Color Theory and Mixing Techniques in Oil Painting Composition and Expression: Create Dynamic and Expressive Artworks using oil painting

Week 6 Fundamentals of Machine Learning and Artificial Neural Networks II Quadratic Perceptron: run premade Python code to explore how XOR Boolean gate is implemented The Hopfield Network, Hebbian rule, associative memory The Hopfield Network is an Ising model at zero temperature. Assignment: use/adapt premade Python script to explore how a quadratic perceptron and a Hopfield network work	**Lab 6 Fundamentals of Arts, Traditional media II** Exercise: Color wheel, shades, and tints, compliments, and mark making Exercise: Add Shades and tints to a gesture drawing
Week 7 Fundamentals of Machine Learning and Artificial Neural Networks III Cybenko theorem ANN architecture, Deep learning, Gradient descent for training of an ANN back-propagation Assignment: use/adapt premade Python script to model a Single-Layer Neural Network for Dog-Cat Image Classification	**Lab 7 Fundamentals of Arts, Traditional media III** Grid and self-portrait (Student Choice: Regular grided portrait or distorted grid portrait realistic or symbolic) Exercise: Self-Portrait using the grid method and acrylic
Week 8 Fundamentals of Machine Learning and Artificial Neural Networks IV Nesterov-type algorithms for training Assignment: use/adapt premade Python script of a deep neural network for a low-dimensional representation of images	**Lab 8 Analog and Digital Sculpting I** 3D sculpture and printing for AI art visit makerspace and applications
Week 9 Fundamentals of Generative AI I Restricted Boltzmann machine (RBM) Assignment: use a premade Python script to learn how a RBM works	**Lab 9 Analog and Digital Sculpting II** 3D sculpture and printing for AI art visit makerspace and applications
Week 10 Fundamentals of Generative AI II Restricted Boltzmann machine (RBM)	**Lab 10 Student Project I** Students work on their final AI project

Assignment: adapt a premade Python script to make an RBM to learn a set of images.	
Week 11 Fundamentals of Generative AI III Generative Adversarial Networks (GANs) Normalizing flow generative AI with real-valued non-volume preserving (real NVP) transformations ANN architectures and training Assignment: use premade Python script to learn how a real NVP works	**Lab 11 Student Project II** Students work on their final AI project
Week 12 Fundamentals of Generative AI IV Normalizing flow generative AI with real-valued non-volume preserving (real NVP) transformations Assignment: use premade Python script to make a real NVP to learn MINST dataset	**Lab 12 Student Project III** Students work on their final AI project
Week 13 Fundamentals of Generative AI V Normalizing flow generative AI with real-valued non-volume preserving (real NVP) transformations Assignment: use premade Python script to make a real NVP to learn a set of art images	**Lab 13 Student Project IV** Students work on their final AI project
Week 14 Art show preparation Choosing and finalizing AI projects and Artwork for final show	**Lab 14 Student Project V** Students work on their final AI project
Week 15 Art show preparation Choosing and finalizing AI projects and Artwork for final show	**Lab 15 Student Project VI** Students finalize their final AI project for final art show on their final AI project

Studio Labs

In the weekly studio labs students will explore several art mediums and the use of Generative AI, including generative adversarial networks (GANs) and other AI algorithms to create original artworks. They will experiment with training models on large datasets of images to generate new visual compositions. **A Collection of VIP AI Art projects is available online [click here]**

Possible topics:

- **Sketching, iteration and creative process**: students will engage with traditional media such as i) drawing with Pencil, Charcoal, Ink and brush and ii) Painting with watercolor, acrylic paint, Airbrush, Spray paint, Stencil, Transfers (Cyanotype, sun prints, Linoleum)
- **Generative Art Media:** Students will explore the use of Generative Adversarial Networks (GANs) to create diverse forms of artwork, including paintings, sketches, and digital compositions. They will learn how to train GAN models, manipulate latent space, and generate original artwork using AI techniques.
- **Neural Style Transfer:** Students will experiment with neural style transfer algorithms to apply the style of famous artworks or artistic movements to their own photographs or digital images. They will explore different style transfer techniques and create visually striking compositions using AI-powered image manipulation.
- **AI-Enhanced Photography:** Students will explore AI-powered tools and techniques for enhancing digital photographs. Projects may include image denoising, super-resolution, content-aware image editing, and automatic image tagging using convolutional neural networks (CNNs) and other AI algorithms.
- **Creative Chatbots, Narrative Generation and AI Storytelling:** Students will design and develop conversational agents or chatbots that engage users in creative interactions, such as storytelling, poetry generation, or collaborative art creation. They will explore natural language processing (NLP) techniques and design principles for building AI-powered conversational interfaces
- **AI for Sound Design using Brain waves via EEG Technologies: students will explore** Brain-Computer Interfaces for Interactive and Generative AI algorithms for sound synthesis using brainwaves via EEG Technologies
- **Data Visualization and Art:** Students will explore the intersection of data visualization and artistic expression, using AI techniques to create visually compelling representations of complex datasets. Projects may include interactive data visualizations, generative art based on data patterns, or AI-driven data sonification experiments.
- **Interactive Art Installations:** Students will design and develop interactive art installations that utilize computer vision and machine learning algorithms. Projects may include interactive sculptures, augmented reality experiences, or responsive environments that react to audience input.

