

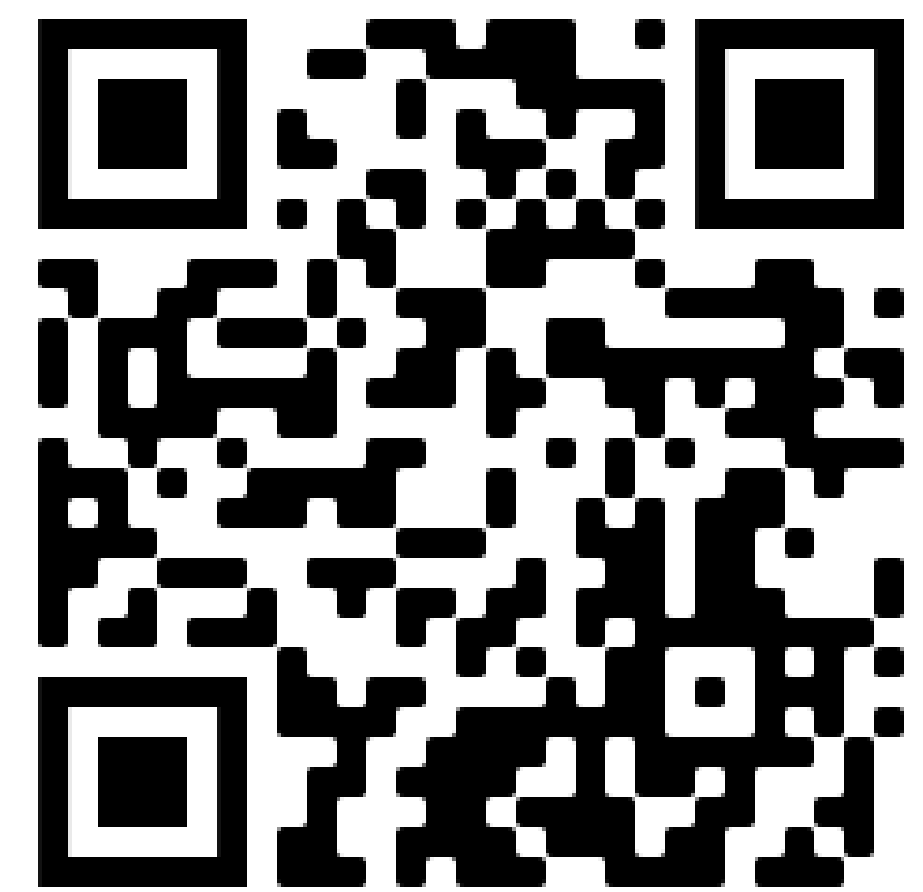
Generative AI Innovative Applications

NVIDIA Generative AI with Diffusion Models Part I

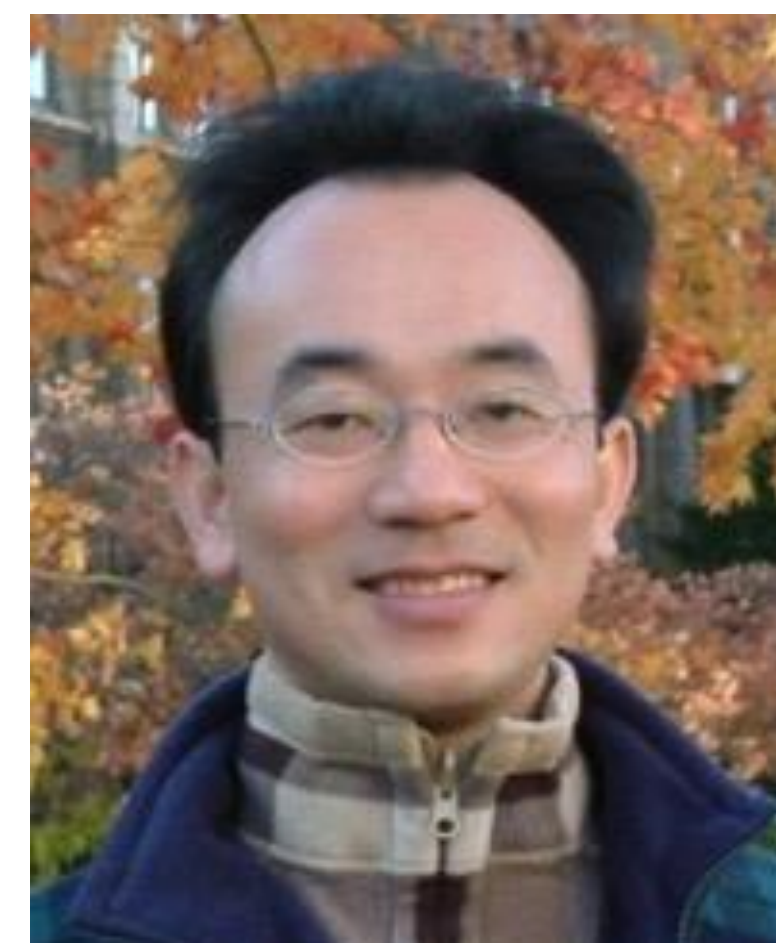
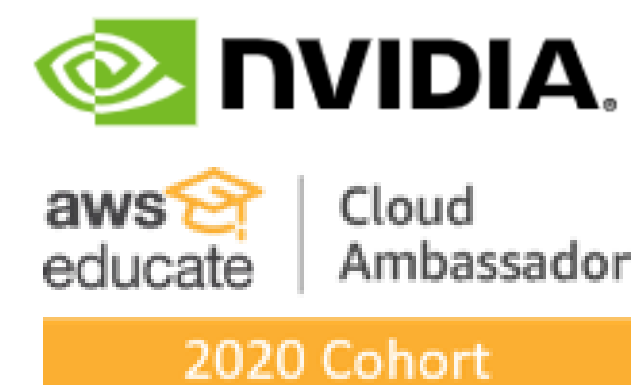
1132GAIIA07

MBA, IM, NTPU (M6031) (Spring 2025)

Tue 2, 3, 4 (9:10-12:00) (B3F17)



<https://meet.google.com/pai-zhj-mya>



Min-Yuh Day, Ph.D.,
Professor

Institute of Information Management, National Taipei University

<https://web.ntpu.edu.tw/~myday>

2025-04-22



Syllabus

Week	Date	Subject/Topics
1	2025/02/18	Introduction to Generative AI Innovative Applications
2	2025/02/25	Transformers for Natural Language Processing and Computer Vision
3	2025/03/04	Large Language Models (LLMs), NVIDIA Building RAG Agents with LLMs Part I
4	2025/03/11	Case Study on Generative AI Innovative Applications I
5	2025/03/18	NVIDIA Building RAG Agents with LLMs Part II
6	2025/03/25	NVIDIA Building RAG Agents with LLMs Part III

Syllabus

Week Date Subject/Topics

7 2025/04/01 Self-Learning

8 2025/04/08 Midterm Project Report

9 2025/04/15 Generative AI for Multimodal Information Generation

10 2025/04/22 NVIDIA Generative AI with Diffusion Models Part I

11 2025/04/29 NVIDIA Generative AI with Diffusion Models Part II

12 2025/05/06 Case Study on Generative AI Innovative Applications II

Syllabus

Week Date Subject/Topics

**13 2025/05/13 NVIDIA DLI and NVIDIA-Certified Associate (NCA)
Generative AI LLMs Certification [Invited Talk]**

**14 2025/05/20 NVIDIA Generative AI with Diffusion Models Part III
AI Agents and Large Multimodal Agents (LMAs)**

15 2025/05/27 Final Project Report I

16 2025/06/03 Final Project Report II

NVIDIA

**Generative AI with
Diffusion Models**

Part I

[0,1,2] [3, 4] [5, 6]

Generative AI with Diffusion Models

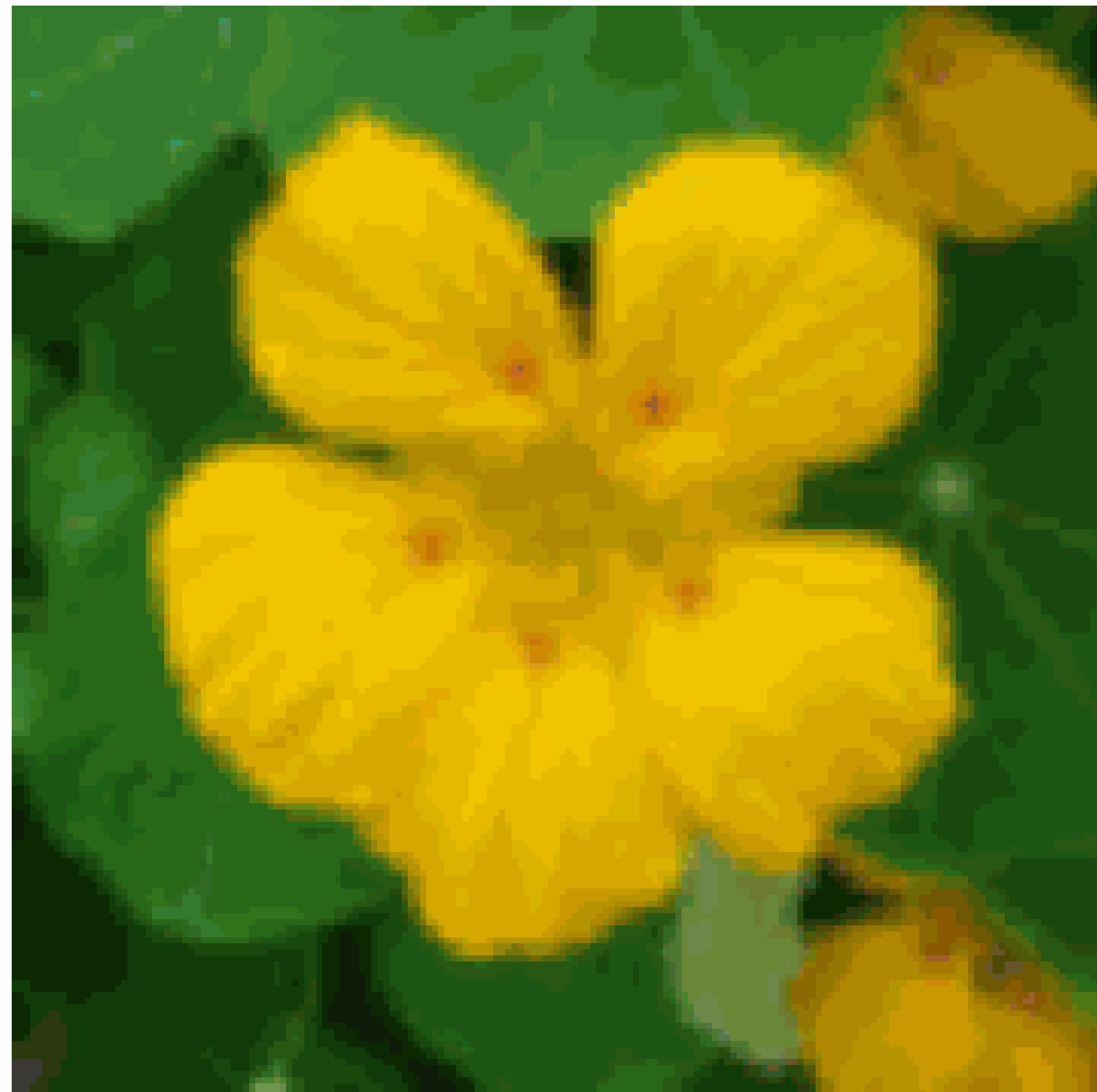
- **Part 1: From U-Nets to Diffusion**
- **Part 2: Denoising Diffusion Probabilistic Models**
- **Part 3: Optimizations**
- **Part 4: Classifier-Free Diffusion Guidance (CFG)**
- **Part 5: CLIP (Contrastive Language-Image Pre-Training)**
- **Part 6: Wrap-up & Assessment**

Diffusion Models

diffusion models are trained to denoise noisy images,
and can generate images by iteratively denoising pure noise.

Forward diffusion

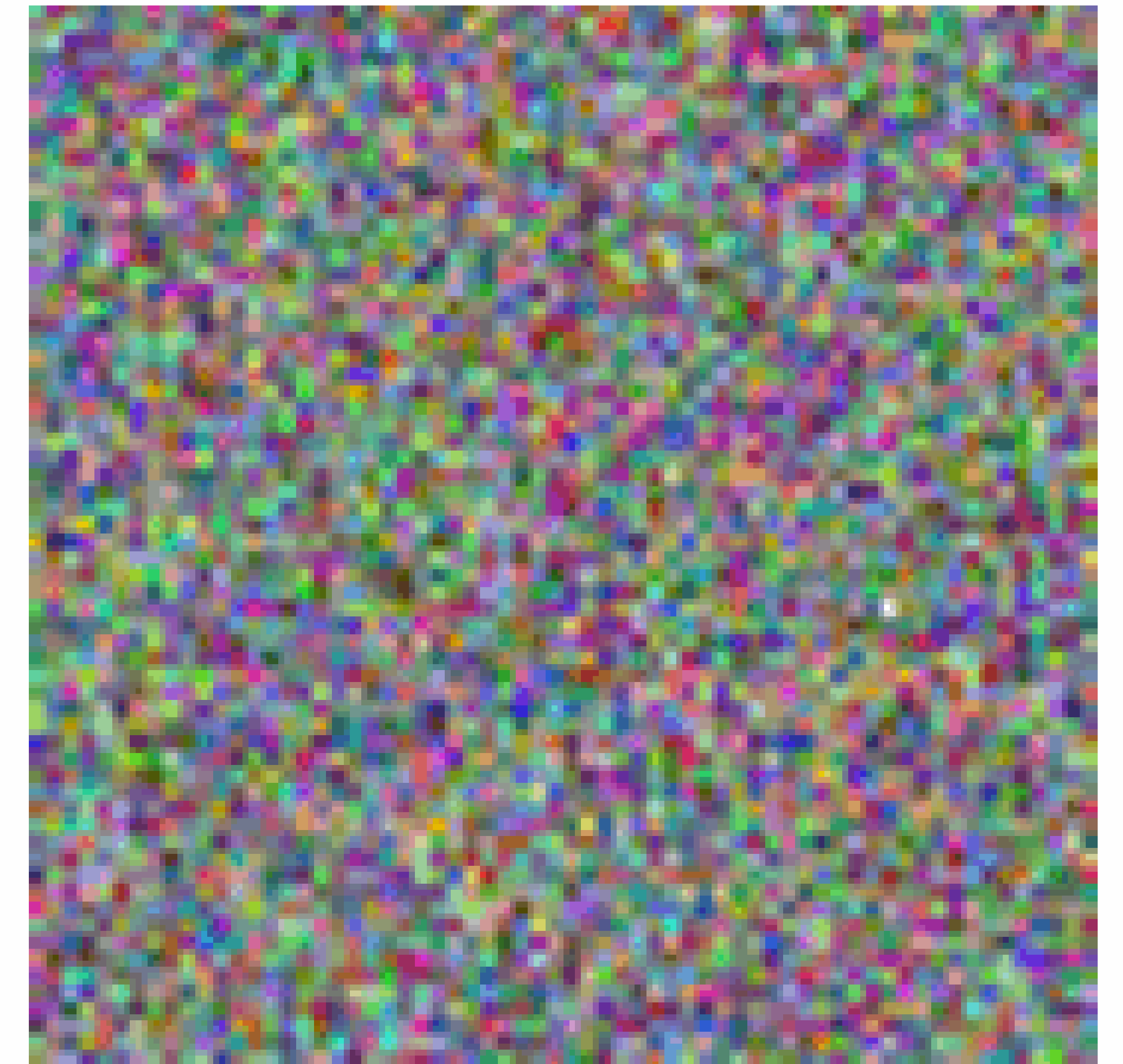
image



noisy image



noise



Source: <https://keras.io/examples/generative/ddim/>

build.nvidia.com Models: Image Generation

Models

Deploy and scale models on your GPU infrastructure of choice with NVIDIA NIM inference microservices

Filter by text | Sort By: Most Recent | Publisher | Use Case (1) | NIM Type

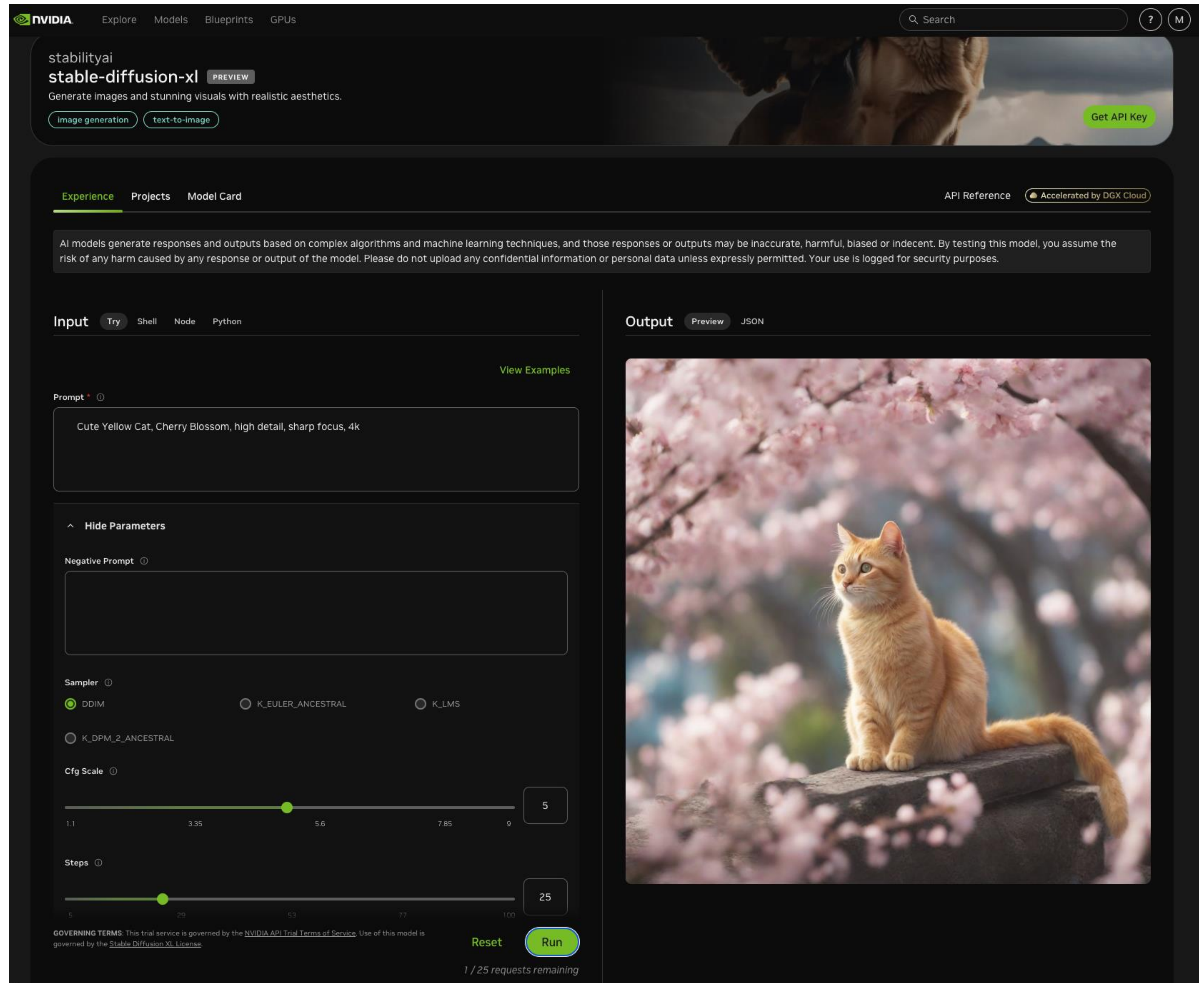
Use Case: Image Generation | Clear Filters

- black-forest-labs FLUX.1-dev**
FLUX.1 is a state-of-the-art suite of image generation...
image generation +3
- nvidia consistency**
Generates consistent characters across a series o...
image generation +2
- briaai BRIA-2.3**
An enterprise-grade text-to-image model trained on a...
image generation +2
- stabilityai stable-diffusion-3-...**
Advanced text-to-image model for generating high...
image generation +2
- nvidia visual-changenet**
Visual Changenet detects pixel-level change maps...
image +9
- stabilityai stable-diffusion-xl**
Generate images and stunning visuals with...
image generation +2
- stabilityai stable-video-diffusi...**
Stable Video Diffusion (SVD) is a generative diffusion...
image generation +2
- stabilityai sdxl-turbo**
A fast generative text-to-image model that can...
image generation +2

https://build.nvidia.com/models?filters=usecase%3Ausecase_image_gen

Input Prompt

Cute Yellow Cat, Cherry Blossom, high detail, sharp focus, 4k



Spring 2025

**Generative AI
Innovative Applications**



University Ambassador

This certificate acknowledges that

Min-Yuh Day

has been certified to deliver NVIDIA instructor-led workshop for
academia

A handwritten signature in black ink, appearing to read "Greg Estes", written over a horizontal line.

Greg Estes

Vice President, NVIDIA

Issue Date: : March 7, 2025

Ambassador Certification ID: cCFh1ZWWTvqKTq7dcKkEWw

<https://learn.nvidia.com/certificates?id=cCFh1ZWWTvqKTq7dcKkEWw>



Certified Instructor



This certificate acknowledges that

Min-Yuh Day

has been certified to deliver the instructor-led workshop

Building RAG Agents with LLMs

A handwritten signature in black ink, appearing to read "Greg Estes".

Greg Estes

Vice President, NVIDIA

Issue Date: : March 7, 2025

Certification ID: OVmqY4cSSya0BdMQBWHxzw

<https://learn.nvidia.com/certificates?id=OVmqY4cSSya0BdMQBWHxzw>

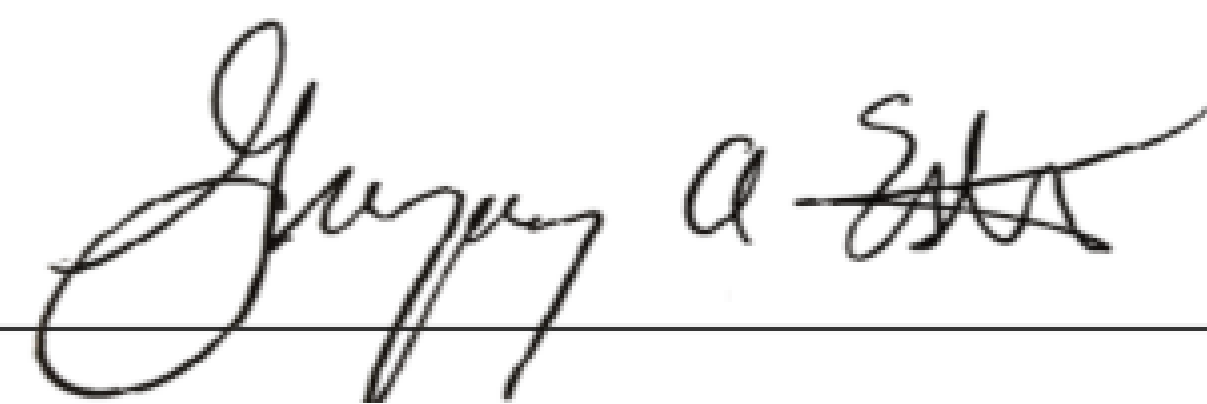
Certificate of Completion

This certificate is awarded to

Min-Yuh Day

for successfully completing

Building RAG Agents with LLMs



Greg Estes

Vice President, NVIDIA

Issue Date: : December 8, 2024

Certification ID: ed-qOCIMQatzU8SNUNxgw |

https://learn.nvidia.com/certificates?id=ed-qOCIMQatzU8SNUNxgw/courses/course?course_id=course-v1:DLI+S-FX-15+V1

<https://learn.nvidia.com/certificates?id=ed-qOCIMQatzU8SNUNxgw>

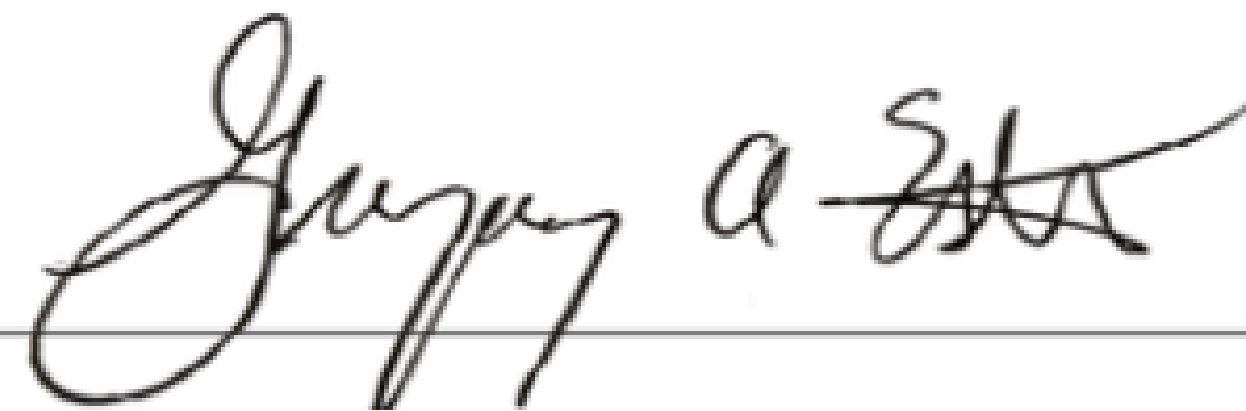
Certificate of Competency

This certificate is awarded to

Min-Yuh Day

for demonstrating competence in the completion of

Generative AI with Diffusion Models



Greg Estes

Vice President, NVIDIA

Issue Date: : February 28, 2025

Certification ID: q3oo-oBhTQKtyCCote2E-Q

NVIDIA Certified Instructors (12 from Taiwan)

The screenshot shows the NVIDIA Deep Learning Institute website's instructor directory search results. The page is titled "Deep Learning Institute" and features a navigation bar with options like "Find Training", "Self Paced Courses", "Instructor-Led Workshops", and "Educator Programs". A search bar at the top right contains the text "Search for instructors by name. Minimum". Below the search bar, there are filter options for "Workshop Certification", "Location [1]", "Organization", and "Specialization", along with a "Reset filters" button. The results are sorted by "Name A-Z".

Name	Organization	Featured Workshop
Chi-Hung Chuang	Chung Yuan Christian University	Fundamentals of Deep Learning, Taiwanese
Chia Yu Hsu	National Taiwan University of Science and Technology (NTUST)	Applications of AI for Predictive Maintenance, Taiwanese
Chien-Yu Chen	National Taiwan University (NTU)	Fundamentals of Deep Learning, Taiwanese
Chun-Yi Lee	National Taiwan University (NTU)	Fundamentals of Deep Learning, Taiwanese
David Tseng	Cavedu	Getting Started with AI on Jetson Nano, Taiwanese
Hsinmin Lu	National Taiwan University (NTU)	Fundamentals of Deep Learning, English
Min-Yuh Day	National Taipei University (NTPU)	Building RAG Agents with LLMs, English
Ming-Che Chen	Southern Taiwan University of Science and Technology (STUST)	Getting Started with AI on Jetson Nano, Taiwanese
MingChe Hu	Chung Yuan Christian University	Fundamentals of Deep Learning, Taiwanese
Ping-Chun Hsieh	National Yang Ming Chiao Tung University (NYCU)	Fundamentals of Deep Learning, English
Po-Chih Kuo	National Tsing Hua University (NTHU)	Fundamentals of Deep Learning, English
Shu-Kai Hsieh	National Taiwan University (NTU)	Fundamentals of Deep Learning, Taiwanese

NVIDIA Certified Instructors (14 from Taiwan) (2 from NTPU)(April 2025)

The screenshot shows a search results page for NVIDIA Certified Instructors. The filters are set to 'Workshop Certification', 'Location [1]', 'Organization', and 'Specialization'. The results are sorted by 'Name A-Z'. There are 14 instructor profiles listed, each with a photo, name, university affiliation, and featured workshop. Two profiles, Ko-Chia Yu and Min-Yuh Day, are highlighted with a red border.

Name	Organization	Featured Workshop
Chi-Hung Chuang	Chung Yuan Christian University	Fundamentals of Deep Learning, Taiwanese
Chia Yu Hsu	National Taiwan University of Science and Technology (NTUST)	Applications of AI for Predictive Maintenance, Taiwanese
Chien-Yu Chen	National Taiwan University (NTU)	Fundamentals of Deep Learning, Taiwanese
Chun-Yi Lee	National Taiwan University (NTU)	Platinum instructor Fundamentals of Deep Learning, Taiwanese
David Tseng	Cavedu	Platinum instructor Building Transformer-Based Natural Language Processing Applications, Taiwanese
Hsinmin Lu	National Taiwan University (NTU)	Fundamentals of Deep Learning, English
Hung-Wen Chen	National Tsing Hua University (NTHU)	Fundamentals of Deep Learning, Taiwanese
Ko-Chia Yu	National Taipei University (NTPU)	Building RAG Agents with LLMs, English
Min-Yuh Day	National Taipei University (NTPU)	Building RAG Agents with LLMs, English
Ming-Che Chen	Southern Taiwan University of Science and Technology (STUST)	Getting Started with AI on Jetson Nano, Taiwanese
MingChe Hu	Chung Yuan Christian University	Fundamentals of Deep Learning, Taiwanese
Ping-Chun Hsieh	National Yang Ming Chiao Tung University (NYCU)	Fundamentals of Deep Learning, English
Po-Chih Kuo	National Tsing Hua University (NTHU)	Fundamentals of Deep Learning, English
Shu-Kai Hsieh	National Taiwan University (NTU)	Fundamentals of Deep Learning, Taiwanese

NVIDIA Developer Program

<https://developer.nvidia.com/join-nvidia-developer-program>

NVIDIA

Deep Learning Institute (DLI)

<https://learn.nvidia.com/>

Get NVIDIA DLI Certificate

- **Step 1. Join NVIDIA Developer Program (Free)**
<https://developer.nvidia.com/join-nvidia-developer-program>
- **Step 2. Visit NVIDIA Deep Learning Institute (DLI)**
<https://learn.nvidia.com/>
- **Step 3. Enroll "Generative AI with Diffusion Models"**
Self-Paced Course (\$90)
https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S-FX-14+V1

Join the NVIDIA Developer Program

take one of the
complimentary
technical self-
paced courses
(worth up to \$90)

Generative AI and LLMs

Graphics and Simulation

Accelerated Computing

Data Science

Deep Learning

8 hours

Getting Started With Deep Learning

Explore the fundamentals of deep learning by training neural networks and using results to improve performance and capabilities.

2 hours

Modeling Time-Series Data With Recurrent Neural Networks in Keras

Explore how to classify and forecast time-series data using recurrent neural networks (RNNs), such as modeling a patient's health over time.

4 hours

Deploying a Model for Inference at Production Scale

Learn how to deploy your own machine learning models on a GPU server.

8 hours

Building Real-Time Video AI Applications

Gain the knowledge and skills needed to enable the real-time transformation of raw video data from widely deployed camera sensors into deep learning-based insights.

2 hours

Introduction to Graph Neural Networks

Learn the basic concepts, models, and applications of graph neural networks.

4 hours

Introduction to Physics-Informed Machine Learning With Modulus

Learn the various building blocks of NVIDIA Modulus, which turbocharges use cases by building physics-based deep learning models that are 100,000X faster than traditional methods and offers high-fidelity simulation results.

2 hours

Get Started With Highly Accurate Custom ASR for Speech AI

Learn to build, train, fine-tune, and deploy a GPU-accelerated automatic speech recognition (ASR) service with NVIDIA® Riva that includes customized features.

2 hours

Integrating Sensors With NVIDIA DRIVE

Find out how to integrate automotive sensors into your applications using NVIDIA DRIVE®.

<https://developer.nvidia.com/join-nvidia-developer-program>

NVIDIA Deep Learning Institute (DLI)

Self-Paced Course

Generative AI Explained

Free
2 hours

Self-Paced Course

Getting Started With Deep Learning

Certificate available
\$90
8 hours

Instructor-Led Workshop

Fundamentals of Deep Learning

Certificate available
\$500
8 hours

Self-Paced Course

Introduction to Transformer-Based Natural Language Processing

Certificate available
\$30
6 hours

Self-Paced Course

Building RAG Agents With LLMs

Certificate available
Free
8 hours

Instructor-Led Workshop

Building RAG Agents With LLMs

Certificate available
\$500
8 hours

Self-Paced Course

Generative AI with Diffusion Models

Certificate available
\$90
8 hours

Instructor-Led Workshop

Generative AI with Diffusion Models

Certificate available
\$500
8 hours

What do you want to learn today?

Filters

Level +

Format +

Topics -

- Deep Learning
- Accelerated Computing
- Generative AI/LLM
- Graphics and Simulation
- OpenUSD
- Data Science
- NIMS
- NIM
- RAPIDS

Free / Paid +

Language +

Generative AI



Sort by: --

Showing 19 results

Generative AI x

Generative AI

All Courses

Self-paced

Generative AI Explained

Free
02:00

Self-paced

Generative AI with Diffusion Models

\$90
08:00

Instructor-Led

Generative AI with Diffusion Models

08:00

Self-paced

Augment your LLM Using

Self-paced

Introduction to Transformer-

Instructor-Led

Rapid Application

Generative AI with Diffusion Models

Self-paced Course

Generative AI with Diffusion Models

Take a deeper dive into denoising diffusion models, which are a popular choice for text-to-image pipelines, with applications in creative content generation, data augmentation, simulation and planning, anomaly detection, drug discovery, personalized recommendations, and more.



About Course Objectives Topics Covered Course Outline Stay Informed Contact Us

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About this Course

Thanks to improvements in computing power and scientific theory, generative AI is more accessible than ever before. Generative AI plays a significant role across industries due to its numerous applications, such as creative content generation, data augmentation, simulation and planning, anomaly detection, drug discovery, personalized recommendations, and more. In this course, learners will take a deeper dive into denoising diffusion models, which are a popular choice for text-to-image pipelines.

Learning Objectives

Course Details

Duration: 08:00

Price: \$90

Subject: Generative AI/LLM

Language: English

Course Prerequisites:

A basic understanding of [Deep Learning Concepts](#).

https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S-FX-14+V1

Building RAG Agents with LLMs

Self-paced Course

Building RAG Agents with LLMs

Agents powered by large language models (LLMs) have shown great retrieval capability for using tools, looking at documents, and plan their approaches. This course will show you how to deploy an agent system in practice with the flexibility to scale up your system to meet the demands of users and customers.



[About Course](#) [Objectives](#) [Topics Covered](#) [Course Outline](#) [Stay Informed](#) [Contact Us](#)

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About this Course

This course is free for a limited time.

The evolution and adoption of large language models (LLMs) have been nothing short of revolutionary, with retrieval-based systems at the forefront of this technological leap. These models are not just tools for automation; they are partners in enhancing productivity, capable of holding informed conversations by interacting with a vast array of tools and documents. This course is designed for those eager to explore the potential of these systems, focusing on practical deployment and the efficient implementation required to manage the considerable demands of both users and deep learning models. As we delve into the intricacies of LLMs, participants will gain insights into advanced orchestration techniques that include internal reasoning, dialog management, and effective tooling strategies.

Course Details

Duration: 08:00

Price: Free

Level: Technical - Intermediate

Subject: Generative AI/LLM

Language: English

Course Prerequisites:

Introductory deep learning knowledge, with comfort

https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S-FX-15+V1

Generative AI Explained

Self-paced Course

Generative AI Explained

In this no-coding course, learn Generative AI concepts and applications, as well as the challenges and opportunities in this exciting field.



[About Course](#) [Objectives](#) [Topics Covered](#) [Course Outline](#) [Stay Informed](#) [Contact Us](#)

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About this Course

Generative AI describes technologies that are used to generate new content based on a variety of inputs. In recent time, Generative AI involves the use of neural networks to identify patterns and structures within existing data to generate new content. In this course, you will learn Generative AI concepts, applications, as well as the challenges and opportunities in this exciting field.

Learning Objectives

Upon completion, you will have a basic understanding of Generative AI and be able to more effectively use the various tools built on this

https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S-FX-15+V1

Course Details

Duration: 02:00

Price: Free

Level: Technical - Beginner

Subject: Generative AI/LLM

Language: English

Introduction to Transformer-Based Natural Language Processing

Self-paced Course

Introduction to Transformer-Based Natural Language Processing

Learn how Transformers are used as the building blocks of modern large language models (LLMs). You'll then use these models for various NLP tasks, including text classification, named-entity recognition (NER), author attribution, and question answering.



