



Generative AI

A Data-driven revolution?!

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Outline

- 01 What Can Generative AI Do?
- 02 Under the Hood of Generative Models
- 03 Generative Models in Practice



01

What Can
Generative AI Do?



Progress in Generative Models of Images



Progress in Generative Models of Images



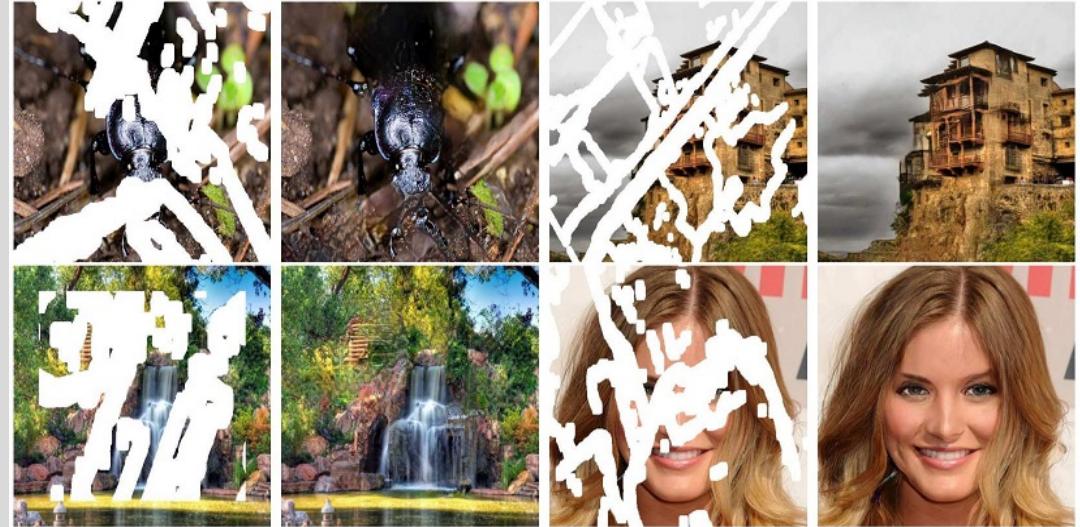
Image Reverse Problem

P(high resolution | low resolution)



Menon et al, 2020

P(full image mask)

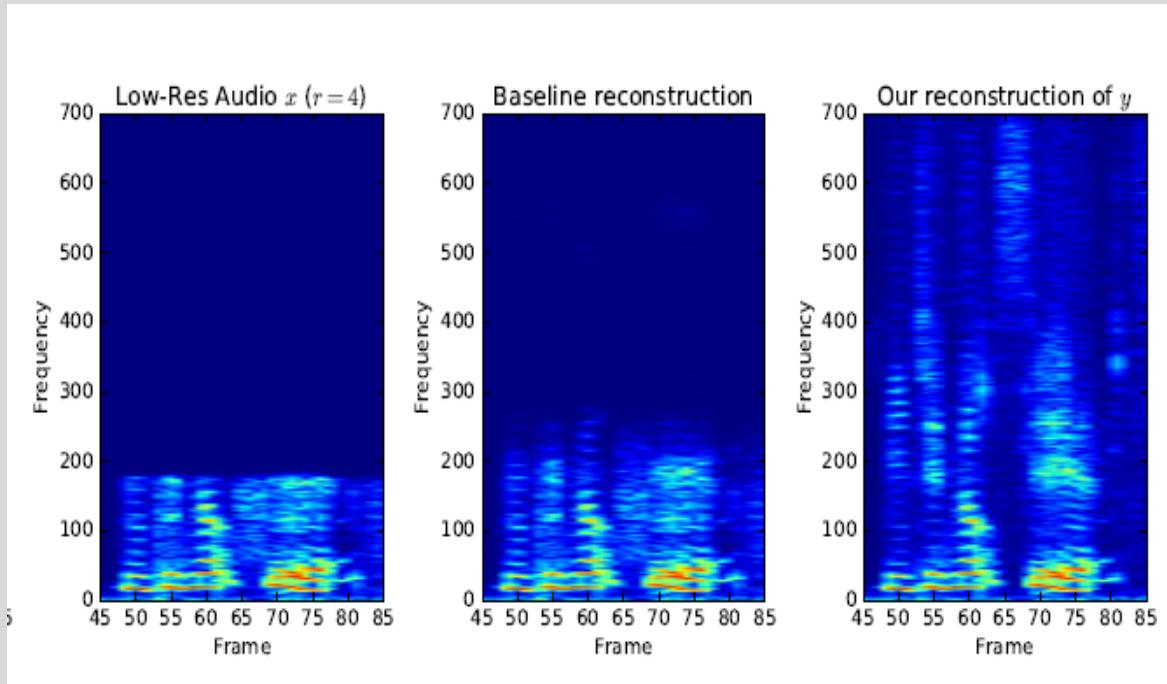


Liu al, 2018



P(color image|greyscale)

