



The Role of Generative AI in Academic Research

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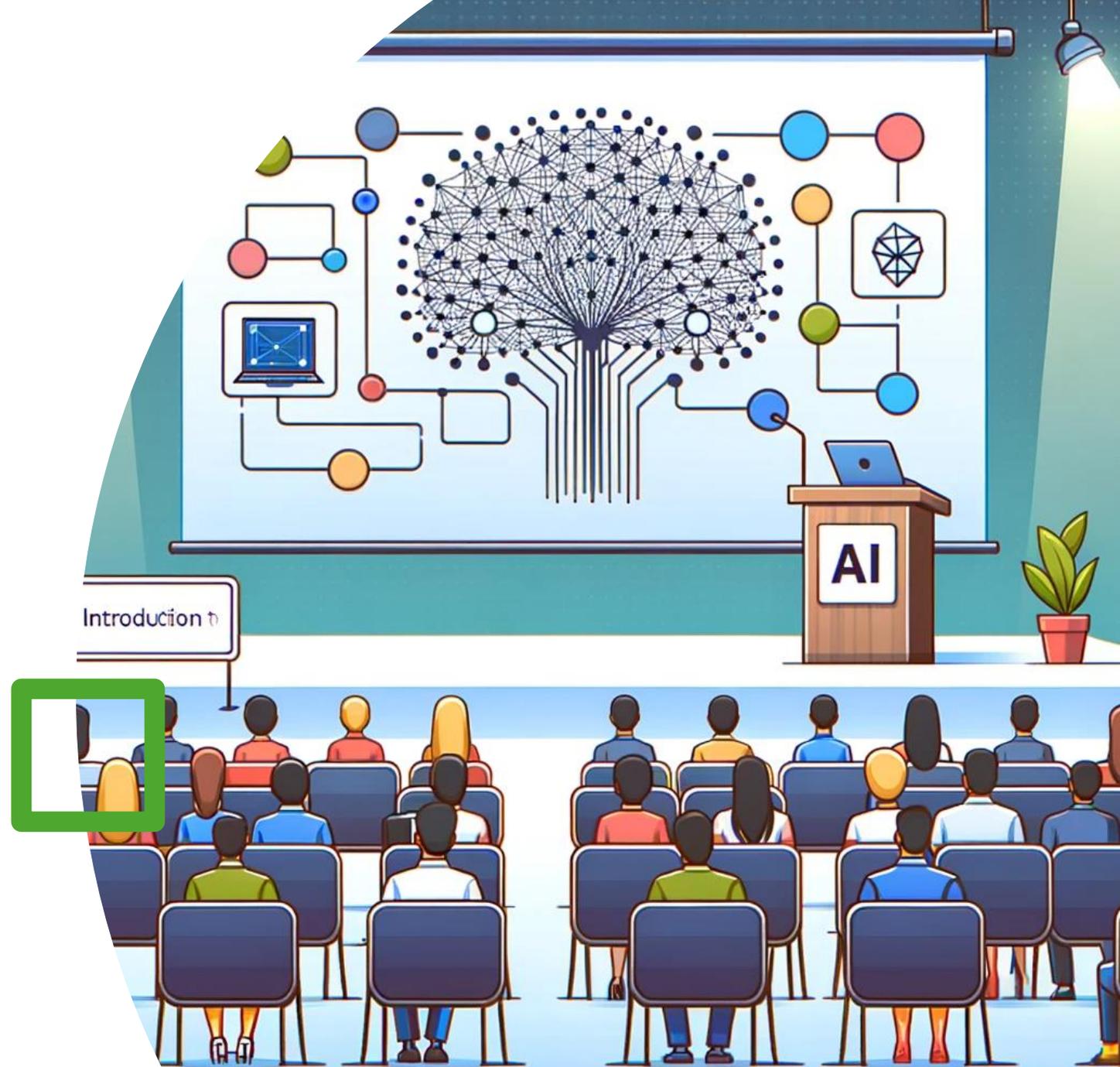
Microsoft Software Technology
Center Asia (STCA)

Agenda

- Introduction to Generative AI
- Generative AI in Research
- Collaborative between Academia and Industry
- Responsible AI for Research



Introduction to Generative AI



What is Generative AI?



Algorithms and models capable of generating new data that resembles a given dataset.



To create diverse, realistic, and high-quality data

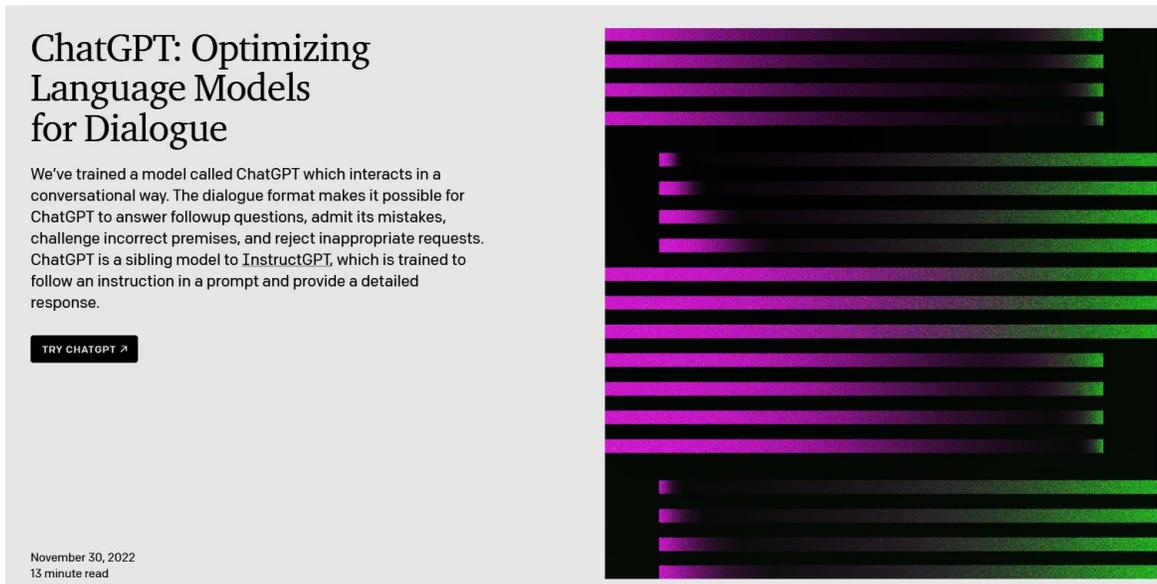


Generated Data type

Text
Image
Audio
Video

AI Text Generation: ChatGPT

- Based on GPT (Generative Pre-trained Transformer) 3.5/4 Model
 - OpenAI
 - Released at 2022.11.30