[About Course](#) [Objectives](#) [Topics Covered](#) [Course Outline](#) [Stay Informed](#) [Contact Us](#)

[Continue Learning](#)

About this Course

Large Language Models (LLMs), or Transformers, have revolutionized the field of natural language processing (NLP). Driven by recent advancements, applications of NLP and generative AI have exploded in the past decade. With the proliferation of applications like chatbots and intelligent virtual assistants, organizations are infusing their businesses with more interactive human-machine experiences. Understanding how Transformer-based large language models (LLMs) can be used to manipulate, analyze, and generate text-based data is essential. Modern pre-trained LLMs can encapsulate the nuance, context, and sophistication of language, just as humans do. When fine-tuned and deployed correctly, developers can use these LLMs to build powerful NLP applications that provide natural and seamless human-computer interactions within chatbots, AI voice agents, and more. In this course, you'll learn how Transformers are used as the building blocks of modern large language models (LLMs). You'll then use these models for various NLP

Course Details

Duration: 06:00

Price: \$30

Level: Technical - Beginner

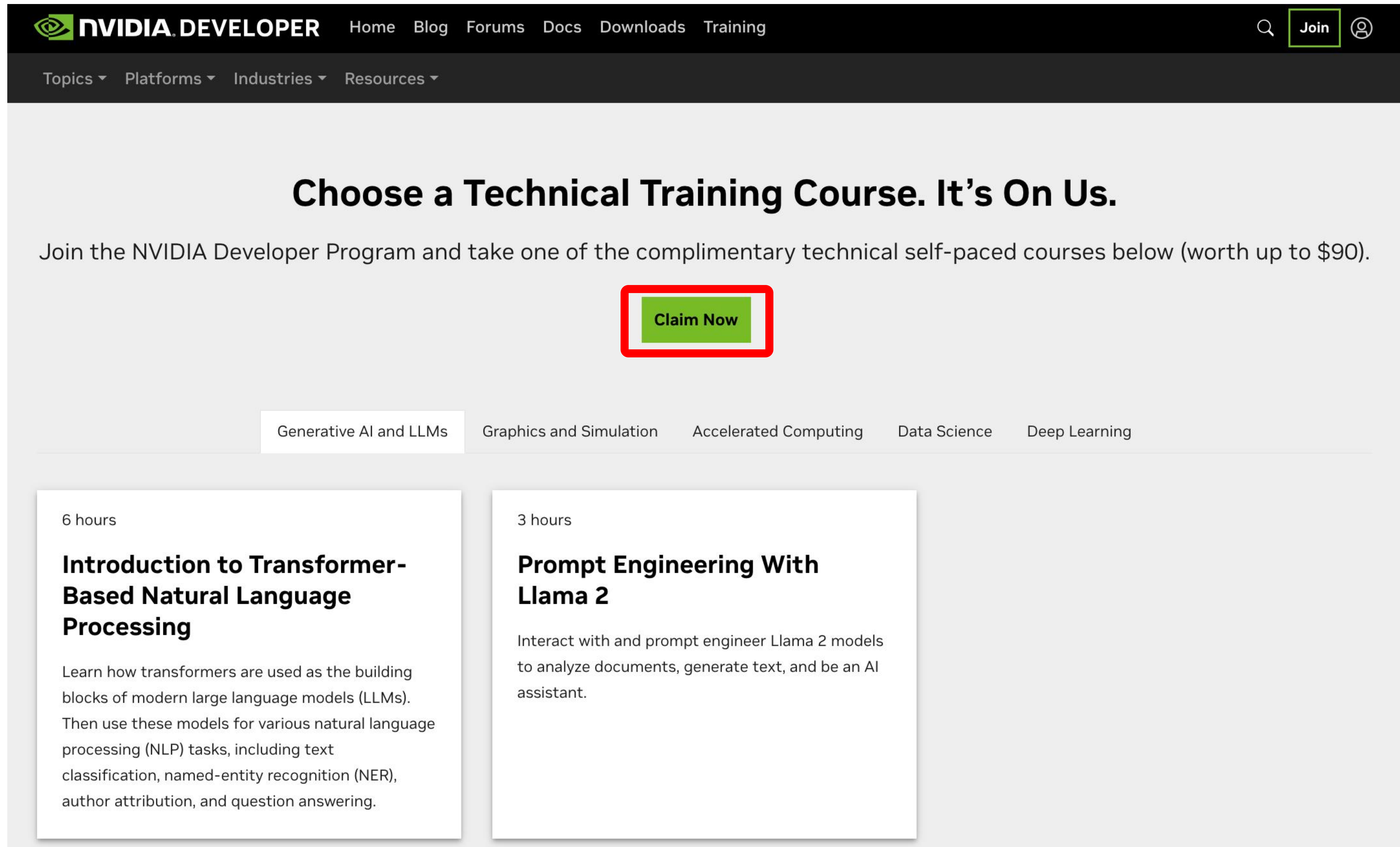
Subject: Generative AI/LLM

Language: English

https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S-FX-08+V1

Join the NVIDIA Developer Program

take one of the complimentary technical self-paced courses (worth up to \$90)

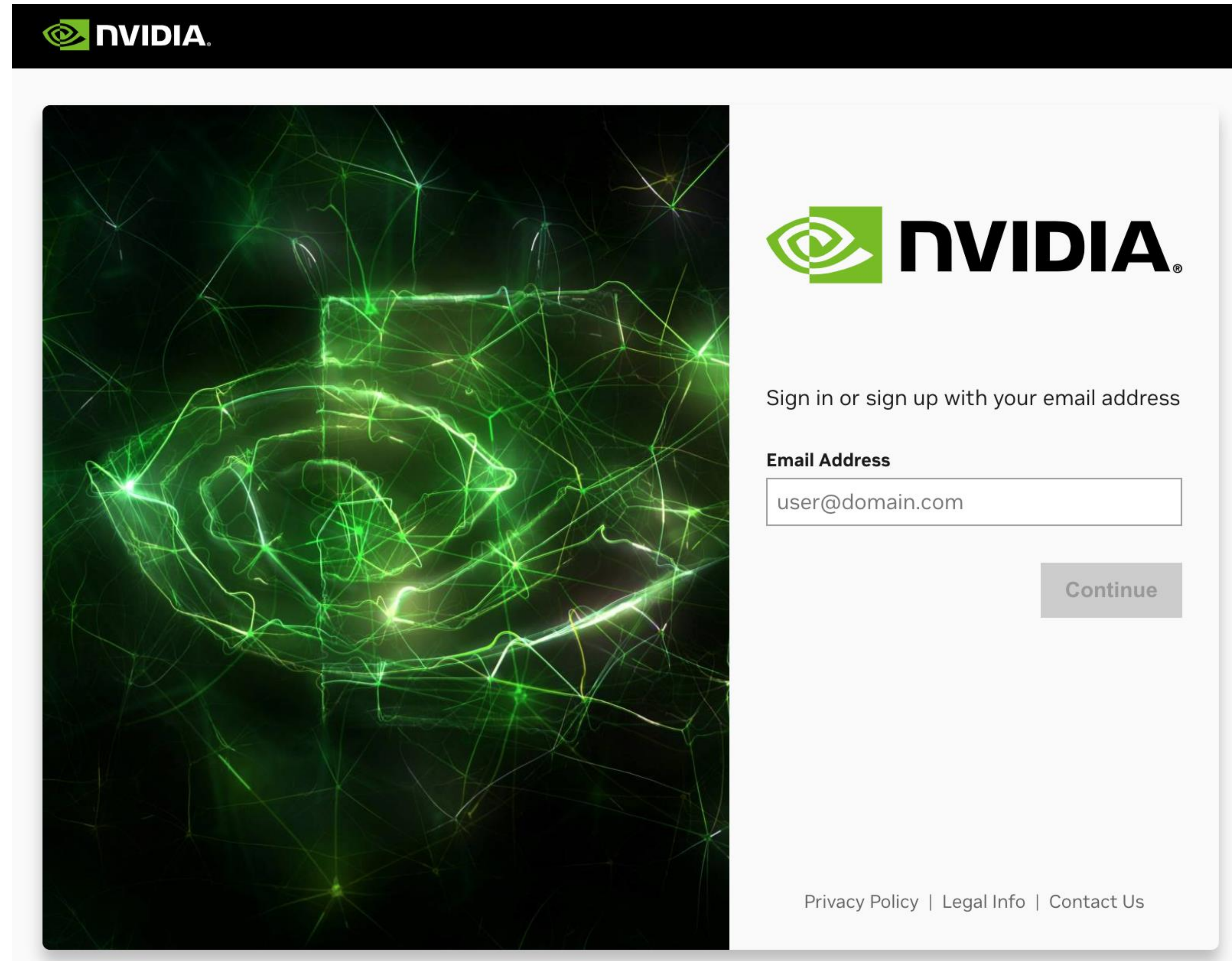


The screenshot shows the NVIDIA Developer Program website. At the top, there is a navigation bar with the NVIDIA logo, the text 'NVIDIA DEVELOPER', and links for Home, Blog, Forums, Docs, Downloads, and Training. A search icon and a 'Join' button are also present. Below the navigation bar, there are dropdown menus for Topics, Platforms, Industries, and Resources. The main content area features a large heading: 'Choose a Technical Training Course. It's On Us.' Below this heading is a paragraph: 'Join the NVIDIA Developer Program and take one of the complimentary technical self-paced courses below (worth up to \$90).' A prominent green 'Claim Now' button is centered on the page, highlighted with a red border. Below the button is a horizontal menu with five categories: 'Generative AI and LLMs' (which is selected), 'Graphics and Simulation', 'Accelerated Computing', 'Data Science', and 'Deep Learning'. Two course cards are displayed below the menu. The first card is titled 'Introduction to Transformer-Based Natural Language Processing', has a duration of 6 hours, and describes learning about transformers and their use in NLP tasks. The second card is titled 'Prompt Engineering With Llama 2', has a duration of 3 hours, and describes interacting with and prompting Llama 2 models.

<https://developer.nvidia.com/join-nvidia-developer-program>

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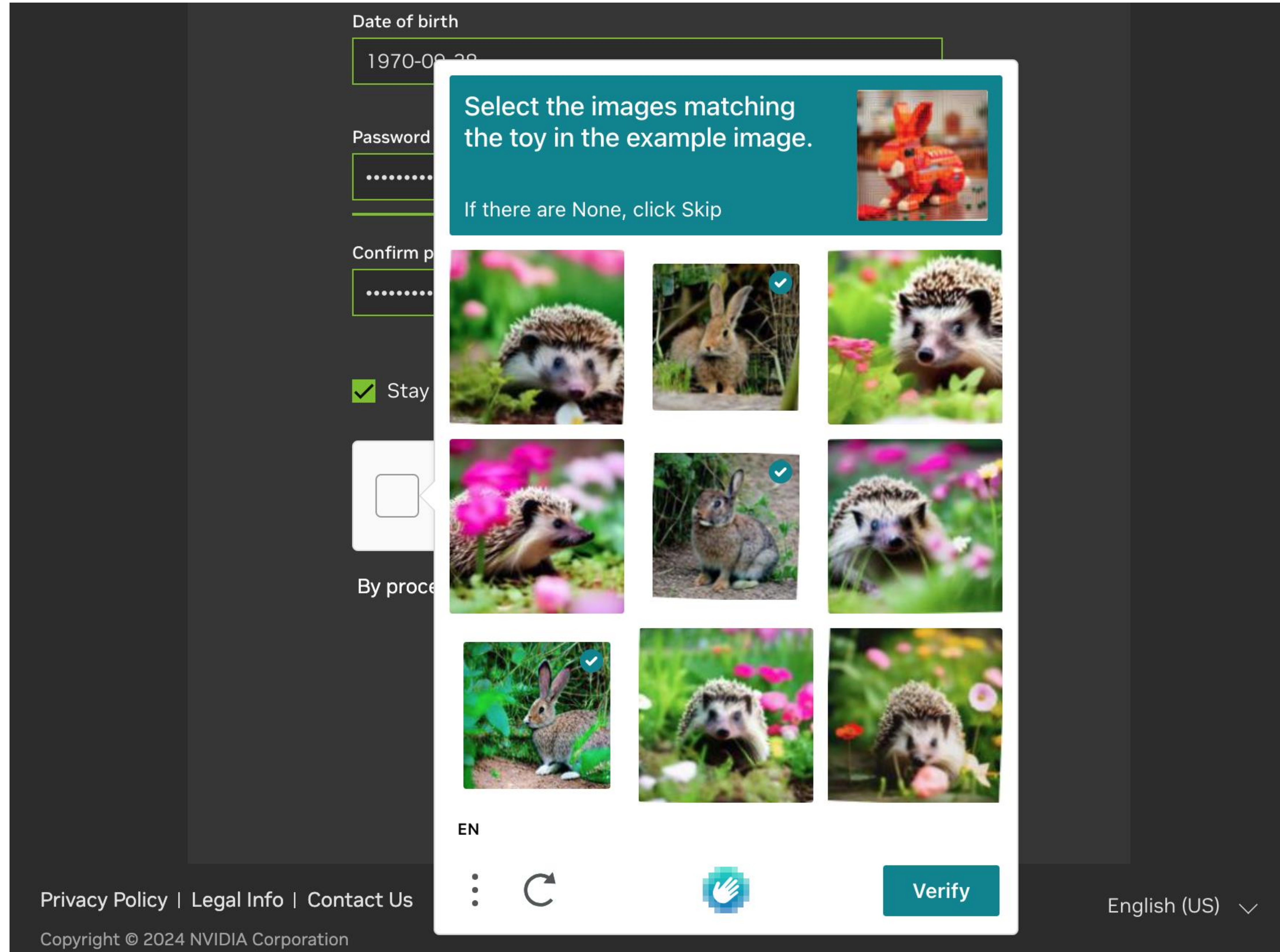


The screenshot shows the NVIDIA Developer Program sign-up page. It features the NVIDIA logo at the top left, a large green abstract graphic on the left, and a sign-up form on the right. The form includes the text "Sign in or sign up with your email address", an "Email Address" label, a text input field containing "user@domain.com", and a "Continue" button. At the bottom of the form, there are links for "Privacy Policy", "Legal Info", and "Contact Us".

<https://developer.nvidia.com/join-nvidia-developer-program>

Join the NVIDIA Developer Program

take one of the complimentary technical self-paced courses (worth up to \$90)



The screenshot displays a registration form with fields for "Date of birth" (1970-09-29), "Password", and "Confirm password". A "Stay" checkbox is checked. A CAPTCHA challenge is overlaid on the form, asking the user to "Select the images matching the toy in the example image." The example image shows a red toy rabbit. The challenge grid contains nine images: three rabbits and six hedgehogs. Two rabbits are selected with blue checkmarks. The interface includes a "Verify" button, a language dropdown set to "English (US)", and a footer with "Privacy Policy | Legal Info | Contact Us" and "Copyright © 2024 NVIDIA Corporation".

<https://developer.nvidia.com/join-nvidia-developer-program>

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 NVIDIA DEVELOPER DEEP LEARNING INSTITUTE PROGRAM BENEFITS

SELECT YOUR FREE COURSE.


Thank you for your participation in the NVIDIA Developer Program. Please select your free DLI course below.


English ▾

- Integrating Sensors with NVIDIA DRIVE®
- Getting Started with Deep Learning
- Deploying a Model for Inference at Production Scale
- Get Started with Highly Accurate Custom ASR for Speech AI
- Introduction to Graph Neural Networks
- Introduction to Transformer-Based Natural Language Processing
- Prompt Engineering with LLaMA-2 (Access Expires Dec. 5th 2025)
- Generative AI with Diffusion Models**
- Building Real-Time Video AI Applications
- Introduction to Robotic Simulations in Isaac Sim

Generative AI with Diffusion Models

Take a deeper dive into denoising diffusion models, which are a popular choice for text-to-image pipelines, with applications in creative content generation, data augmentation, simulation and planning, anomaly detection, drug discovery, personalized recommendations, and more.

 Certificate Available

 Duration: 08:00

Continue >



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NVIDIA DEVELOPER DEEP LEARNING INSTITUTE PROGRAM BENEFITS

SELECT YOUR FREE COURSE.

Thank you for your participation in the NVIDIA Developer Program. Please select your free DLI course below.

English

- Modeling Time Series Data with Recurrent Neural Networks in Keras (Access ends 10/16/2024)
- Optimizing CUDA Machine Learning Codes With Nsight Profiling Tools
- Getting Started with Accelerated Computing in CUDA C/C++
- Fundamentals of Accelerated Computing with CUDA Python
- Fundamentals of Accelerated Computing with OpenACC
- Integrating Sensors with NVIDIA DRIVE®
- Getting Started with Deep Learning**
- Deploying a Model for Inference at Production Scale
- Get Started with Highly Accurate Custom ASR for Speech AI

Getting Started with Deep Learning

Learn how deep learning works through hands-on exercises in computer vision and natural language processing.

Certificate Available

Duration: 08:00

Continue >

<https://developer.nvidia.com/join-nvidia-developer-program>

NVIDIA Deep Learning Institute (DLI)

Deep Learning Institute Find Training Self Paced Courses Instructor-Led Workshops Educator Programs Enterprise Solutions Certification Resources

Search



Monthly Activity

Skill Points 0

Time Spent

Courses in Progress 1

Courses Completed 0

Watched Videos

Assessments

Skills

Certificates



No Certificates

You don't have any certificates yet.

Courses in Progress

Self-paced

Generative AI with Diffusion Models

0% Completed

08:00

Generative AI with Diffusion Models

Course Progress Bookmarks Updates

Generative AI with Diffusion Models > Start Here > 0: Server Access

Generative AI with Diffusion Models

Start Here

Next Steps

Feedback

Previous

Next



0: Server Access

Bookmark this page

Welcome to Generative AI with Diffusion Models. Please click "Next" below to get started.

Underneath each video is a link to start your own private server for hands-on coding practice. Click the "Start" button to boot up the server. In a few minutes after the server is done loading, click "Launch" to access the code labs.

1: From U-Nets to Diffusion

Bookmark this page

Theory

<https://learn.nvidia.com/my-learning>





NVIDIA Deep Learning Institute (DLI)

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Deep Learning Institute

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Generative AI with Diffusion Models

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Course Progress Bookmarks Updates

<https://learn.nvidia.com/my-learning>

Deep Learning Institute (DLI)

Search

Monthly Activity

Skill Points	0
Time Spent	
Courses in Progress	16
Courses Completed	12
Watched Videos	
Assessments	

Skills

Certificates

- Introduction to Transformer-Based Natural Language Processing
- Building RAG Agents with LLMs
- Building RAG Agents with LLMs
- Accelerating End-to-End Data Science Workflows
- Generative AI with Diffusion Models**
- Building Agentic AI Applications with LLMs

Certificates

- Introduction to Transformer-Based Natural Language Processing
- Building RAG Agents with LLMs
- Building RAG Agents with LLMs
- Accelerating End-to-End Data Science Workflows
- Generative AI with Diffusion Models
- Building Agentic AI Applications with LLMs
- Building Agentic AI Applications with LLMs
- Rapid Application Development with Large Language Models (LLMs)
- Getting Started with Deep Learning

Completed Courses

- Accelerating End-to-End Data Science Workflows
- Rapid Application Development with Large Language Models (LLMs)
- Sizing LLM Inference Systems
- Building RAG Agents with LLMs
- Generative AI with Diffusion Models**

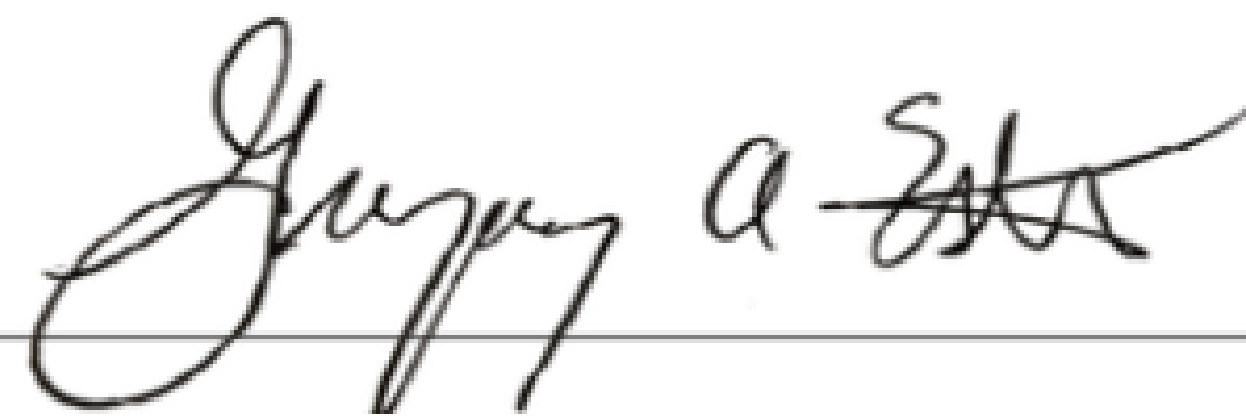
Certificate of Competency

This certificate is awarded to

Min-Yuh Day

for demonstrating competence in the completion of

Generative AI with Diffusion Models



Greg Estes

Vice President, NVIDIA

Issue Date: : February 28, 2025

Certification ID: q3oo-oBhTQKtyCCote2E-Q

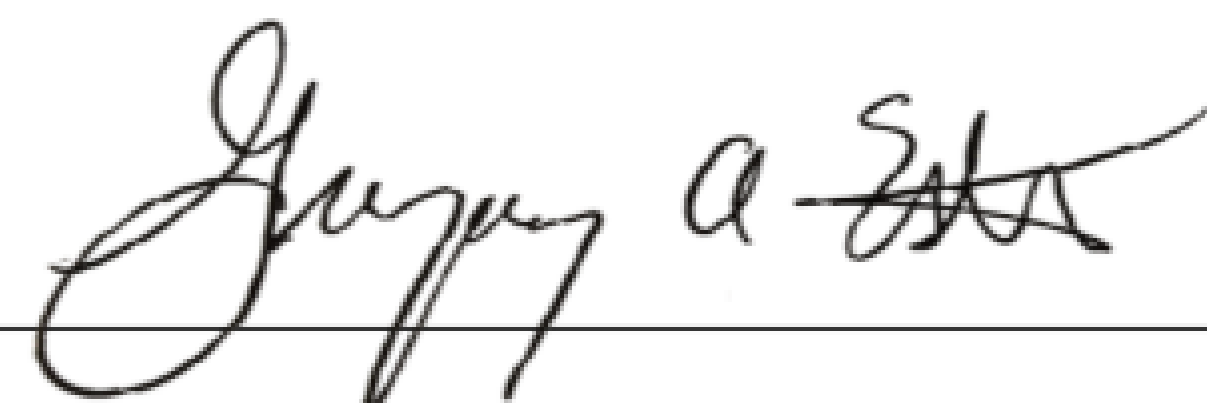
Certificate of Completion

This certificate is awarded to

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Building RAG Agents with LLMs



Greg Estes

Vice President, NVIDIA

Issue Date: : December 8, 2024

Certification ID: ed-qOCIMQatzU8SNUNxgw |

https://learn.nvidia.com/certificates?id=ed-qOCIMQatzU8SNUNxgw/courses/course?course_id=course-v1:DLI+S-FX-15+V1

<https://learn.nvidia.com/certificates?id=ed-qOCIMQatzU8SNUNxgw>

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<p>Self-paced</p> <p>Techniques for Improving the Effectiveness of RAG Systems</p> <p>\$30 03:00</p>	<p>Self-paced</p> <p>Introduction to Transformer-Based Natural Language Processing</p> <p>\$30 06:00</p>	<p>Self-paced</p> <p>Building LLM Applications With Prompt Engineering</p> <p>\$90 08:00</p>	<p>Self-paced</p> <p>Synthetic Tabular Data Generation Using Transformers</p> <p>\$30 04:00</p>
<p>Self-paced</p> <p>Sizing LLM Inference Systems</p> <p>Free 03:00</p>	<p>Self-paced</p> <p>Building RAG Agents with LLMs</p> <p>Free 08:00</p>	<p>Self-paced</p> <p>Augment your LLM Using Retrieval Augmented Generation</p> <p>Free 01:00</p>	

NVIDIA Deep Learning Institute (DLI)

Generative AI with Diffusion Models

Self-paced Course

Generative AI with Diffusion Models

Take a deeper dive into denoising diffusion models, which are a popular choice for text-to-image pipelines, with applications in creative content generation, data augmentation, simulation and planning, anomaly detection, drug discovery, personalized recommendations, and more.



[About Course](#)
[Objectives](#)
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About this Course

Thanks to improvements in computing power and scientific theory, generative AI is more accessible than ever before. Generative AI plays a significant role across industries due to its numerous applications, such as creative content generation, data augmentation, simulation and planning, anomaly detection, drug discovery, personalized recommendations, and more. In this course, learners will take a deeper dive into denoising diffusion models, which are a popular choice for text-to-image pipelines.

Learning Objectives

Course Details

Duration: 08:00

Price: \$90

Subject: Generative AI/LLM

Language: English

Course Prerequisites:

A basic understanding of [Deep Learning Concepts](#).

https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S-FX-14+V1

Generative AI with Diffusion Models

Generative AI with Diffusion Models

Start Here

0: Server Access

1: From U-Nets to Diffusion

2: Denoising Diffusion Probabilistic Models

3: Optimizations

4: Classifier-Free Diffusion Guidance

5: CLIP

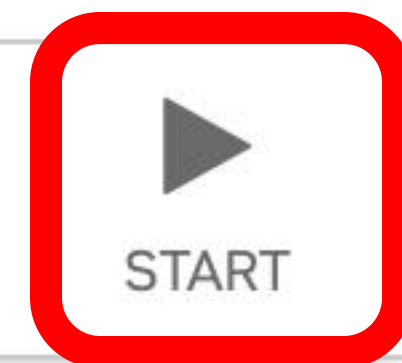
6: Wrap-up and Assessment

Next Steps

Feedback

Previous

Next



Please click the start button to the top-right. The course will take about 5 minutes to load. The course lecture slide decks will appear here when you launch the course. The numbers on the lectures correspond to the numbers of the interactive notebooks in the course.

1: From U-Nets to Diffusion

Generative AI with Diffusion Models

Products Solutions Industries For You Shop Drivers Support Min-Yuh Day

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Generative AI with Diffusion Models

Course Progress Bookmarks Updates

Generative AI with Diffusion Models Start Here 1: From U-Nets to Diffusion

Generative AI with Diffusion Models

Start Here

- 0: Server Access
- 1: From U-Nets to Diffusion**
- 2: Denoising Diffusion Probabilistic Models
- 3: Optimizations
- 4: Classifier-Free Diffusion Guidance
- 5: CLIP
- 6: Wrap-up and Assessment

Next Steps

Feedback

Previous Next

17:54 / 17:55 Speed 1.0x

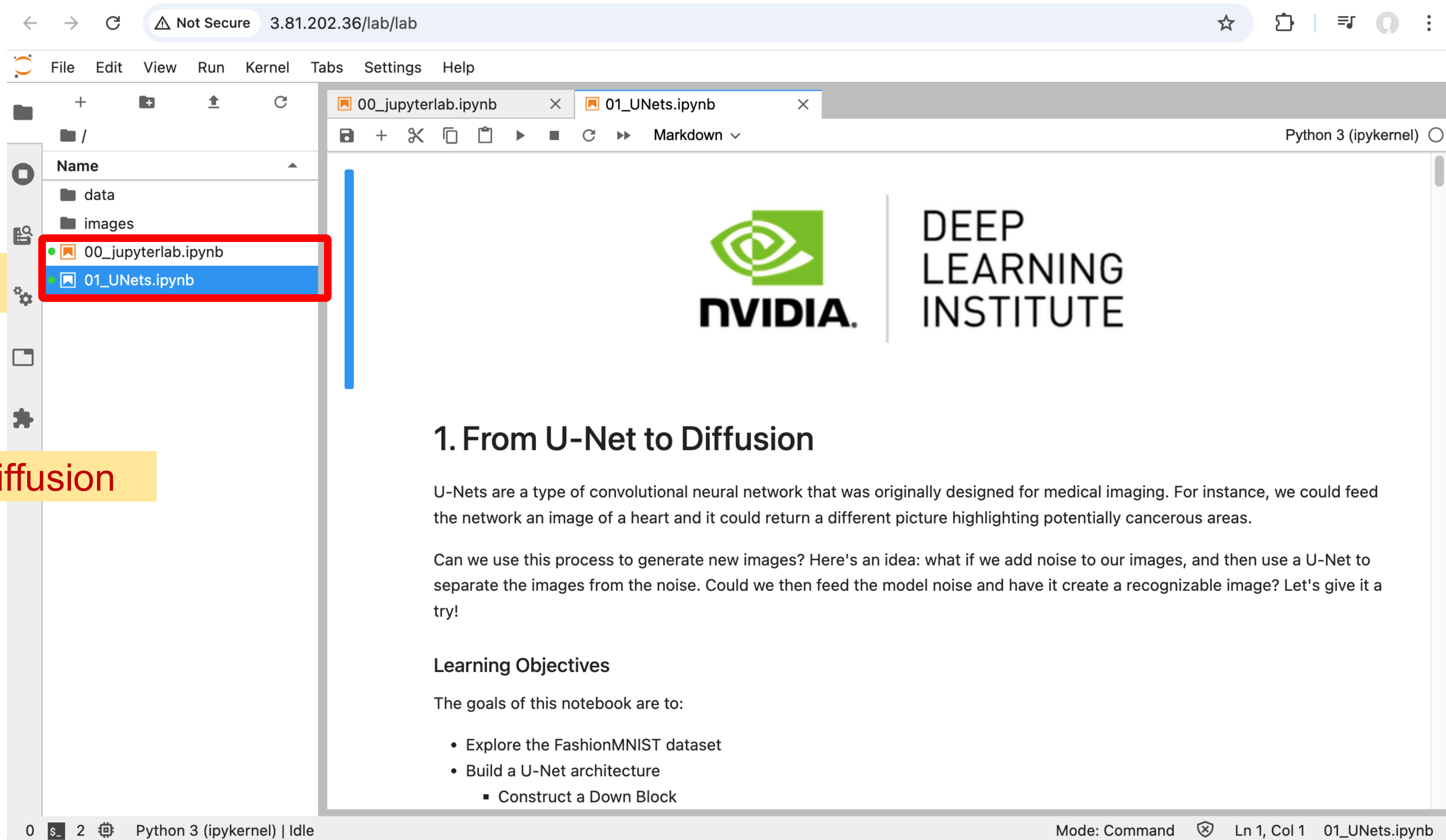
DEEP LEARNING INSTITUTE This Lab 0:10:54 / 1:30:00
Course 8:18:49 / 24:00:00

LAUNCH STOP TASK

Generative AI with Diffusion Models
Part 1: From U-Nets to Diffusion


1: From U-Nets to Diffusion

Generative AI with Diffusion Models



00_jupyterlab.ipynb | 01_UNets.ipynb

Python 3 (ipykernel)



DEEP
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1. From U-Net to Diffusion

U-Nets are a type of convolutional neural network that was originally designed for medical imaging. For instance, we could feed the network an image of a heart and it could return a different picture highlighting potentially cancerous areas.

Can we use this process to generate new images? Here's an idea: what if we add noise to our images, and then use a U-Net to separate the images from the noise. Could we then feed the model noise and have it create a recognizable image? Let's give it a try!

Learning Objectives

The goals of this notebook are to:

- Explore the FashionMNIST dataset
- Build a U-Net architecture
 - Construct a Down Block

0 \$ 2 Python 3 (ipykernel) | Idle Mode: Command Ln 1, Col 1 01_UNets.ipynb

01_UNets.ipynb

1: From U-Nets to Diffusion



Generative AI with Diffusion Models

Part 1: From U-Nets to Diffusion

Agenda

- Part 1: From U-Nets to Diffusion
- Part 2: Denoising Diffusion Probabilistic Models
- Part 3: Optimizations
- Part 4: Classifier Free Diffusion
- Part 5: CLIP
- Part 6: Wrap-up & Assessment

Prerequisites

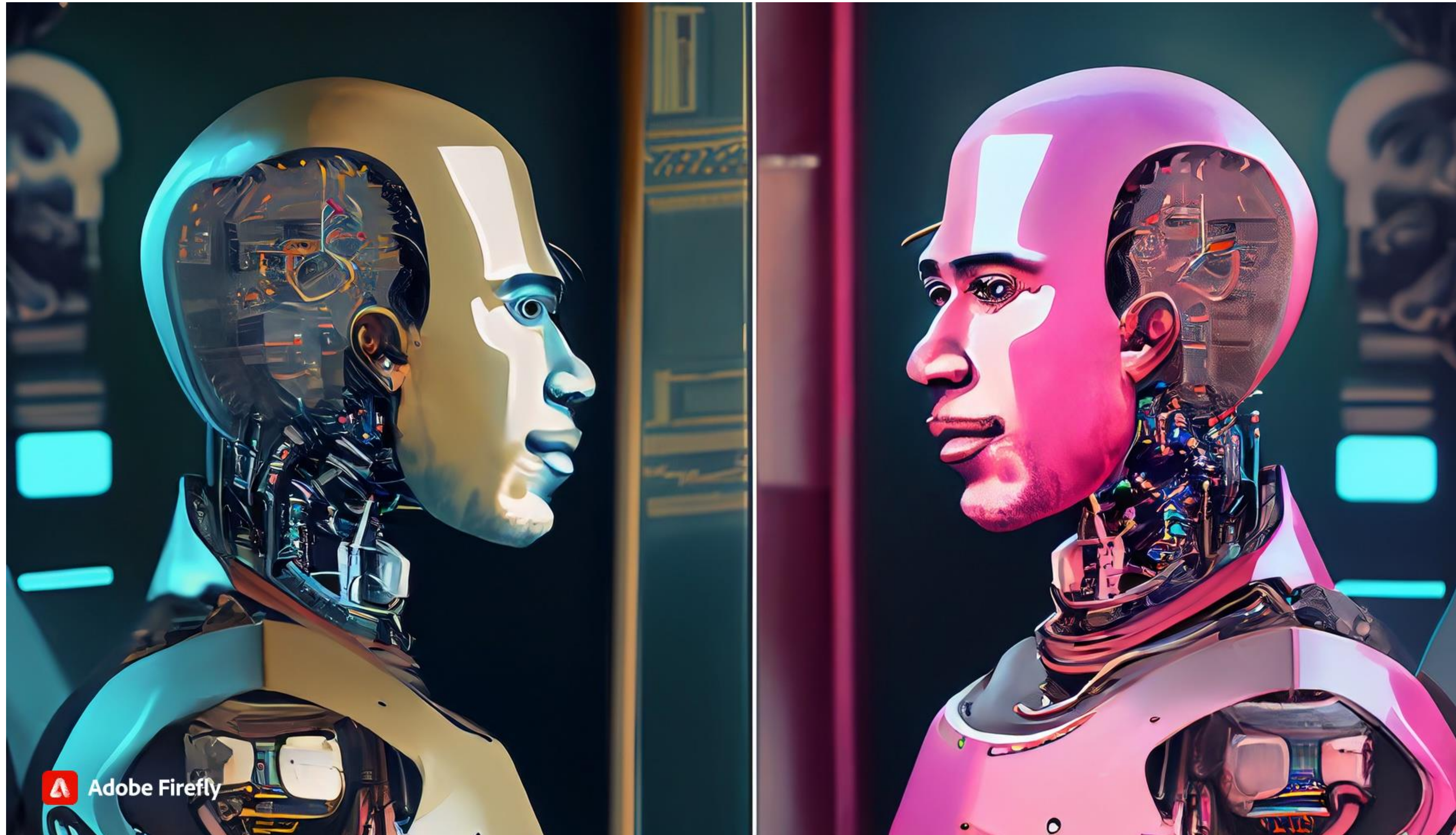
- Basic familiarity with convolutional neural networks (CNNs)
- Basic familiarity with a deep learning framework such as:
 - PyTorch
 - TensorFlow



A Brief History of Generative AI

The Imitation Game

A.K.A The Turing Test



A robot looks in a mirror and the reflection is human, cyberpunk

IBM 704

The First Singing Computer



Eliza

The First Gen AI Chatbot?

Talk to Eliza

```
> Hello, I am Eliza.  
* Nice to meet you  
> Oh... ?  
* How are you  
> Would you prefer if I were not ?  
* were not what?  
> Have you asked anyone else?
```

Input:



Generative AI of the 70's, 80's and 90s?