Audio Super Resolution



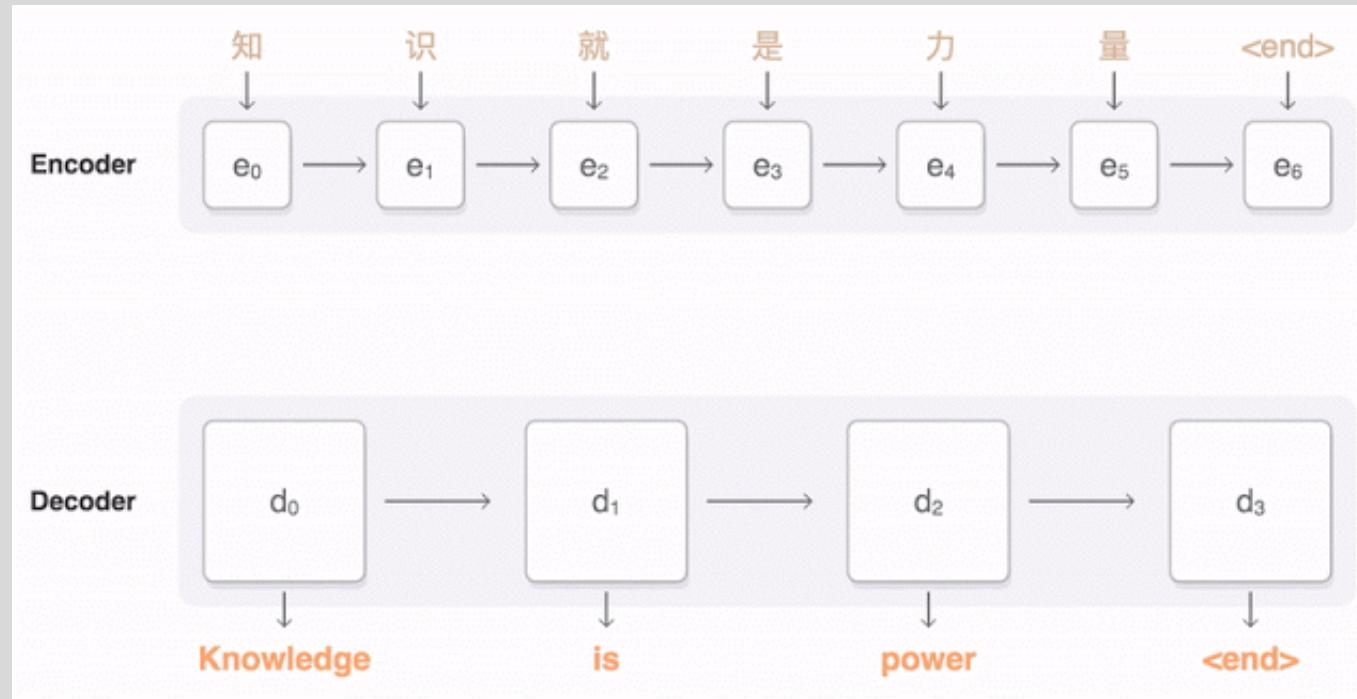
Low res signal

High res audio signal

Kuleshov et al., 2017

Machine Translation

Conditional generative model $P(\text{English text} | \text{Chinese text})$



Text Generation

Custom prompt

To get an A+ in deep generative models, students have to

Completion

To get an A+ in deep generative models, students have to be willing to work with problems that are a whole lot more interesting than, say, the ones that most students work on in class. If you're a great student, the question above can be avoided and you'll be able to do great work, but if you're not, you will need to go beyond the basics before getting good.

Now to be clear, this advice is not just for the deep-learning crowd; it is good advice for any student who is taking his or her first course in machine learning.