<https://openai.com/blog/chatgpt>

AI Image Generation

Stable-diffusion

<https://beta.dreamstudio.ai/dream>



Dall-E

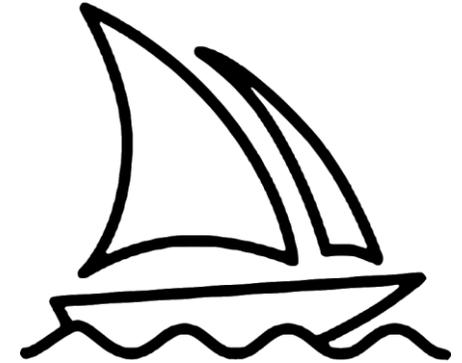
<https://labs.openai.com/>



OpenAI

Midjourney

<https://www.midjourney.com/>

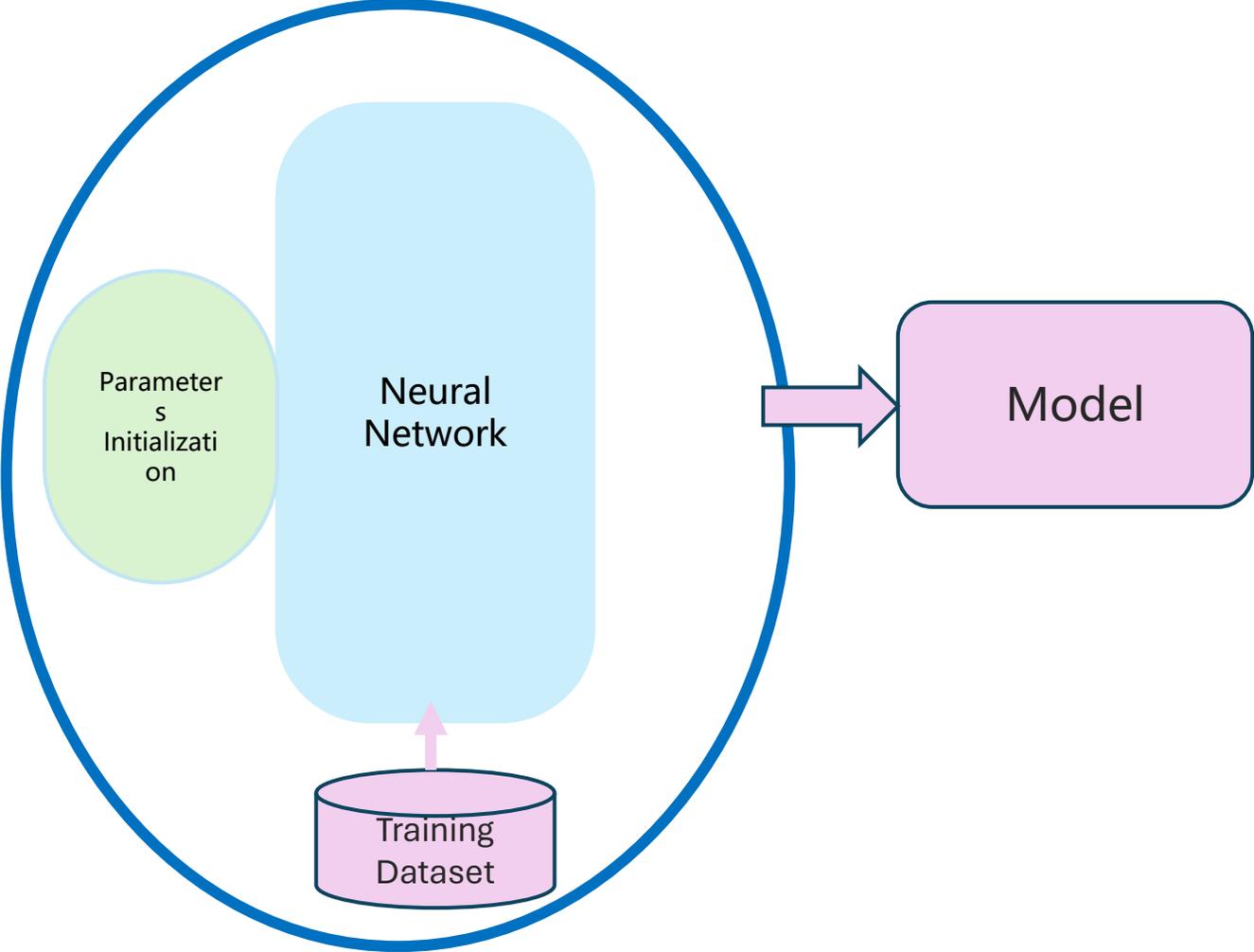




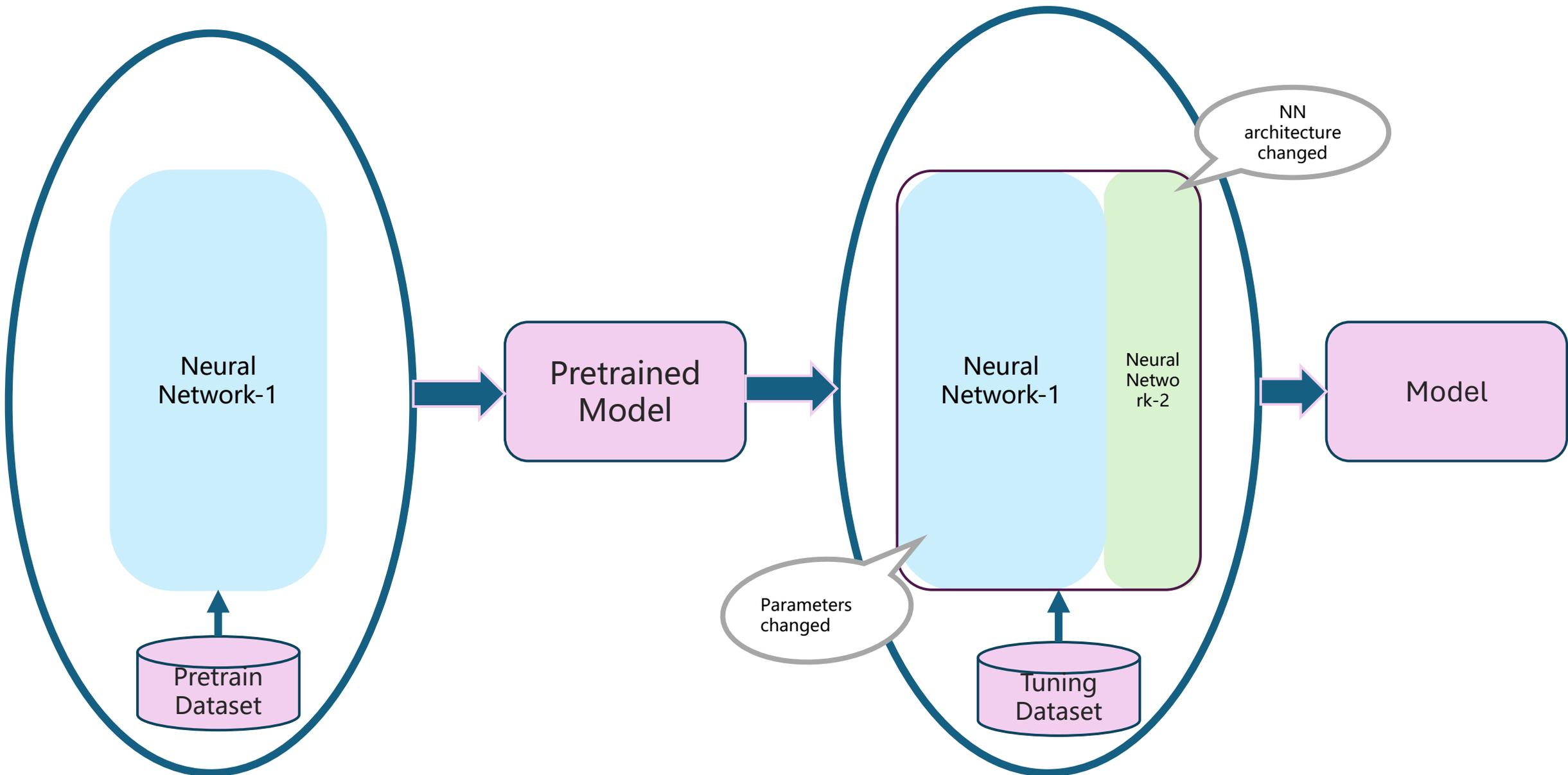
The Evolution of AI Paradigms

- The Core of AI Technology
 - Models: *mathematical frameworks or computational systems that are trained on data to perform tasks such as making predictions, identifying patterns, or making decisions*
 - Model = $f_{algorithm}(Data)$
- AI Paradigm
 - #1: Training from scratch
 - #2: Pretrained model + fine tuning
 - #3: Pretrained large model + prompt engineering

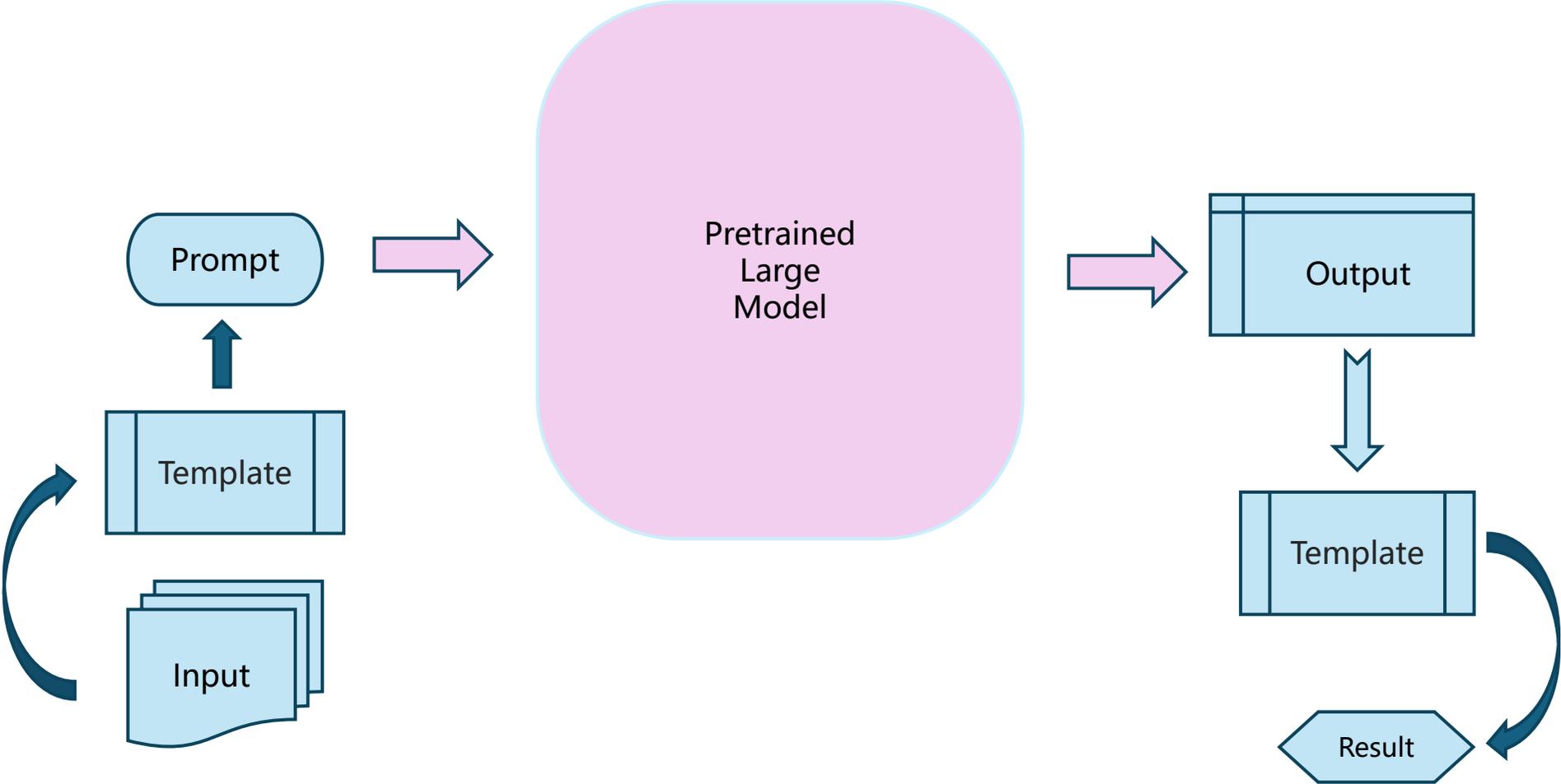
Training From Scratch



Pretrained Model + Fine tuning



Pretrained Large Model + Prompt Engineering



Examples of Generative Models



Generative Pre-trained Transformer (GPT)

Architecture: Transformer-based model for natural language processing.

Real-world application examples

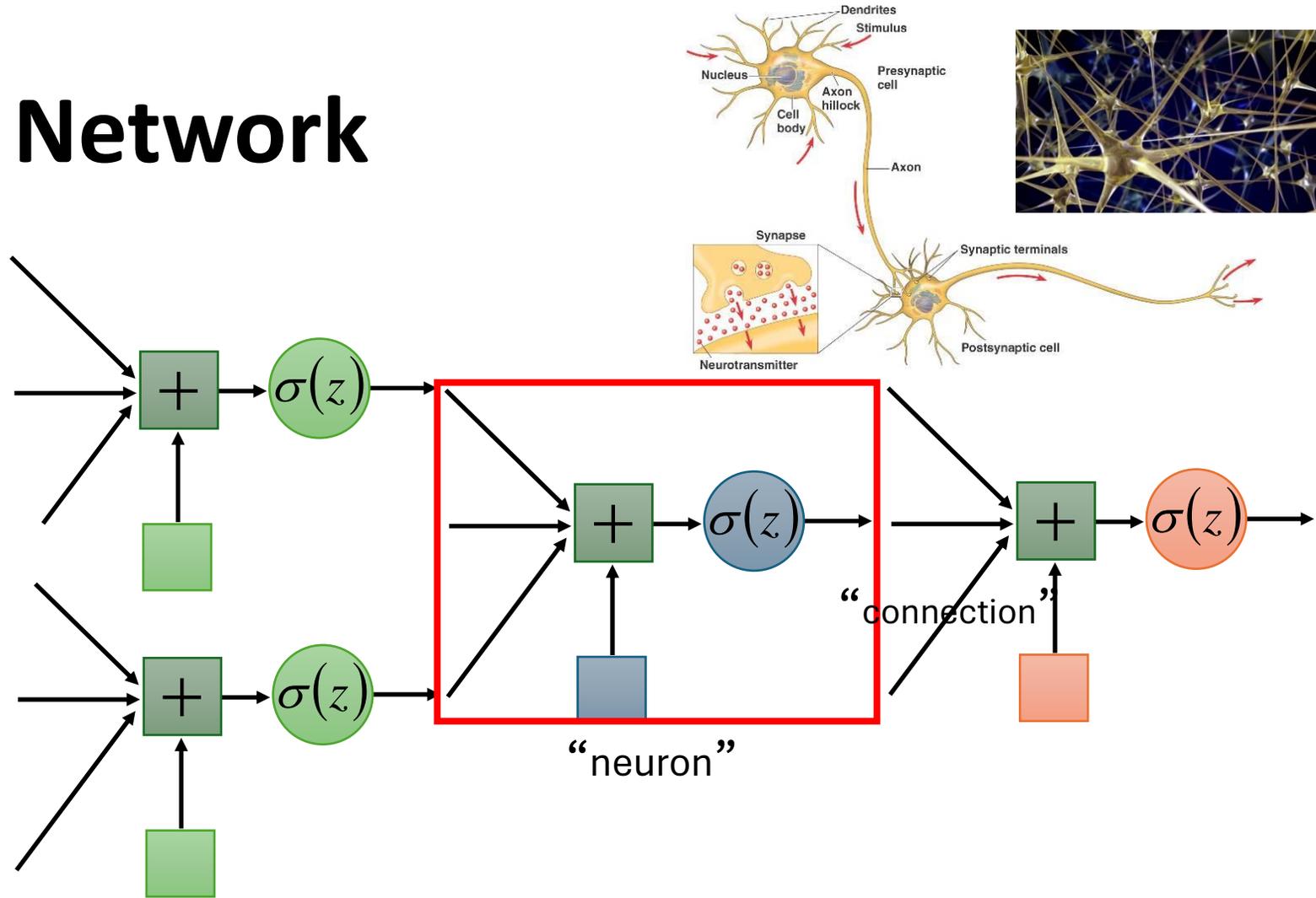


Diffusion Models

Probabilistic generative model for data generation.