Grading

Homework	**30%**
Final Project	**65%**
In-Class attendance	**5%**

Course Grading Scale

$$90 < A \leq 100$$
$$80 < B \leq 90$$
$$70 < C \leq 80$$
$$60 < D \leq 70$$
$$F \leq 60$$

Mental Health and Well-Being

We will practice 5-min meditation at the beginning of class. Introducing meditation in the classroom can positively impact students' well-being by promoting relaxation, focus, and emotional regulation. It can help reduce stress and improve concentration, leading to a more conducive learning environment.

Course Policy

- In-Class attendance: if you miss less than 4 classes you will receive 5% toward your grade. Signatures will be collected in class.
- Plagiarizing is defined by Webster's Dictionary as "to steal and pass off (the ideas or words of another) as one's own: use (another's production) without crediting the source." If caught plagiarizing, you will be dealt with according to the GT Academic Honor Code.
- Cheating by using someone else's work is a direct violation of the GT Academic Honor Code and will be addressed appropriately. For any questions involving these or any other Academic Honor Code issues, please consult the instructor o*r* www.honor.gatech.edu.
- Please review Student-Faculty Expectations at https://catalog.gatech.edu/rules/21/
- Homework: We expect to receive your submissions posted in Canvas by the due time. Canvas automatically assigns a **zero grade** to a late submission.
- You may work with other classmates to solve/prepare homework and lab assignments. However, you must turn in separate versions with the following written on it: your name and the names of everyone you collaborated with.
- Unauthorized use of any previous semester course materials, such as tests, quizzes, homework, projects, and any other coursework, other than that provided by the instructor, is prohibited in this course. Using these materials will be considered a direct violation of academic policy and will be dealt with according to the GT Academic Honor Code. For any questions involving these or any other Academic Honor Code issues, please consult the instructor or www.honor.gatech.edu.
- **Office Hours**: weekly office hours on Fridays after the labs.
- **Recordings of Class Sessions and Required Permissions:** classes may not be recorded by students without the express consent of the instructor unless it is pursuant to an accommodation granted by the Office of Disability services. Class recordings, lectures, presentations, and other materials posted on Canvas or Piazza are for the sole purpose of educating the students currently enrolled in the course. Students may not record or share the materials or recordings, including screen capturing or automated bots, unless the instructor gives permission.

Policy on Labs, Homework and Final Project

- The weekly lab sessions will focus on the practical application of AI Technologies to create art
- Homework will be assigned to assess students' comprehension of the theoretical concepts and how to apply them to solve engineering problems. Premade Python codes will be used by students to learn-by-doing AI fundamentals at a beginner level.
- Students have the flexibility to select their final project aligned with their personal research interests. They will utilize any of the machine learning techniques covered during the course. Subsequently, students will be responsible for creating and submitting a final report, which could potentially serve as a draft for a thesis chapter or as a submission to a scientific journal or conference proceedings.

AI Use Policy for Art Creation

- Our expectation is to use AI to create, generate, and iterate prompts to produce novel and expressive artifacts. Any artwork produced with AI should include detailed documentation of the process involved, including how AI was used. For example:

  "*We used Python within Google Colab to generate our script. Our image database was stored in Google Drive and linked to our Colab file. The images' mediums are paintings and photography. We used the TensorFlow Keras library for applying Convolutional Neural Networking and deep learning. We have also used the Numpy Library for graphing and presentation purposes*"

- Be thoughtful when using AI. Every time you generate an image, write an email, or ask a chatbot a question, it has an environmental cost. Generating an image with AI can use as much energy as fully charging a smartphone (Heikkilä, 2023). Therefore, plan carefully when designing AI prompts to avoid unnecessary iterations and help reduce carbon emissions.

References

Heikkilä, Melissa (2023) Making an image with generative AI uses as much energy as charging your phone, *MIT Technology Review*

OFFICE OF DISABILITY SERVICES

The Georgia Institute of Technology has policies regarding disability accommodation, which are administered through The Office of Disability Services (http://disabilityservices.gatech.edu/). For students with disabilities, please contact this Office to request classroom accommodations.

Communication Protocol

- In addition to the weekly Office Hours, questions regarding lectures/homework will be addressed through the venue of PIAZZA (www.piazza.com).
- Students are strongly encouraged to participate in discussions in PIAZZA so they can learn from their peers.
- SUBJECT line in email: SUBJECT: CEEXXXX- Meaningful Tag Line. Family name