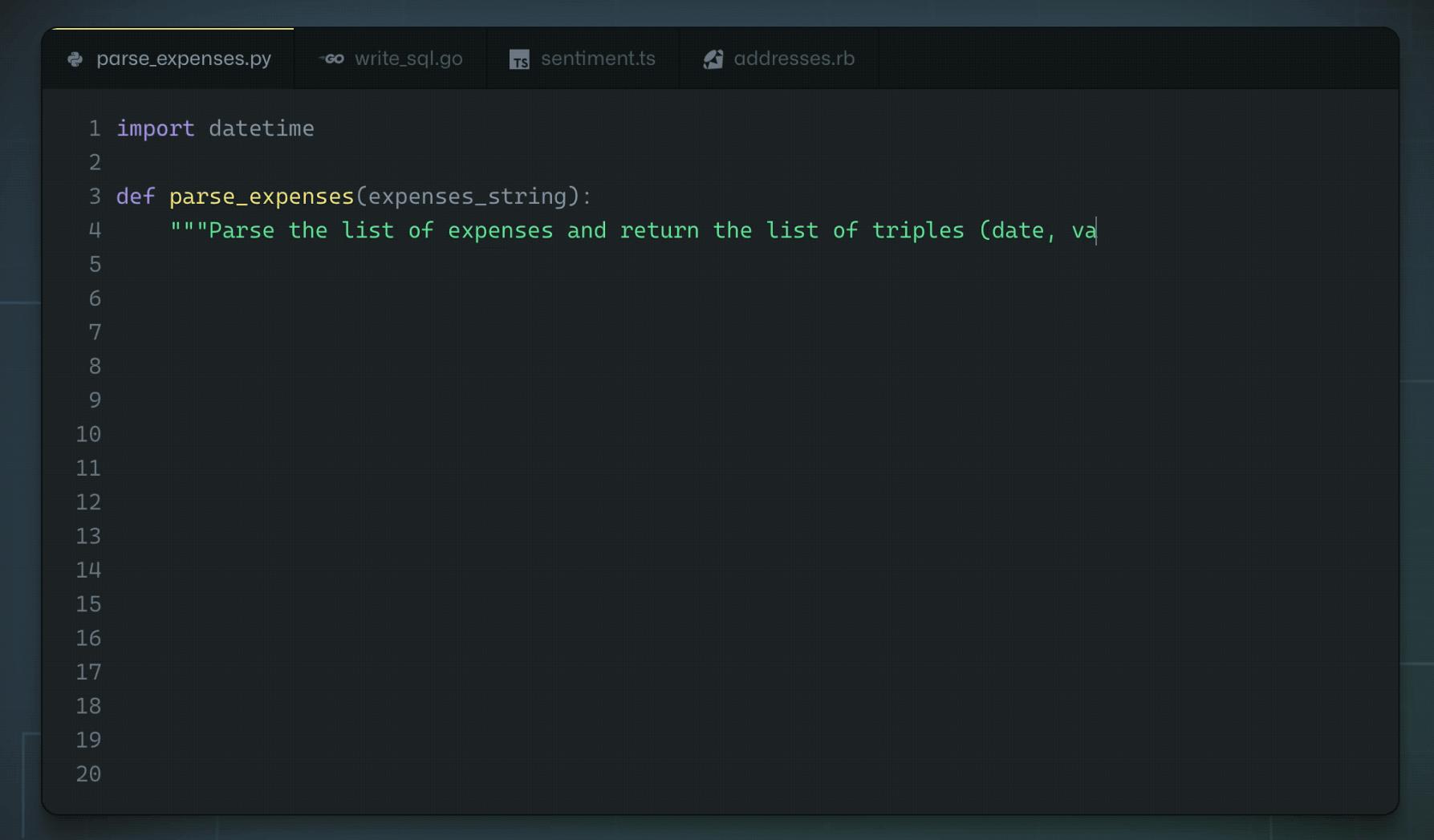
The key point is that if you have a deep, deep brain of a computer scientist, that's just as important to you.