Real-world application examples

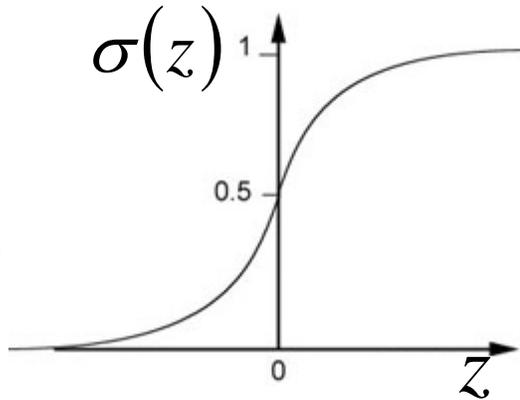
Neural Network



Fully connected neural network (FCNN)

Sigmoid Function

$$\sigma(z) = \frac{1}{1 + e^{-z}}$$

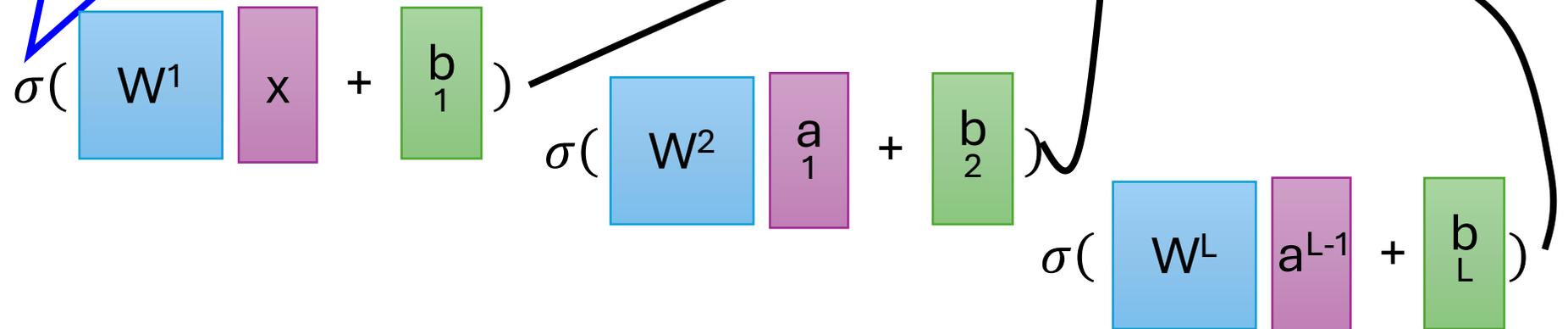
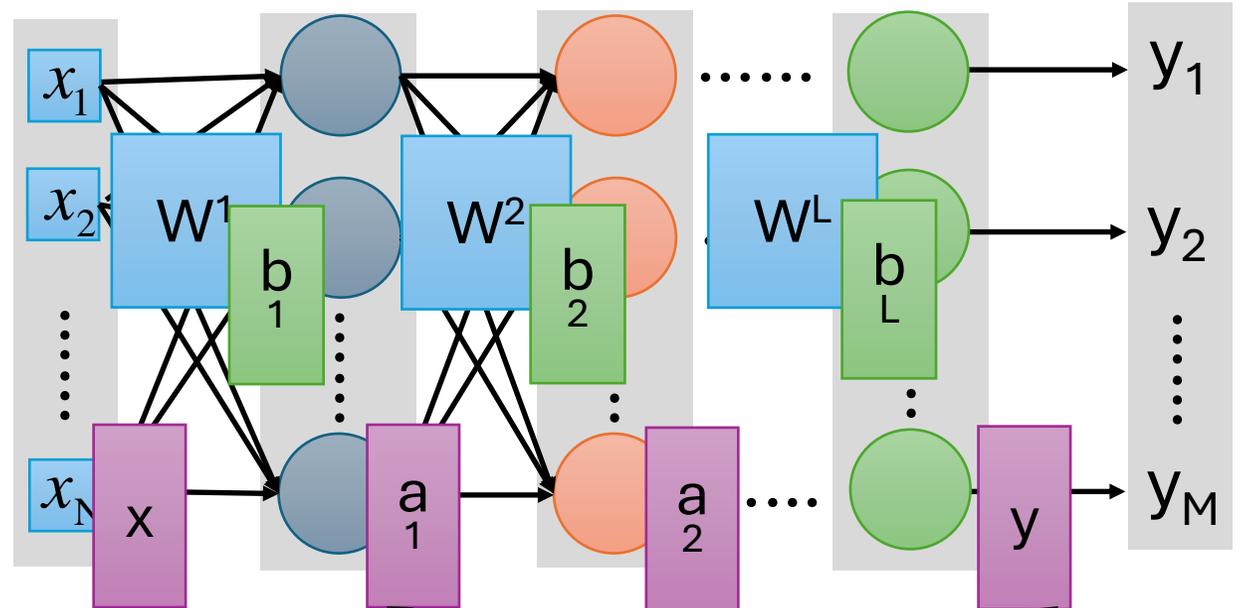