- Electronic music
- Video games graphics
- Video game AI
- Computer animation
- Instant messaging chatbots

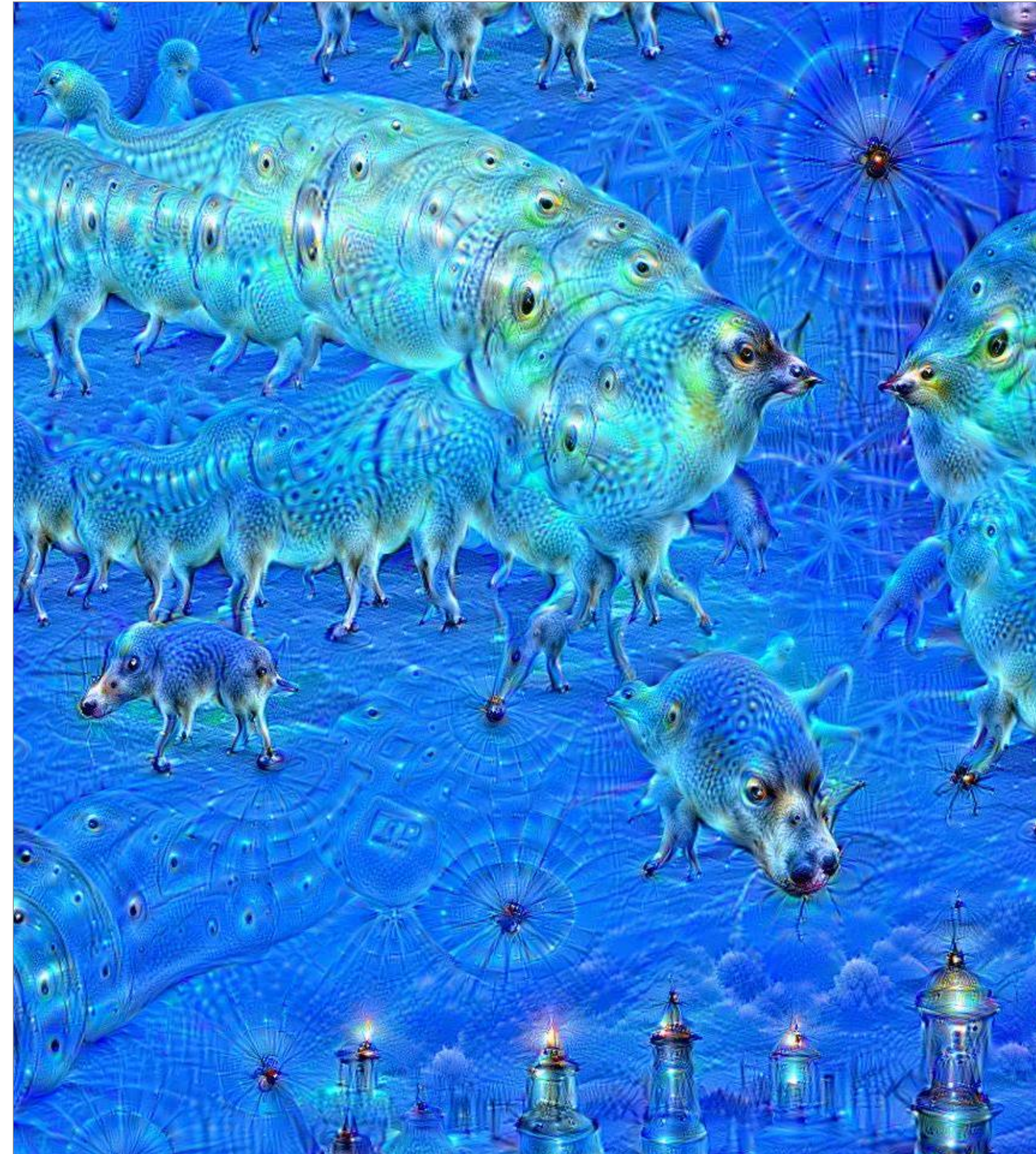
The Rise of Neural Networks

Deep Dreaming

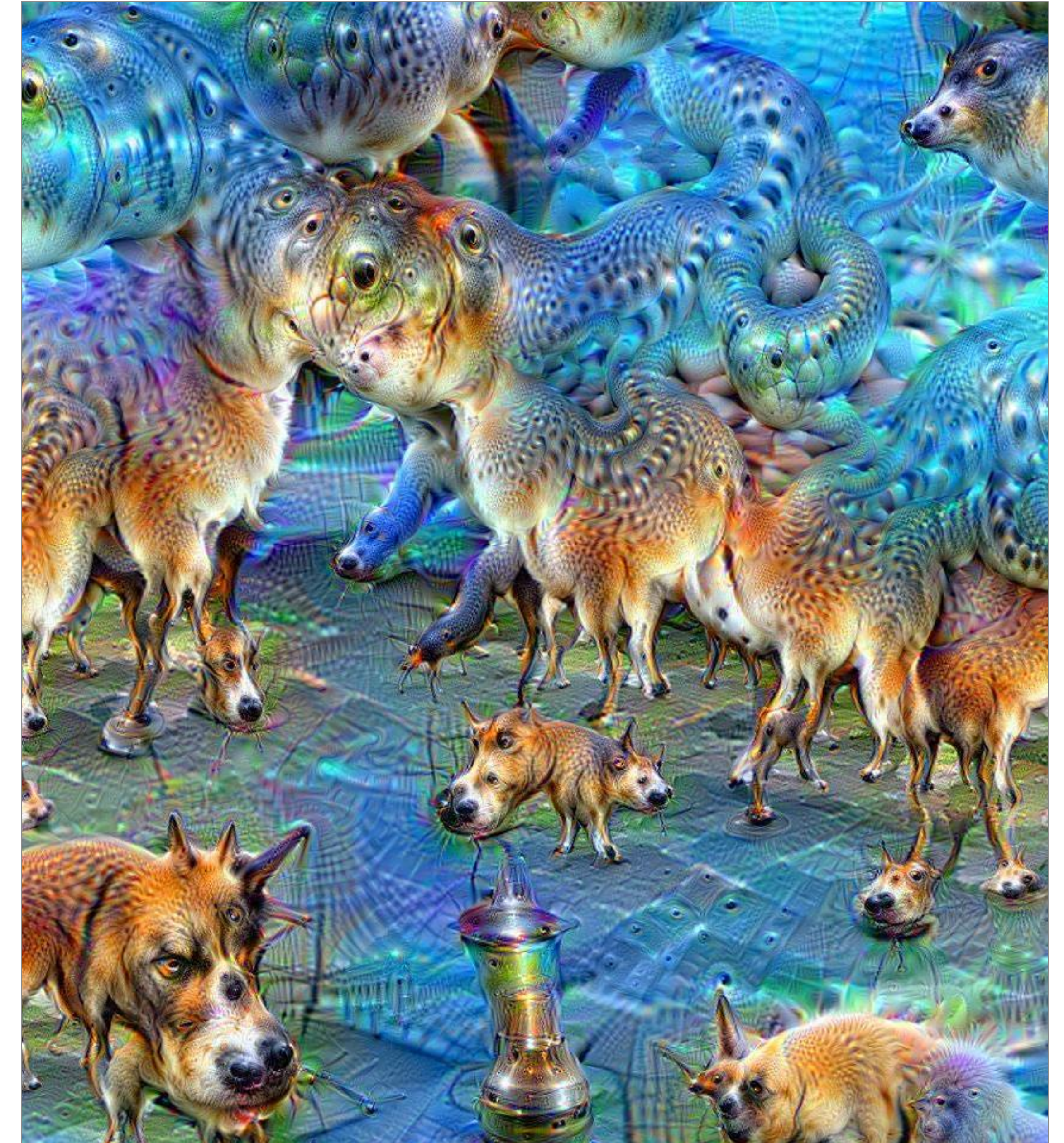
Images by Martin Thoma



Original



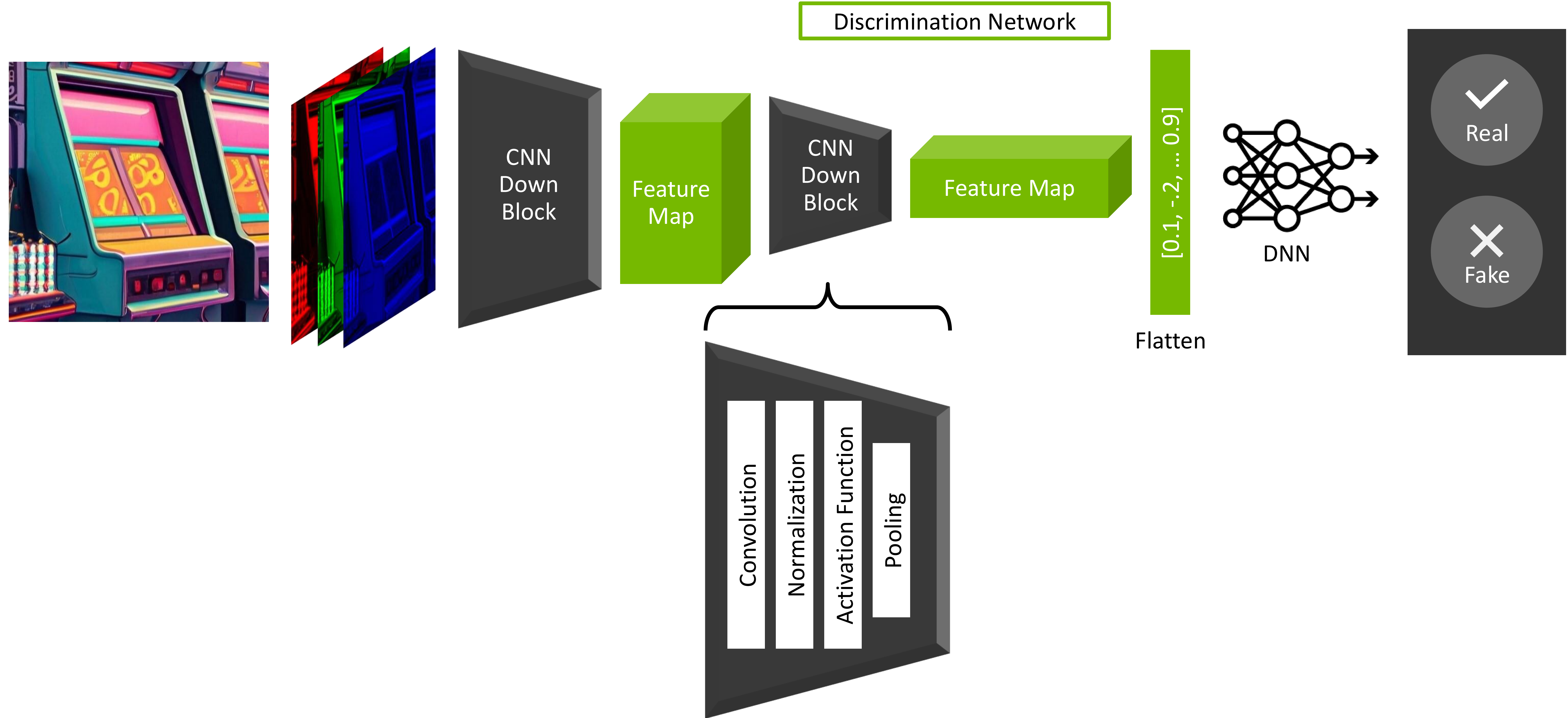
10 Iterations



50 Iterations

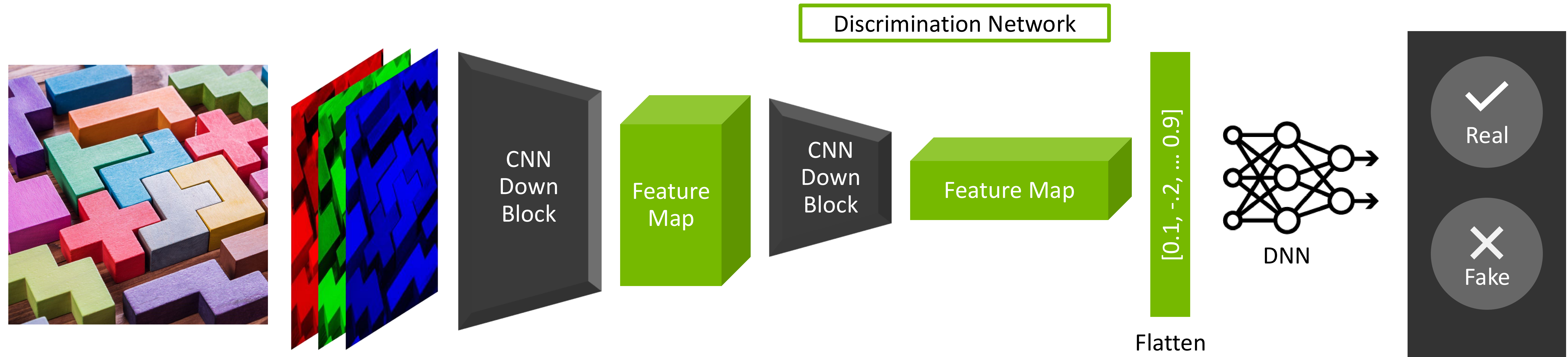
GANs

Generative Adversarial Networks



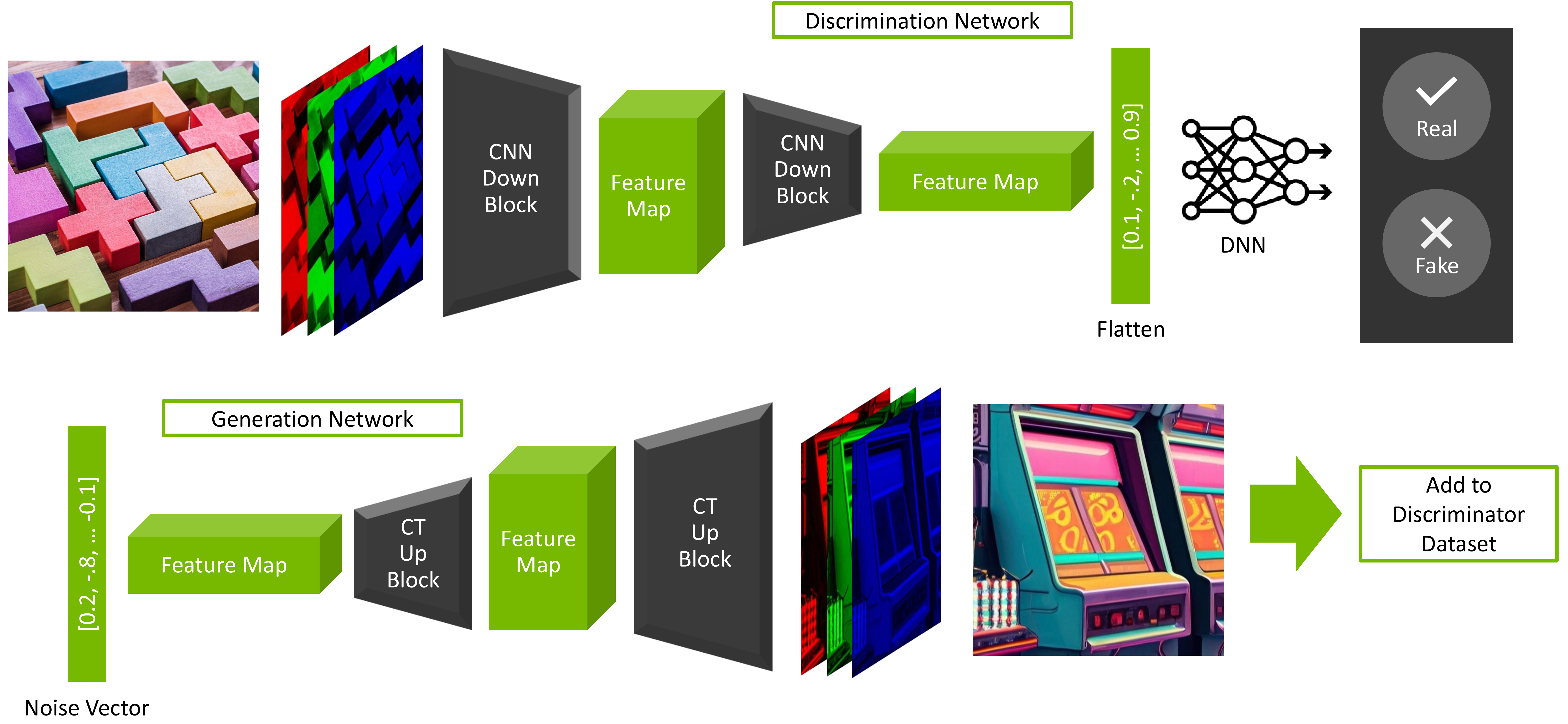
GANs

Generative Adversarial Networks



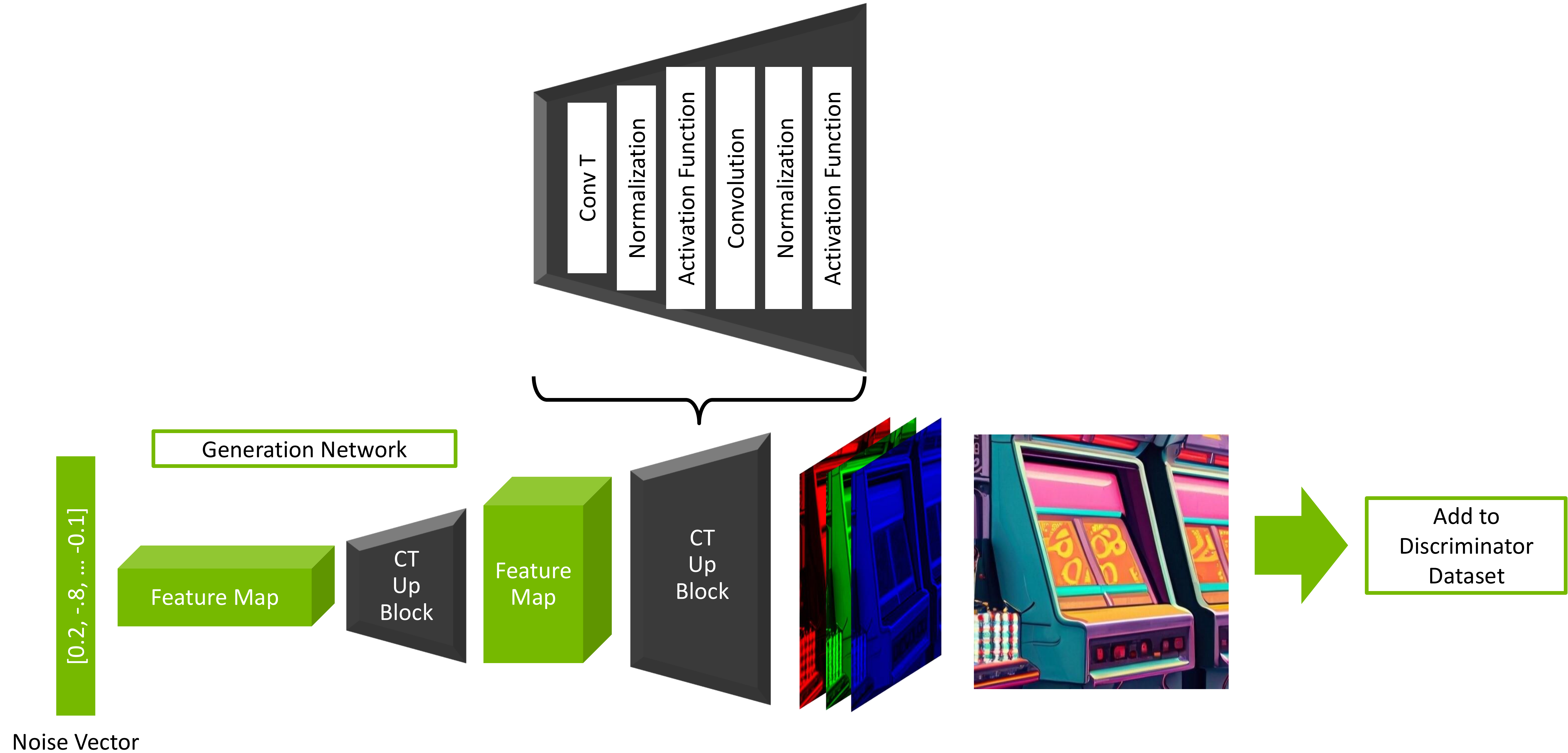
GANs

Generative Adversarial Networks



GANs

Generative Adversarial Networks



GANs

Generative Adversarial Networks

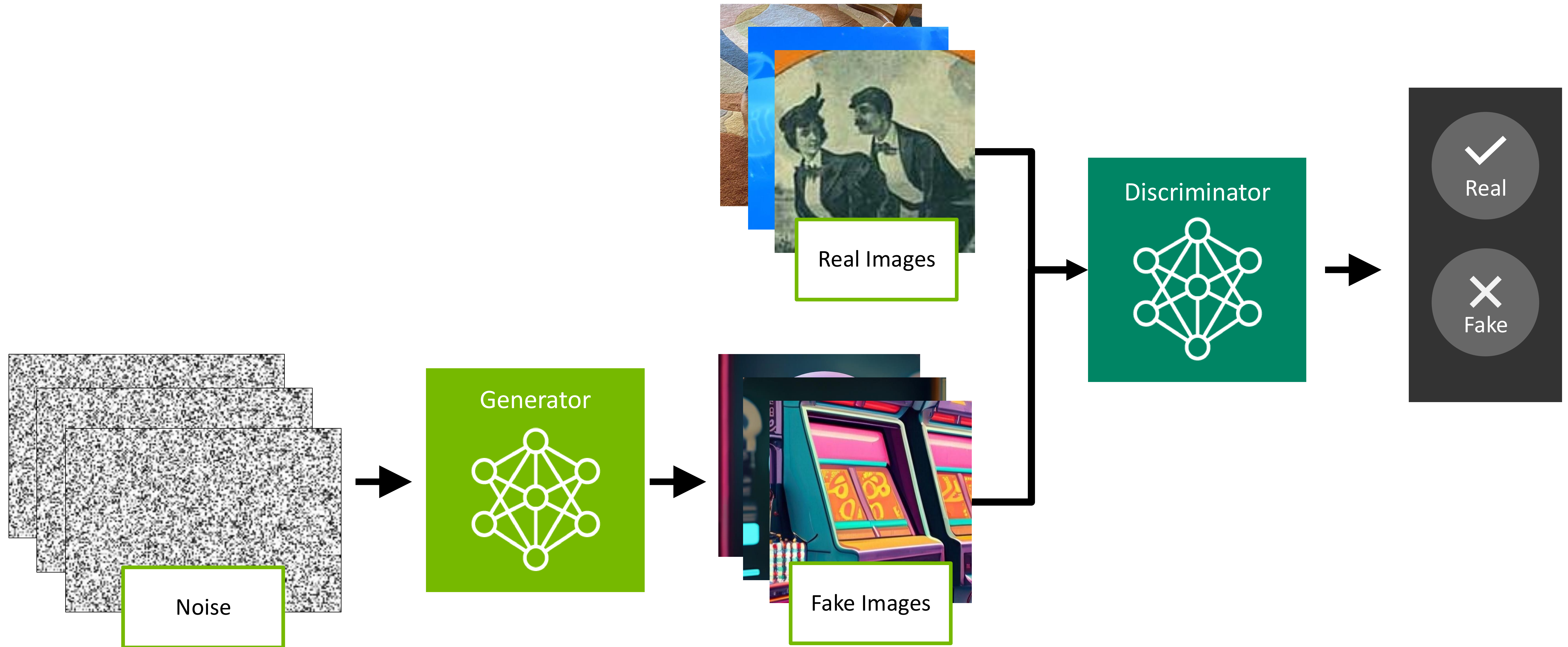


Image Segmentation

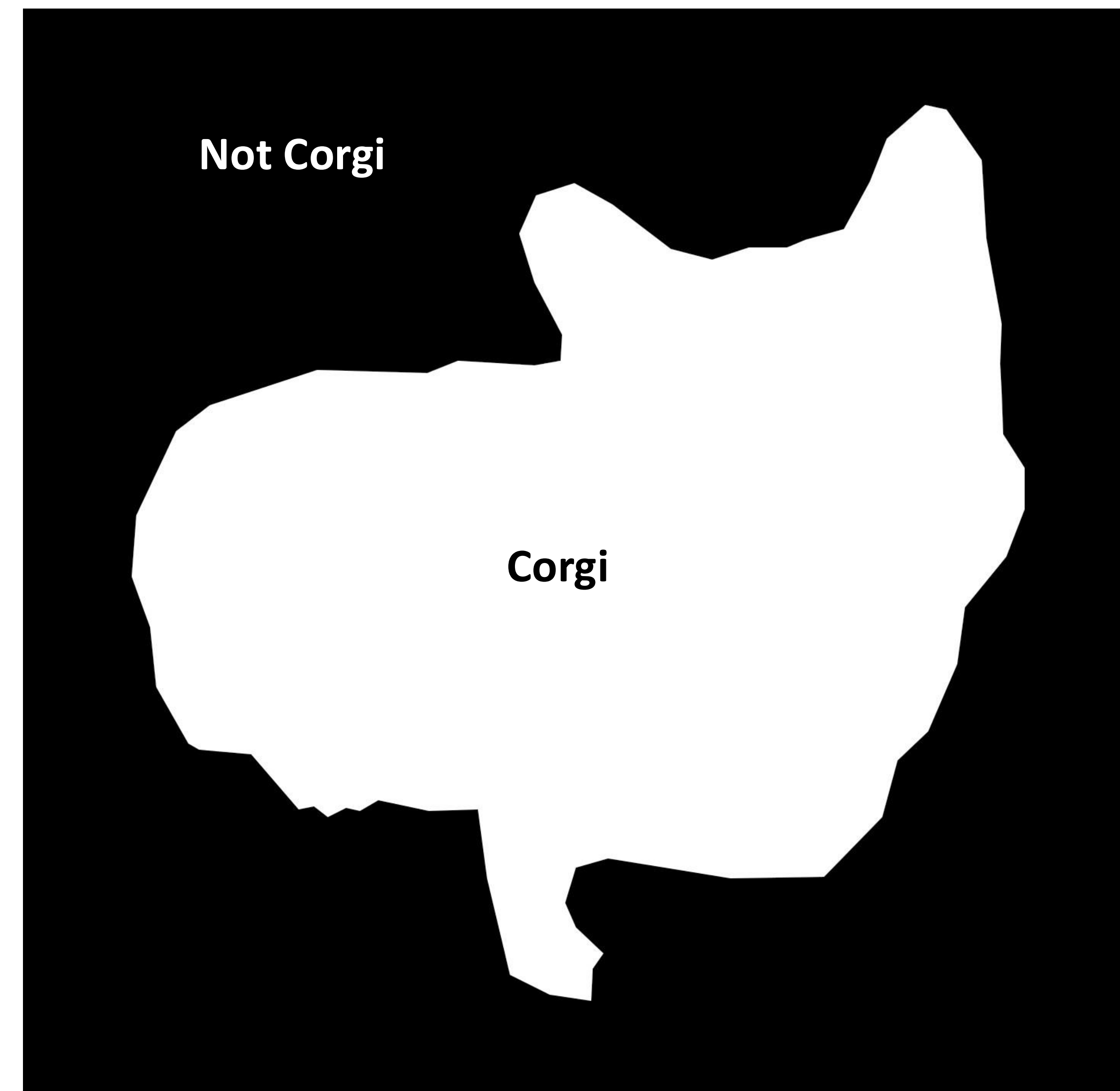
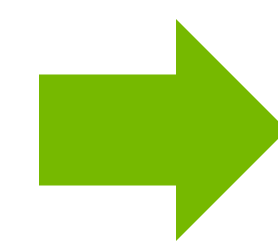
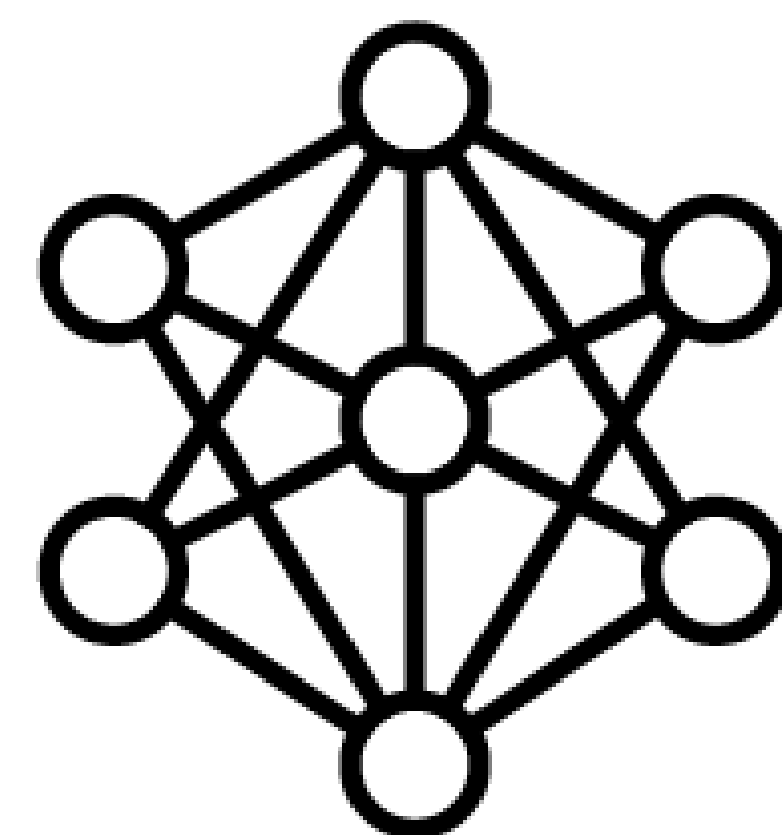
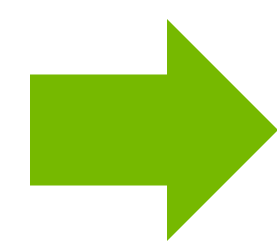
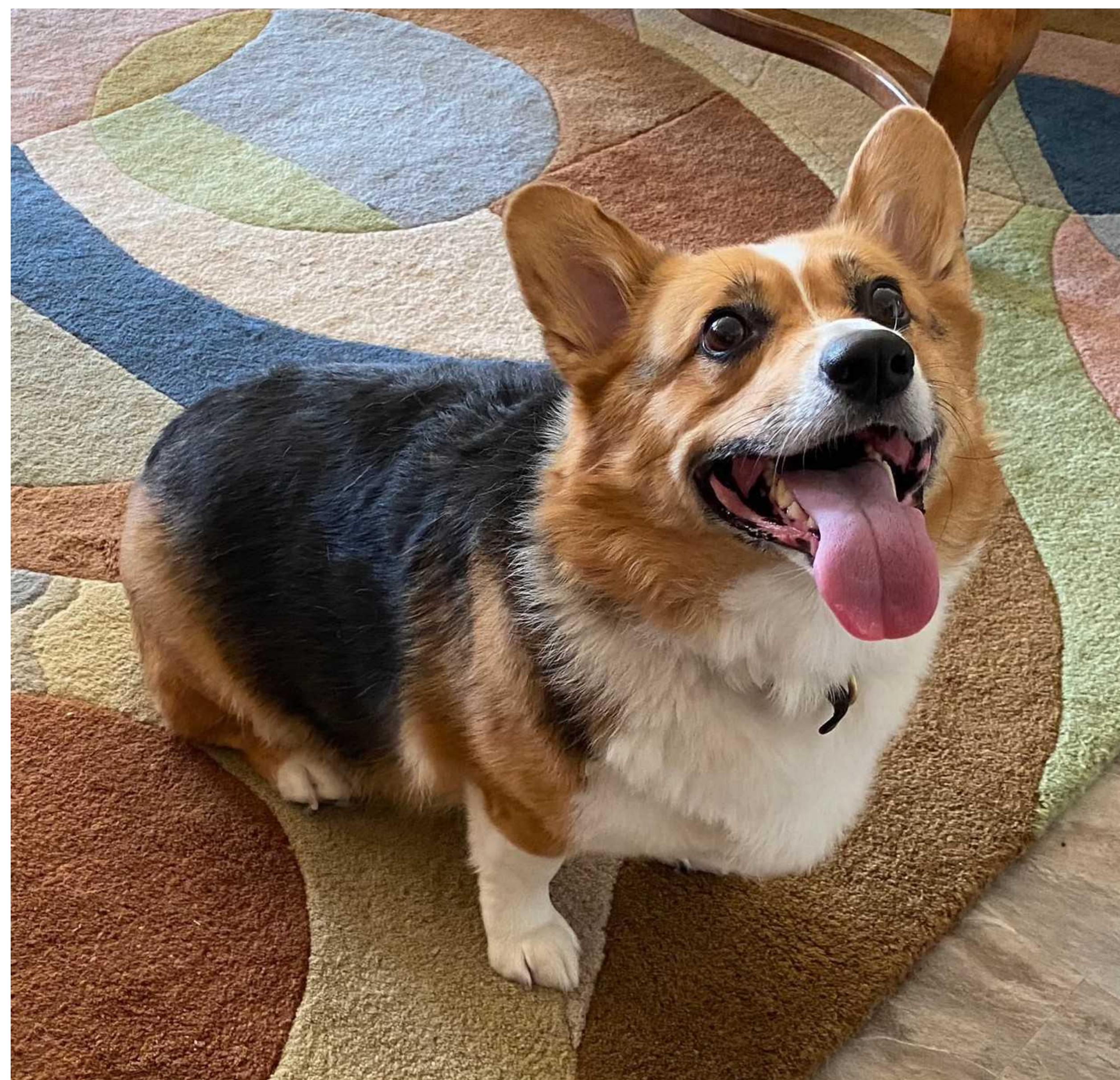
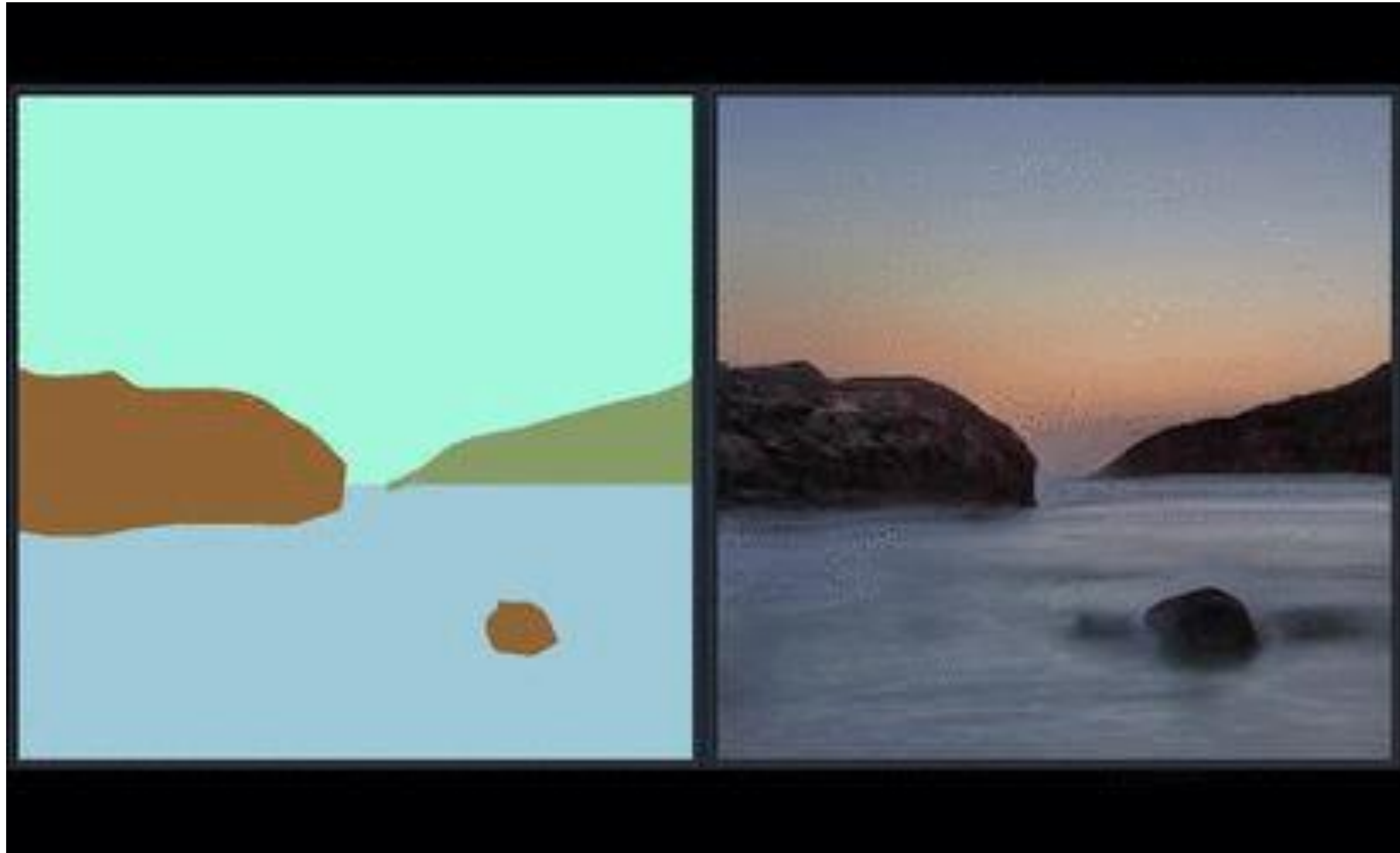


Image Segmentation + GANs

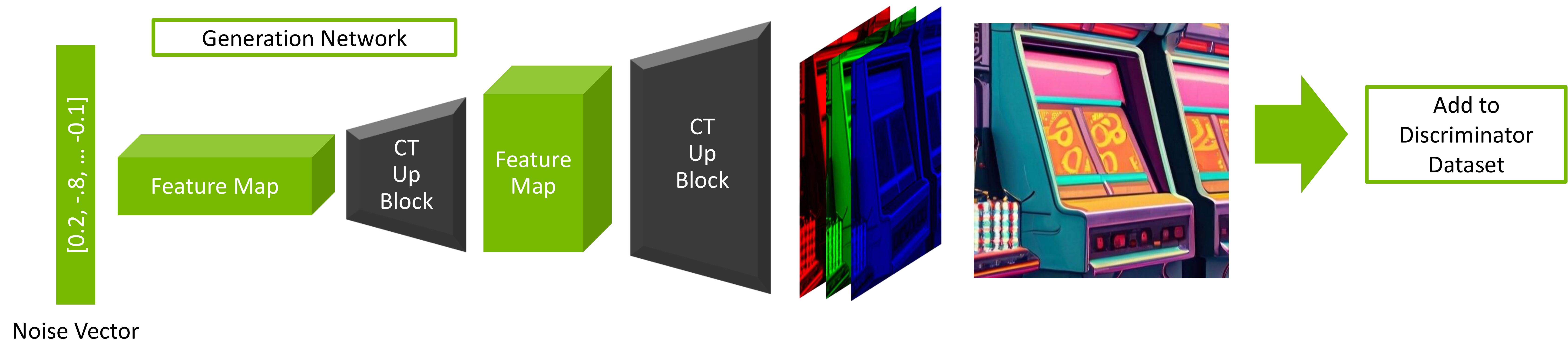
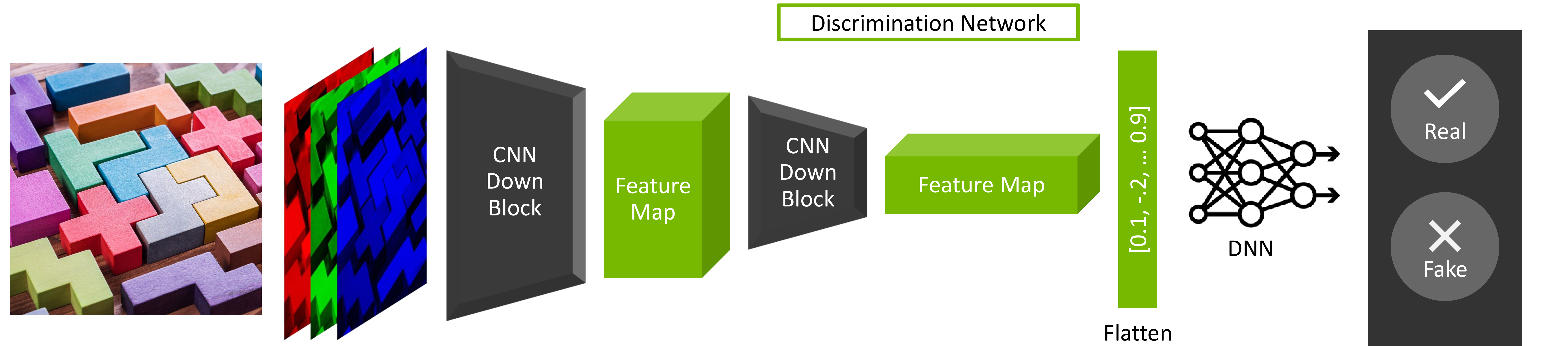
NVIDIA Spade