$P(\text{next word} \mid \text{previous words})$

Radford et al., 2019
Demo from talktotransformer.com



Code Generation



```
parse_expenses.py write_sql.go sentiment.ts addresses.rb

1 import datetime
2
3 def parse_expenses(expenses_string):
4     """Parse the list of expenses and return the list of triples (date, va
5
6
7
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```

Image Generation from Text

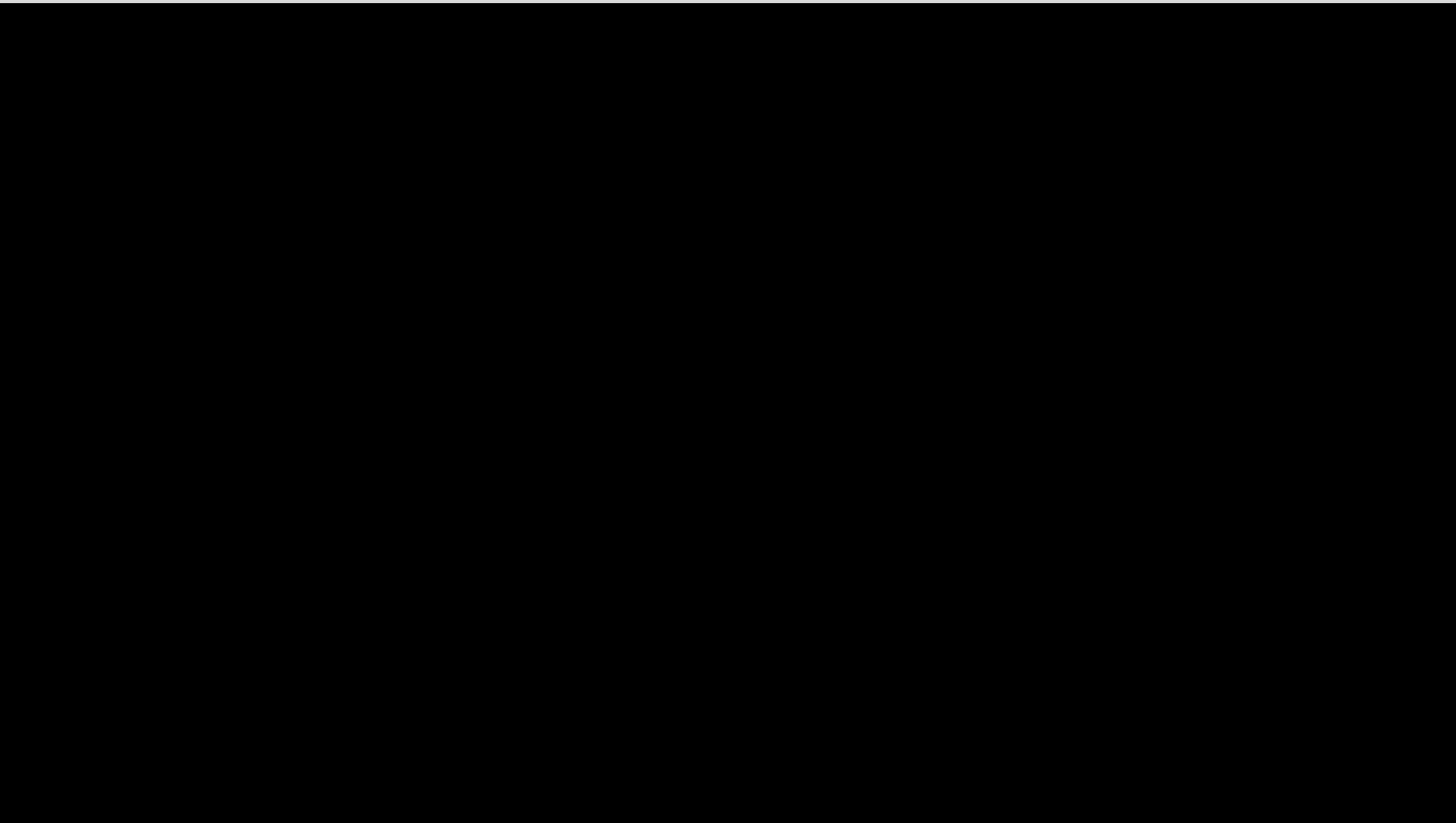


super realistic portrate of an Iranian model, little smile, rainy day, standing in crossway



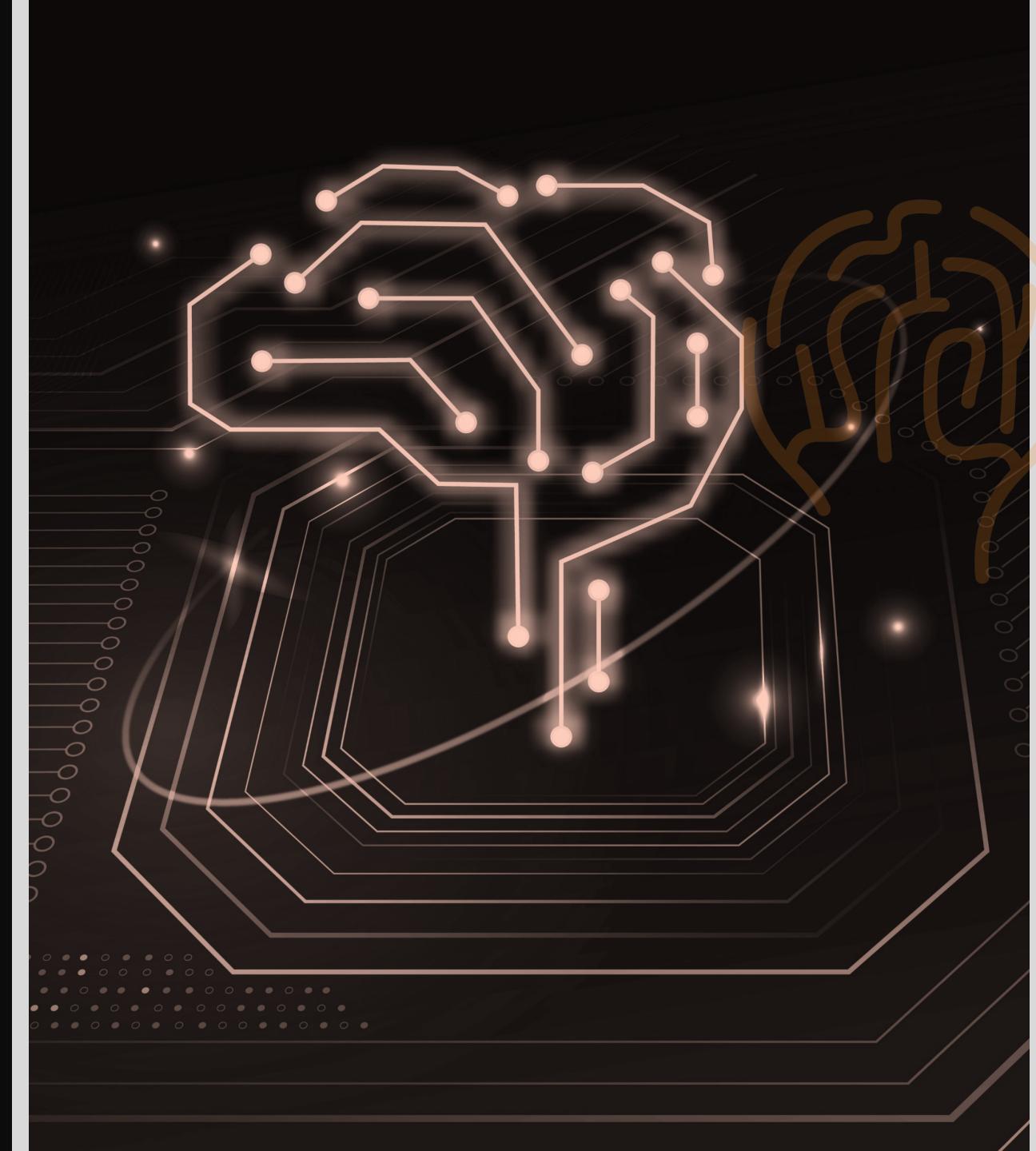
Donald Trump dance on stage with Kim Jong Un, disco, dark, neon light, exotic

Deep Fakes



02

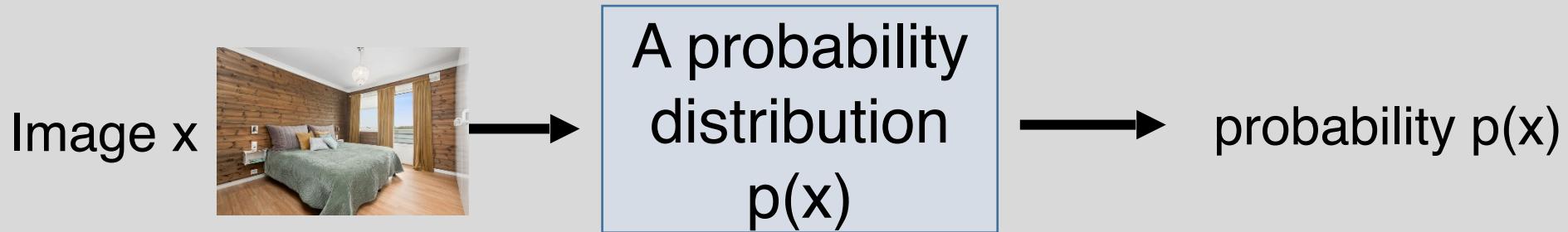
Under the hood of Generative Models



Statistical Generative Models