- hidden layer
 - weighted sum of input data
 - activation function
- layers

$$\sigma(W^1 x + b_1)$$

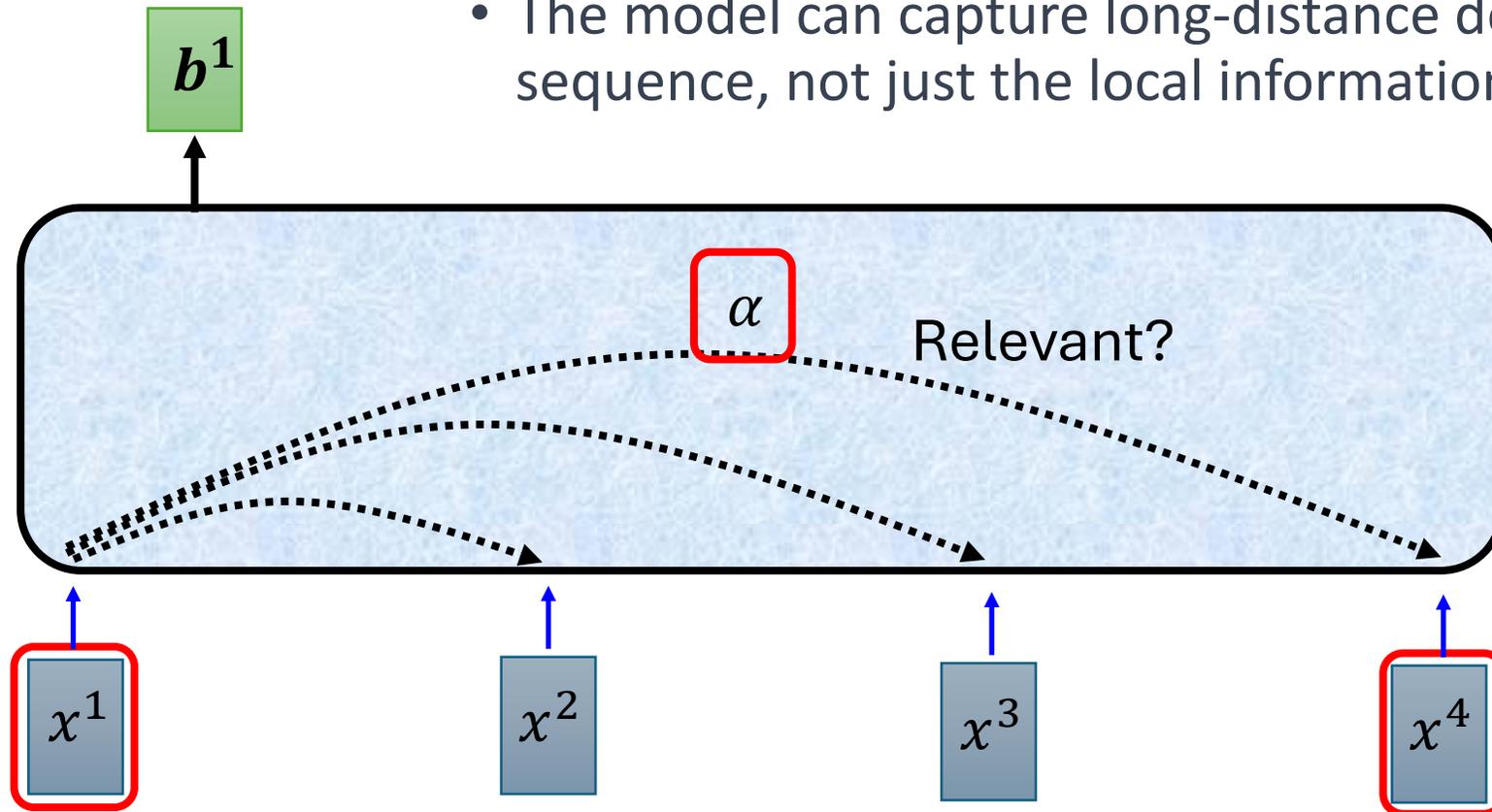
$$\sigma(W^2 a_1 + b_2)$$

$$\sigma(W^L a^{L-1} + b_L)$$

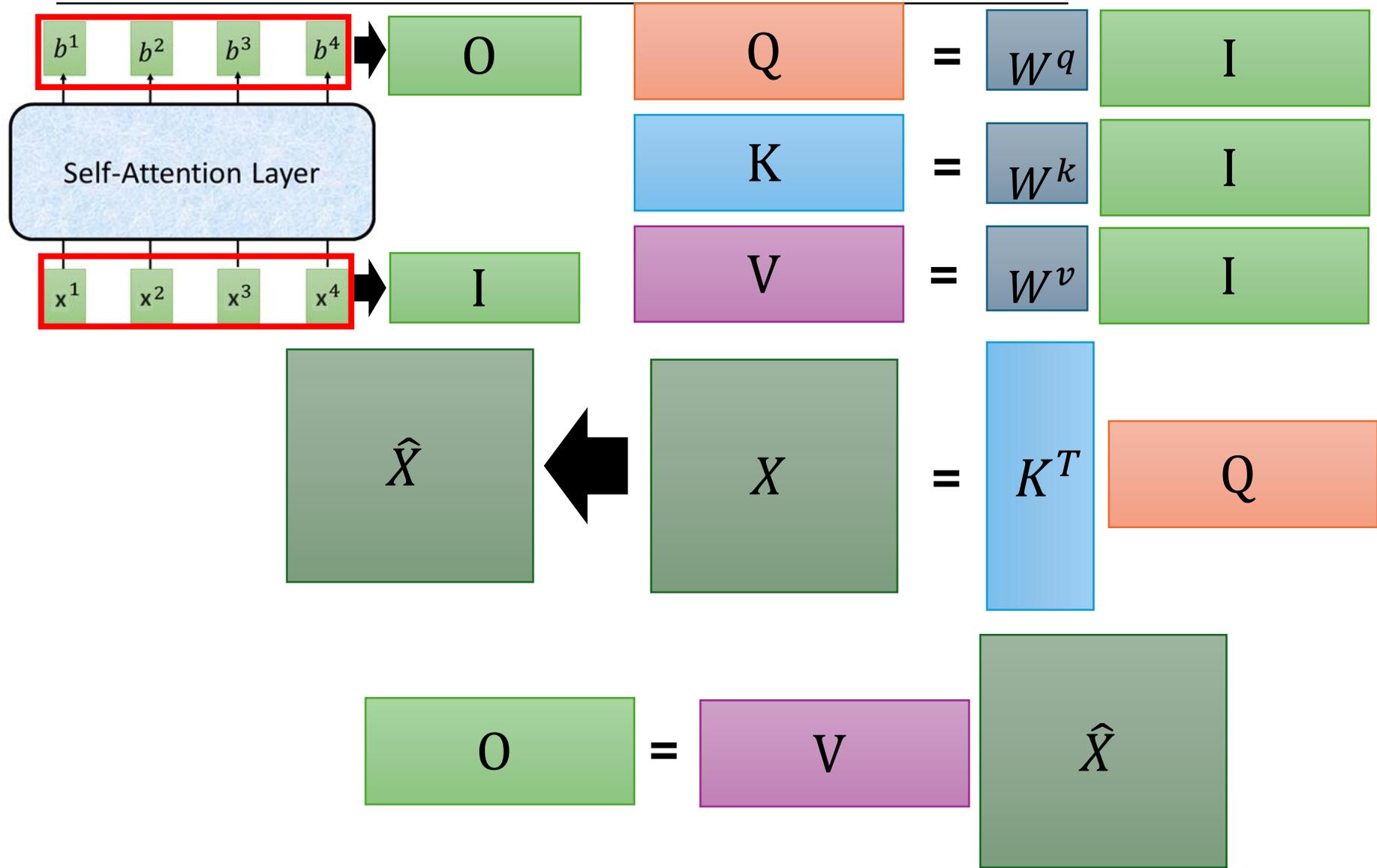


Self-Attention

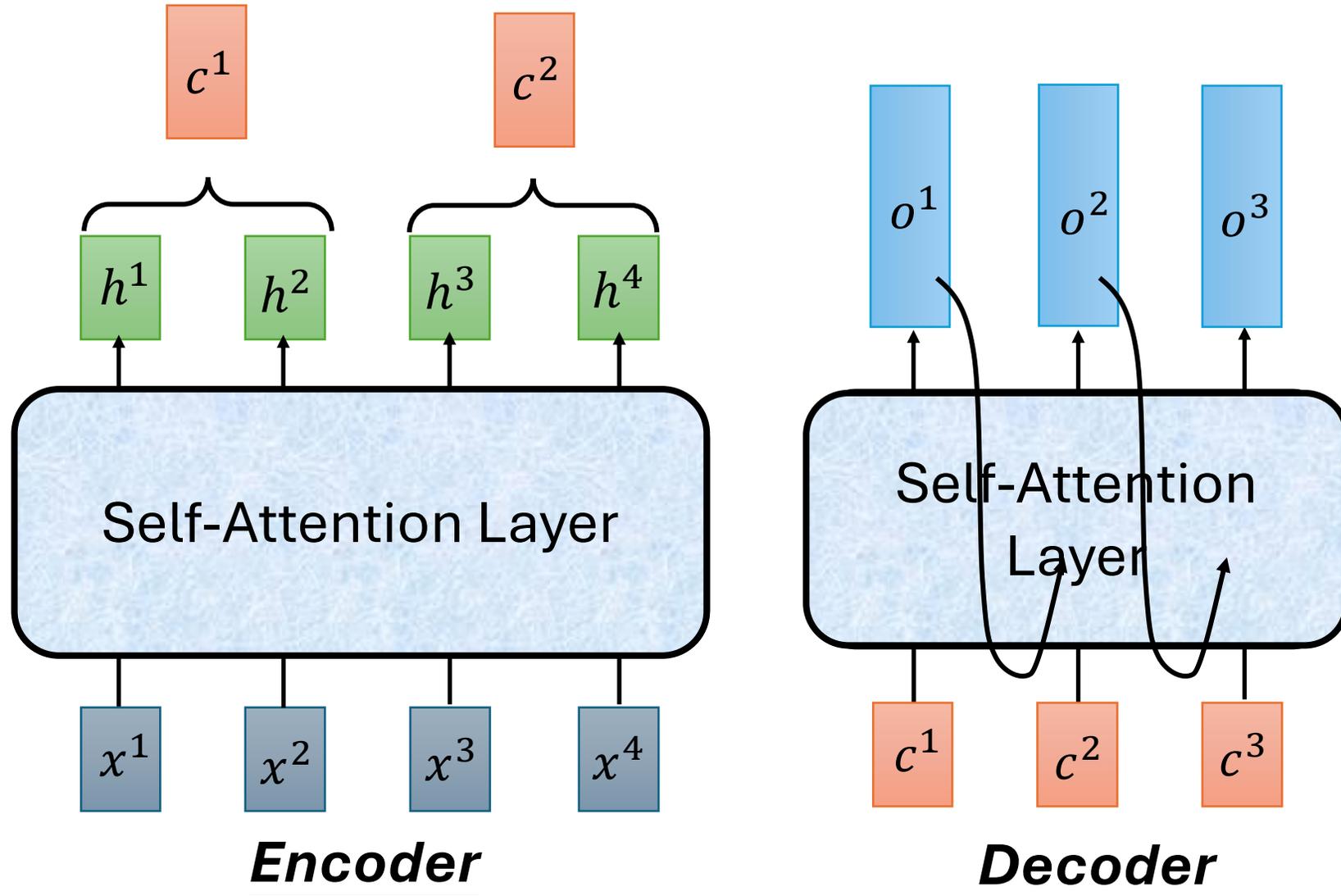
- Computing the similarity between each element and other elements in the input sequence as weights
- The model can capture long-distance dependencies in the sequence, not just the local information



Matrix Operations of Self-attention



Transformer: Seq2seq model with Self-Attention



Text Generation

Predict-Next-Word



- Input: token sequence
- Output: the next token (word) to the sequence

GPT (Generative Pre-trained Transformer)

Attention-based deep transformers

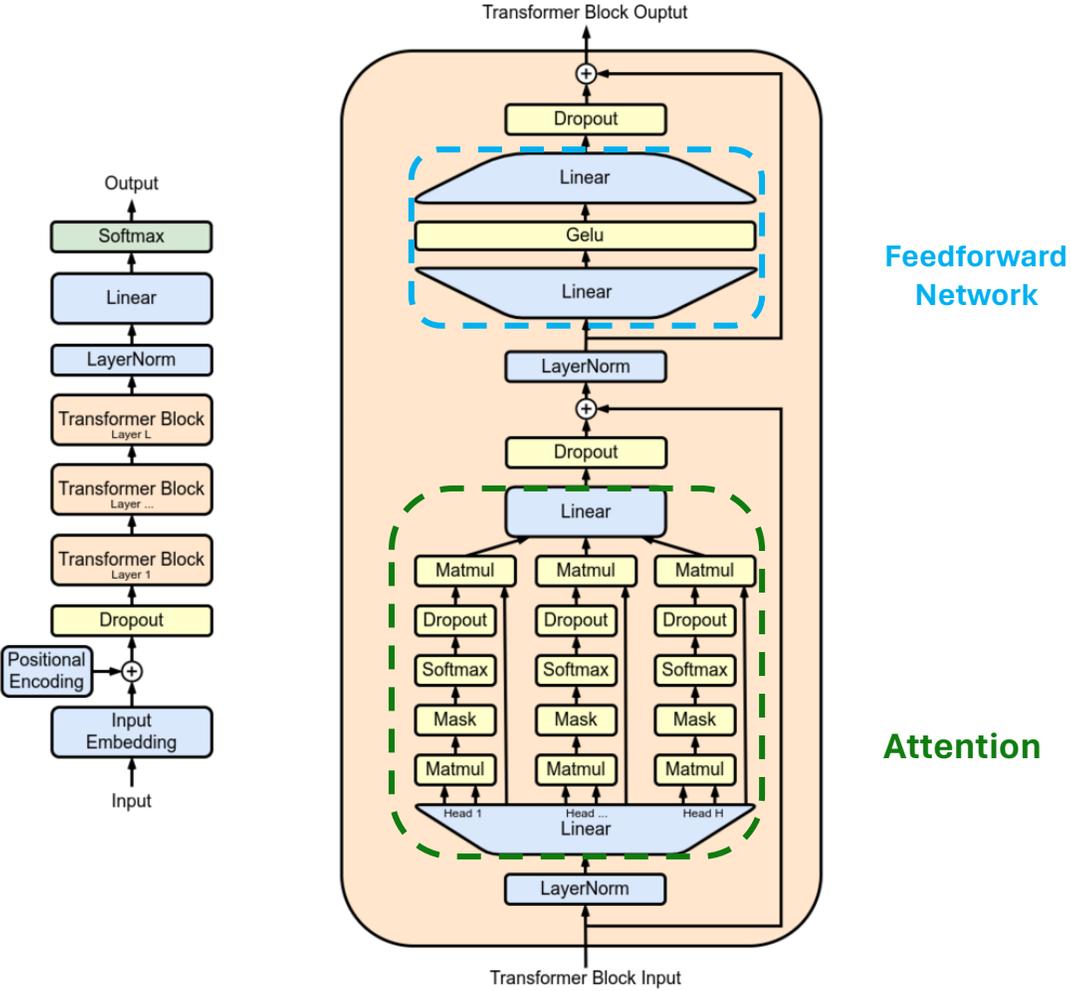
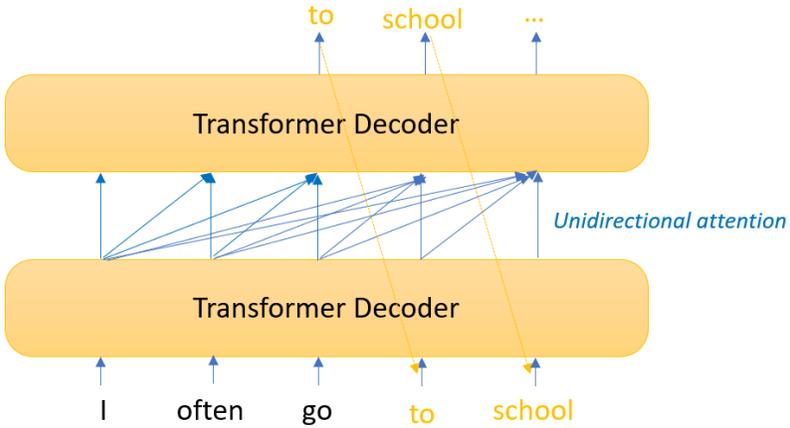