U-Nets

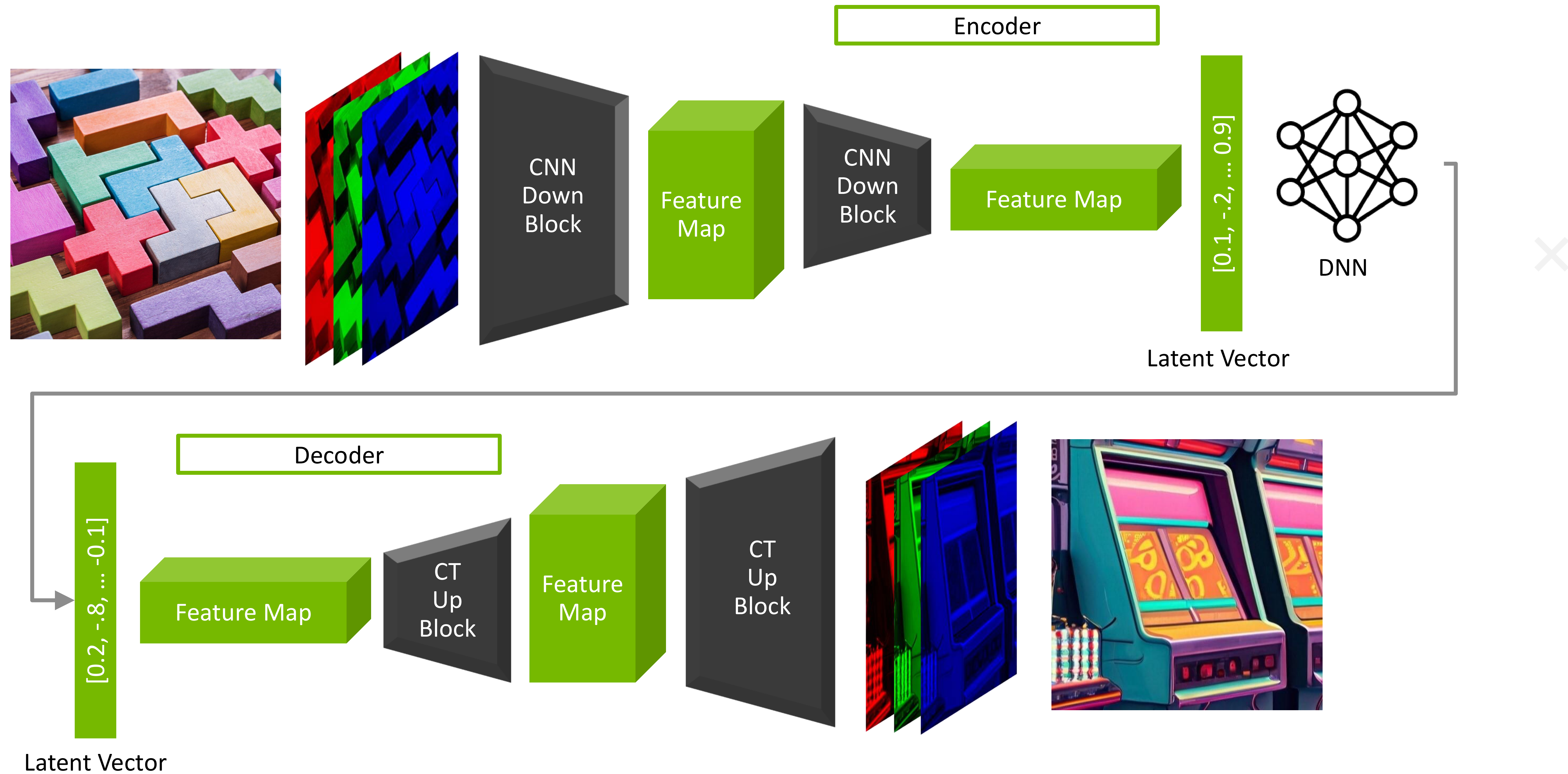
GANs

Generative Adversarial Networks



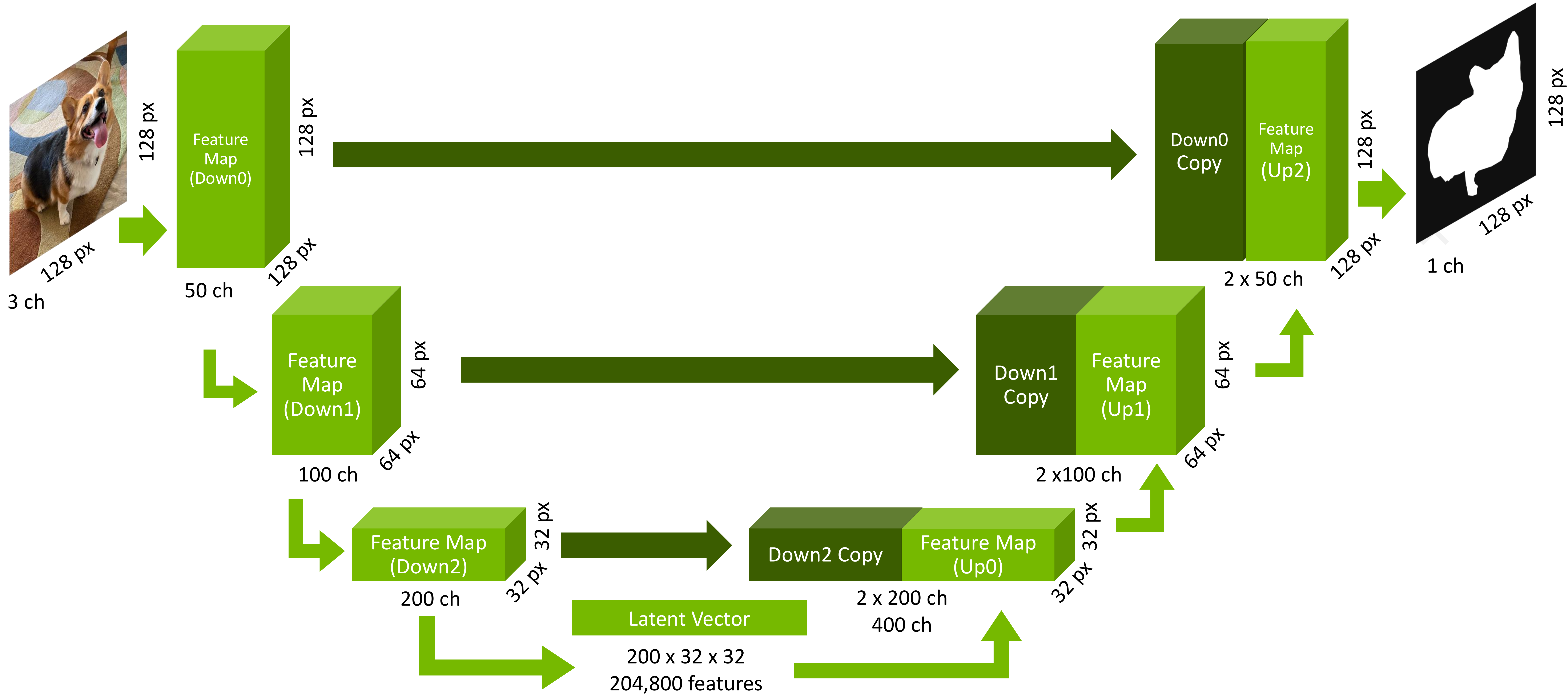
GANs U-Nets

The U shaped Autoencoder



U-Nets

The U shaped Autoencoder



Transposed Convolution

Transposed Convolution

Convolution Review

Kernel

.25	.25
.25	.25

Image

1	0	1
0	1	0
1	0	1

Output

Transposed Convolution

Convolution Review

Kernel

.25	.25
.25	.25

Image

$1 \cdot .25$	$0 \cdot .25$	1
$0 \cdot .25$	$1 \cdot .25$	0
1	0	1

Output

.5	

Transposed Convolution

Convolution Review

Kernel

.25	.25
.25	.25

Image

1	$0 \cdot .25$	$1 \cdot .25$
0	$1 \cdot .25$	$0 \cdot .25$
1	0	1

Output

.5	.5

Transposed Convolution

Convolution Review

Kernel

.25	.25
.25	.25

Image

1	0	1
0 • .25	1 • .25	0
1 • .25	0 • .25	1

Output

.5	.5
.5	

Transposed Convolution

Convolution Review

Kernel

.25	.25
.25	.25

Image

1	0	1
0	1 • .25	0 • .25
1	0 • .25	1 • .25

Output

.5	.5
.5	.5

Transposed Convolution

Image Upscaling

Kernel

.25	.25
.25	.25

Image

1	0	1
0	1	0
1	0	1

Output

Transposed Convolution

Image Upscaling

Kernel

.25	.25
.25	.25

Image

Stride = 2

1	0	0	0	1
0	0	0	0	0
0	0	1	0	0
0	0	0	0	0
1	0	0	0	1

Output

Transposed Convolution

Image Upscaling

Kernel

.25	.25
.25	.25

Image

Stride = 2

1 • .25	0 • .25	0	0	1
0 • .25	0 • .25	0	0	0
0	0	1	0	0
0	0	0	0	0
1	0	0	0	1

Output

.25			

Transposed Convolution

Image Upscaling

Kernel

.25	.25
.25	.25

Image

Stride = 2

1	0 • .25	0 • .25	0	1
0	0 • .25	0 • .25	0	0
0	0	1	0	0
0	0	0	0	0
1	0	0	0	1

Output

.25	0		

Transposed Convolution

Image Upscaling

Kernel

.25	.25
.25	.25

Image

Stride = 2

1	0	0	0	1
0	0	0	0	0
0	0	1	0	0
0	0	0	0	0
1	0	0	0	1

Output

.25	0	0	.25
0	.25	.25	0
0	.25	.25	0
.25	0	0	.25

Transposed Convolution

Stride

Image
Stride = 2

1	0	0	0	1
0	0	0	0	0
0	0	1	0	0
0	0	0	0	0
1	0	0	0	1

Image
Stride = 3

1	0	0	0	0	0	1
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	1	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
1	0	0	0	0	0	1

Transposed Convolution

Padding

Image
Stride = 3 Padding = 0

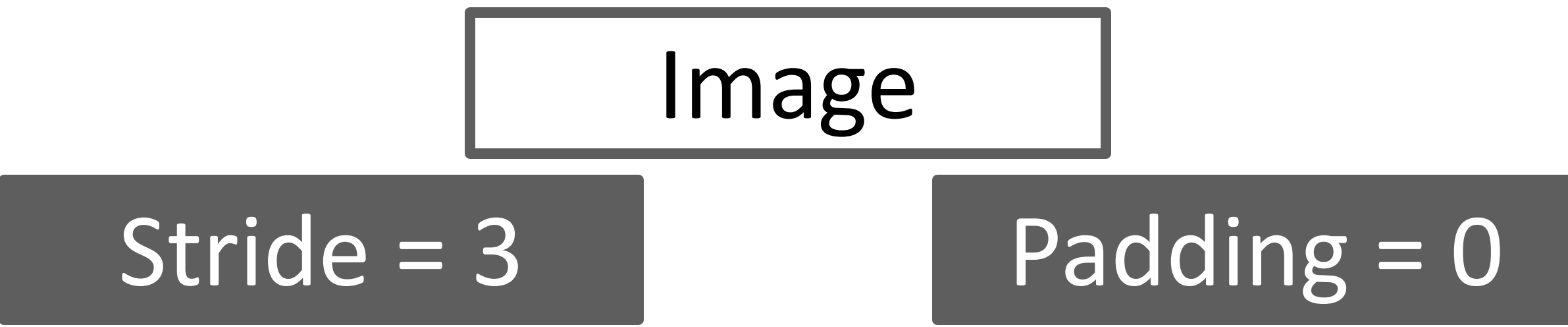
1	0	0	0	0	0	1
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	1	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
1	0	0	0	0	0	1

Image
Stride = 3 Padding = 2

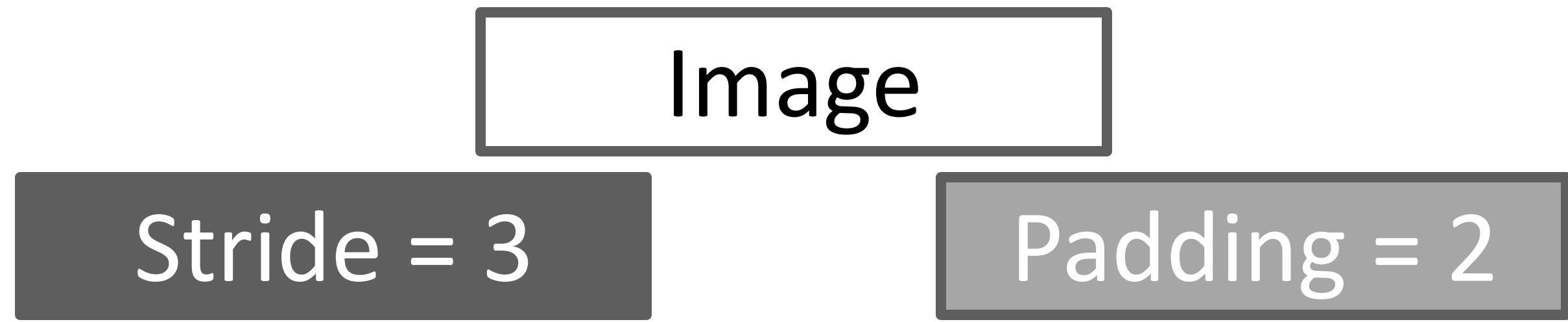
		0	0	0		
		0	1	0		
		0	0	0		

Transposed Convolution

Padding



1	0	0	0	0	0	1
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	1	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
1	0	0	0	0	0	1



0	0	0
0	1	0
0	0	0

Transposed Convolution

Out Padding

Image

Out Padding = 0

1	0	1
0	1	0
1	0	1

Image

Out Padding = 1

1	0	1	0
0	1	0	0
1	0	1	0
0	0	0	0

Image

Out Padding = 2

1	0	1	0	0
0	1	0	0	0
1	0	1	0	0
0	0	0	0	0
0	0	0	0	0

Image Resizing

Upsampling



64 px

64 px



128 px

128 px

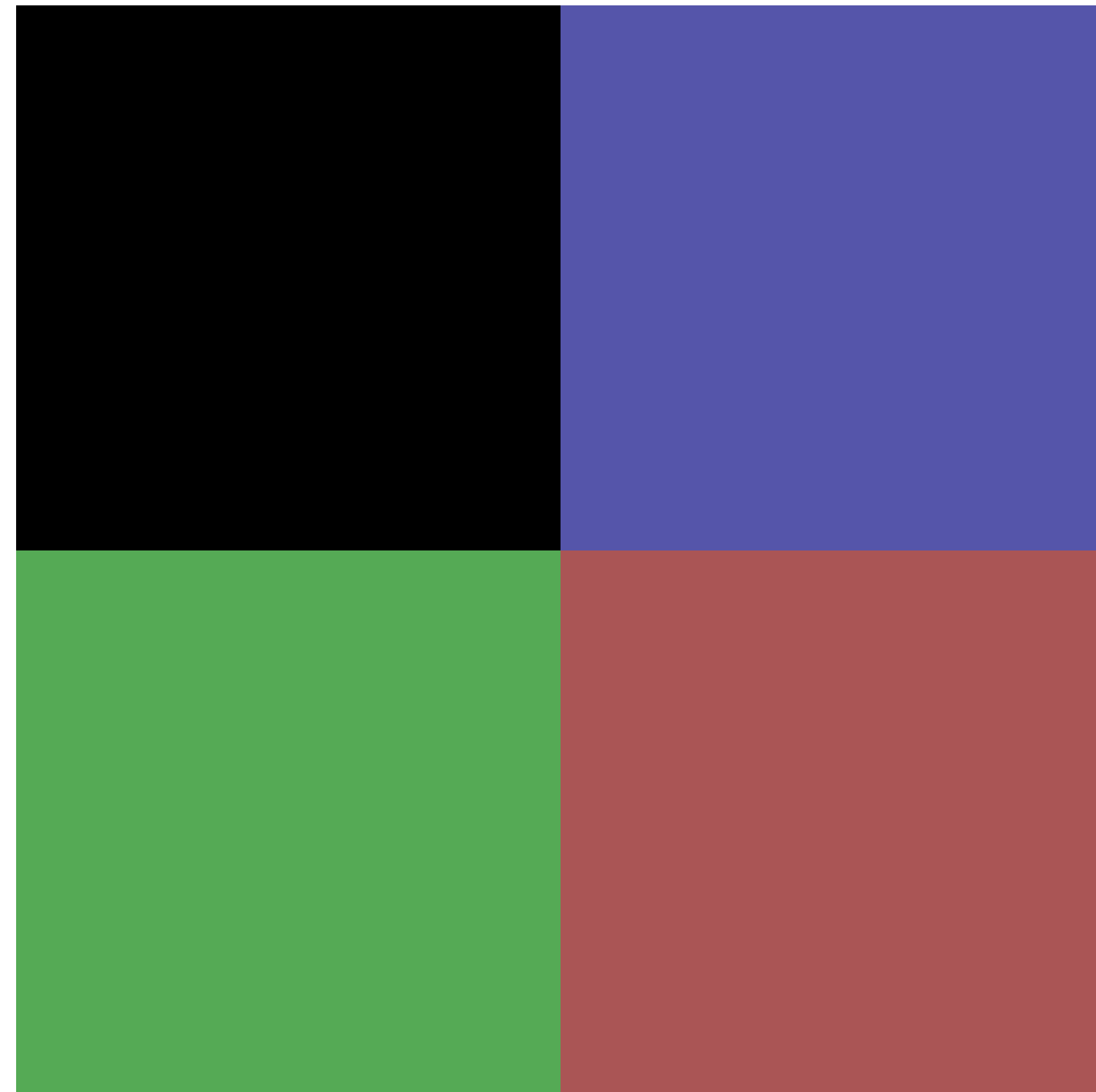


192 px

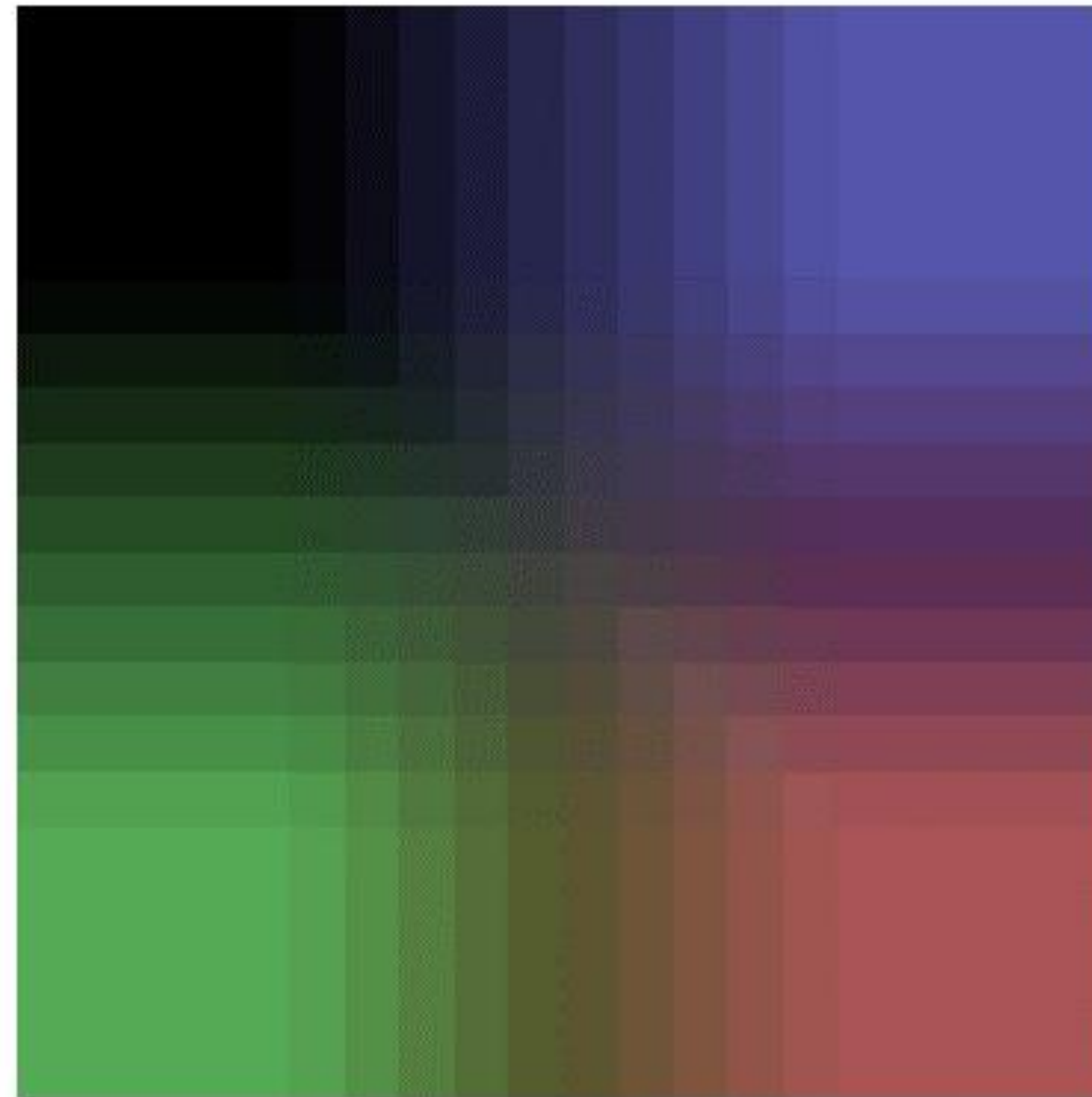
192 px

Image Resizing

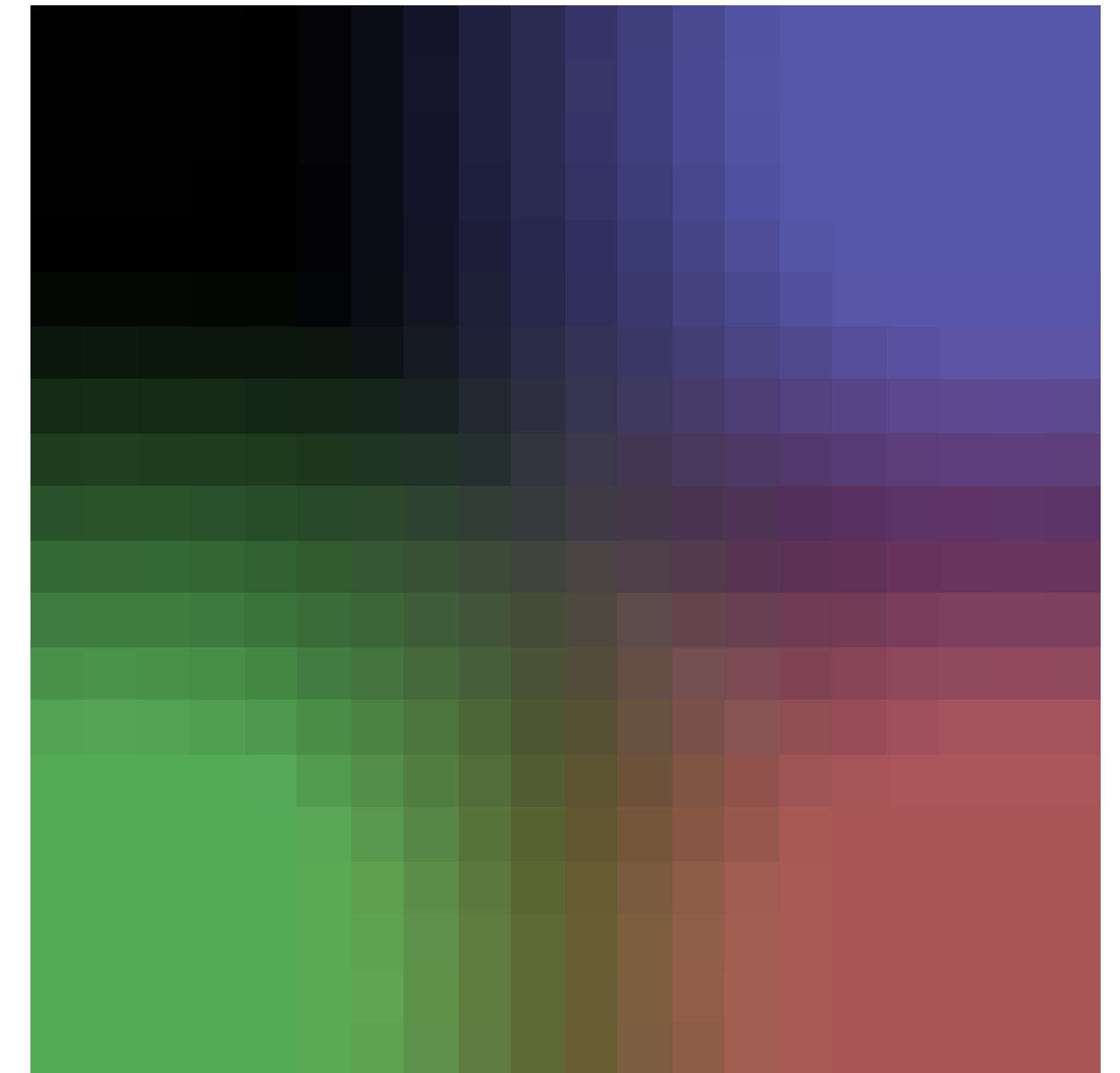
Upsampling



Nearest



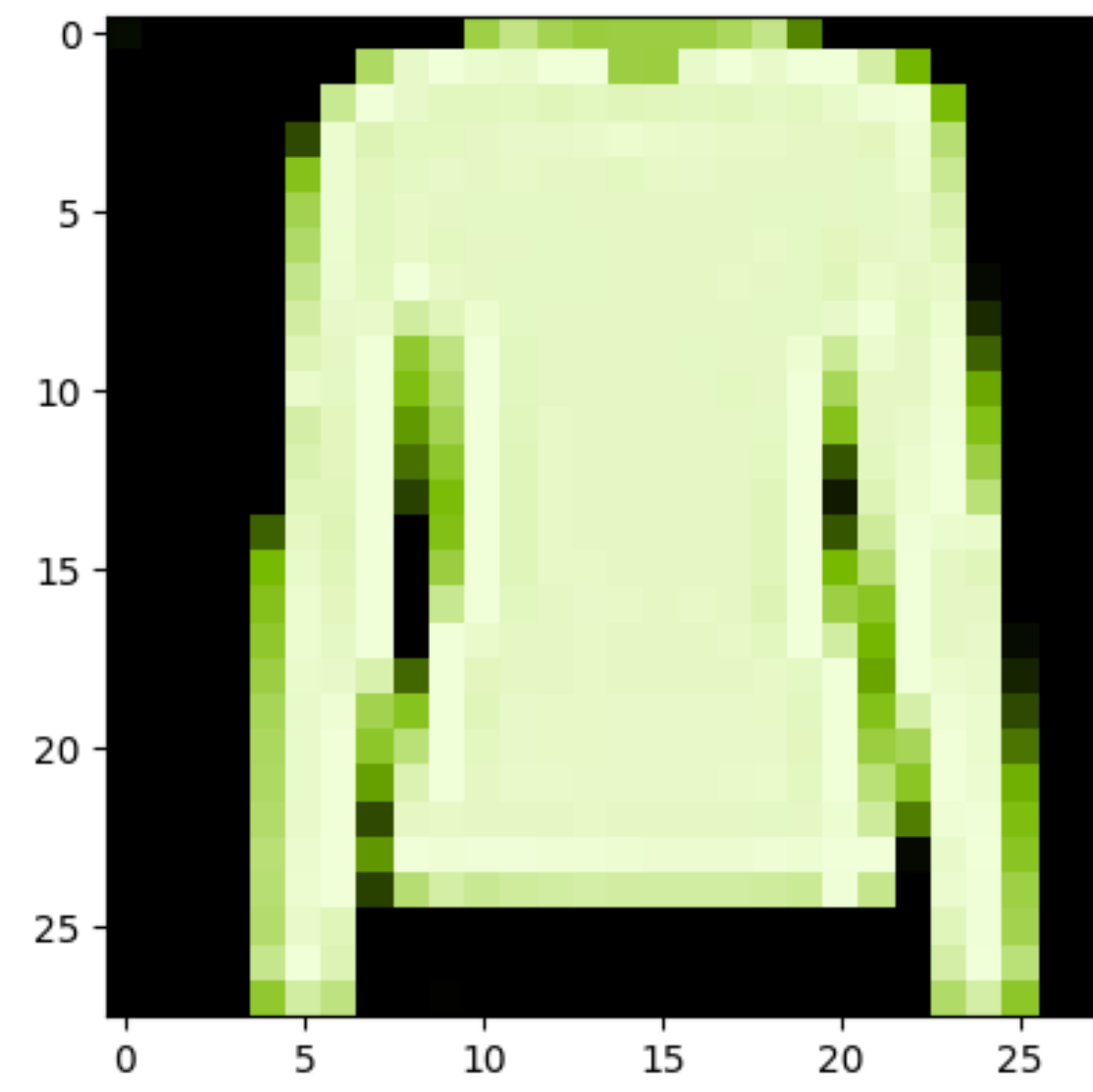
Bilinear



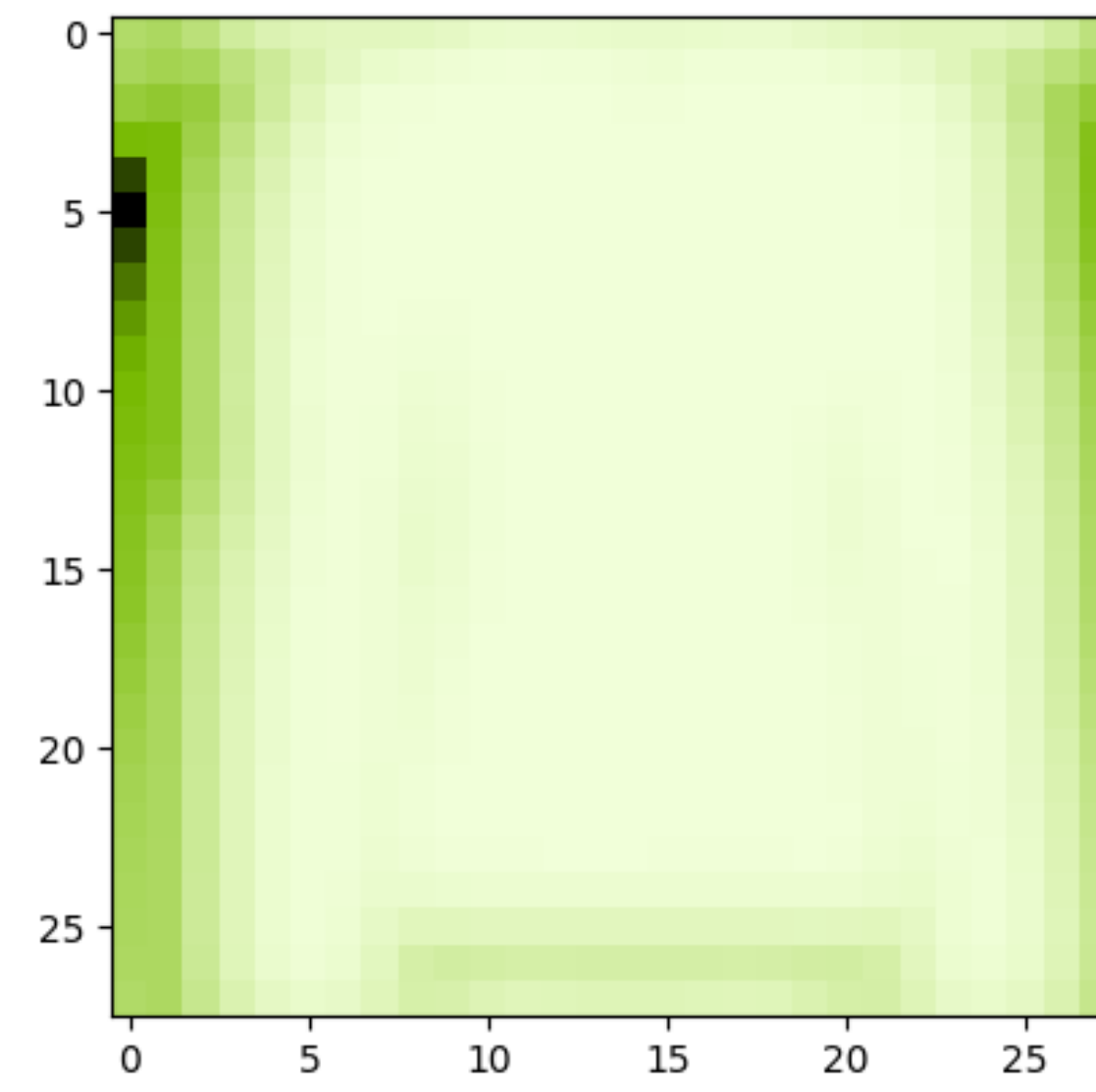
Bicubic

Deconvolution?

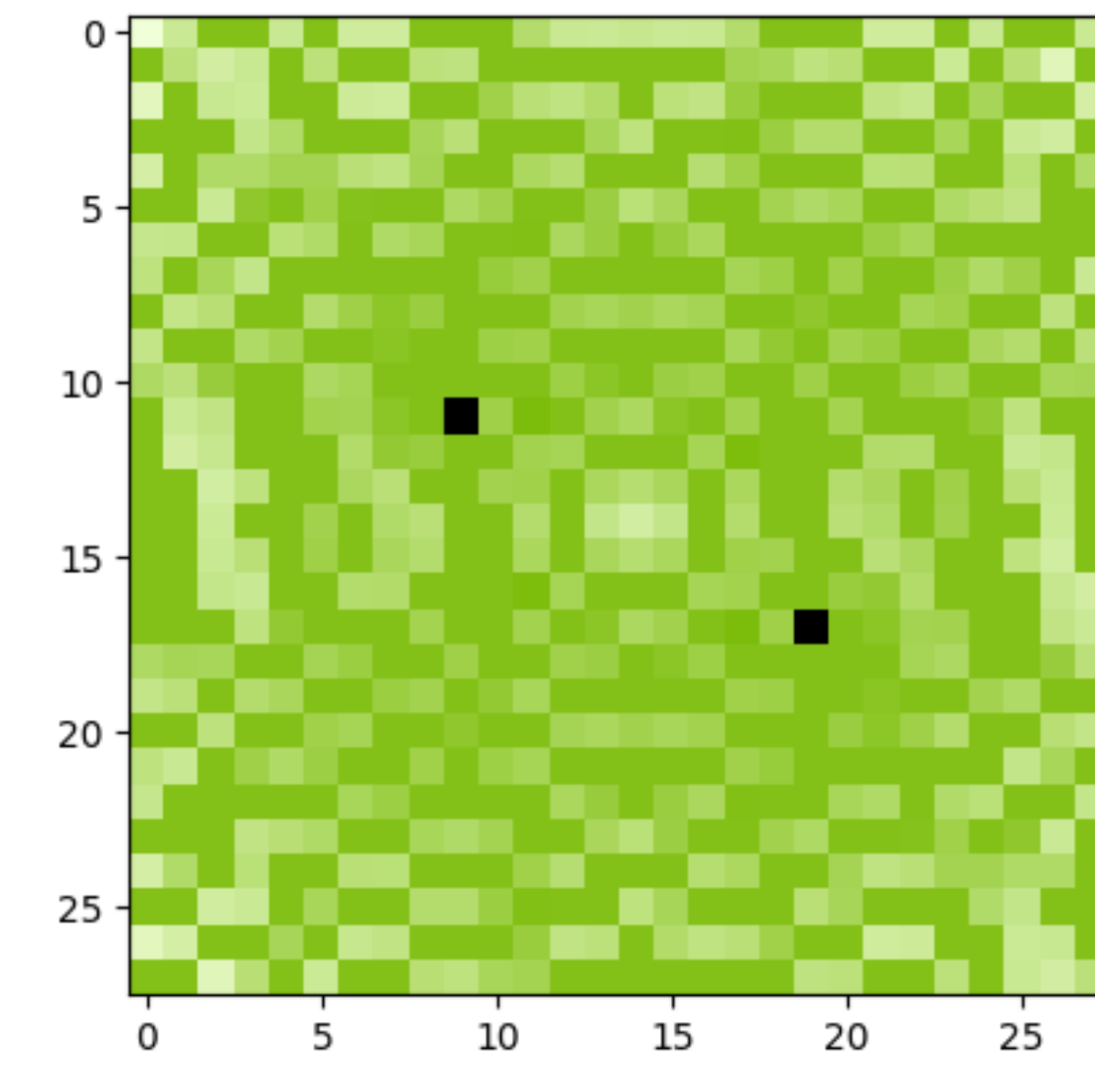
Same as Transposed Convolution?