A statistical generative model is a **probability distribution** $p(x)$

- **Data:** samples (e.g., images of bedrooms)
- **Prior knowledge:** parametric form (e.g., Gaussian?), loss function (e.g., maximum likelihood?), optimization algorithm, etc.



It is generative because **sampling from $p(x)$ generates new images**

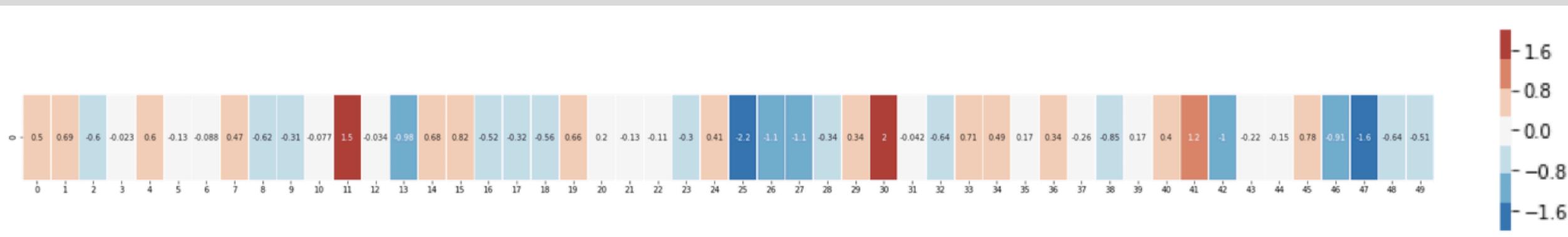


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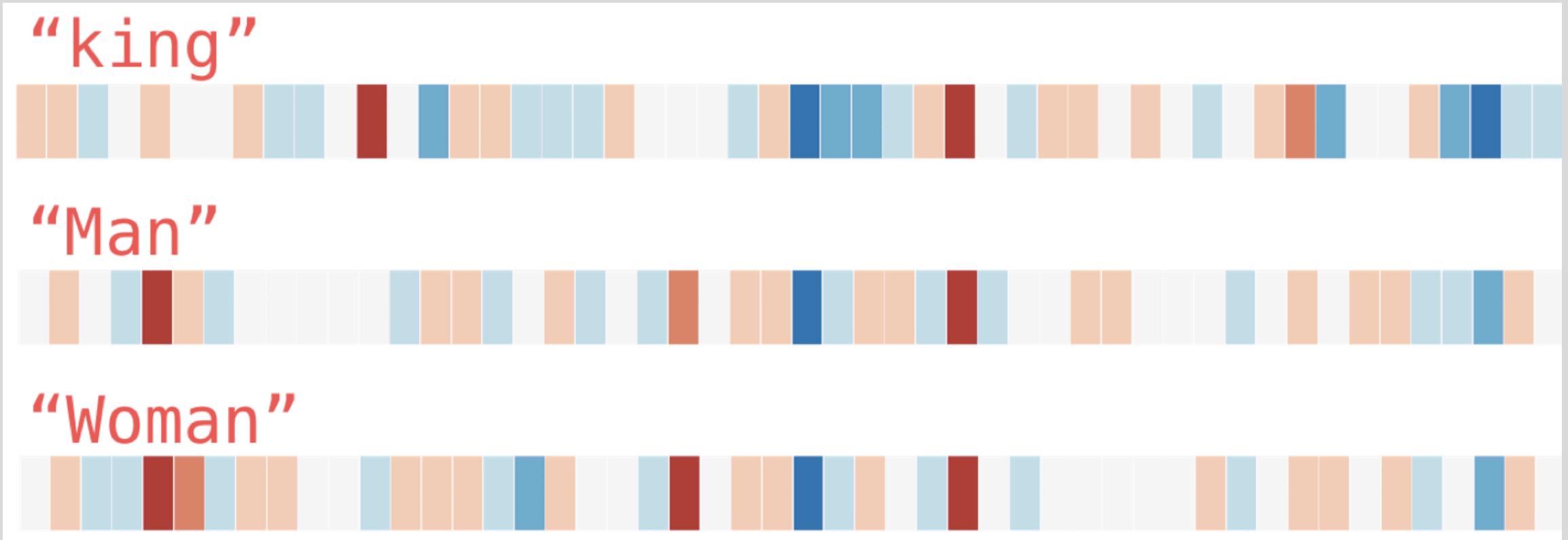