Image Generation

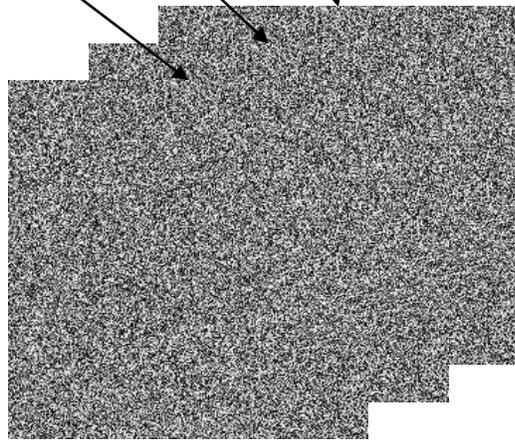
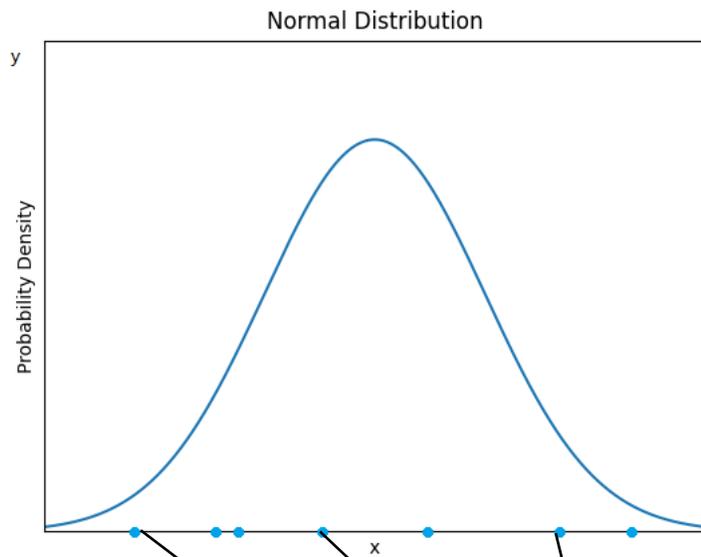
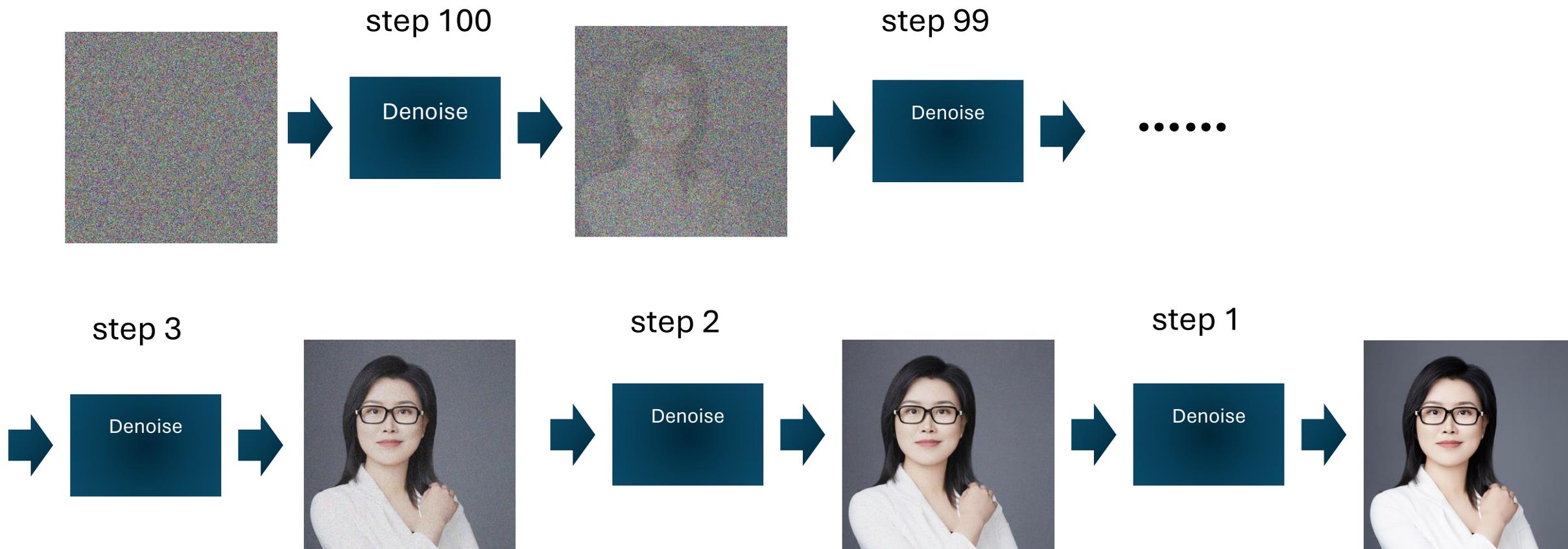


Image Generation Model
(Neural Network)

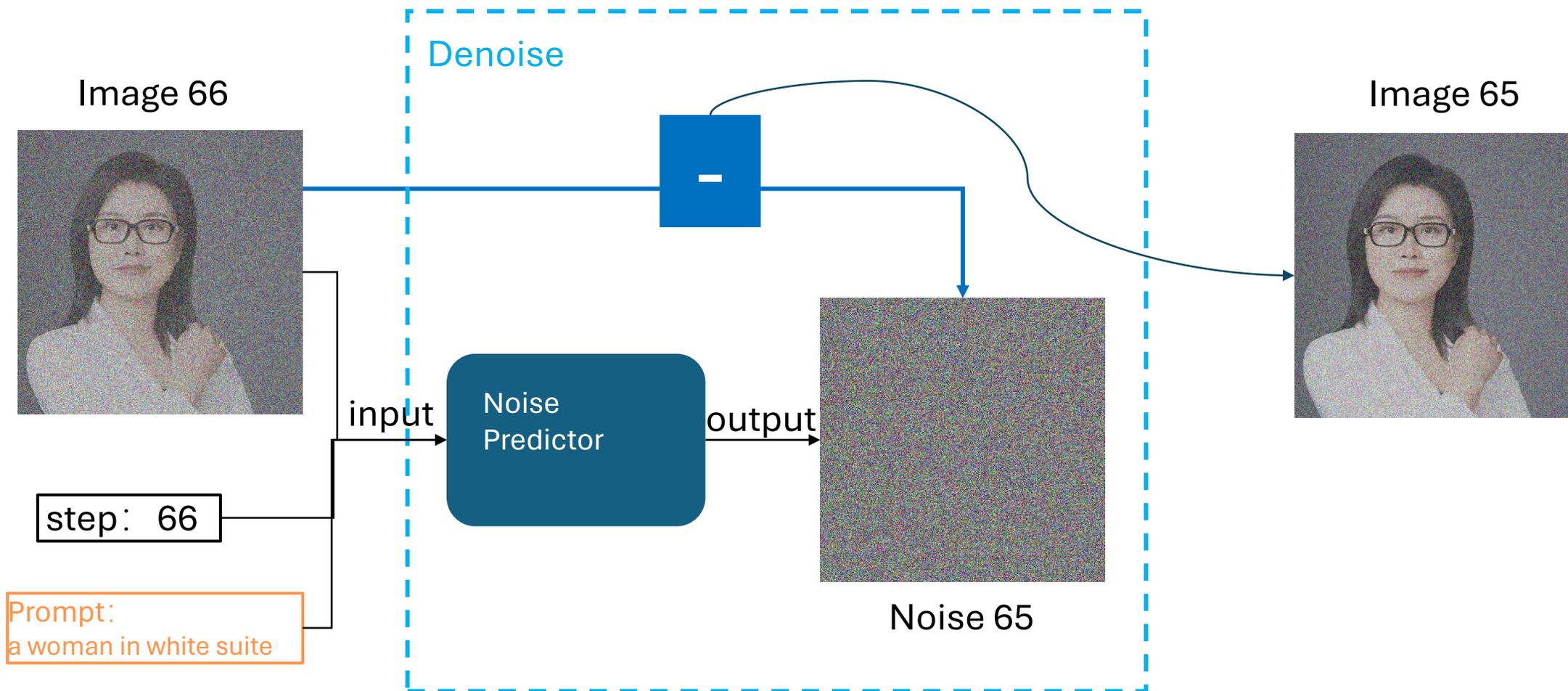


paired data

Diffusion Model: Generate Images from Noise



Denoise => Predict noise



Math principals of diffusion model

Algorithm 1 Training

- 1: **repeat**
- 2: $\mathbf{x}_0 \sim q(\mathbf{x}_0)$
- 3: $t \sim \text{Uniform}(\{1, \dots, T\})$
- 4: $\boldsymbol{\epsilon} \sim \mathcal{N}(\mathbf{0}, \mathbf{I})$
- 5: Take gradient descent step on
$$\nabla_{\theta} \left\| \boldsymbol{\epsilon} - \boldsymbol{\epsilon}_{\theta}(\sqrt{\bar{\alpha}_t} \mathbf{x}_0 + \sqrt{1 - \bar{\alpha}_t} \boldsymbol{\epsilon}, t) \right\|^2$$
- 6: **until** converged

Algorithm 2 Sampling

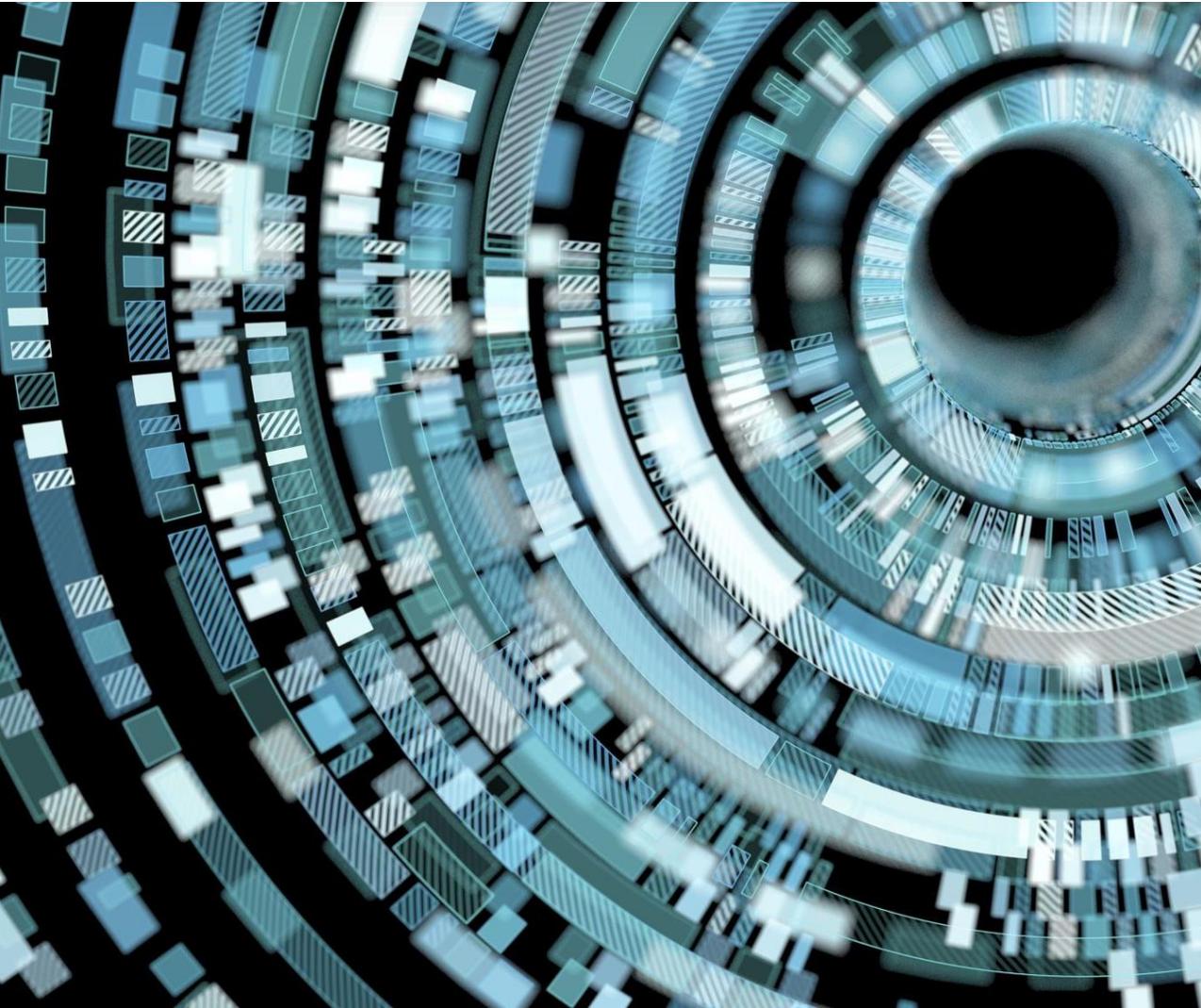
- 1: $\mathbf{x}_T \sim \mathcal{N}(\mathbf{0}, \mathbf{I})$
- 2: **for** $t = T, \dots, 1$ **do**
- 3: $\mathbf{z} \sim \mathcal{N}(\mathbf{0}, \mathbf{I})$ if $t > 1$, else $\mathbf{z} = \mathbf{0}$
- 4: $\mathbf{x}_{t-1} = \frac{1}{\sqrt{\alpha_t}} \left(\mathbf{x}_t - \frac{1 - \alpha_t}{\sqrt{1 - \bar{\alpha}_t}} \boldsymbol{\epsilon}_{\theta}(\mathbf{x}_t, t) \right) + \sigma_t \mathbf{z}$
- 5: **end for**
- 6: **return** \mathbf{x}_0