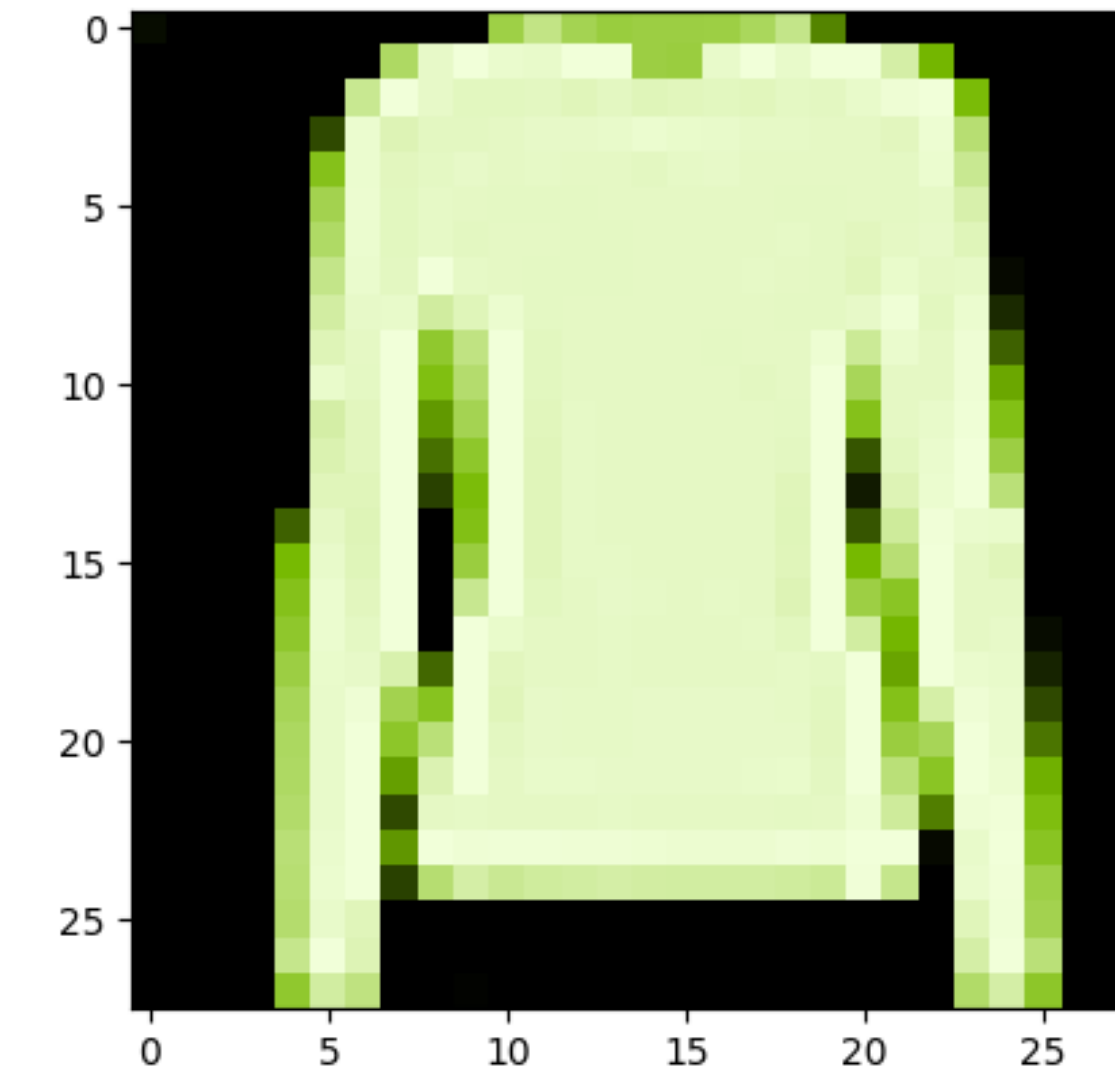
Image



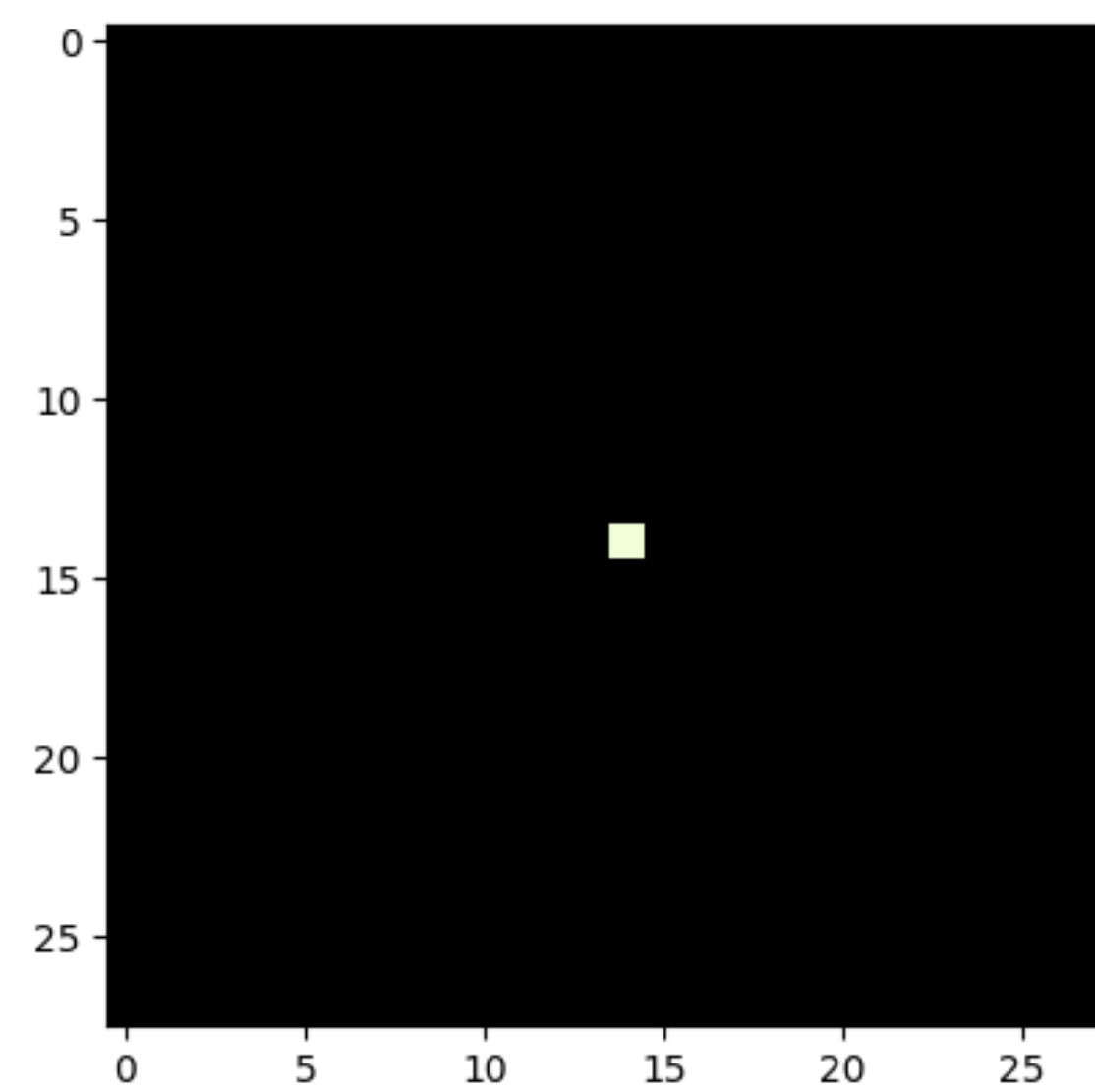
Convolved Image



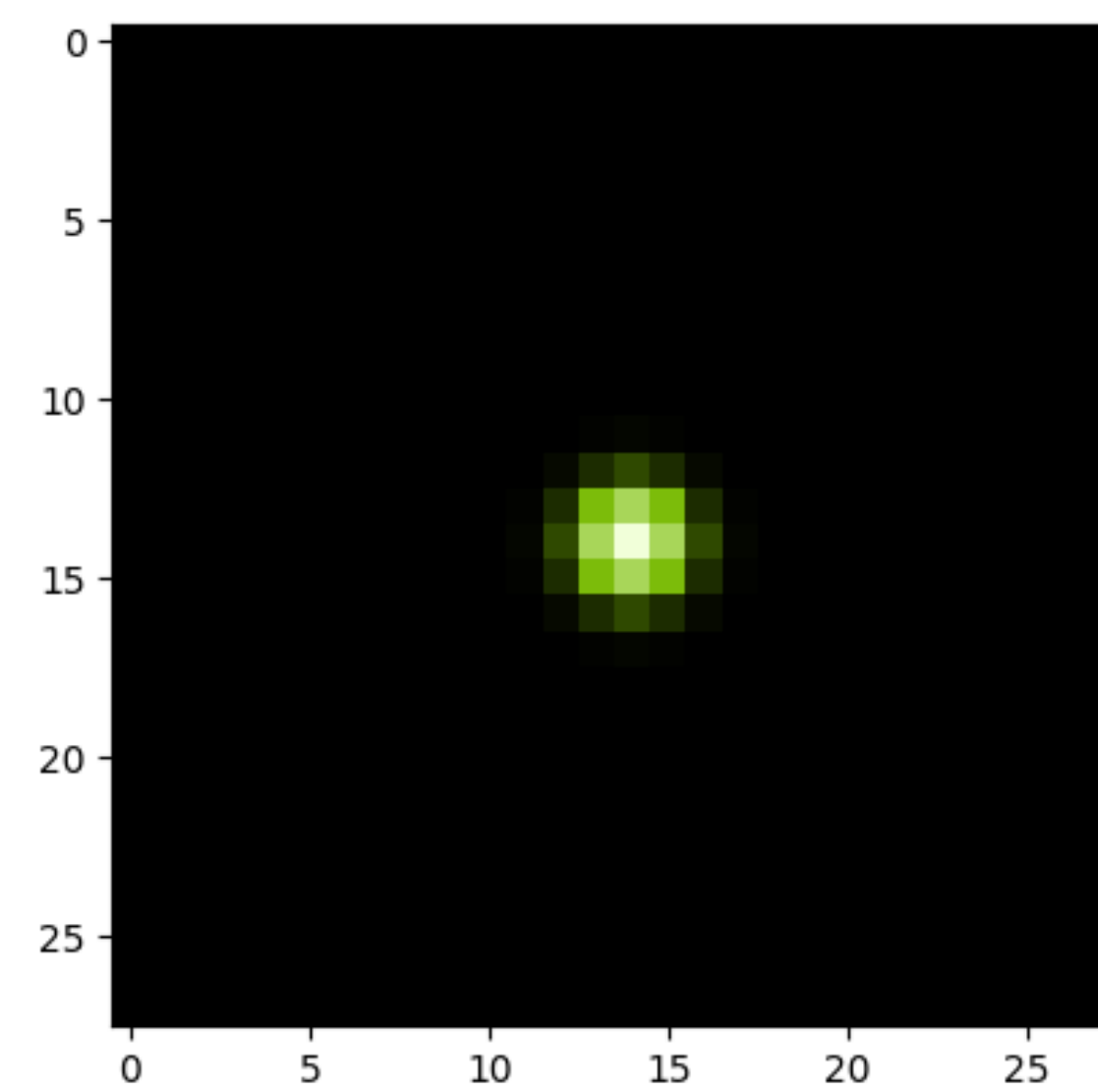
FFT Convolved



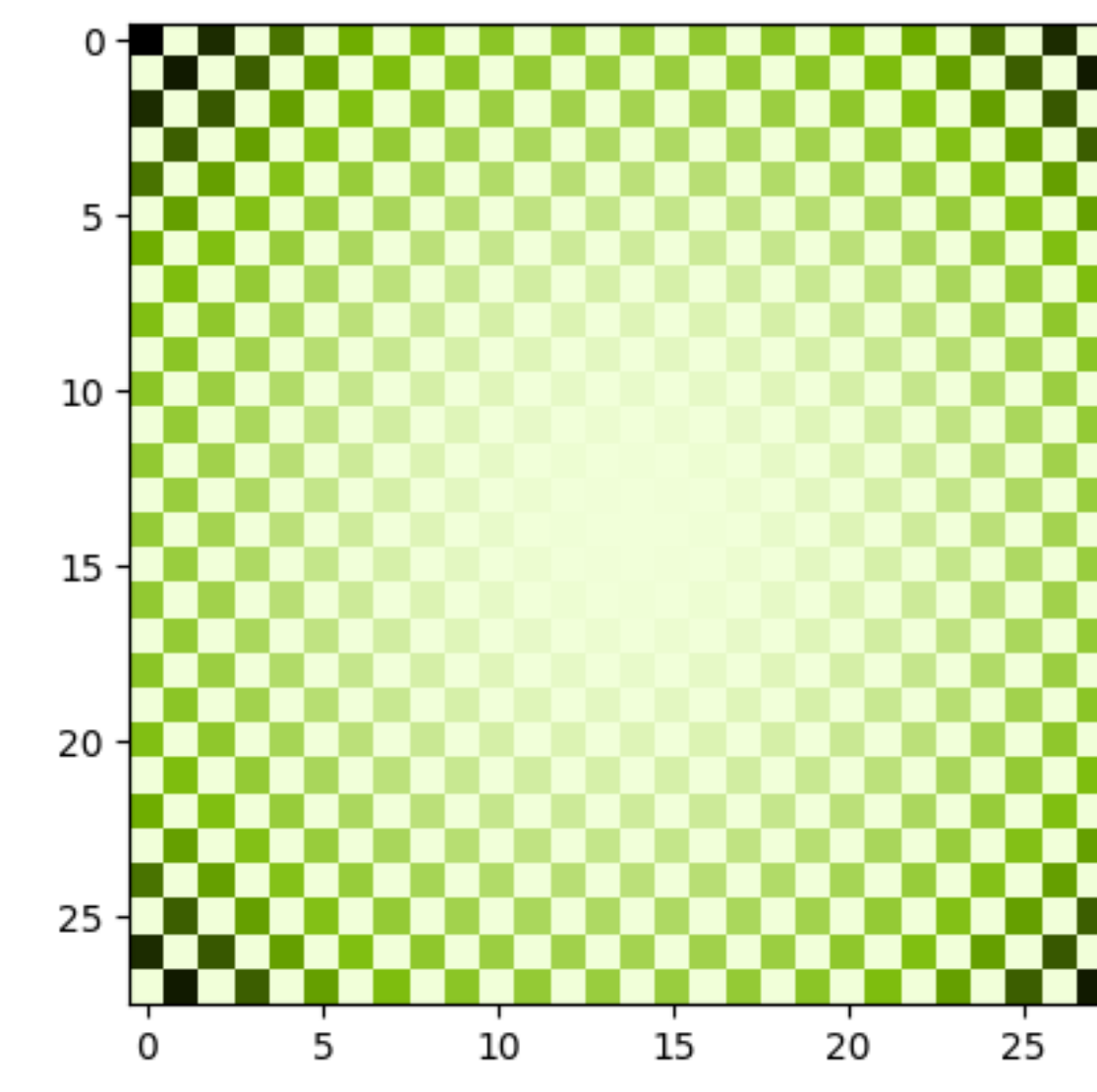
Deconvolved
Convolved Image



Point



Point Spread
Function

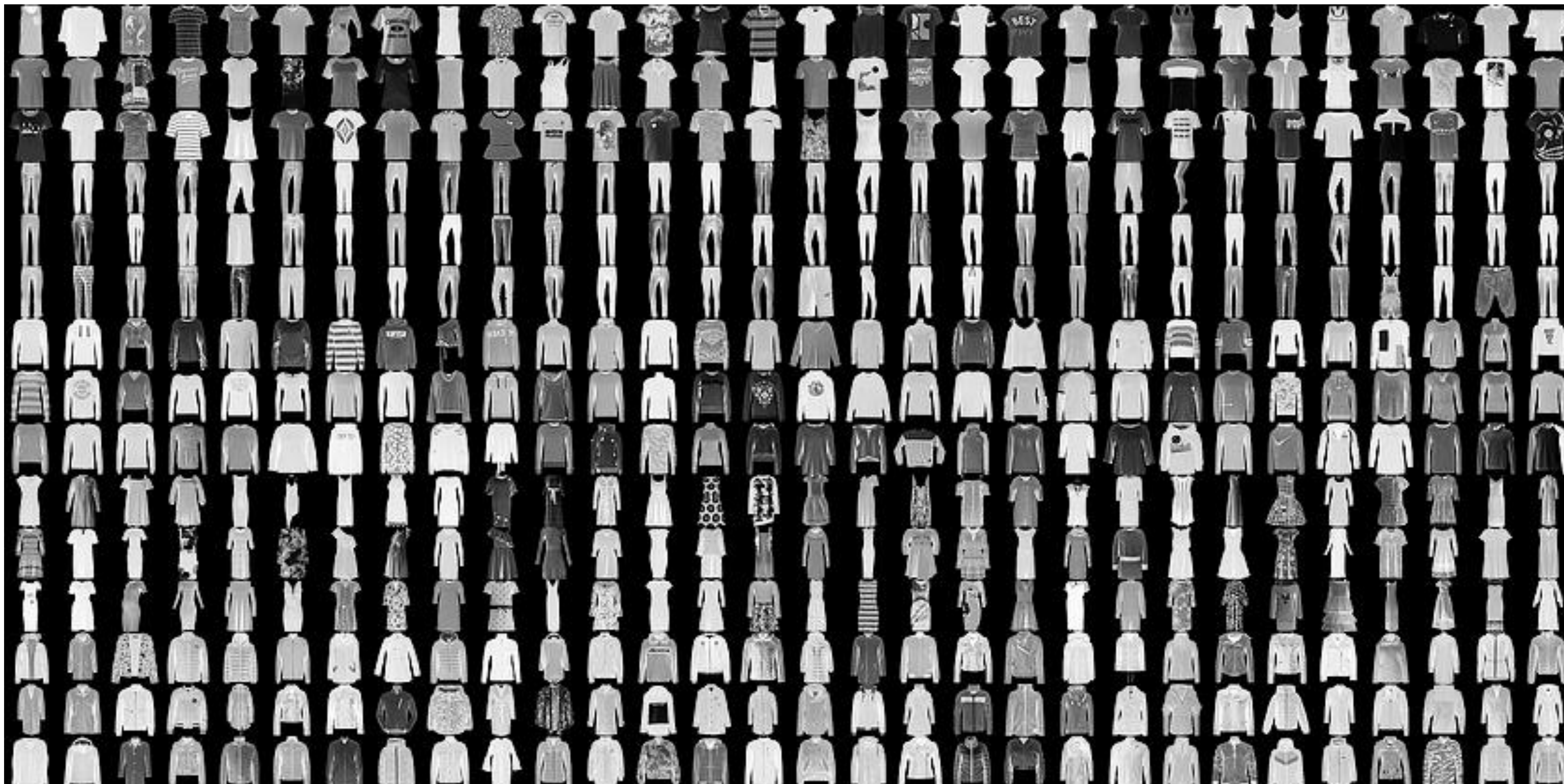


FFT Point Spread
Function

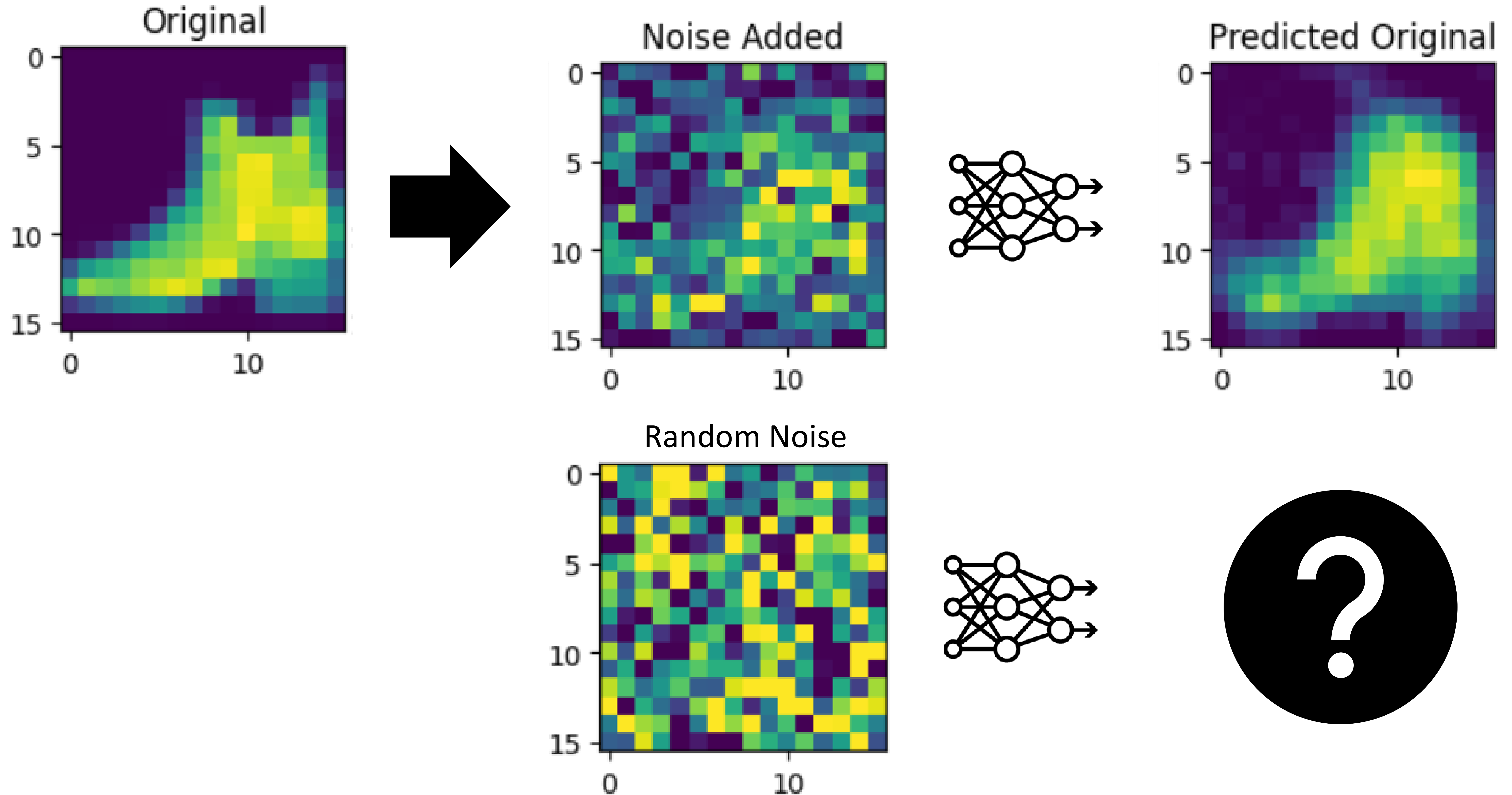
Lab

FashionMNIST

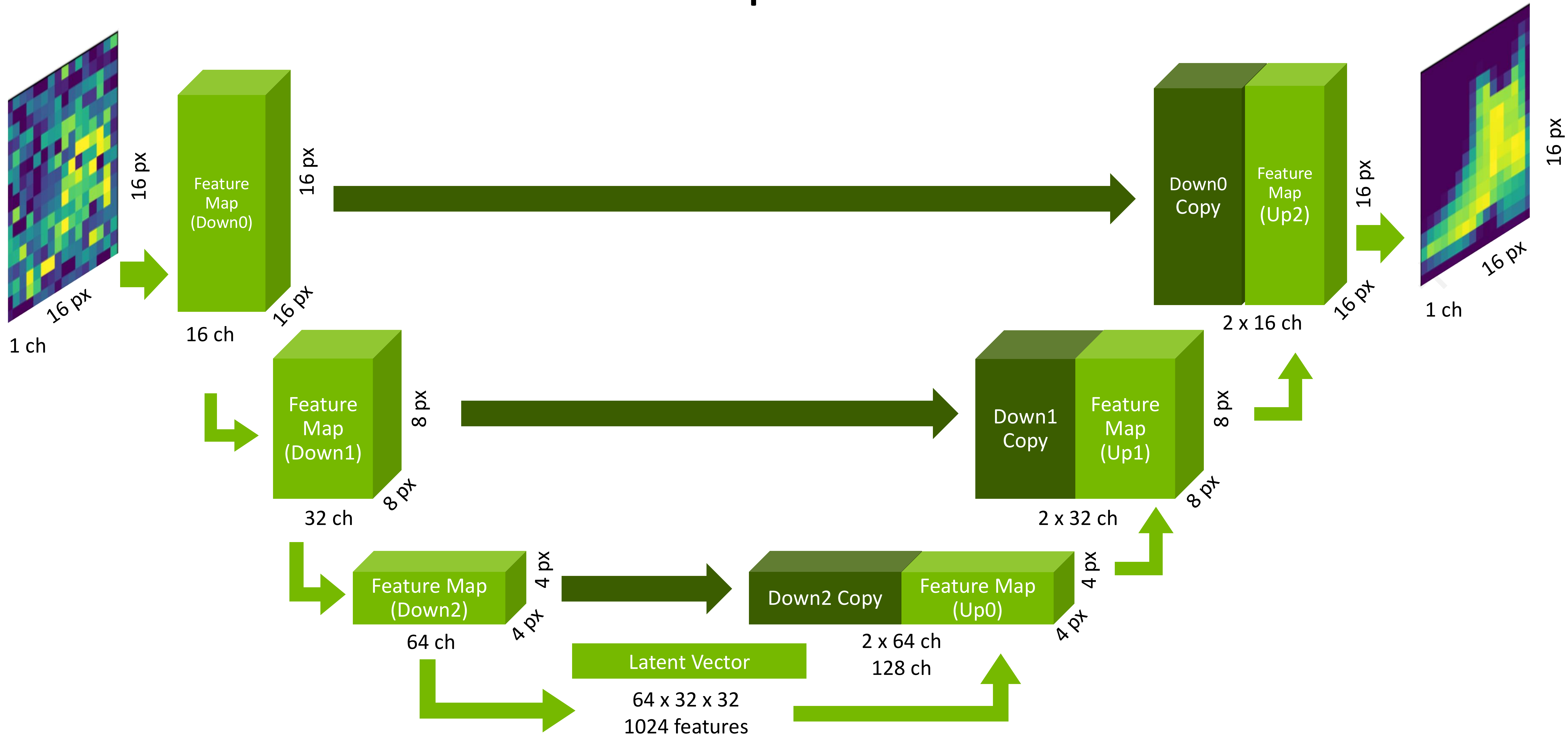
Convolutional Neural Network “Hello World”



Hypothesis: Generate an image from Noise



The Experiment



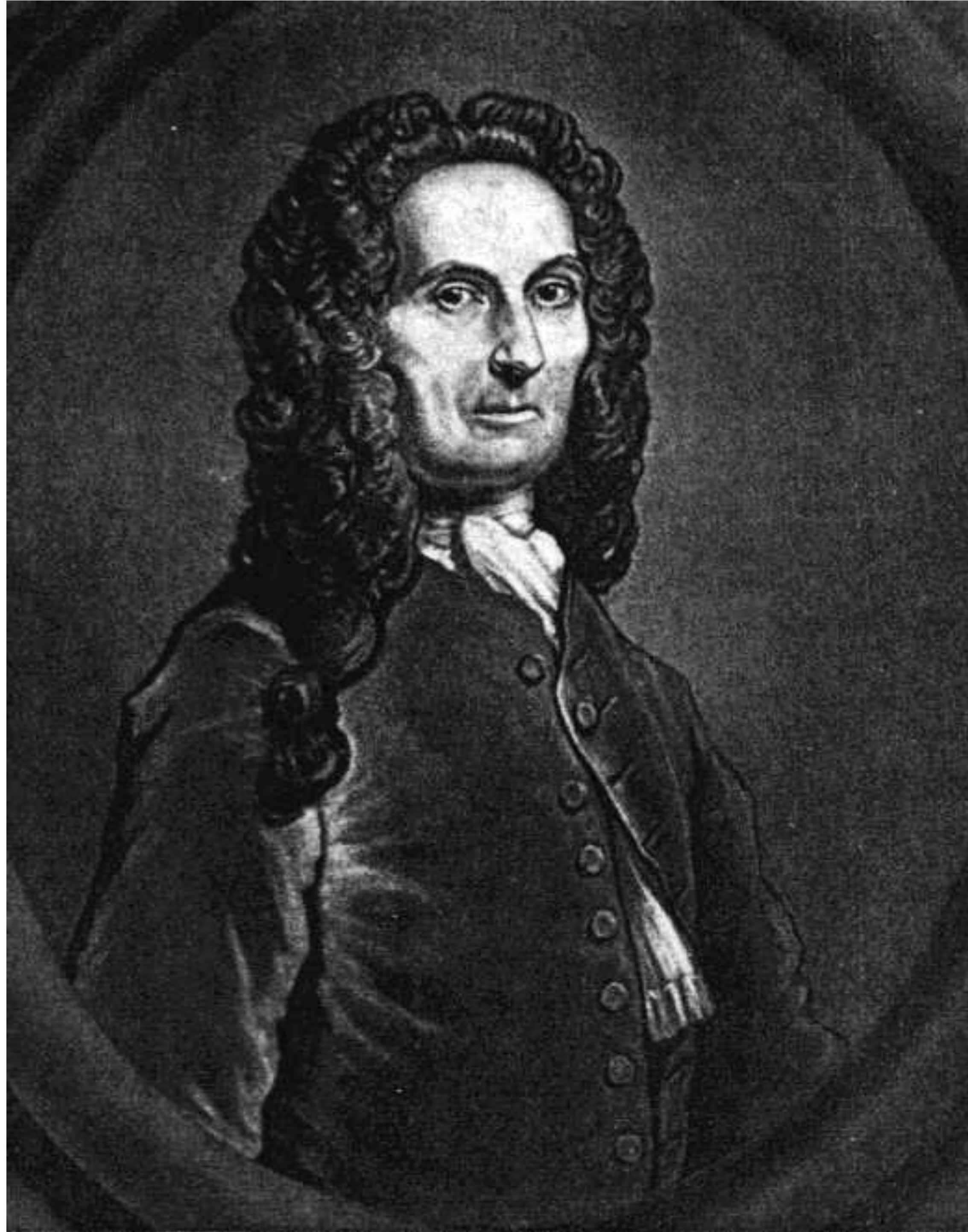
Let's get started!

1: From U-Nets to Diffusion

Appendix: The Normal Distribution

De Moivre

From Coin Flips to Bells



$$\Pr(X = k) = \binom{n}{k} p^k (1 - p)^{n-k}$$

$$p = \frac{1}{2}$$

$$\Pr(X = k) = \frac{n!}{k! (n - k)!} p^k (1 - p)^{n-k}$$

$$n = 4$$

$$\Pr(X = 2) = \frac{4!}{2! (4 - 2)!} \left(\frac{1}{2}\right)^2 \left(1 - \frac{1}{2}\right)^{4-2}$$

$$k = 2$$

$$\Pr(X = 2) = \frac{4 \cdot 3 \cdot 2 \cdot 1}{2 \cdot 1 \cdot 2 \cdot 1} \left(\frac{1}{4}\right) \left(\frac{1}{4}\right)$$

$$\Pr(X = 2) = \frac{6}{16}$$

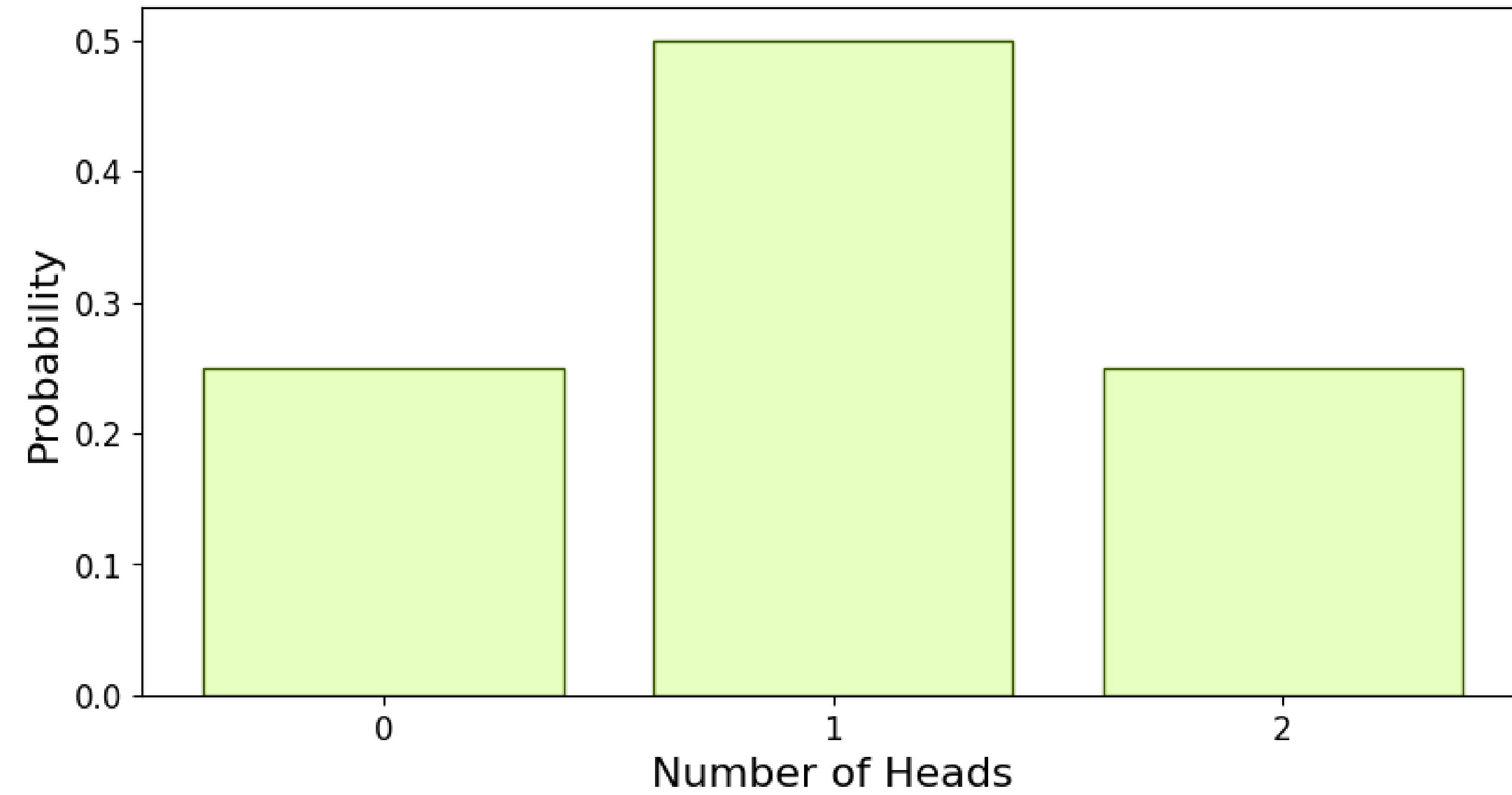
A weighted coin flipping through the air
like a cartoon