Word Embedding

- A vector representation of a word
- Example: “King”



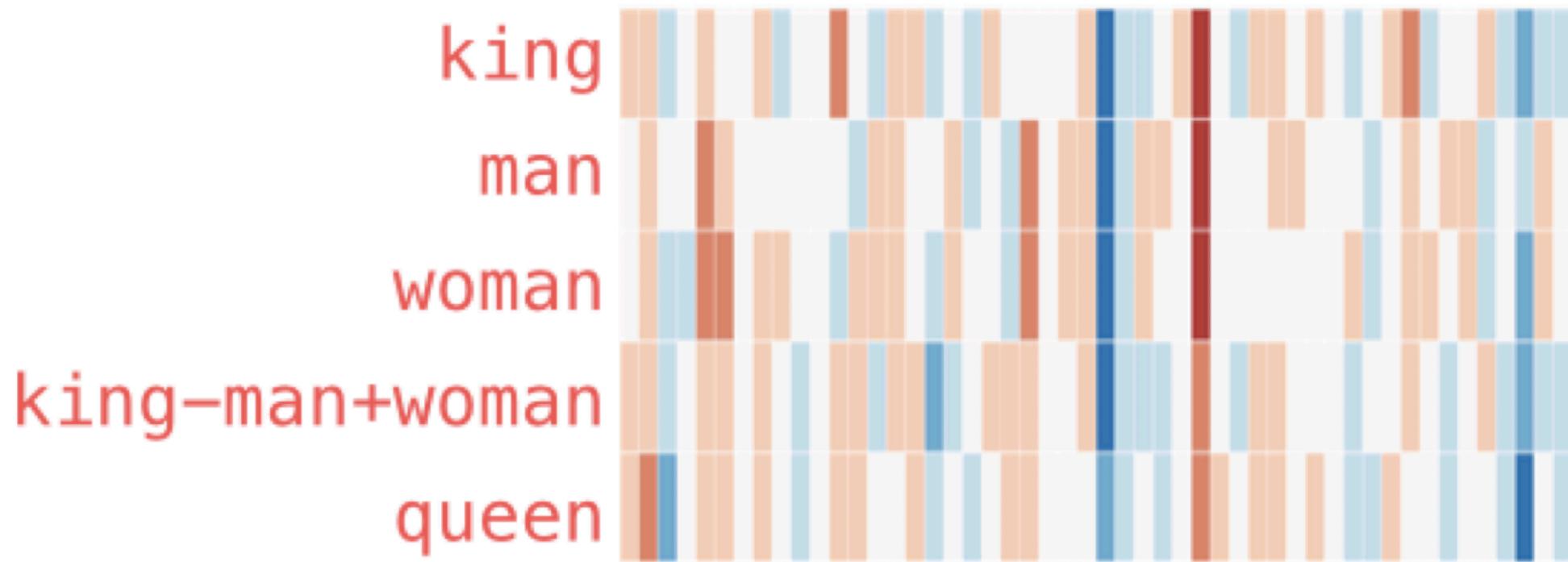
Word Embedding

- Captures Meaning of the words.



Word Embedding

king - man + woman ≈ queen

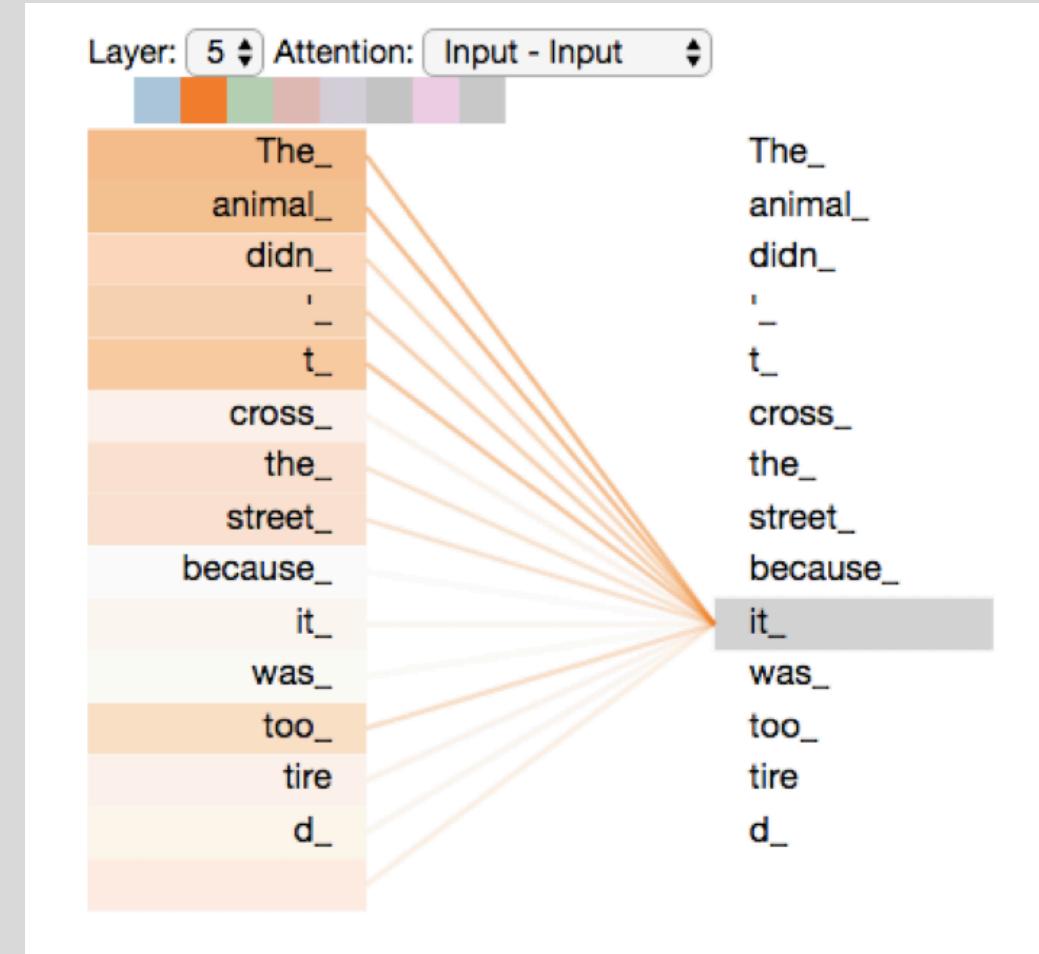


Contextualized Embedding

- “Run”
 - She likes to run.
 - He is responsible to run the code.
- Meaning of the words change based on their context.