Denoising Diffusion Probabilistic Models

Submitted on 19 Jun 2020, last revised 16 Dec 2020

[\[2006.11239\] Denoising Diffusion Probabilistic Models \(arxiv.org\)](https://arxiv.org/abs/2006.11239)

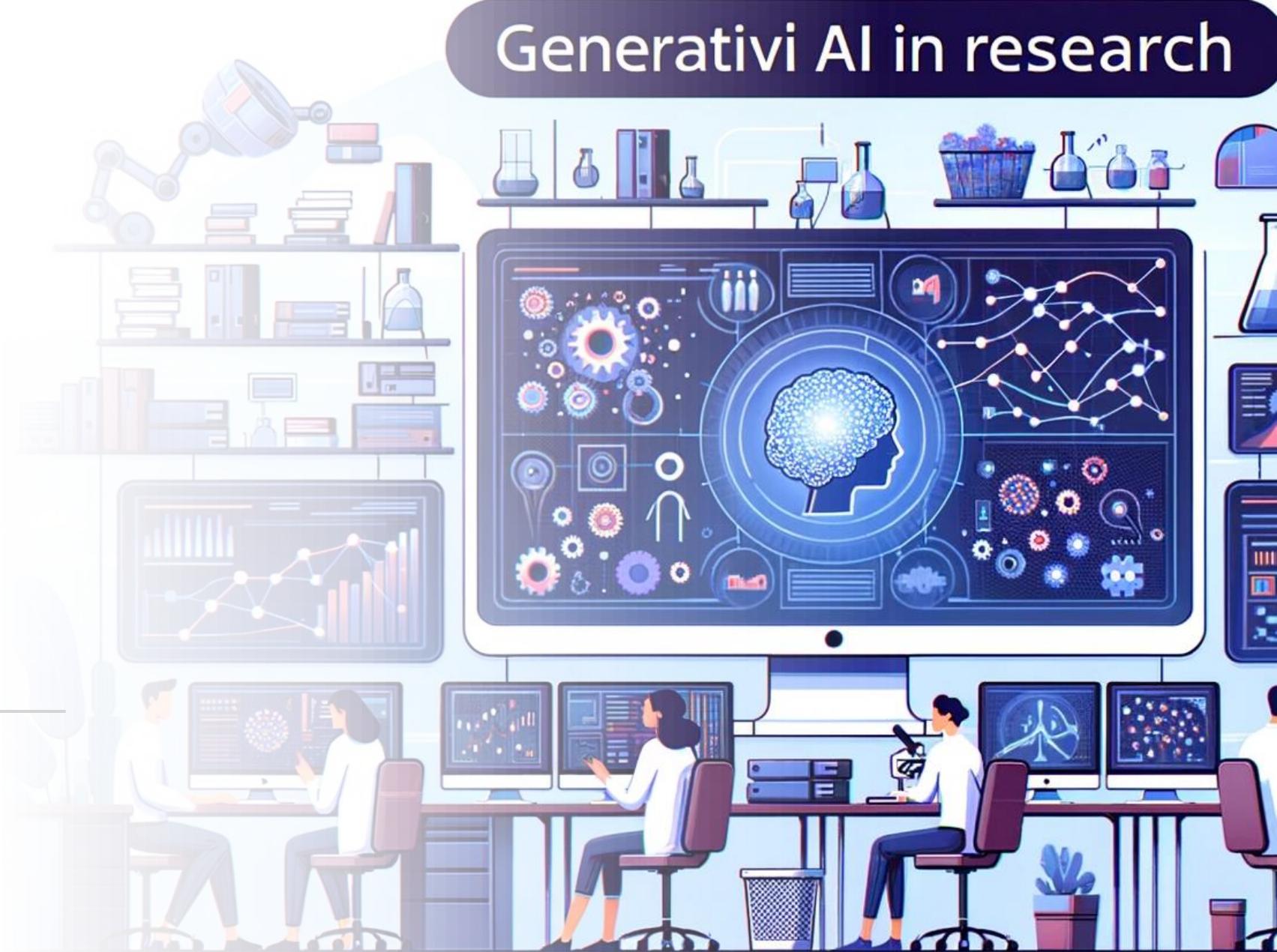
The Spread of Prompt Engineering



- Prompt Engineering
 - a method to enhancing model performance by crafting effective prompts
 - the process of carefully crafting and refining input prompts to guide machine learning models, particularly language models, towards producing desired outputs
- The Revolution of AI adoption
 - Input with natural language instead of code
 - AI models are accessible for unprofessional users
 - Prompts are description of user's requirements

Generative AI in research

Generative AI in Research



Generative AI aids in academic reading

- Automated Abstraction
- Automated summarization
- Knowledge extraction
- The dominant **sequence transduction models** are based on complex recurrent or convolutional neural networks that include an encoder and a decoder. The best performing models also connect the encoder and decoder through an attention mechanism. We **propose** a new simple network architecture, the **Transformer**, based **solely** on attention mechanisms, **dispensing** with recurrence and convolutions entirely.
- **Experiments** on two machine translation tasks show these models to be superior in quality while being more parallelizable and requiring significantly less time to train. Our model **achieves** 28.4 BLEU on the WMT 2014 English-to-German translation task, improving over the existing best results, including ensembles, by over 2 BLEU. On the WMT 2014 English-to-French translation task, our model establishes a new single-model state-of-the-art BLEU score of 41.8 after training for 3.5 days on eight GPUs, a small fraction of the training costs of the best models from the literature. We show that the Transformer generalizes well to other tasks by applying it successfully to English constituency parsing both with large and limited training data.

Attention Is All You Need

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Abstract

The dominant sequence transduction models are based on complex recurrent or convolutional neural networks that include an encoder and a decoder. The best performing models also connect the encoder and decoder through an attention mechanism. We propose a new simple network architecture, the Transformer, based solely on attention mechanisms, dispensing with recurrence and convolutions entirely. Experiments on two machine translation tasks show these models to be superior in quality while being more parallelizable and requiring significantly less time to train. Our model achieves 28.4 BLEU on the WMT 2014 English-to-German translation task, improving over the existing best results, including ensembles, by over 2 BLEU. On the WMT 2014 English-to-French translation task, our model establishes a new single-model state-of-the-art BLEU score of 41.8 after training for 3.5 days on eight GPUs, a small fraction of the training costs of the best models from the literature. We show that the Transformer generalizes well to other tasks by applying it successfully to English constituency parsing both with large and limited training data.

An academic assistant aids in paper reading

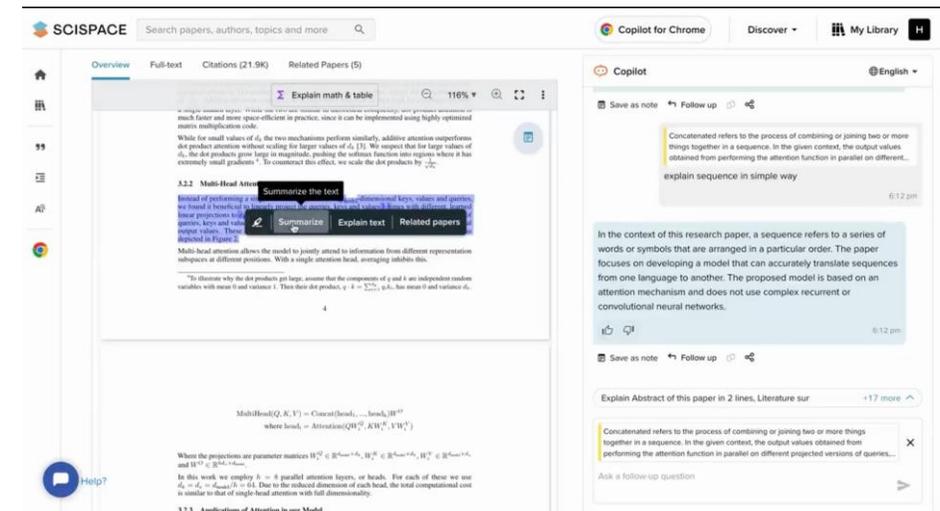
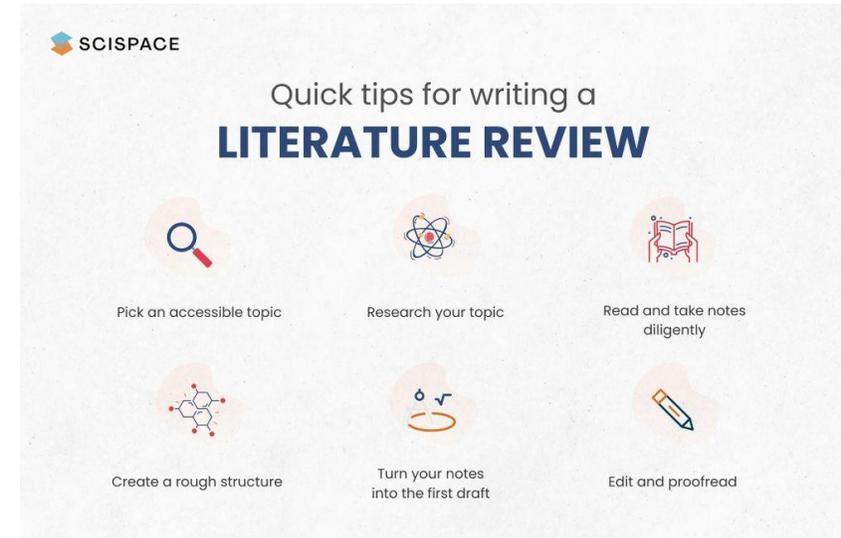
- Basic Information
- Paper Structure
- Key points
- Related information

Structure of “Attention is all your need”

1. Introduction
2. Background
3. Model Architecture
 - 3.1 Transformer Architecture
 - 3.2 Attention
-
4. Why Self-Attention
5. Training
6. Results
7. Conclusion

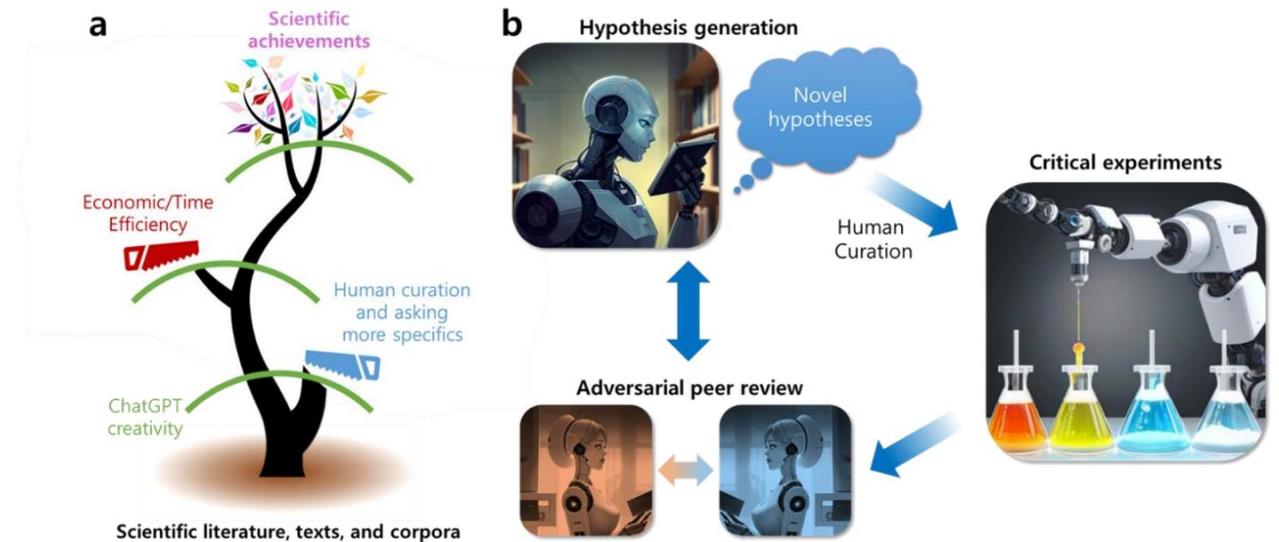
Automated Literature Review

- Utilizing AI to streamline the literature review process
- AI-powered tools for literature review
 - Time-saving
 - comprehensive analysis
 - bias reduction