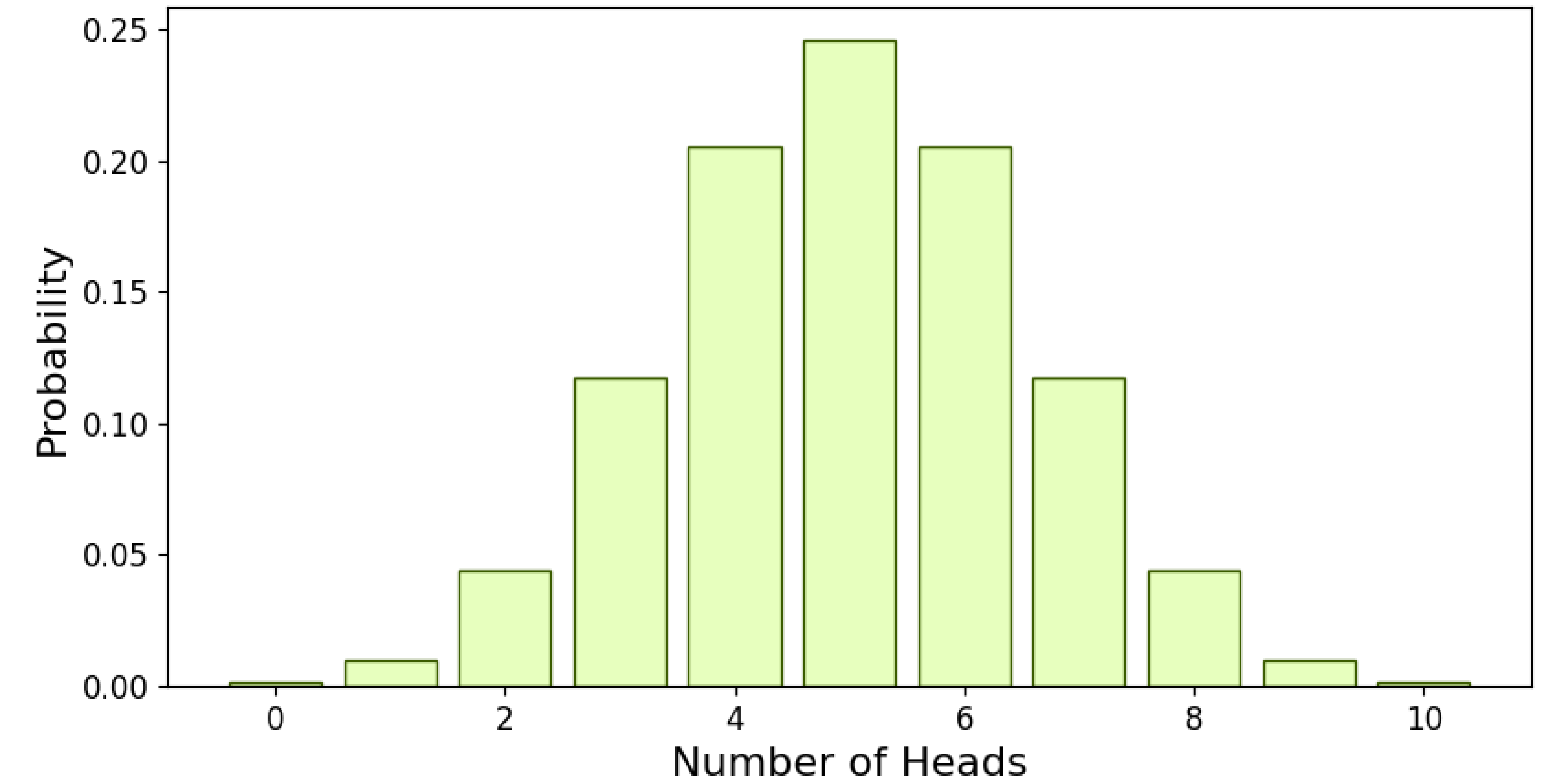
De Moivre

From Coin Flips to Bells

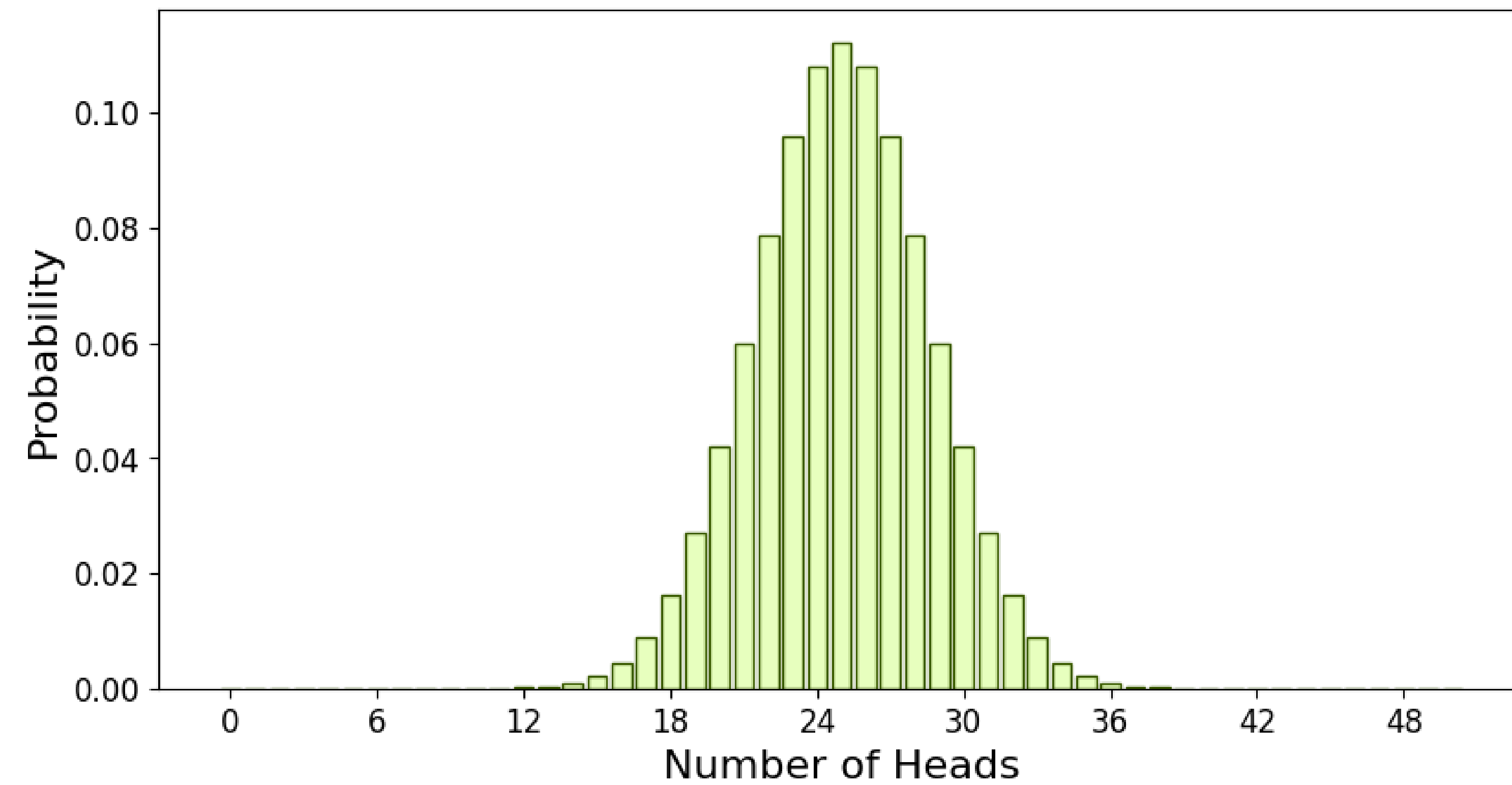
$N = 2$



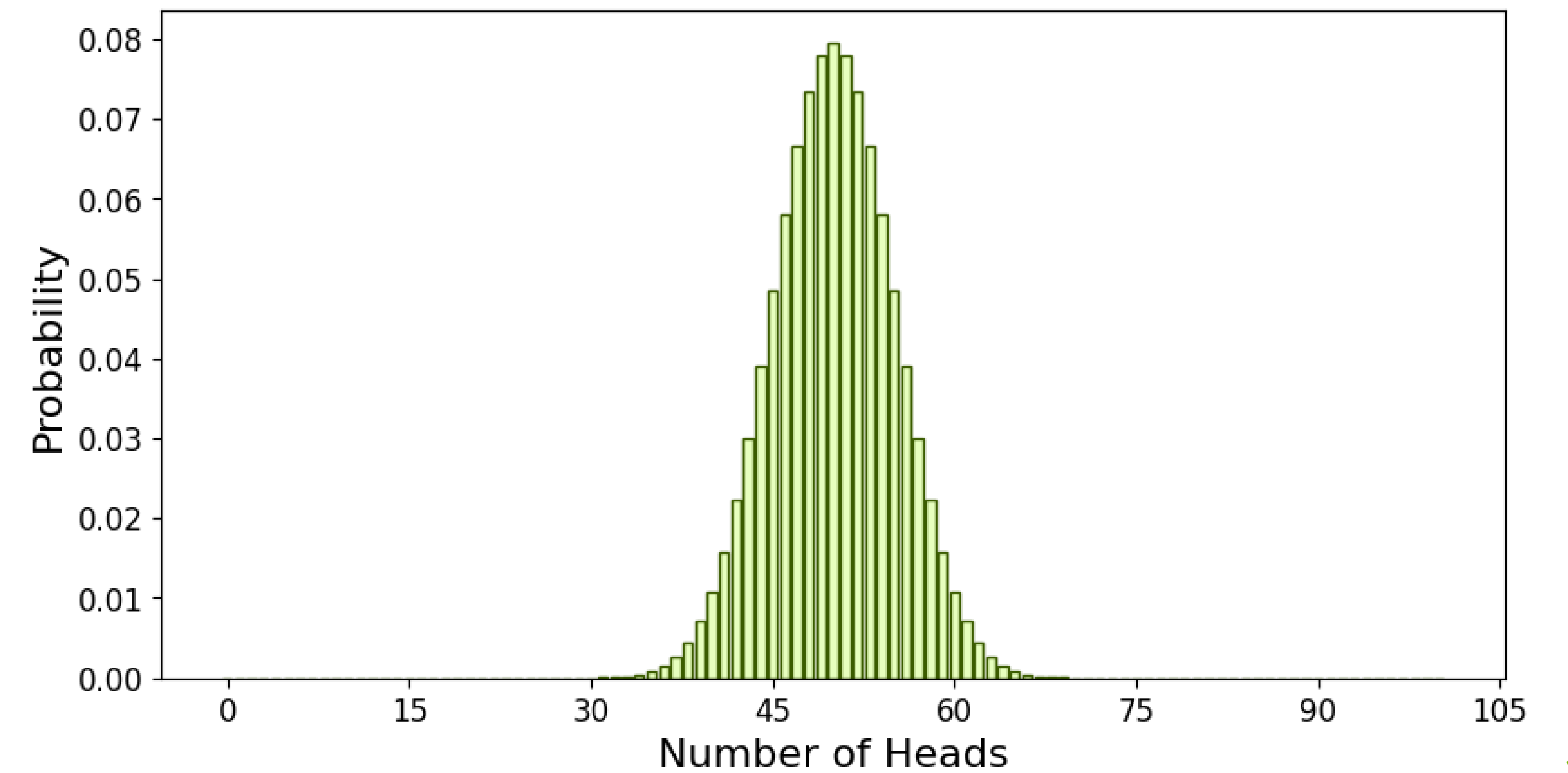
$N = 10$



$N = 50$

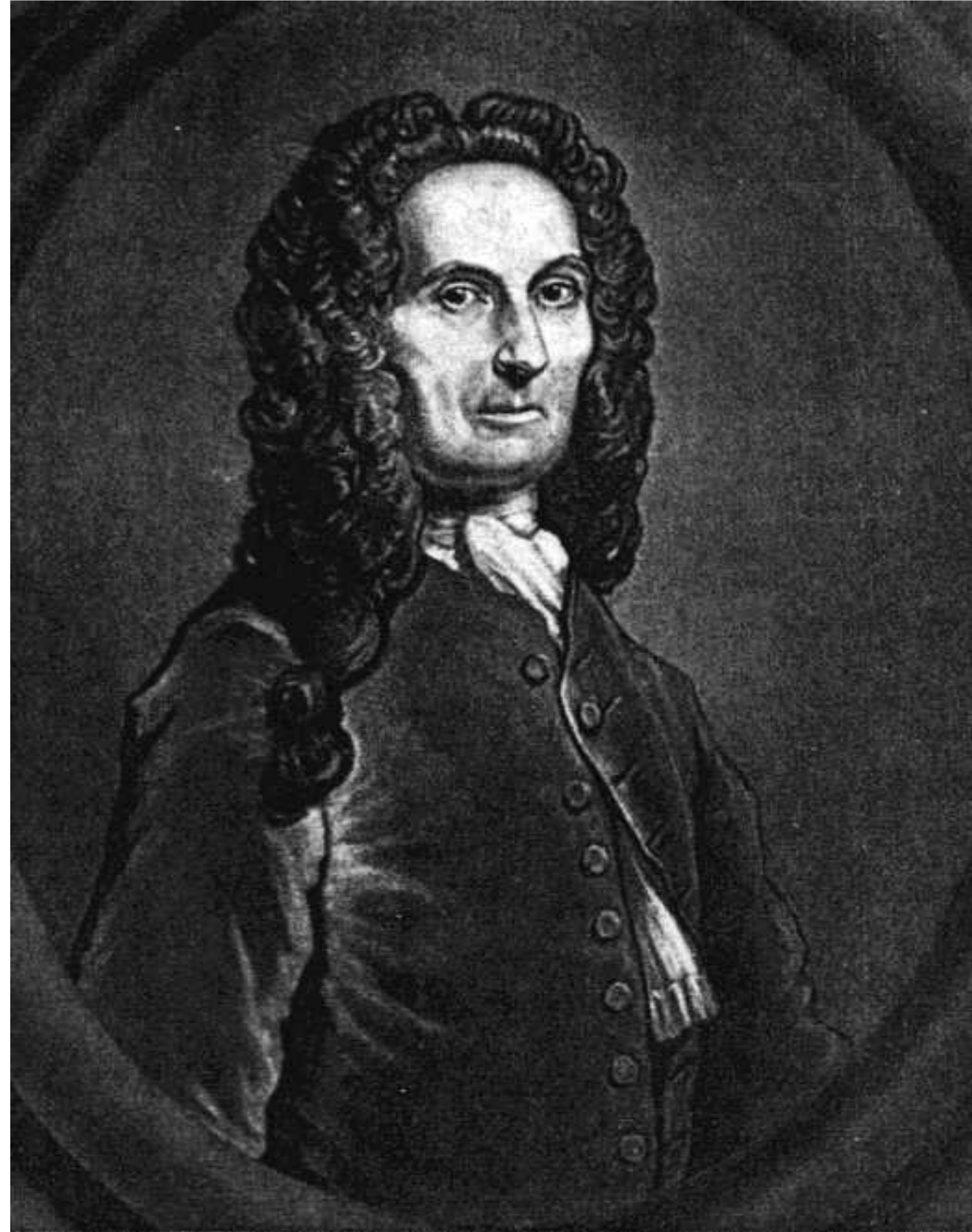


$N = 100$



De Moivre

From Coin Flips to Bells



$$\Pr(X = k) = \binom{n}{k} p^k (1 - p)^{n-k}$$

$$\Pr(X = k) = \frac{n!}{k! (n - k)!} p^k (1 - p)^{n-k}$$

$$n! \approx \sqrt{2\pi} \left(\frac{n}{e}\right)^n$$

$$\binom{n}{k} p^k q^{n-k} \approx \frac{1}{\sqrt{2\pi n p q}} e^{-\frac{(k-np)^2}{2npq}}$$

$$N(x; \mu, \sigma^2) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$$

A weighted coin flipping through the air
like a cartoon



De Moivre

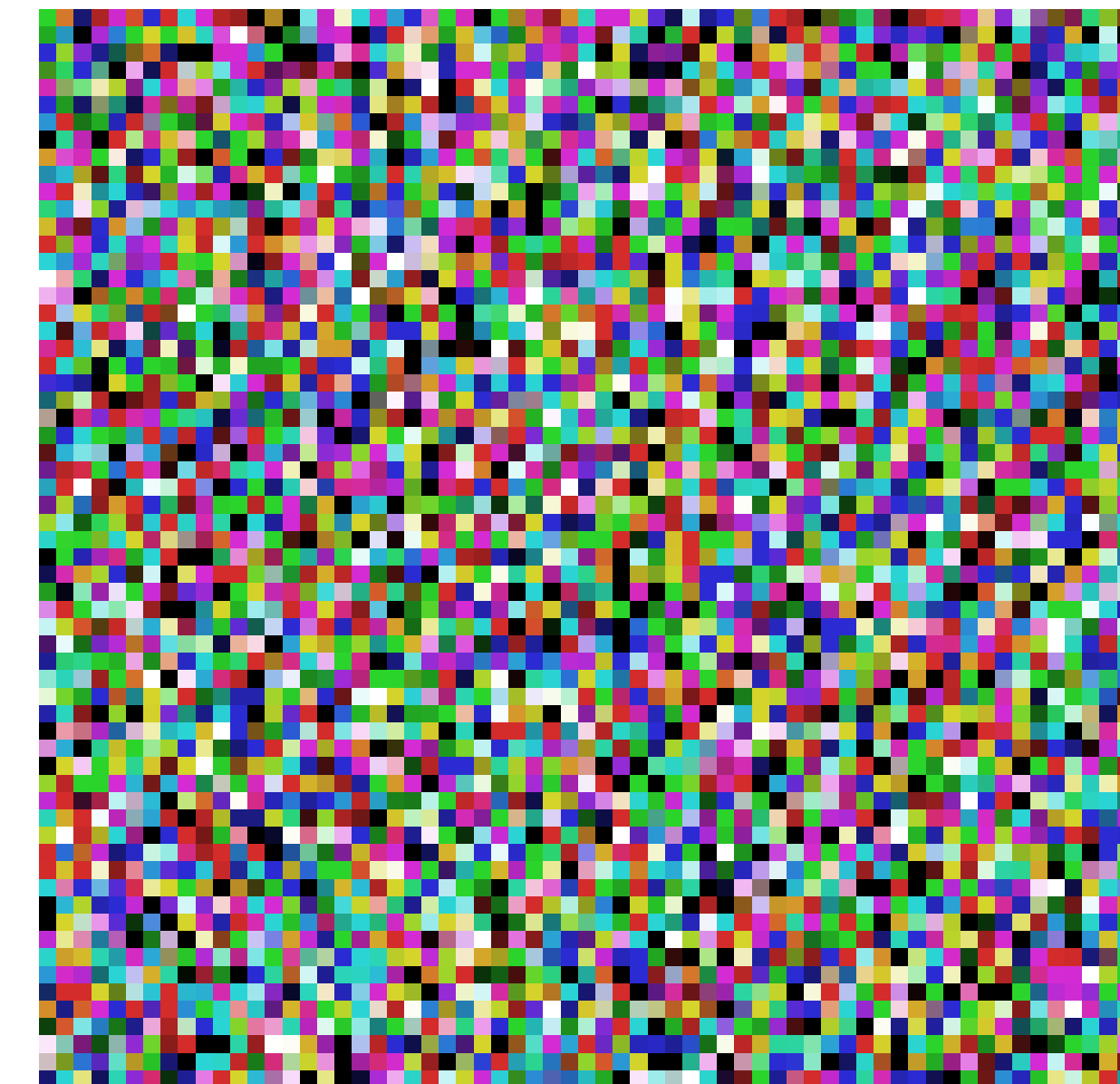
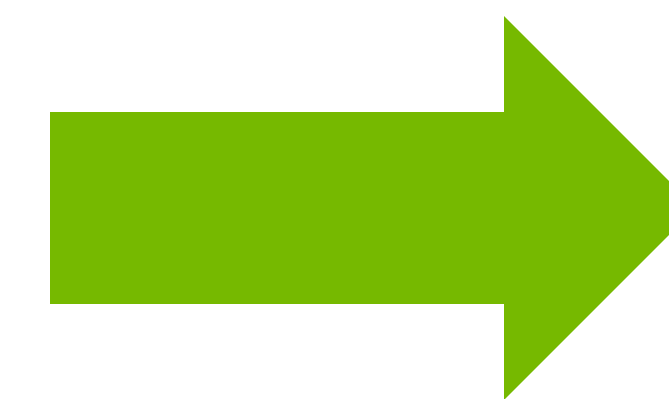
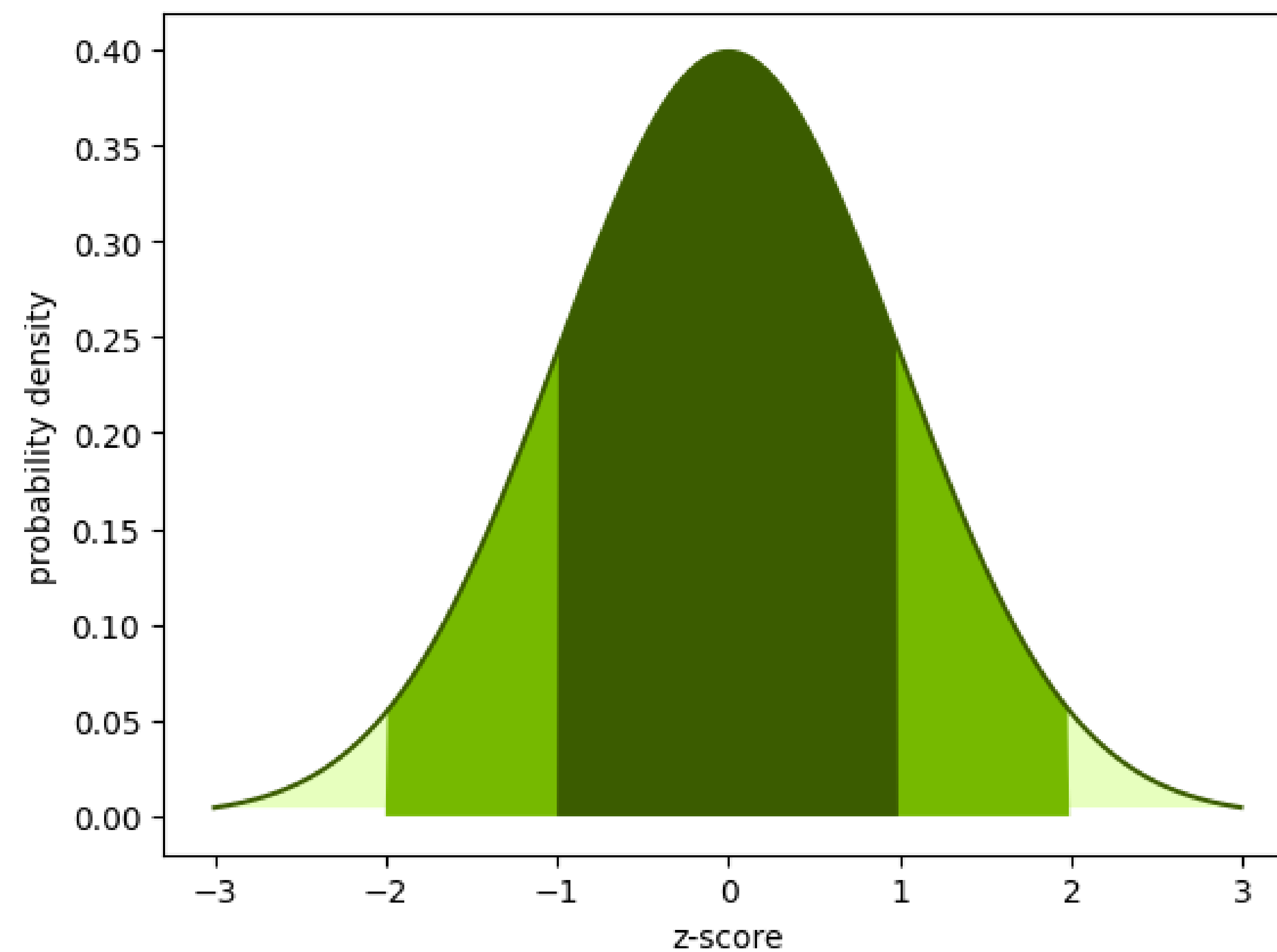
From Coin Flips to Bells

$$N(x; \mu, \sigma^2) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$$

$\mu = \text{mean, a.k.a. average}$

$\sigma = \text{standard deviation, a.k.a. spread}$

$$z = \frac{x - \mu}{\sigma}$$



Generative AI with Diffusion Models

Products Solutions Industries For You Shop Drivers Support Min-Yuh Day

Deep Learning Institute Find Training Self Paced Courses Instructor-Led Workshops Educator Programs Enterprise Solutions Certification Resources

Generative AI with Diffusion Models

Course Progress Bookmarks Updates

Generative AI with Diffusion Models Start Here 1: From U-Nets to Diffusion

Generative AI with Diffusion Models

Start Here

- 0: Server Access
- 1: From U-Nets to Diffusion**
- 2: Denoising Diffusion Probabilistic Models
- 3: Optimizations
- 4: Classifier-Free Diffusion Guidance
- 5: CLIP
- 6: Wrap-up and Assessment

Next Steps

Feedback

Previous Next

17:54 / 17:55 ▶ Speed 1.0x

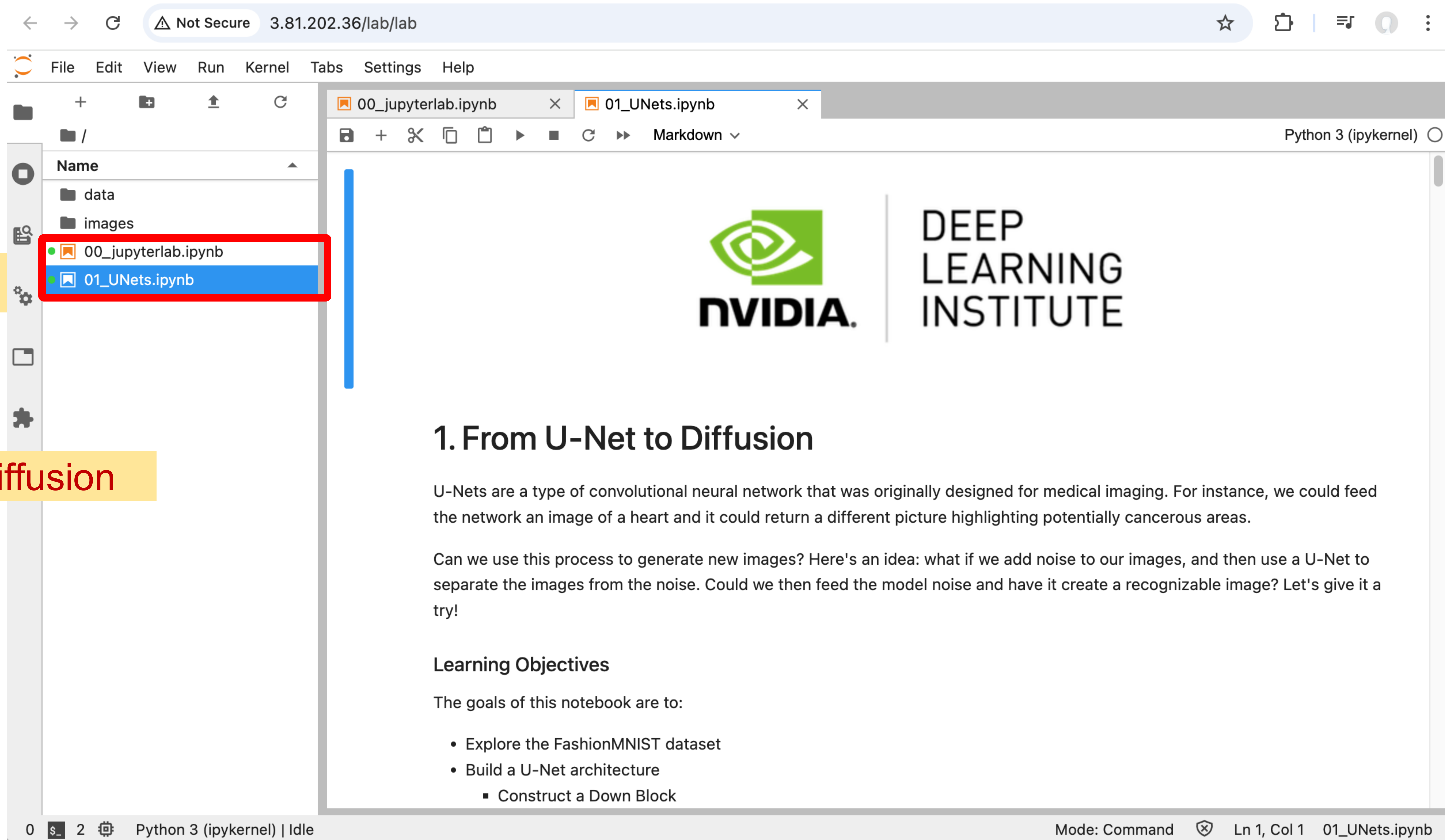
DEEP LEARNING INSTITUTE This Lab 0 : 10 : 54 / 1 : 30 : 00
Course 8 : 18 : 49 / 24 : 00 : 00

LAUNCH STOP TASK

Generative AI with Diffusion Models
Part 1: From U-Nets to Diffusion


1: From U-Nets to Diffusion

Generative AI with Diffusion Models



00_jupyterlab.ipynb | 01_UNets.ipynb

Python 3 (ipykernel)



DEEP
LEARNING
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1. From U-Net to Diffusion

U-Nets are a type of convolutional neural network that was originally designed for medical imaging. For instance, we could feed the network an image of a heart and it could return a different picture highlighting potentially cancerous areas.

Can we use this process to generate new images? Here's an idea: what if we add noise to our images, and then use a U-Net to separate the images from the noise. Could we then feed the model noise and have it create a recognizable image? Let's give it a try!

Learning Objectives

The goals of this notebook are to:

- Explore the FashionMNIST dataset
- Build a U-Net architecture
 - Construct a Down Block

0 \$ 2 Python 3 (ipykernel) | Idle Mode: Command Ln 1, Col 1 01_UNets.ipynb

01_UNets.ipynb

1: From U-Nets to Diffusion



Generative AI with Diffusion Models

Part 2: Denoising Diffusion Probabilistic Models

Agenda

- Part 1: From U-Nets to Diffusion
- Part 2: Denoising Diffusion Probabilistic Models
- Part 3: Optimizations
- Part 4: Classifier-Free Diffusion Guidance
- Part 5: CLIP
- Part 6: Wrap-up & Assessment

Diffusion Inspiration

Thermodynamic Origins



Adobe Firefly

Deep Unsupervised Learning using Nonequilibrium Thermodynamics

Jascha Sohl-Dickstein Stanford University	JASCHA@STANFORD.EDU
Eric A. Weiss University of California, Berkeley	EAWISS@BERKELEY.EDU
Niru Maheswaranathan Stanford University	NIRUM@STANFORD.EDU
Surya Ganguli Stanford University	SGANGULI@STANFORD.EDU

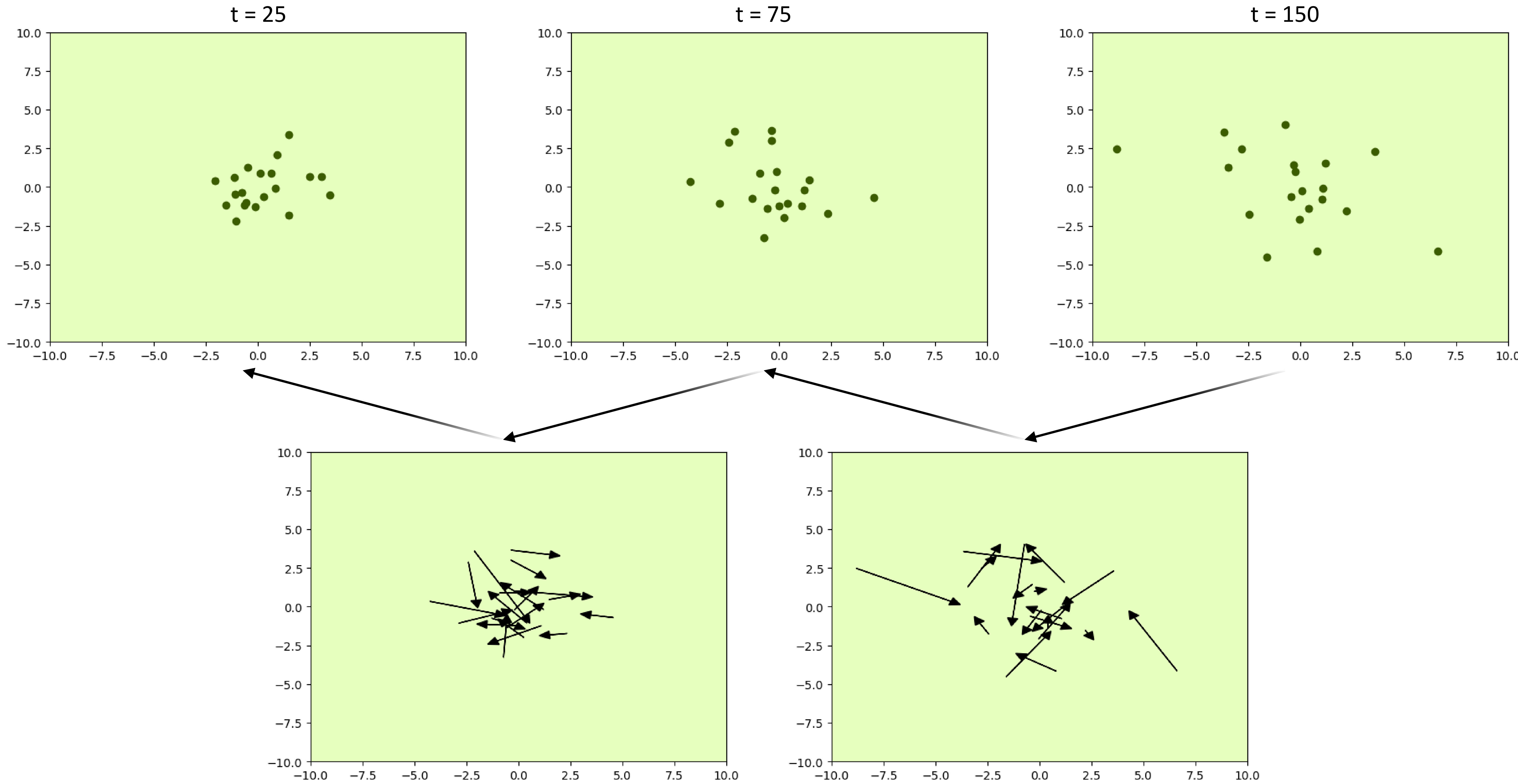
Abstract

A central problem in machine learning involves modeling complex data-sets using highly flexible families of probability distributions in which learning, sampling, inference, and evaluation

these models are unable to aptly describe structure in rich datasets. On the other hand, models that are *flexible* can be molded to fit structure in arbitrary data. For example, we can define models in terms of any (non-negative) function $\phi(\mathbf{x})$ yielding the flexible distribution $p(\mathbf{x}) = \frac{\phi(\mathbf{x})}{Z}$, where Z is a normalization constant. However, computing this

Green food coloring dissolving in a glass of water

Thermodynamic Origins



Source: NVIDIA DLI (2024), Generative AI with Diffusion Models, https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S-FX-14+V1