Automated Hypothesis Generation

- Leveraging AI to formulate research hypotheses
 - AI-driven tools analyze vast literature using NLP
 - Identify connections across research areas
- Generate innovative hypotheses
 - Data analytics to discover new patterns or relations
 - Beyond traditional methods



Data Augmentation & Synthetic Data Generation

- Data Augmentation
 - Transformations (rotation, flipping, cropping) to diversify dataset
 - Common in image tasks.
- Synthetic Data Generation
 - Create new data points via algorithms
 - Addresses data scarcity and aids when labeling is challenging.
- Expanding datasets through synthetic data generation
- Enhance training data quality & quantity



Prewrite & Draft Academic Papers

- Prewriting
 - Expand on your research questions with an AI brainstorming session
 - Turn your ideas into an outline with an AI outline generator
- Drafting
 - Streamline the writing process with an AI-powered content generator by offering personalized content that reflects your varied sources and ideas

✕ Tell Wordtune what to generate

Type your AI prompt

0 / 1000

or select a Template

Business Marketing **Product & Project** HR Personal

Product Description
Generate a brief description of the features and benefits of your product.

Personas
Identify and illustrate the profile of your users

Blog Post
Write a choice

Example

Experience seamless banking like never before. Take control of your finances, save effortlessly, and enjoy peace of mind knowing that our fee-free services are backed by round-the-clock support:

- Auto-savings: Our app takes the hassle out of saving by automating the process. Set your savings goals and watch as the app intelligently saves for you, helping you reach your financial targets faster.
- Fee-free: Say goodbye to unnecessary fees. Our app is completely fee-free,...

Brief

Banking app

Features

Auto-savings, Fee-free, 24/7 support

Cancel Generate

What are some controversies in th

1 free prompt(s) left. [Start your free](#)

Fact-checking my answer to make sure it is correct, hang on... (11/11)

Controversies in the field of nephrology encompass a range of topics that are still subject to intense debate and differing opinions within the nephrology community. One area of controversy is the definition and classification of chronic kidney disease. The Kidney Disease: Improving Global Outcomes (KDIGO) organization conducted a survey and sponsored a controversies conference to address this issue and develop a global consensus [1].

Another controversial topic is the management of kidney disease in patients with hematological malignancies and the burden of cancer after kidney transplantation. The KDIGO Controversies Conference on onco-nephrology focused on

The use of intravenous iron products in patients with end-stage renal disease (ESRD) and inflammatory bowel disease (IBD) is also a subject of controversy. The chronic indiscriminate use of these products can lead to iron overload, and with this practice is still debated within the nephrology community [3].

Preservation of residual renal function (RRF) in dialysis patients is another area of controversy. While there are attempts to preserve RRF in patients with Stage 5 CKD, there are differing opinions on the benefits and drawbacks of this ap

The evaluation and management of vitamin D deficiency in nephrology is also a topic of controversy. Guidelines and recommendations vary, and there is ongoing debate about the optimal approach to addressing vitamin D deficiency in p [6].

Other controversial topics in nephrology include the use of angiotensin receptor antagonists and angiotensin-converting enzyme inhibitors in the treatment of kidney disease, the role of estimated glomerular filtration rate in live kidney evidence-based approach to the treatment of chronic kidney disease-mineral and bone disorder [7][8][9].

Overall, controversies in nephrology arise from the complexity of the field and the ongoing research and advancements in understanding kidney diseases and their management. These controversies highlight the need for continued research and discussion within the nephrology community to improve patient outcomes and guide clinical practice.

View searches run to ground this response

[disputes nephrology](#)
[controversies nephrology](#)
[controversial topics nephrology](#)
[Controversies in the use of immunosuppressive therapy in nephrology](#)
[Controversies in renal transplantation: An update](#)
[Controversies in the diagnosis and management of chronic kidney disease](#)

View publications consulted

[1] Levey et al., "Definition and classification of chronic kidney disease: A position statement from Kidney Disease: Improving Global Outcomes (KDIGO)," *Kidney International* (2005). doi:10.1111/j.1523-1755.2005.00365.x
[2] Bellizzi et al., "Controversial issues in CKD clinical practice: position statement of the CKD-treatment working group of the Italian Society of Nephrology," *Journal of nephrology* (2016). doi:10.1007/s40620-016-0338-x
[3] "Announcements," *American journal of kidney diseases* (2006). doi:10.1053/j.ajkd.2006.04.01466-1
[4] Spasovski, "A Review of Sevelamer Hydrochloride in End-Stage Renal Disease Patients on Dialysis," *Clinical medicine insights therapeutics* (2011). doi:10.4137/cm.55990
[5] Rickard et al., "Prenatal hydronephrosis: Bridging pre- and postnatal management," *Prenatal diagnosis* (2022). doi:10.1002/pd.6114
[6] Canaud et al., "Bicarbonate and Citrate: The Iron Between Evidence-Based and Practice-Based Medicine: The Case for Hemodialysis"

View publications used

[1] Rostoker and Vaziri, "Risk of iron overload with chronic indiscriminate use of intravenous iron products in ESRD and IBD populations," *Heliyon* (2019). doi:10.1016/j.heliyon.2019.e02045
[2] Bover et al., "Evidence in chronic kidney disease-mineral and bone disorder guidelines: is it time to treat or time to wait?" *Clinical kidney journal* (2020). doi:10.1093/cjk/stz137
[3] Levey et al., "Definition and classification of chronic kidney disease: A position statement from Kidney Disease: Improving Global Outcomes (KDIGO)," *Kidney International* (2005). doi:10.1111/j.1523-1755.2005.00365.x
[4] Bellizzi et al., "Controversial issues in CKD clinical practice: position statement of the CKD-treatment working group of the Italian Society of Nephrology," *Journal of nephrology* (2016). doi:10.1007/s40620-016-0338-x
[5] Canaud et al., "Residual renal function and dialysis modality: is it really beneficial?"

What do you need help with?



- Utilizing AI to mentor and guide junior researchers, especially through chat-based interactions
- Benefits
 - Enhanced learning
 - Personalized feedback
 - Accelerated research progress

Junior Researchers Coaching

Collaborative
BETWEEN ACADEMIC & INDUSTRY
**Opportunities between
Industry and Academia**



Benefits of Collaboration

- Knowledge Exchange
 - Sharing expertise and resources for mutual growth.
- Talent Development
 - Training the next generation of AI researchers and practitioners.
- Problem-Solving
 - Tackling real-world challenges with combined efforts.



- Joint Research Projects
 - Initiatives in the realm of Generative AI
 - Driven by requirements from industry
- Product Development
 - Academic guidance from academia (e.g. algorithms, prompts)
 - Collect feedback from customers directly

Areas for Collaboration (1)

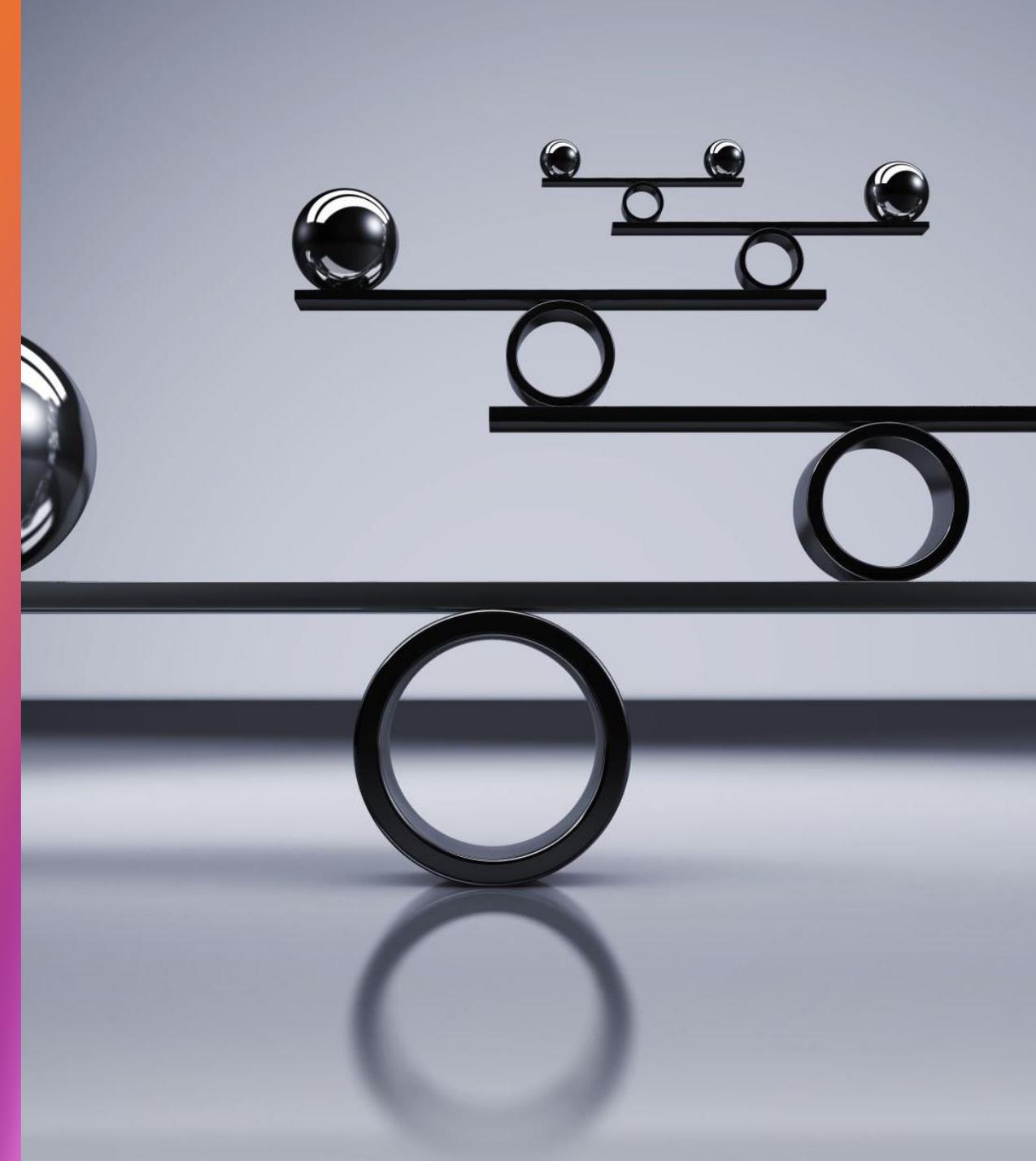
Areas for Collaboration (2)

- Educational Programs
 - Co-developed courses, workshops, and training programs
 - Public lectures and knowledge sharing
- Community Engagements
 - Hackathons
 - Competitions
 - Fostering an ecosystem





Responsible AI for Research

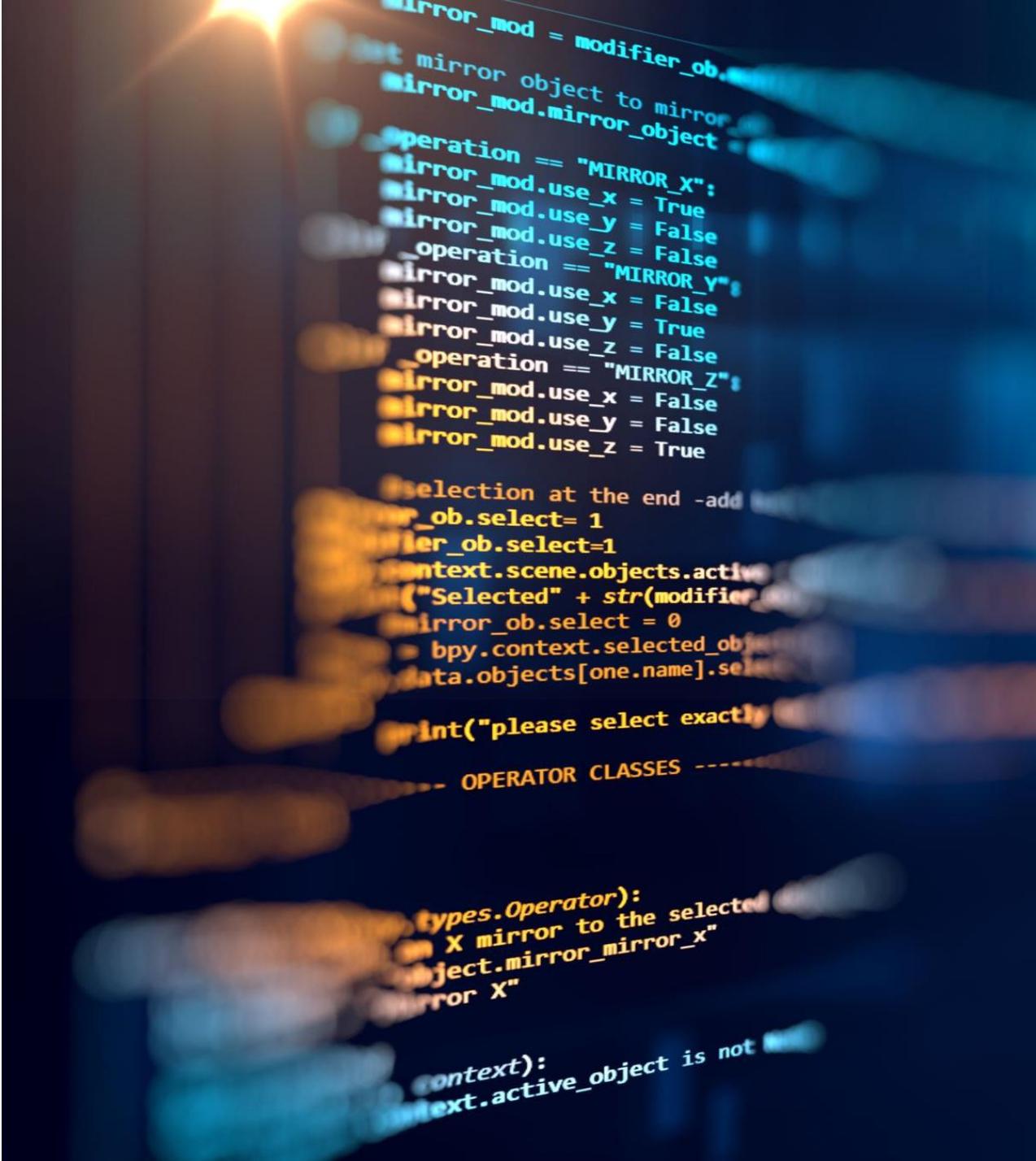


Bias and Fairness

- Biases in AI models
- Principle: Ensuring fairness and avoiding discrimination.
- Strategies
 - Bias detection
 - fairness-aware algorithms
 - diverse data collection.

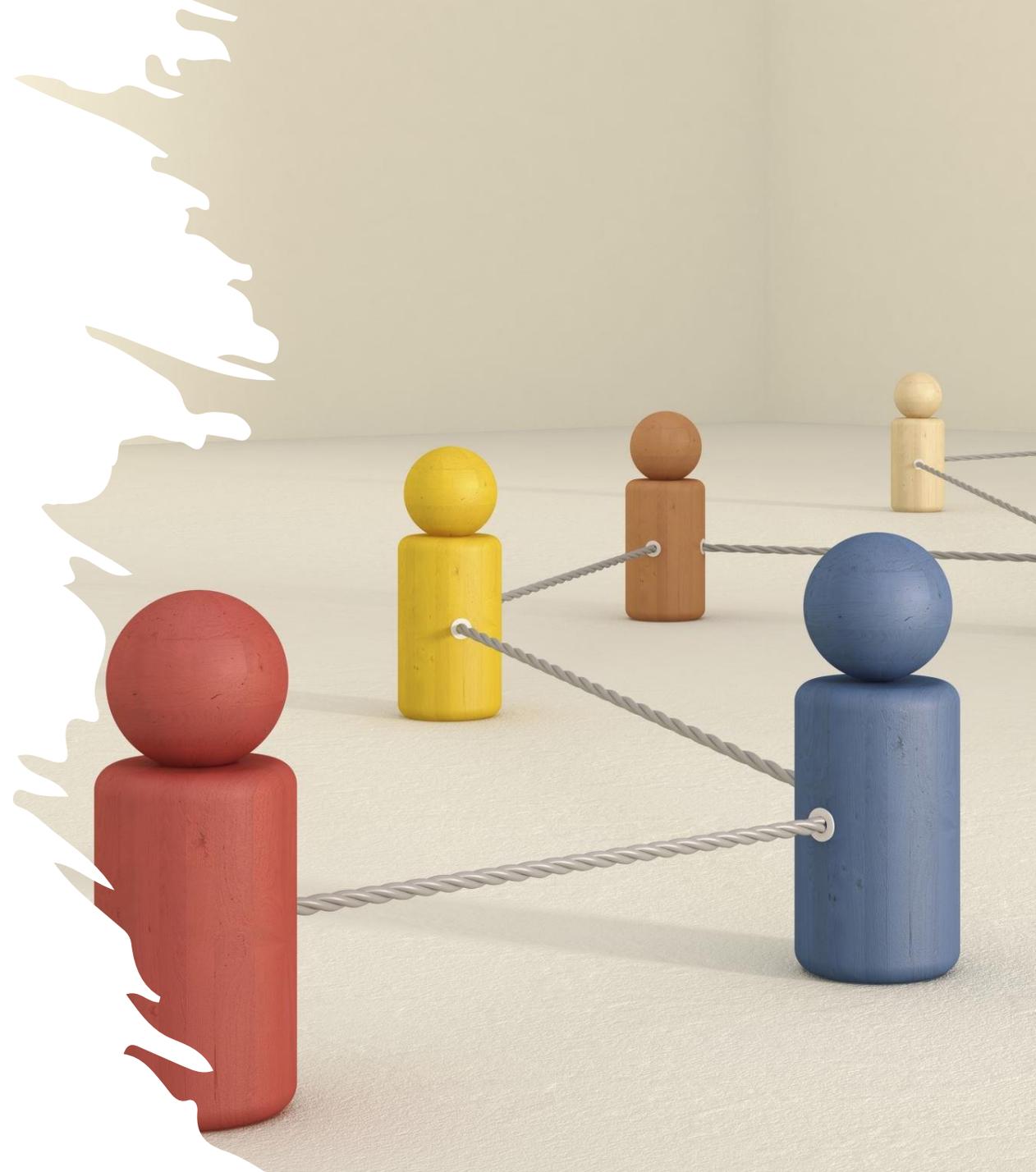
Data Privacy

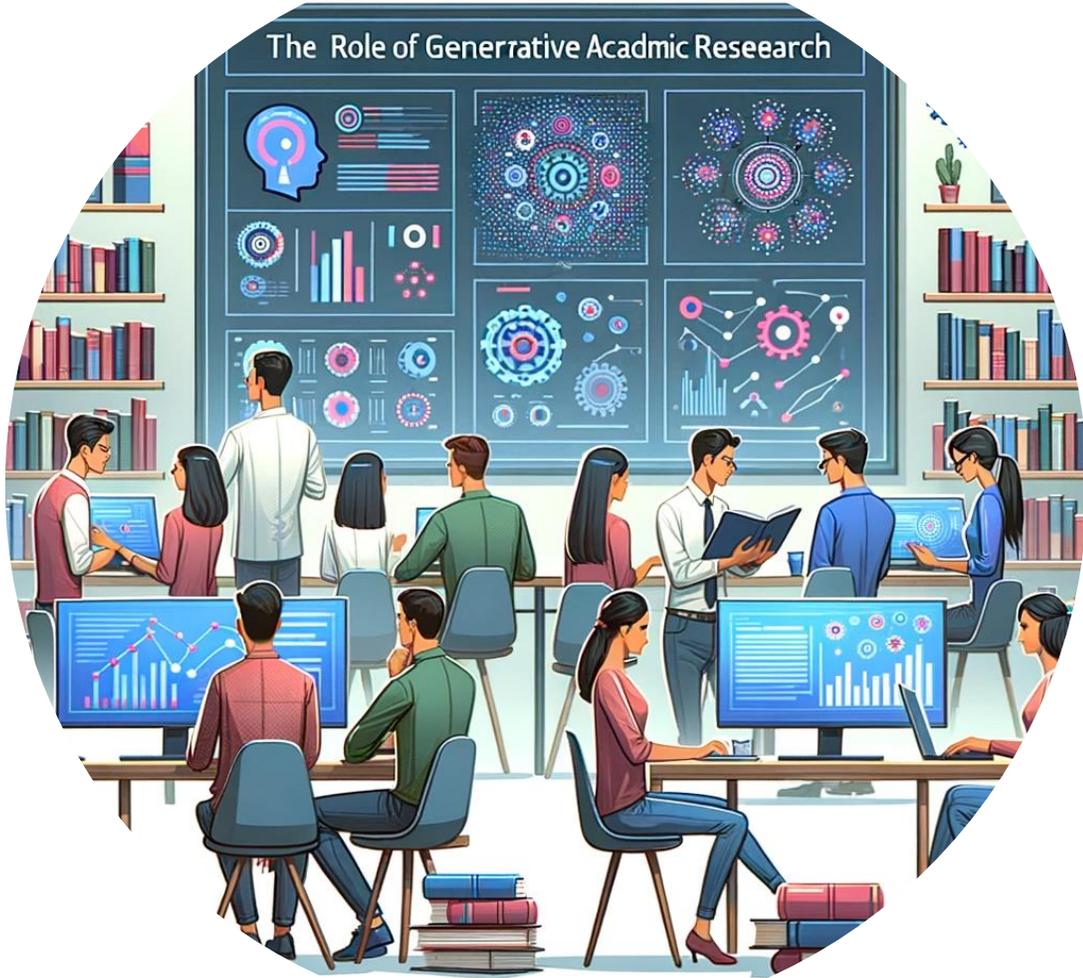
- Ethical handling of data, especially in sensitive research areas to protect individuals' data and ensuring privacy compliance
- Strategies
 - Privacy-preserving data augmentation
 - differential privacy



Accountability and Transparency

- Build trust and understanding among stakeholders by Ensuring clarity and openness in AI systems and research processes.
- Strategies
 - Transparent reporting
 - open-source models
 - explainable AI





Thank you

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