Denoising Diffusion Probabilistic Models

Getting Lost in the Noise

Denoising Diffusion Probabilistic Models

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Ajay Jain

UC Berkeley

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Pieter Abbeel

UC Berkeley

pabbeel@cs.berkeley.edu

Abstract

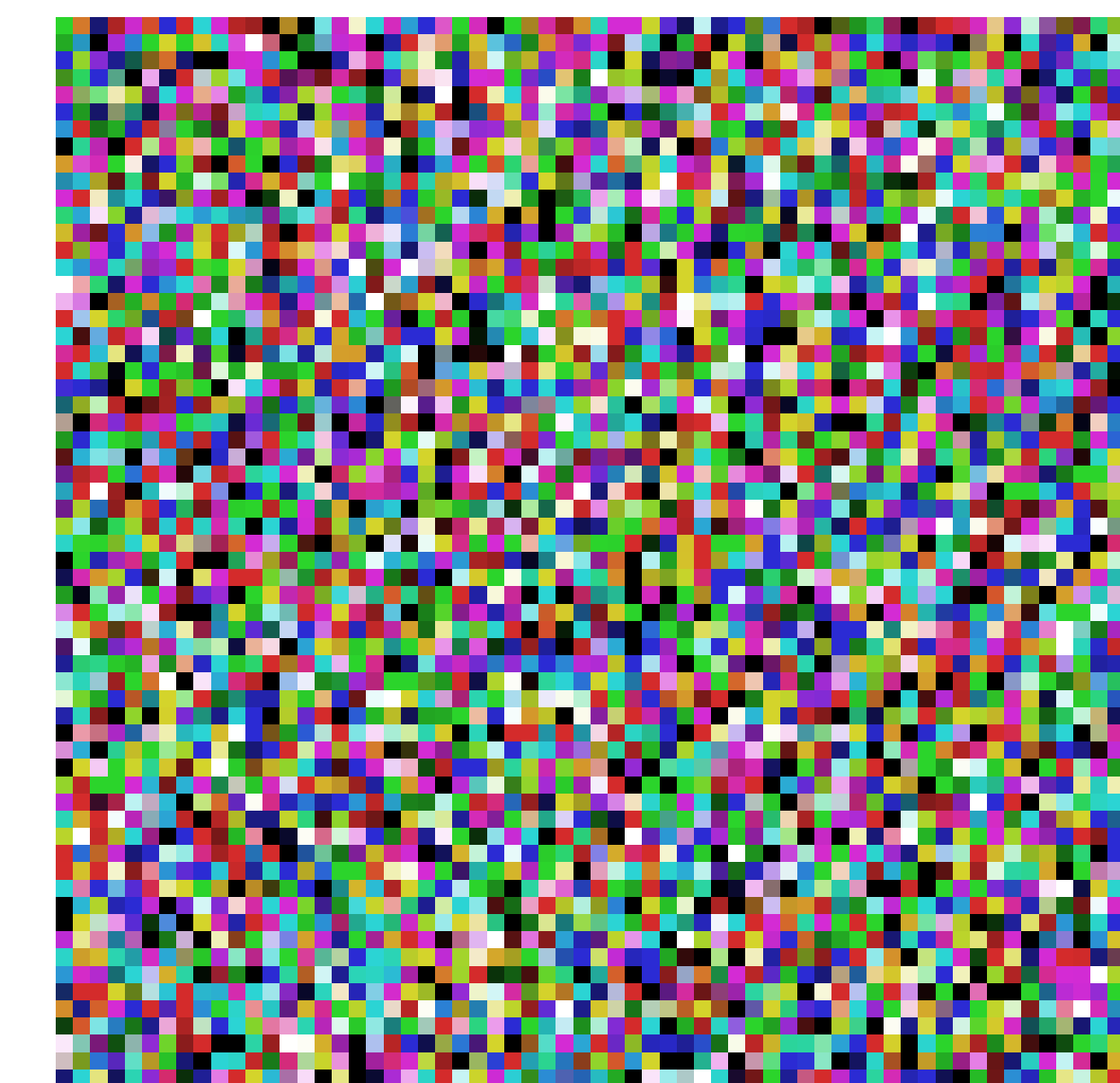
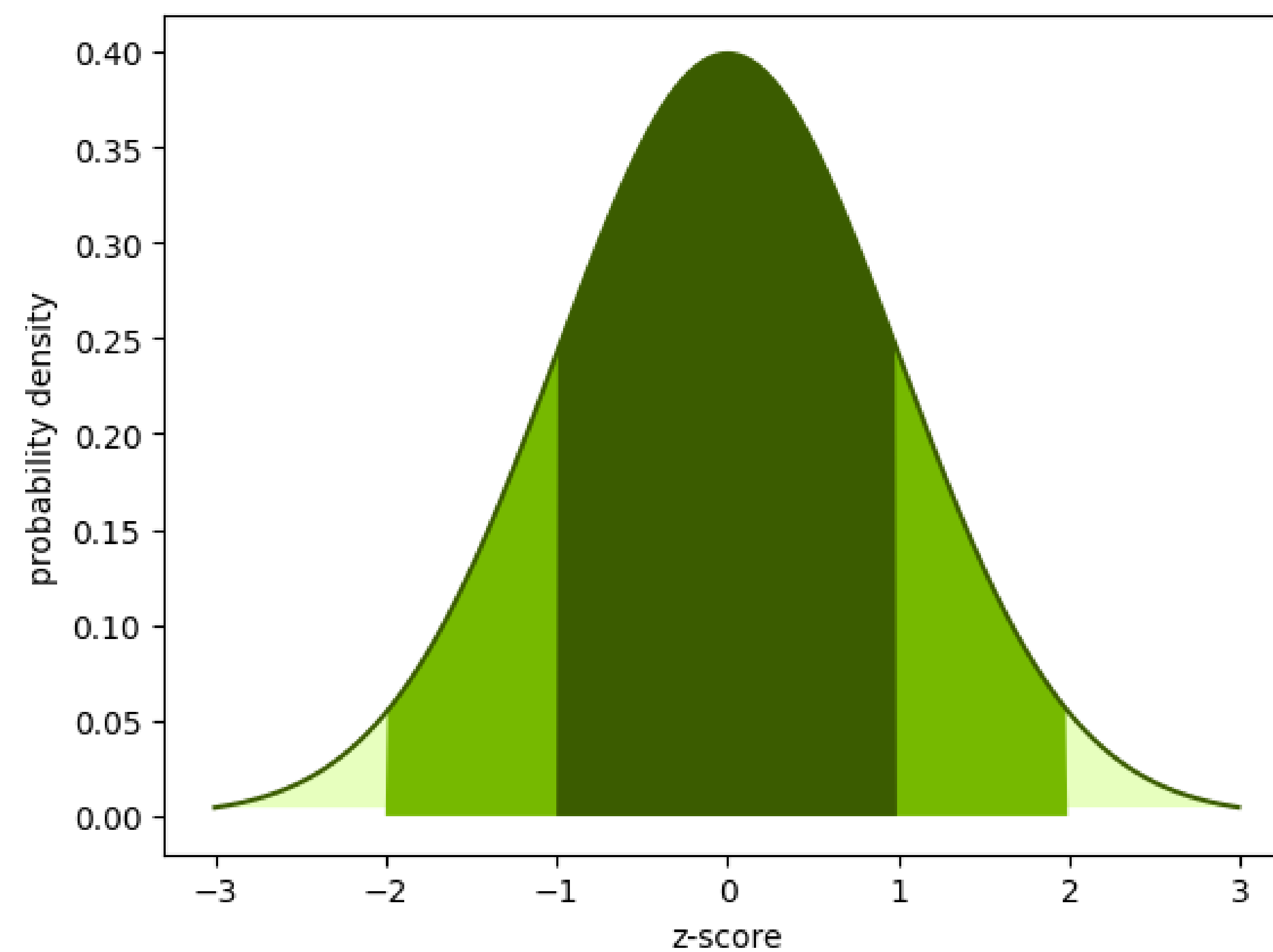
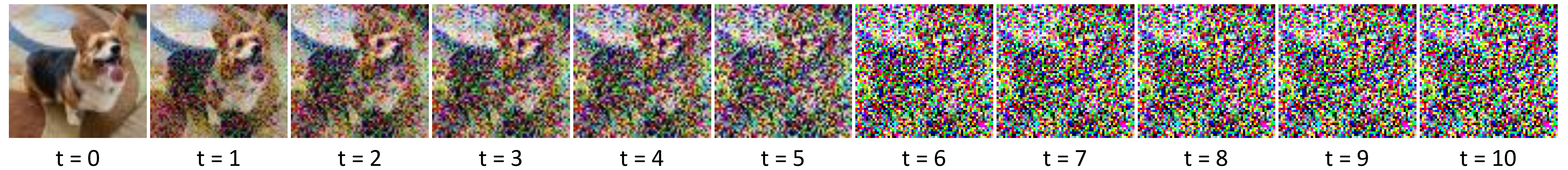
We present high quality image synthesis results using diffusion probabilistic models, a class of latent variable models inspired by considerations from nonequilibrium thermodynamics. Our best results are obtained by training on a weighted variational bound designed according to a novel connection between diffusion probabilistic models and denoising score matching with Langevin dynamics, and our models naturally admit a progressive lossy decompression scheme that can be interpreted as a



Forward Diffusion

Getting Lost in the Noise

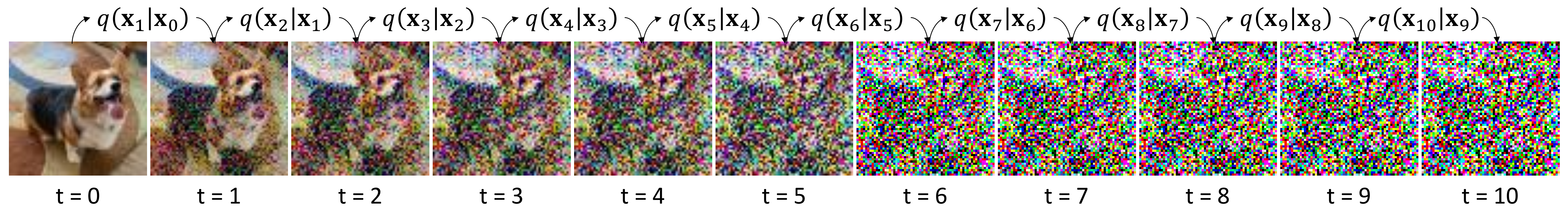
Forward Diffusion



$$N(x; \mu, \sigma^2) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$$

Getting Lost in the Noise

Forward Diffusion



$$\beta = [0.0001, 0.0023, 0.0045, 0.0067, \dots, 0.0200]$$

$t=0$ $t=1$ $t=3$ $t=4$ $t=10$

$$T = 10$$

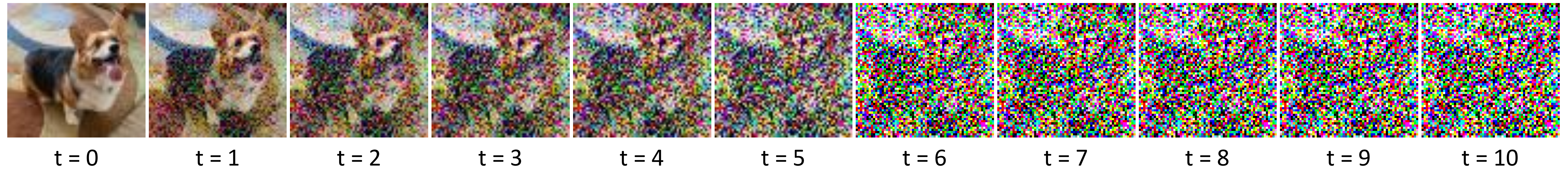
Total number of timesteps

$$\alpha = 1 - \beta$$

Convenient shorthand

Getting Lost in the Noise

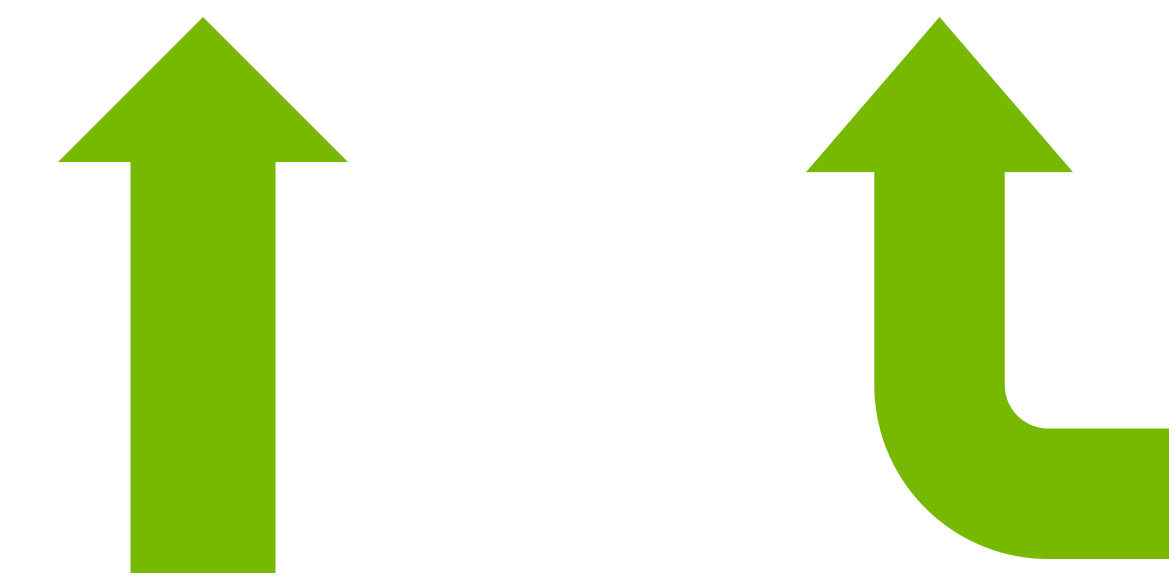
Forward Diffusion



$$q(\mathbf{x}_t | \mathbf{x}_{t-1}) = N(\mathbf{x}_t; \sqrt{1 - \beta_t} \cdot \mathbf{x}_{t-1}, \beta_t \cdot \mathbf{I})$$

Code:

```
noise = torch.randn_like(x_t)
x_t = torch.sqrt(1 - B[t]) * x_t
      + torch.sqrt(B[t]) * noise
```



Step 1:

- Generate noise from a standard normal distribution
- Multiply result by $\sqrt{\beta_t}$

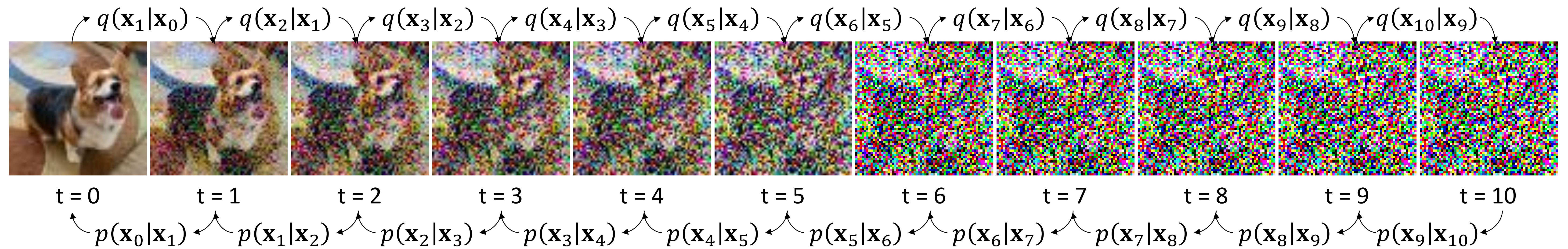
Step 2:

- Multiply image at previous step by $\sqrt{1 - \beta_t}$
- Add it to the result from step 1

Reverse Diffusion

Getting Lost in the Noise

Reverse Diffusion

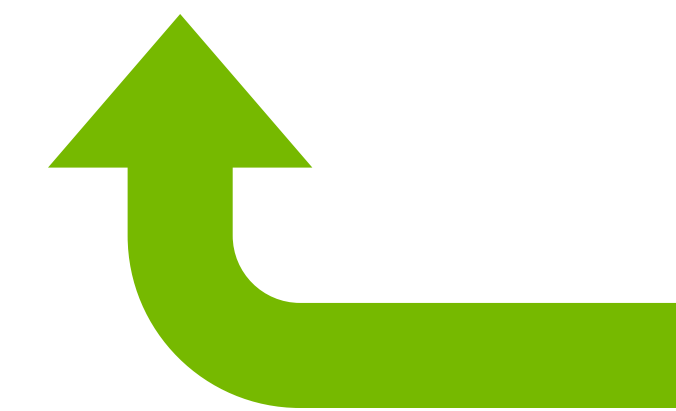


$$p(\mathbf{x}_{t-1}|\mathbf{x}_t) = N(\mathbf{x}_{t-1}; \boldsymbol{\mu}_\theta(\mathbf{x}_t, t), \boldsymbol{\Sigma}_\theta(\mathbf{x}_t, t))$$

Difficult to calculate

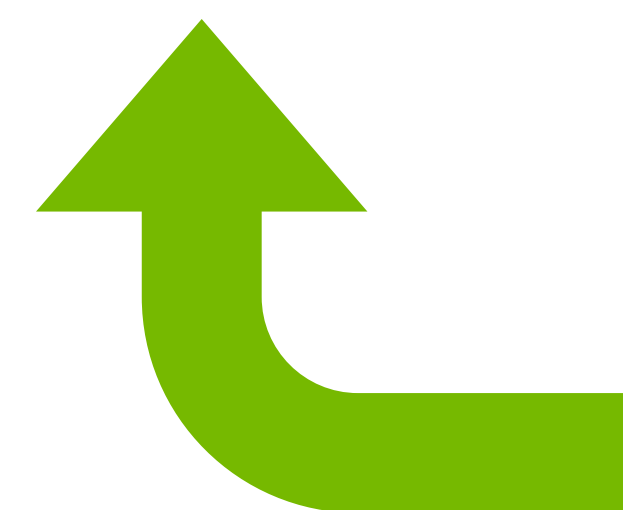
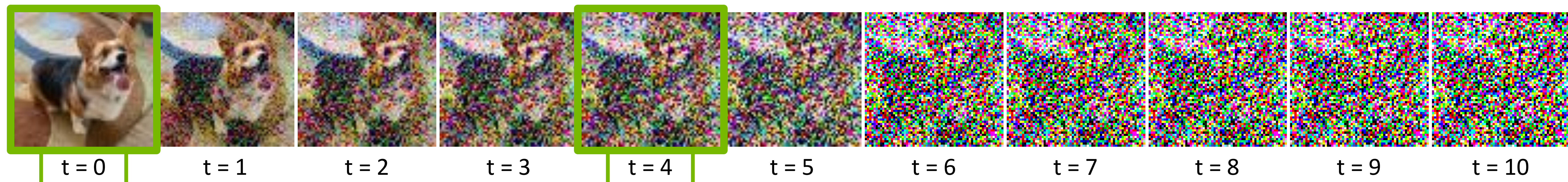


Approximate average used to create \mathbf{x}_t

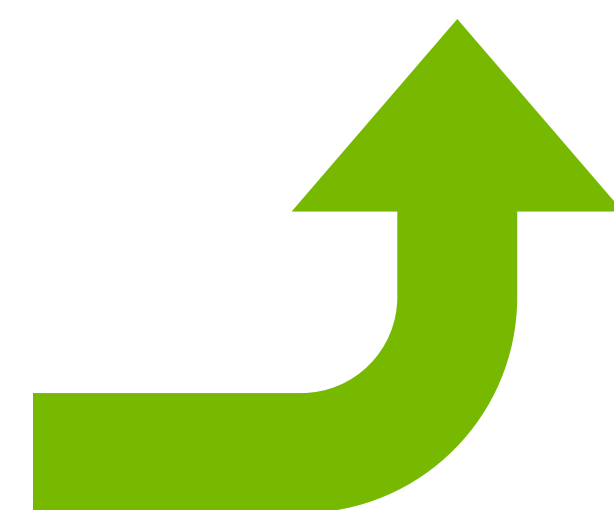


Getting Lost in the Noise

Reverse Diffusion

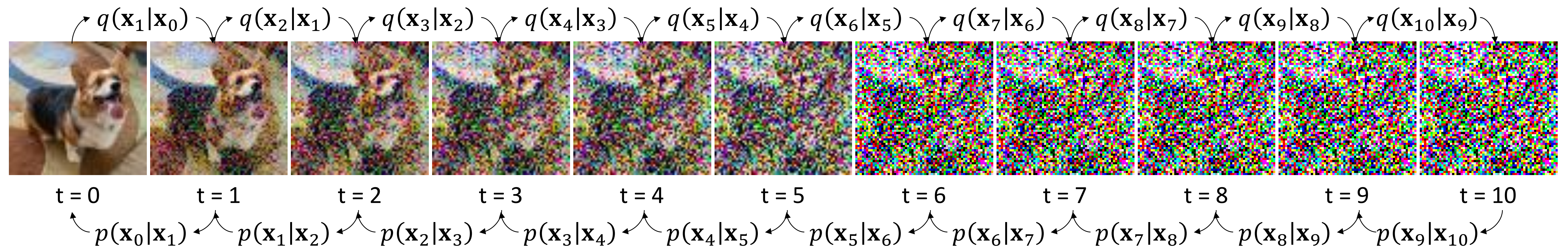


Can generate "evidence" of p using q



Getting Lost in the Noise

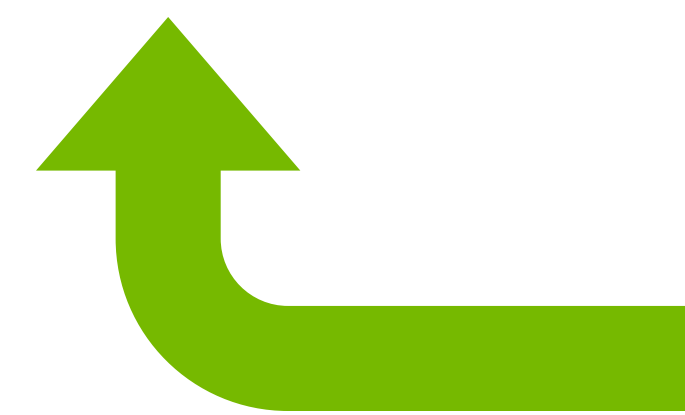
Reverse Diffusion



$$p(\mathbf{x}_{t-1} | \mathbf{x}_t) = N(\mathbf{x}_{t-1}; \boldsymbol{\mu}_\theta(\mathbf{x}_t, t), \Sigma_\theta(\mathbf{x}_t, t))$$

$$q(\mathbf{x}_{t-1} | \mathbf{x}_t, \mathbf{x}_0) = N(\mathbf{x}_{t-1}; \tilde{\boldsymbol{\mu}}(\mathbf{x}_t, \mathbf{x}_0), \tilde{\boldsymbol{\beta}}_t \cdot \mathbf{I})$$

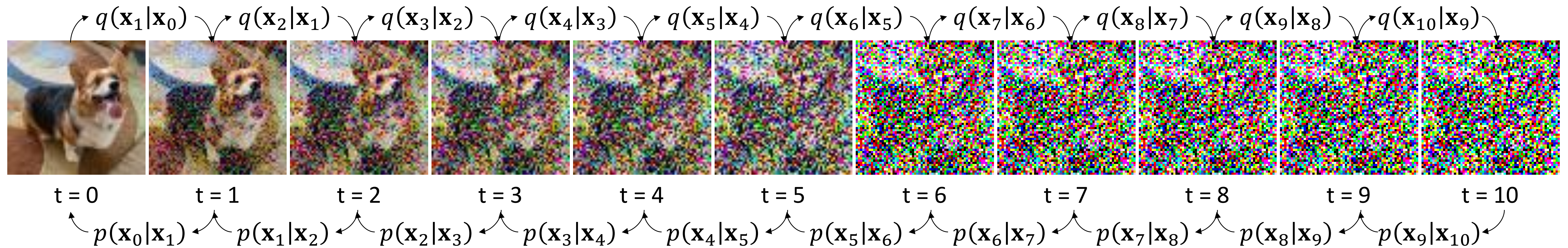
$$\tilde{\boldsymbol{\beta}}_t = \frac{1 - \bar{\alpha}_{t-1}}{1 - \bar{\alpha}_t} \boldsymbol{\beta}_t$$



Use Bayes' Rule and ...

Getting Lost in the Noise

Reverse Diffusion



$$p(\mathbf{x}_{t-1}|\mathbf{x}_t) = N(\mathbf{x}_{t-1}; \boldsymbol{\mu}_\theta(\mathbf{x}_t, t), \Sigma_\theta(\mathbf{x}_t, t))$$

$$q(\mathbf{x}_{t-1}|\mathbf{x}_t, \mathbf{x}_0) = N(\mathbf{x}_{t-1}; \tilde{\boldsymbol{\mu}}(\mathbf{x}_t, \mathbf{x}_0), \tilde{\boldsymbol{\beta}}_t \cdot \mathbf{I})$$

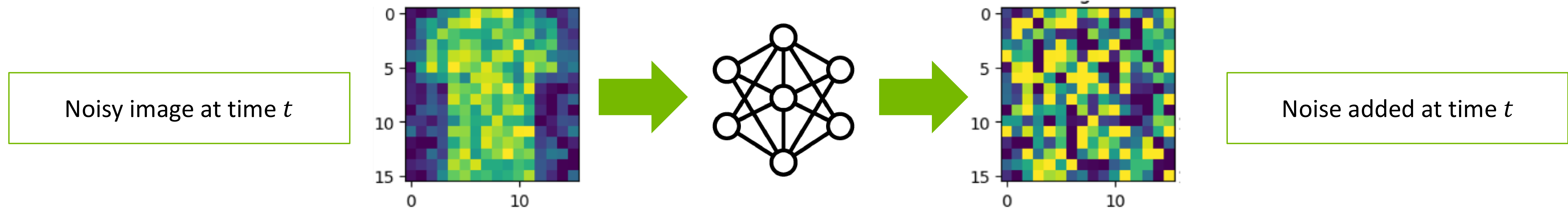
$$\tilde{\boldsymbol{\mu}}_t = \frac{1}{\sqrt{\alpha_t}} \left(x_t - \frac{1 - \alpha_t}{\sqrt{1 - \alpha_t}} \epsilon_t \right)$$

The noise added at time t
This is what the neural network will estimate

Model Training

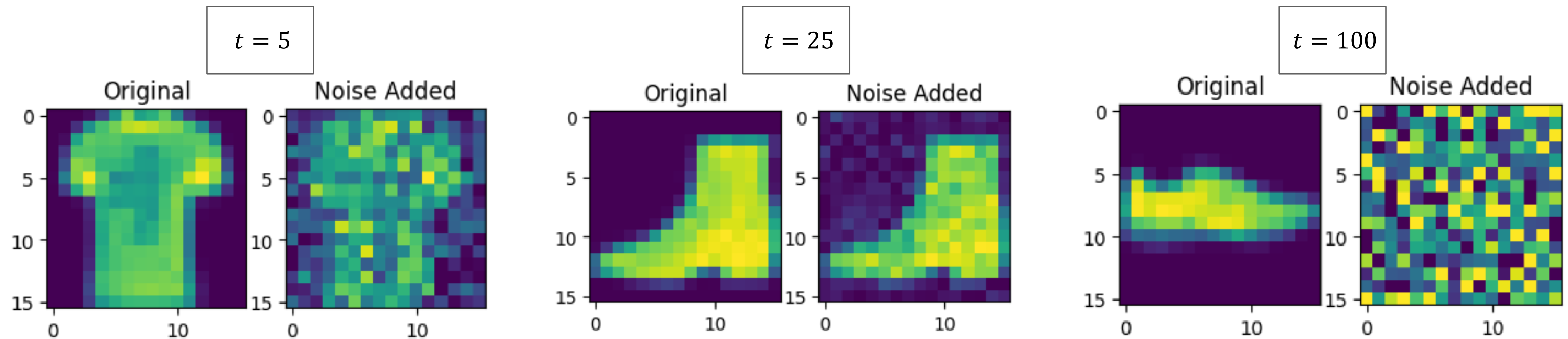
Model Training

Training Data



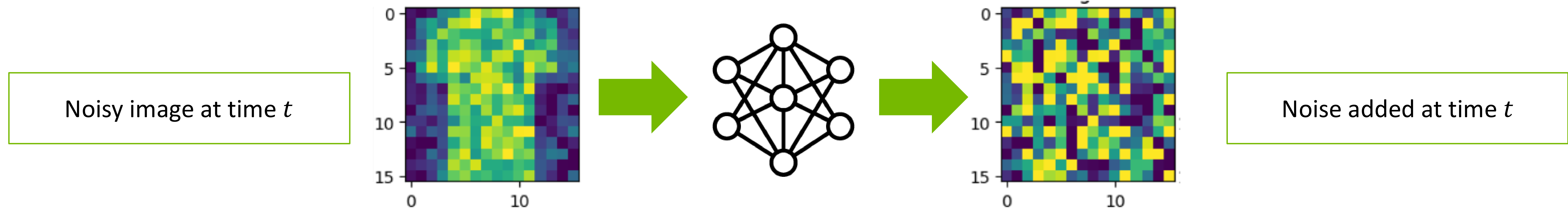
$$q(\mathbf{x}_t | \mathbf{x}_0) = N(\mathbf{x}_t; \sqrt{\bar{\alpha}_t} \cdot \mathbf{x}_0, (1 - \bar{\alpha}_t) \cdot \mathbf{I})$$

“Skip ahead” function



Model Training

ELBO Loss



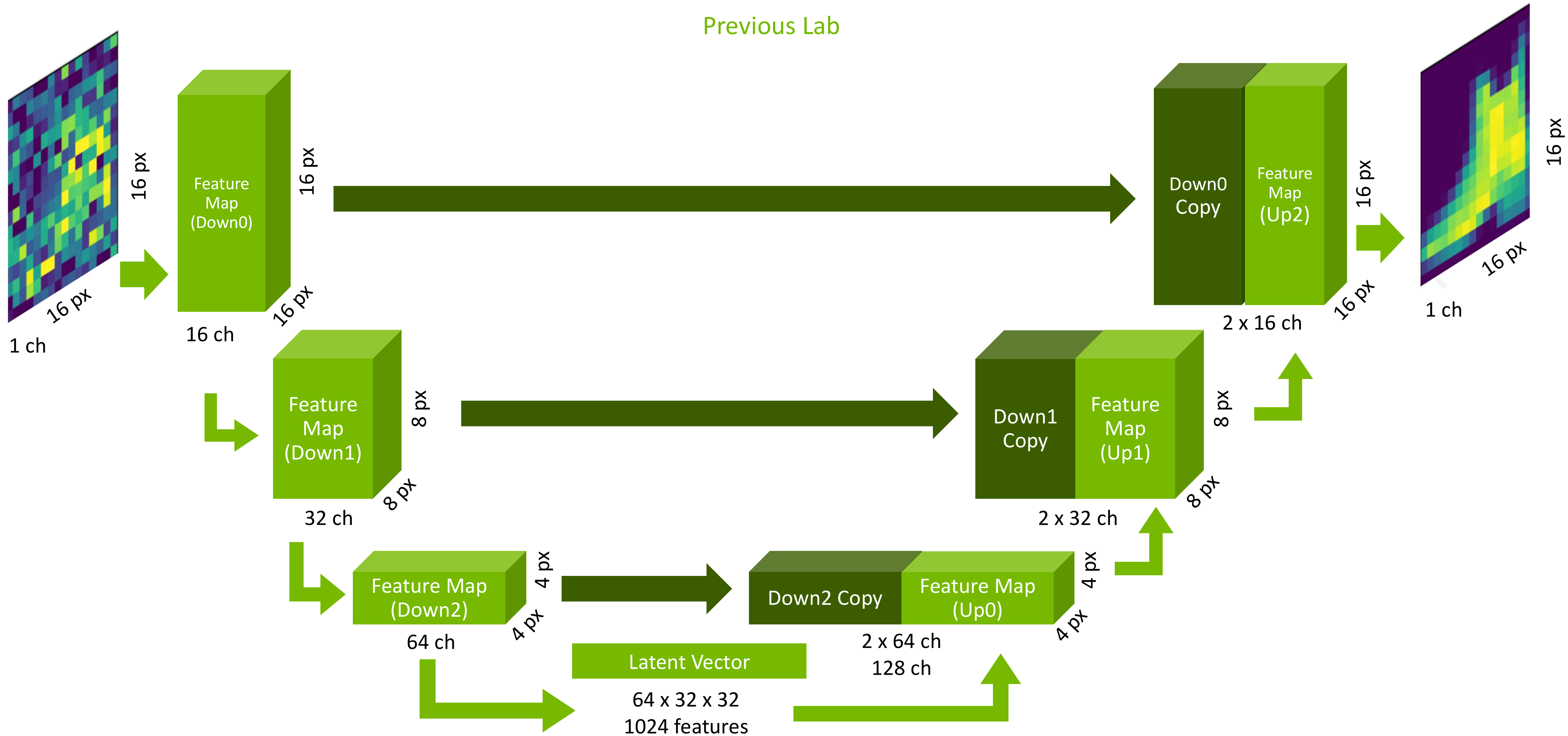
~~ELBO = $\mathbb{E}_{q(\theta)} \left[\log p(y_i | \theta) \right] - \mathbb{E}_{q(\theta)} \left[\log p(y_i | \hat{y}_i) \right]$~~

$$MSE = \frac{1}{n} \sum_{i=1}^n (y_i - \hat{y}_i)^2$$

Model Architecture

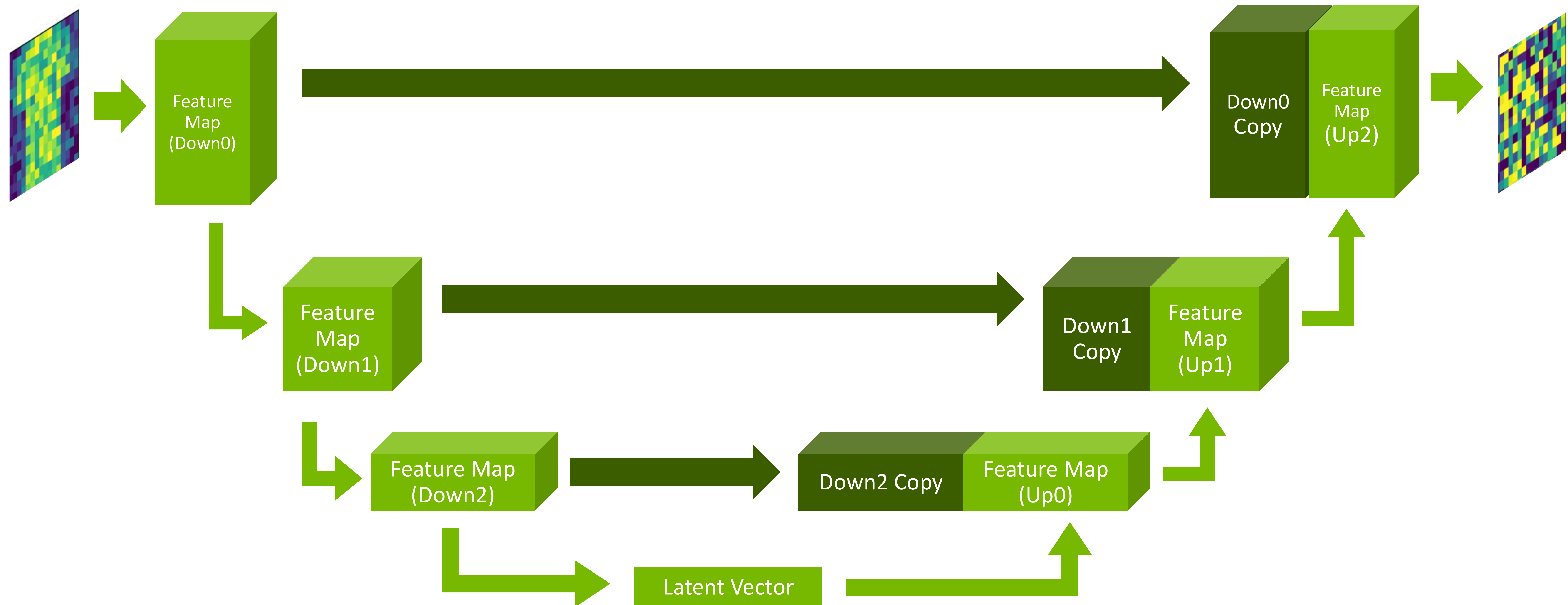
The U-Net Architecture

Previous Lab



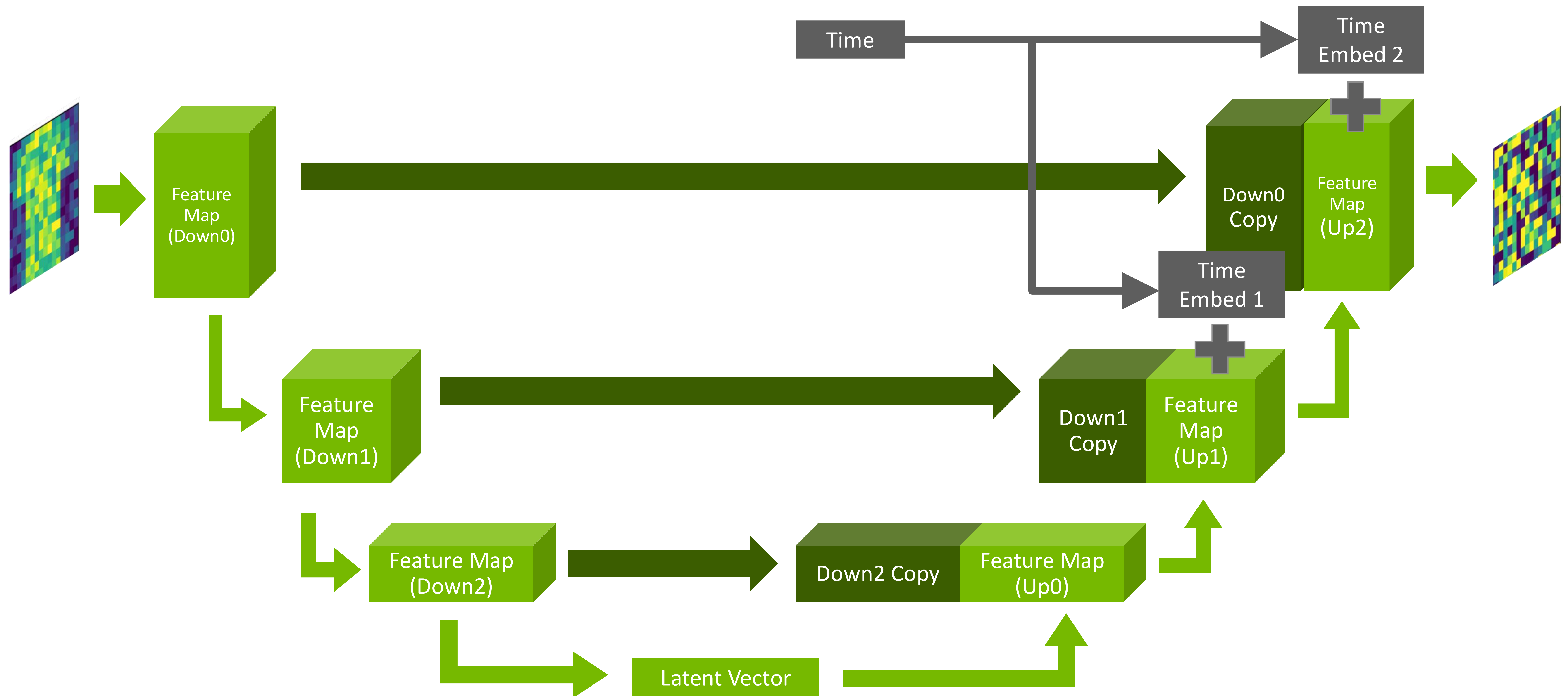
The U-Net Architecture

Next Lab



It's About Time

Adding Time



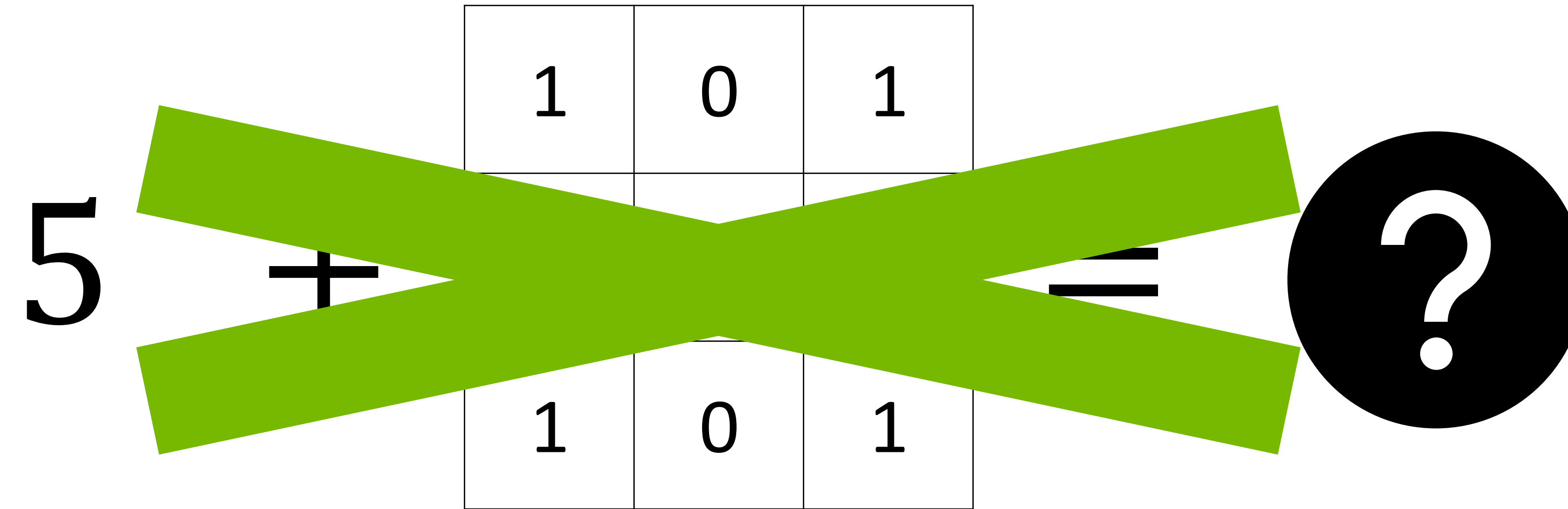
It's About Time

Broadcasting

5 +

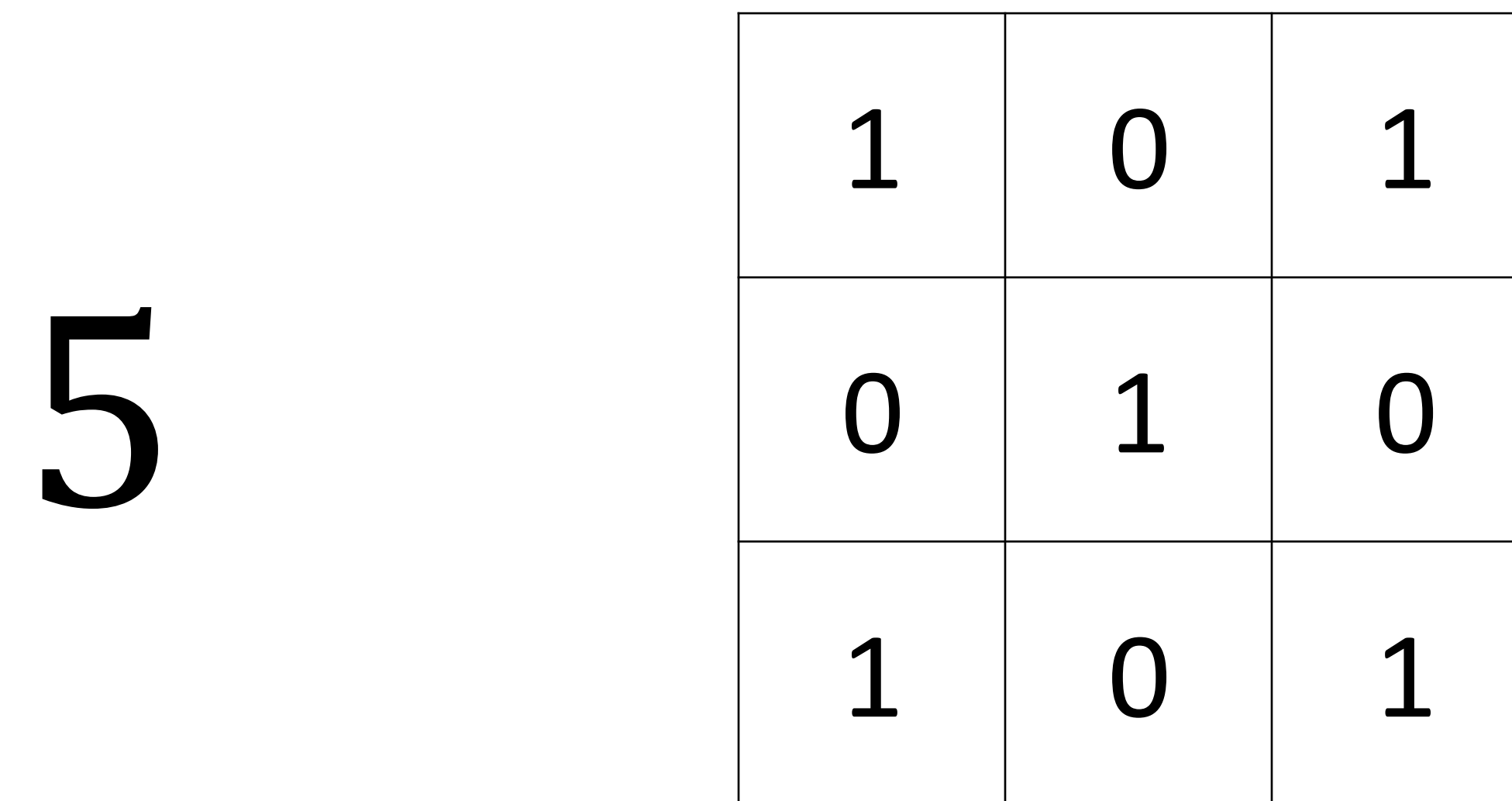
1	0	1
1	0	1

 = ?



5

1	0	1
0	1	0
1	0	1



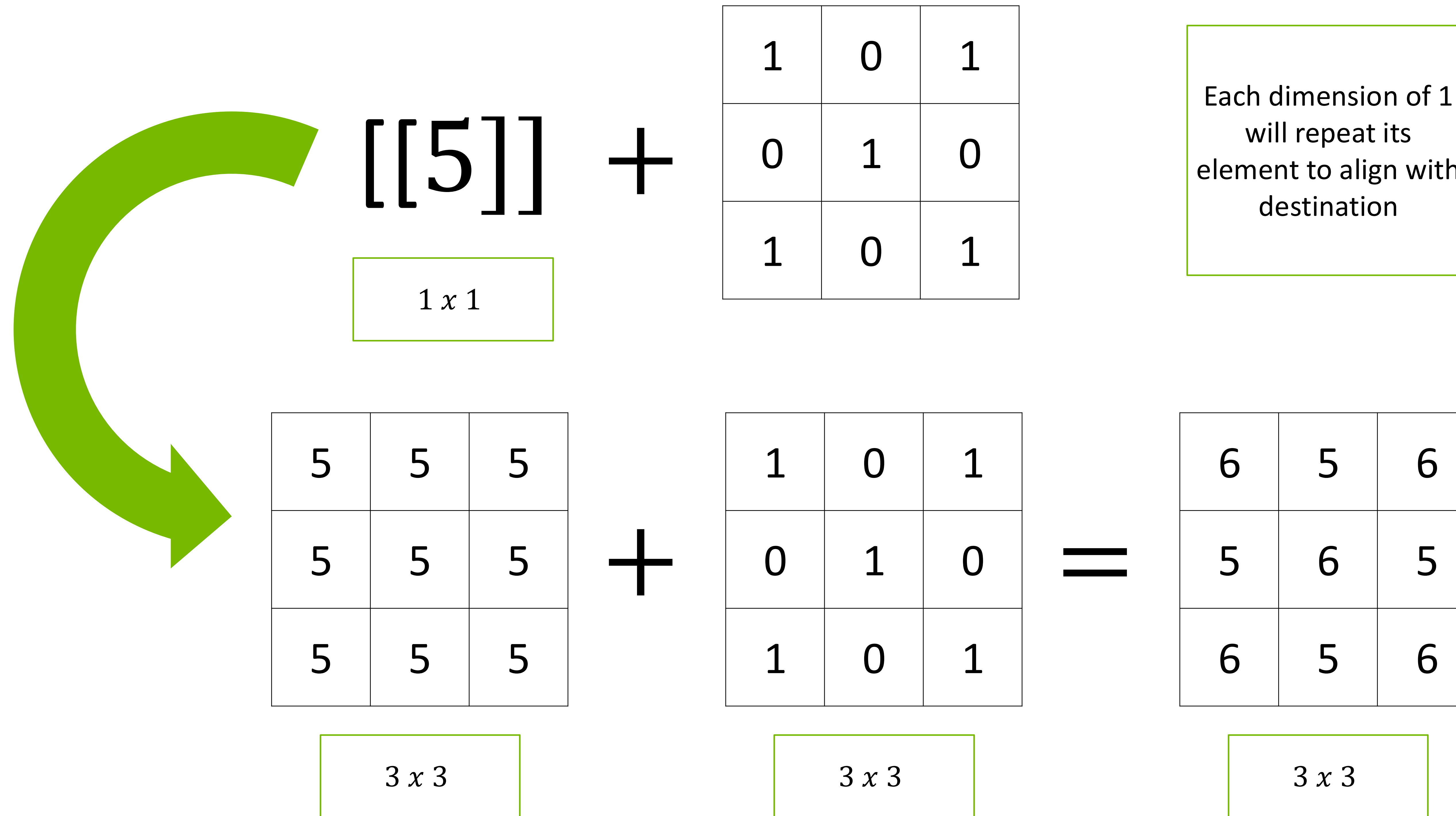
0 or 1

3 x 3

Dimensions

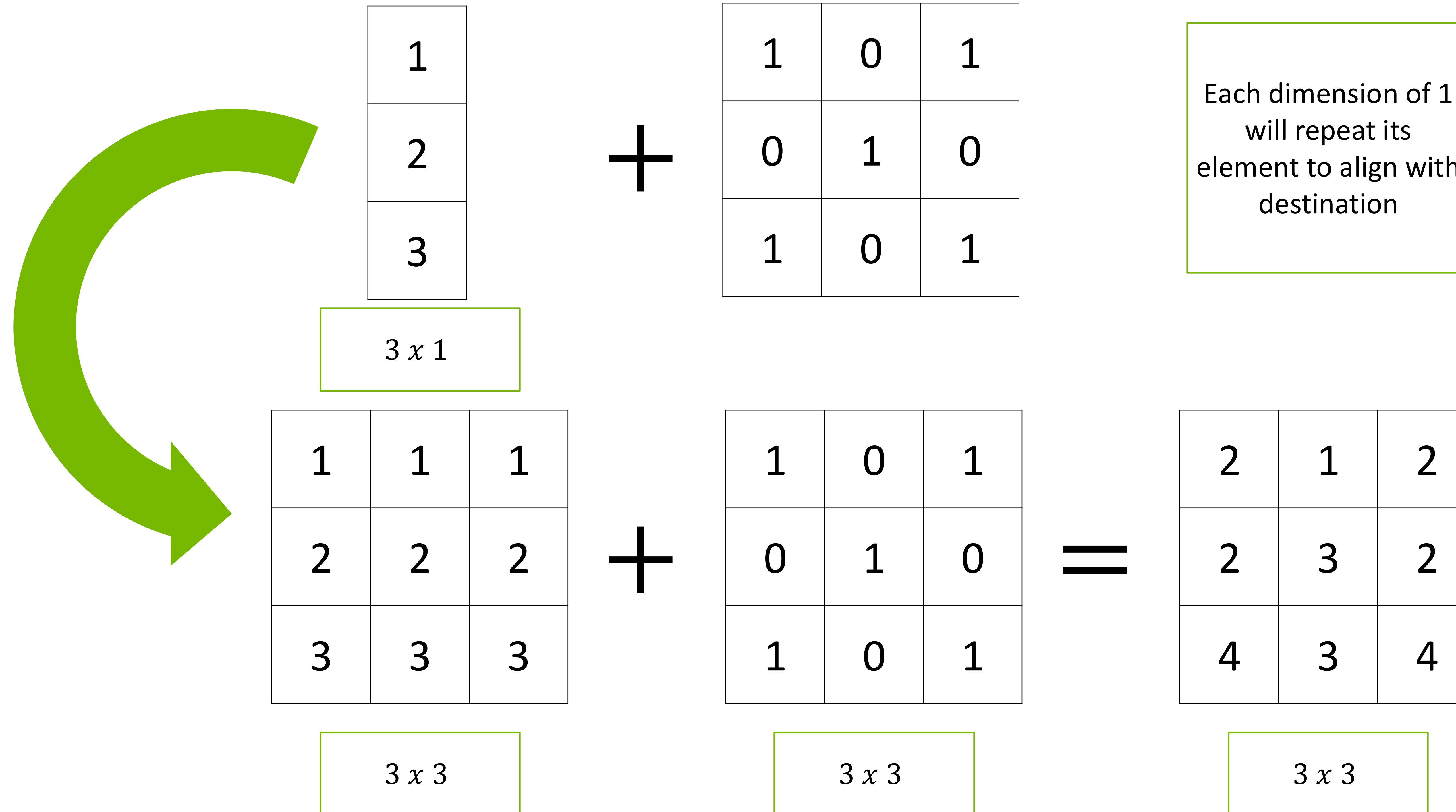
It's About Time

Broadcasting



It's About Time

Broadcasting



Let's get started!

2: Denoising Diffusion Probabilistic Models

Generative AI with Diffusion Models

Generative AI with Diffusion Models

Course Progress Bookmarks Updates

Generative AI with Diffusion Models Start Here 2: Denoising Diffusion Probabilistic Models

Generative AI with Diffusion Models

Start Here

0: Server Access

1: From U-Nets to Diffusion

2: Denoising Diffusion Probabilistic Models

3: Optimizations

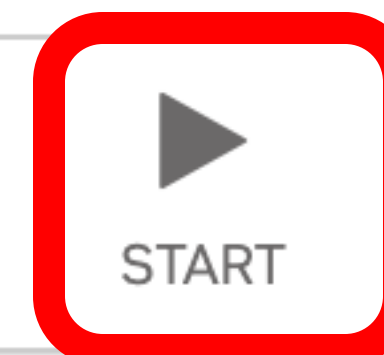
4: Classifier-Free Diffusion Guidance

5: CLIP

6: Wrap-up and Assessment

Previous

Next



Please click the start button to the top-right. The course will take about 5 minutes to load. The course lecture slide decks will appear here when you launch the course. The numbers on the lectures correspond to the numbers of the interactive notebooks in the course.

2: Denoising Diffusion Probabilistic Models

Generative AI with Diffusion Models

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Generative AI with Diffusion Models

Course Progress Bookmarks Updates

Generative AI with Diffusion Models Start Here 2: Denoising Diffusion Probabilistic Models

- Generative AI with Diffusion Models
- Start Here
- 0: Server Access
- 1: From U-Nets to Diffusion
- 2: Denoising Diffusion Probabilistic Models**
- 3: Optimizations
- 4: Classifier-Free Diffusion Guidance
- 5: CLIP
- 6: Wrap-up and Assessment
- Next Steps
- Feedback

Previous Next



LOADING STOP TASK



2: Denoising Diffusion Probabilistic Models

Generative AI with Diffusion Models

The screenshot shows the NVIDIA Deep Learning Institute website. At the top, there is a navigation bar with links for 'Products', 'Solutions', 'Industries', and 'For You'. Below this is a dark header for the 'Deep Learning Institute' with various course options. The main title 'Generative AI with Diffusion Models' is prominently displayed. A secondary navigation bar includes 'Course', 'Progress', 'Bookmarks', and 'Updates'. The current page is '2: Denoising Diffusion Probabilistic Models', with 'Start Here' and '2: Denoising Diffusion Probabilistic Models' in the breadcrumb trail. On the left, a table of contents lists modules from '0: Server Access' to '6: Wrap-up and Assessment', with '2: Denoising Diffusion Probabilistic Models' highlighted. The main content area features a video player with a green abstract background, a progress bar at 10:52 / 10:54, and playback controls. Below the video, there is a 'DEEP LEARNING INSTITUTE' logo and a 'LAUNCH' button (highlighted with a red box) next to a 'STOP TASK' button. A progress indicator shows 'This Lab 0:23:10 / 1:30:00' and 'Course -68:43:45 / 24:00:00'. At the bottom, a banner for the course is visible.

2: Denoising Diffusion Probabilistic Models

Generative AI with Diffusion Models

File Edit View Run Kernel Tabs Settings Help

Name	Last Modified
data	37 minutes ago
images	37 minutes ago
utils	37 minutes ago
02_Diffusion_Models.ipynb	a year ago

Launcher 02_Diffusion_Models.ipynk Python 3 (ipykernel)

DEEP LEARNING INSTITUTE

2. Diffusion Models

In the previous notebook, we learned how to separate noise from an image using a U-Net, but it was not capable of generating believable new images from noise. Diffusion models are much better at generating images from scratch.

The good news, our neural network model will not change much. We will be building off of the U-Net architecture with some slight modifications.

Instead, the big difference is how we use our model. Rather than adding noise to our images all at once, we will be adding a small amount of noise multiple times. We can then use our neural network on a noisy image multiple times to generate a new image like so:

02_Diffusion_Models.ipynb

2: Denoising Diffusion Probabilistic Models

Generative AI with Diffusion Models

Generative AI with Diffusion Models

Course Progress Bookmarks Updates

Generative AI with Diffusion Models Start Here 6: Wrap-up and Assessment

Generative AI with Diffusion Models

Start Here

0: Server Access

1: From U-Nets to Diffusion

2: Denoising Diffusion Probabilistic Models

3: Optimizations

4: Classifier-Free Diffusion Guidance

5: CLIP

6: Wrap-up and Assessment

Next Steps

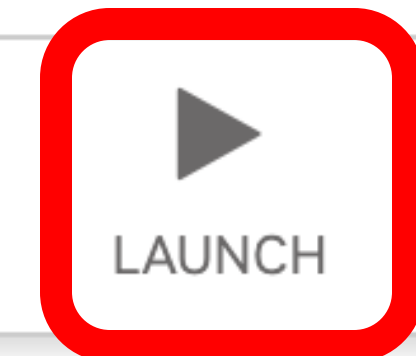
Feedback

Previous Next



This Lab 0:14:10 / 2:00:00

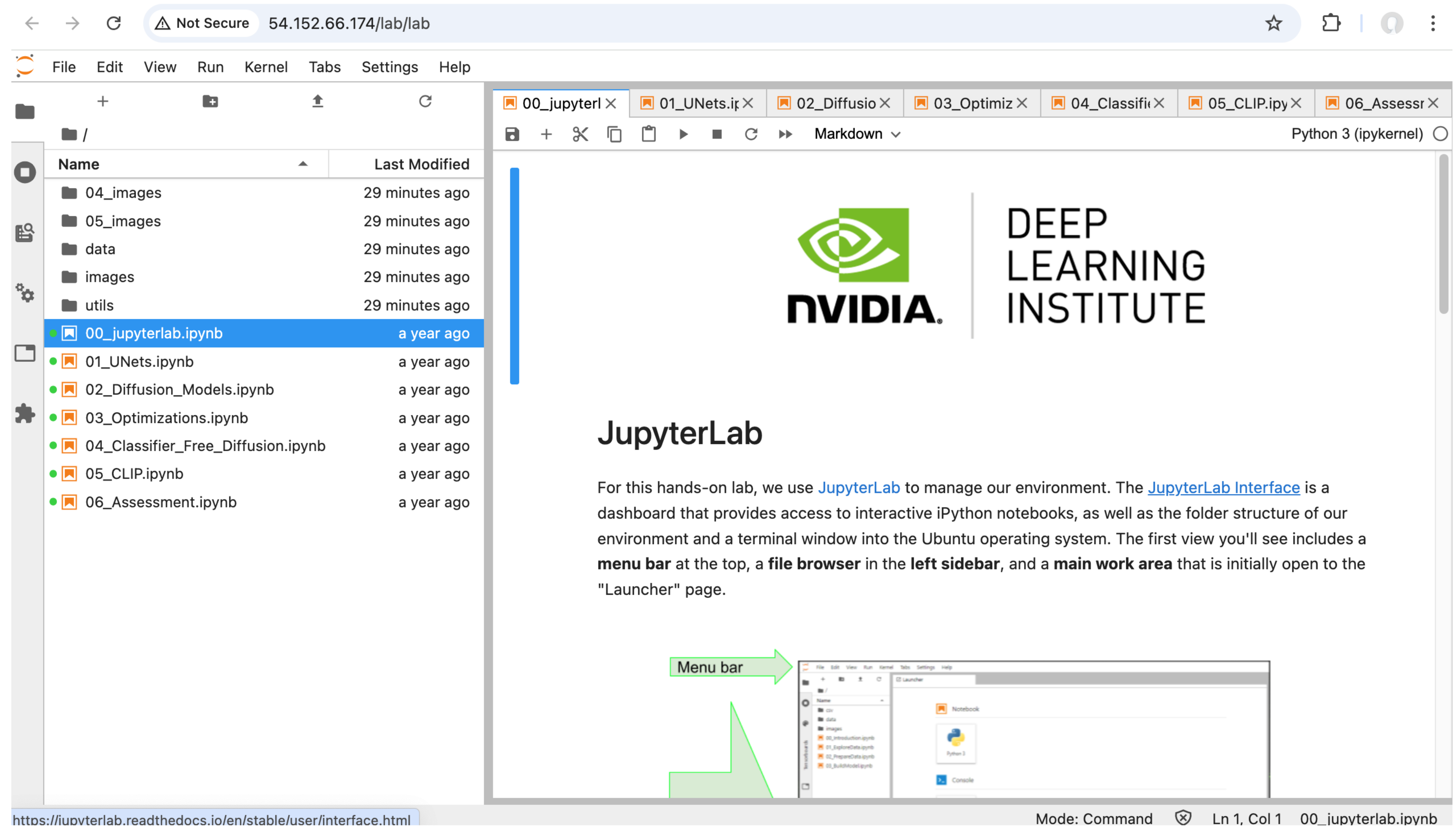
Course 8:03:08 / 24:00:00



6: Wrap-up and Assessment



NVIDIA Generative AI with Diffusion Models



The screenshot shows a JupyterLab interface in a browser window. The address bar shows "54.152.66.174/lab/lab". The interface includes a menu bar (File, Edit, View, Run, Kernel, Tabs, Settings, Help), a file browser on the left, and a notebook editor on the right. The notebook editor displays the NVIDIA logo and "DEEP LEARNING INSTITUTE" text. A green arrow points to the "Menu bar" at the top of the notebook editor.

Name	Last Modified
04_images	29 minutes ago
05_images	29 minutes ago
data	29 minutes ago
images	29 minutes ago
utils	29 minutes ago
00_jupyterlab.ipynb	a year ago
01_UNets.ipynb	a year ago
02_Diffusion_Models.ipynb	a year ago
03_Optimizations.ipynb	a year ago
04_Classifier_Free_Diffusion.ipynb	a year ago
05_CLIP.ipynb	a year ago
06_Assessment.ipynb	a year ago

JupyterLab

For this hands-on lab, we use [JupyterLab](#) to manage our environment. The [JupyterLab Interface](#) is a dashboard that provides access to interactive iPython notebooks, as well as the folder structure of our environment and a terminal window into the Ubuntu operating system. The first view you'll see includes a **menu bar** at the top, a **file browser** in the **left sidebar**, and a **main work area** that is initially open to the "Launcher" page.

Mode: Command Ln 1, Col 1 00_jupyterlab.ipynb

NVIDIA Generative AI with Diffusion Models

The screenshot shows a JupyterLab notebook interface. The browser address bar indicates the URL is 54.152.66.174/lab/lab. The notebook has several tabs open, with the current tab being '01_UNets.ipynb'. The left sidebar shows a file explorer with a list of files and folders, including '04_images', '05_images', 'data', 'images', 'utils', and several '.ipynb' files. The main content area displays the NVIDIA logo and the text 'DEEP LEARNING INSTITUTE'. Below this, the notebook title is '1. From U-Net to Diffusion'. The text in the notebook reads: 'U-Nets are a type of convolutional neural network that was originally designed for medical imaging. For instance, we could feed the network an image of a heart and it could return a different picture highlighting potentially cancerous areas. Can we use this process to generate new images? Here's an idea: what if we add noise to our images, and then use a U-Net to separate the images from the noise. Could we then feed the model noise and have it create a recognizable image? Let's give it a try!'. Below the text, there is a section titled 'Learning Objectives' with the text 'The goals of this notebook are to:' followed by a bulleted list: 'Explore the FashionMNIST dataset' and 'Build a U-Net architecture'. The bottom status bar shows 'Python 3 (ipykernel) | Idle', 'Mode: Command', and 'Ln 1, Col 1 01_UNets.ipynb'.

Name	Last Modified
04_images	28 minutes ago
05_images	28 minutes ago
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images	28 minutes ago
utils	28 minutes ago
00_jupyterlab.ipynb	a year ago
01_UNets.ipynb	a year ago
02_Diffusion_Models.ipynb	a year ago
03_Optimizations.ipynb	a year ago
04_Classifier_Free_Diffusion.ipynb	a year ago
05_CLIP.ipynb	a year ago
06_Assessment.ipynb	a year ago

1. From U-Net to Diffusion

U-Nets are a type of convolutional neural network that was originally designed for medical imaging. For instance, we could feed the network an image of a heart and it could return a different picture highlighting potentially cancerous areas.

Can we use this process to generate new images? Here's an idea: what if we add noise to our images, and then use a U-Net to separate the images from the noise. Could we then feed the model noise and have it create a recognizable image? Let's give it a try!

Learning Objectives

The goals of this notebook are to:

- Explore the FashionMNIST dataset
- Build a U-Net architecture

NVIDIA Generative AI with Diffusion Models

File Edit View Run Kernel Tabs Settings Help

00_jupyterl × 01_UNets.ip × 02_Diffusio × 03_Optimiz × 04_Classific × 05_CLIP.ipy × 06_Assessr ×

Python 3 (ipykernel)

Name	Last Modified
04_images	36 minutes ago
05_images	36 minutes ago
data	36 minutes ago
images	36 minutes ago
utils	36 minutes ago
00_jupyterlab.ipynb	a year ago
01_UNets.ipynb	a year ago
02_Diffusion_Models.ipynb	a year ago
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04_Classifier_Free_Diffusion.ipynb	a year ago
05_CLIP.ipynb	a year ago
06_Assessment.ipynb	a year ago

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NVIDIA Generative AI with Diffusion Models

The screenshot shows a JupyterLab environment. On the left is a file browser with a table of files and folders. The right pane shows a notebook cell with the following content:

Name	Last Modified
04_images	37 minutes ago
05_images	37 minutes ago
data	37 minutes ago
images	37 minutes ago
utils	37 minutes ago
00_jupyterlab.ipynb	a year ago
01_UNets.ipynb	a year ago
02_Diffusion_Models.ipynb	a year ago
03_Optimizations.ipynb	a year ago
04_Classifier_Free_Diffusion.ipynb	a year ago
05_CLIP.ipynb	a year ago
06_Assessment.ipynb	a year ago

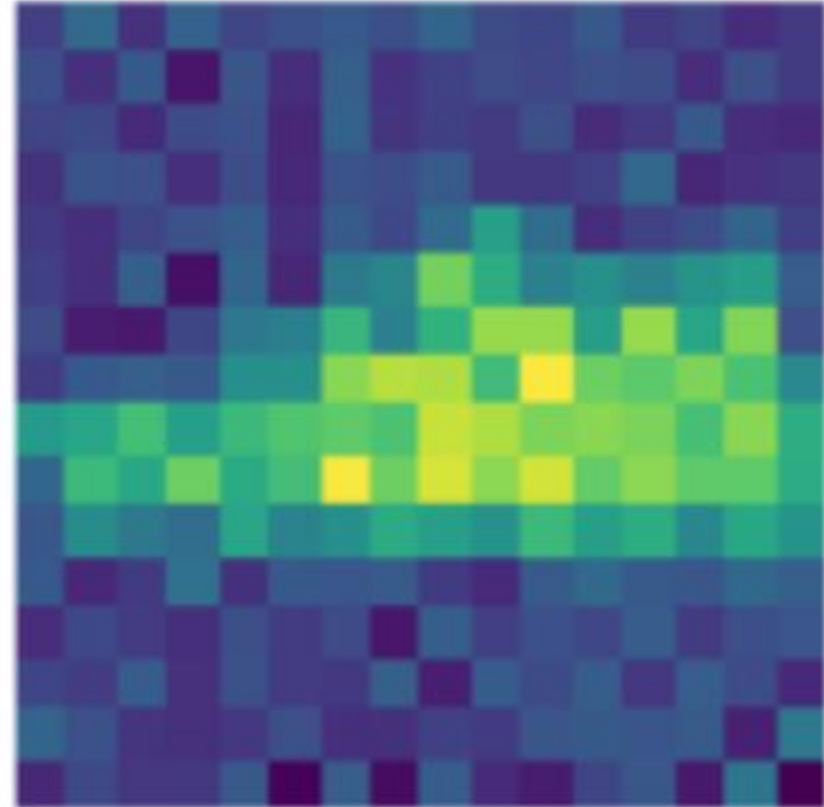
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Python 3 (ipykernel)

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3. Optimizations

Currently, the model is experiencing the [checkerboard problem](#).



Thankfully, we have a few tricks up our generated T-shirt sleeve to resolve this and generally improve the performance of the model.


0 \$ 7 Python 3 (ipykernel) | Idle Mode: Command Ln 1, Col 1 03_Optimizations.ipynb

NVIDIA Generative AI with Diffusion Models

The screenshot shows a JupyterLab interface with a file explorer on the left and a notebook cell on the right. The file explorer lists several folders and notebooks, with '04_Classifier_Free_Diffusion.ipynb' selected. The notebook cell contains the following content:

00_jupyterl × 01_UNets.ip × 02_Diffusio × 03_Optimiz × 04_Classifi × 05_CLIP.ip × 06_Assessr ×

Python 3 (ipykernel)

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4. Classifier-Free Diffusion Guidance

So far, we have been able to train a model to generate images of clothing using the [FashionMNIST](#) dataset. However, there is no way for the user to specify what kind of images should be generated. Let's fix that by using [Classifier-Free Diffusion Guidance](#), a relatively simple way to create a [Conditional Diffusion Model](#).

Learning Objectives

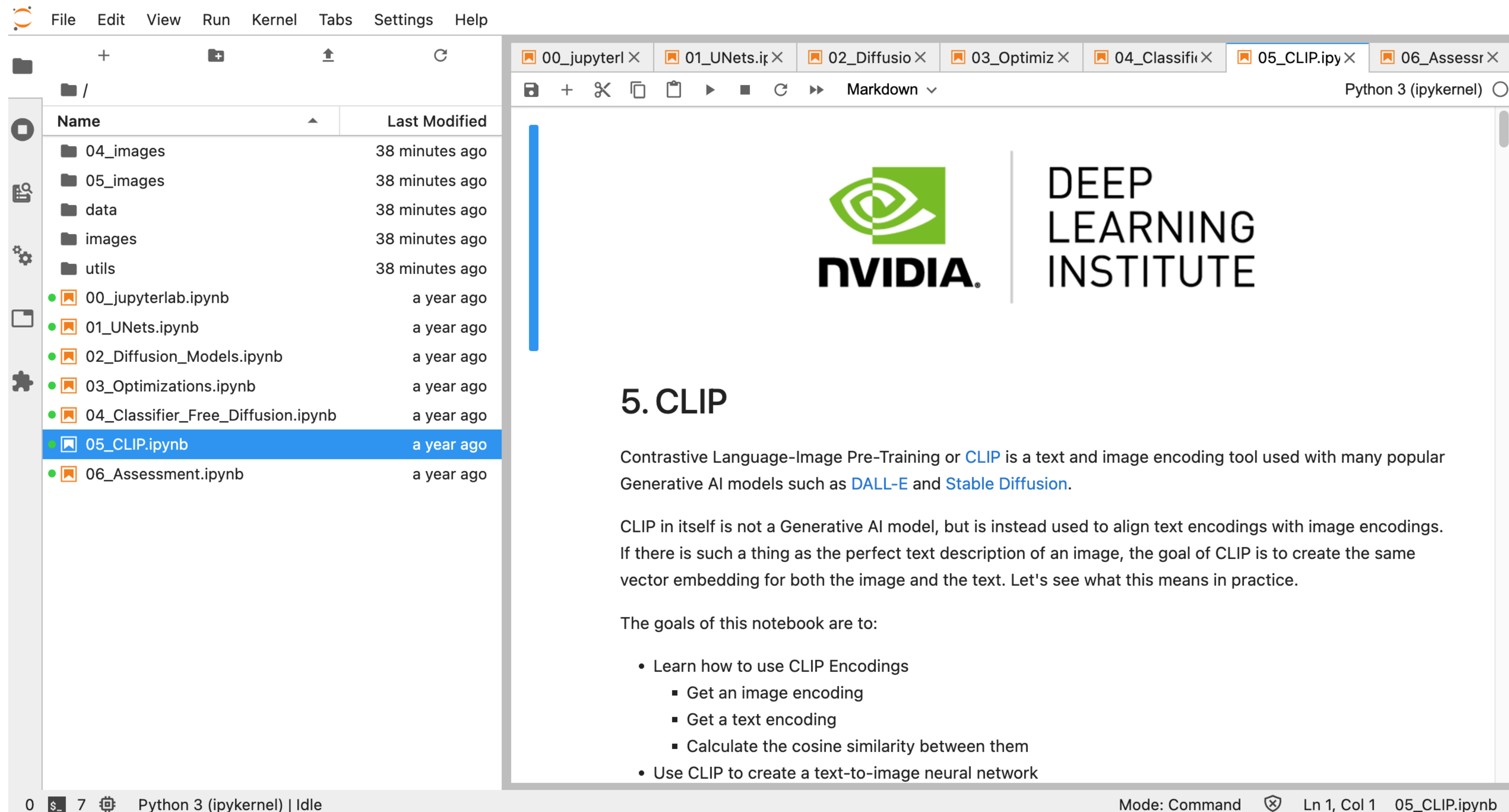
The goals of this notebook are to:

- Add categorical embeddings to a U-Net
- Train a model with a Bernoulli mask
- Add a weight the reverse diffusion process
- Practice learnings on a more challenging dataset

Before we get started, let's load the necessary libraries and dataset information.

0 \$ 7 Python 3 (ipykernel) | Idle Mode: Command Ln 1, Col 1 04_Classifier_Free_Diffusion.ipynb

NVIDIA Generative AI with Diffusion Models




File Edit View Run Kernel Tabs Settings Help

04_images 38 minutes ago
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data 38 minutes ago
images 38 minutes ago
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02_Diffusion_Models.ipynb a year ago
03_Optimizations.ipynb a year ago
04_Classifier_Free_Diffusion.ipynb a year ago
05_CLIP.ipynb a year ago
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Python 3 (ipykernel)

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5. CLIP

Contrastive Language-Image Pre-Training or [CLIP](#) is a text and image encoding tool used with many popular Generative AI models such as [DALL-E](#) and [Stable Diffusion](#).

CLIP in itself is not a Generative AI model, but is instead used to align text encodings with image encodings. If there is such a thing as the perfect text description of an image, the goal of CLIP is to create the same vector embedding for both the image and the text. Let's see what this means in practice.

The goals of this notebook are to:

- Learn how to use CLIP Encodings
 - Get an image encoding
 - Get a text encoding
 - Calculate the cosine similarity between them
- Use CLIP to create a text-to-image neural network


0 \$ 7 Python 3 (ipykernel) | Idle Mode: Command Ln 1, Col 1 05_CLIP.ipynb

NVIDIA Generative AI with Diffusion Models

The screenshot shows a JupyterLab interface. On the left is a file browser with a table of files and folders. The right pane shows a notebook cell with the following content:

Name	Last Modified
04_images	38 minutes ago
05_images	38 minutes ago
data	38 minutes ago
images	38 minutes ago
utils	38 minutes ago
00_jupyterlab.ipynb	a year ago
01_UNets.ipynb	a year ago
02_Diffusion_Models.ipynb	a year ago
03_Optimizations.ipynb	a year ago
04_Classifier_Free_Diffusion.ipynb	a year ago
05_CLIP.ipynb	a year ago
06_Assessment.ipynb	a year ago

Dec 2, 2023 7:32 AM

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6. Assessment

Congratulations on going through today's course! Hope it was a fun journey with some new skills as souvenirs. Now it's time to put those skills to the test.

In this assessment, the challenge is to train a new model that is able to generate handwritten images based on the [MNIST dataset](#). Traditionally, neural networks have a test dataset, but that is not necessarily the case with generative AI. Beauty is in the eye of the beholder, and it is up to you as the developer if overfitting is acceptable or not.

So instead, we have created a classifier model that has been trained on the MNIST dataset. It has an accuracy on the MNIST test dataset of over 99%. If this model can correctly identify 95% of your generated images, you will earn a certificate!

6.1 The Dataset

Let's get started. below are the libraries used in this assessment.

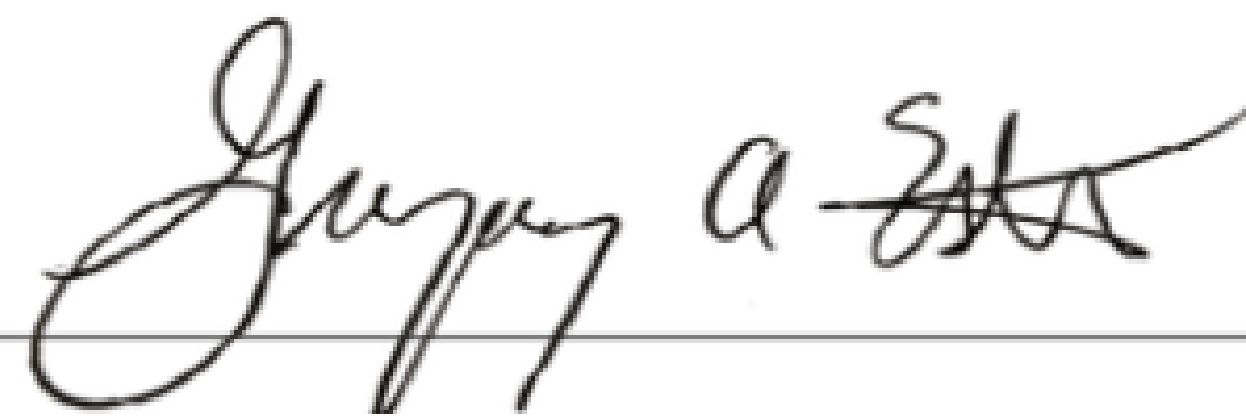
Certificate of Competency

This certificate is awarded to

Min-Yuh Day

for demonstrating competence in the completion of

Generative AI with Diffusion Models



Greg Estes

Vice President, NVIDIA

Issue Date: : February 28, 2025

Certification ID: q3oo-oBhTQKtyCCote2E-Q

References

- NVIDIA DLI (2024), Building RAG Agents with LLMs,
https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S-FX-15+V1
- NVIDIA DLI (2024), Generative AI with Diffusion Models,
https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S-FX-14+V1