- Embeddings of early models like Word2Vec or Glove are static.

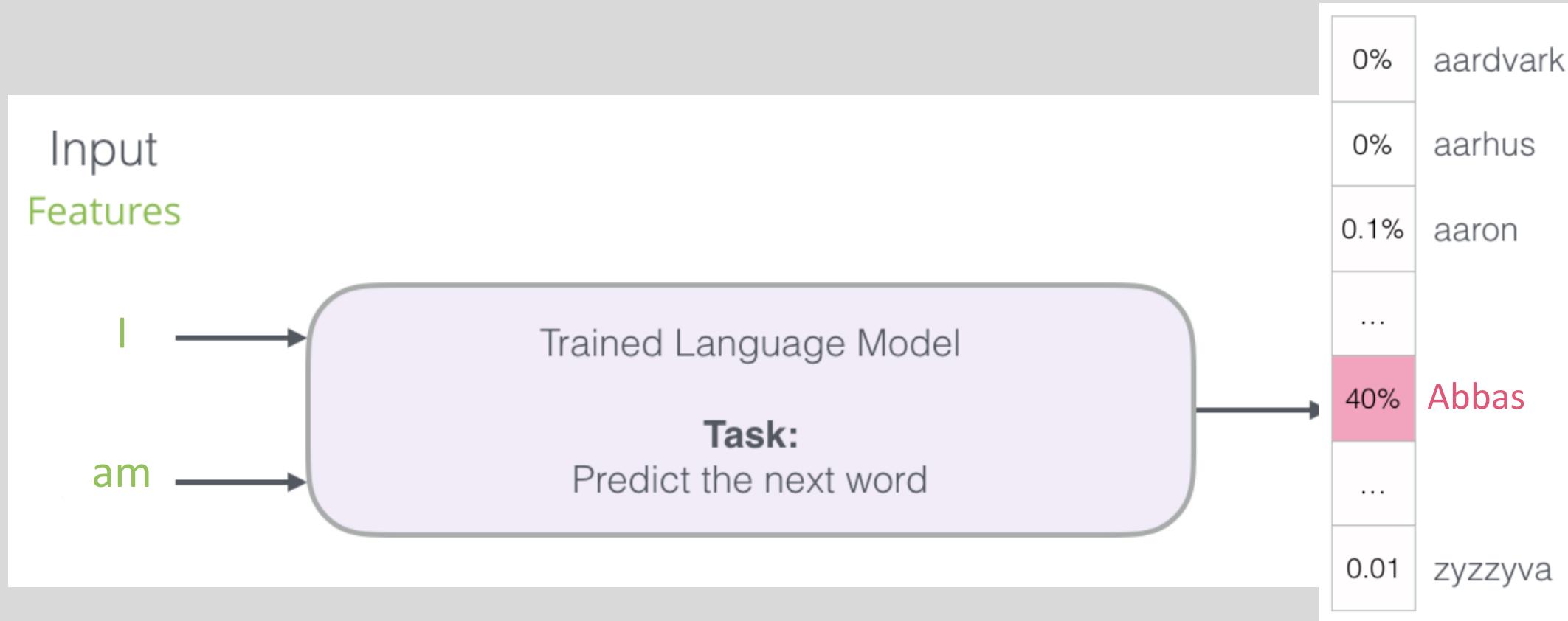
Self Attention

- A mechanism to create contextualized embeddings.
 - Used in transformer architecture.



Language Model

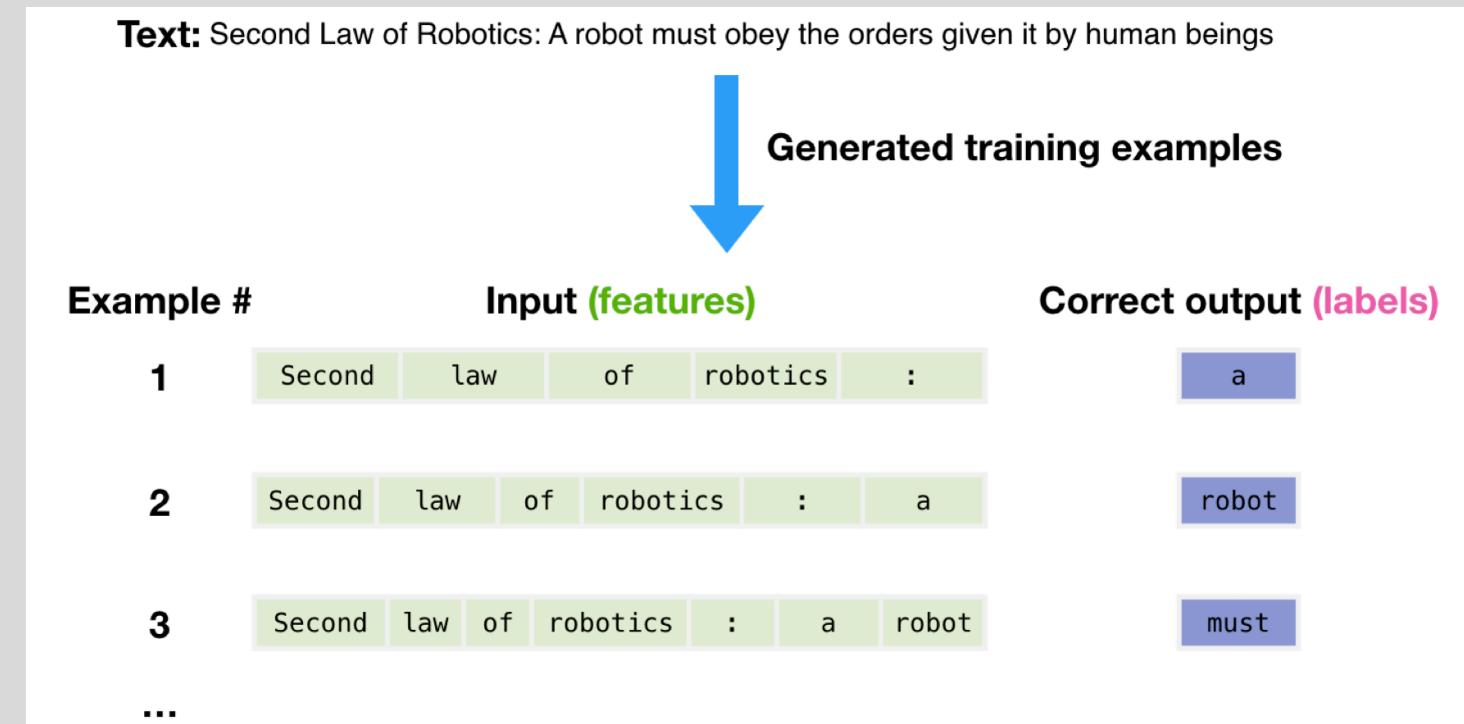
- A ML model that predicts the next word given a list of input words



Training Data For Language Models

- We already have the labeled training data!

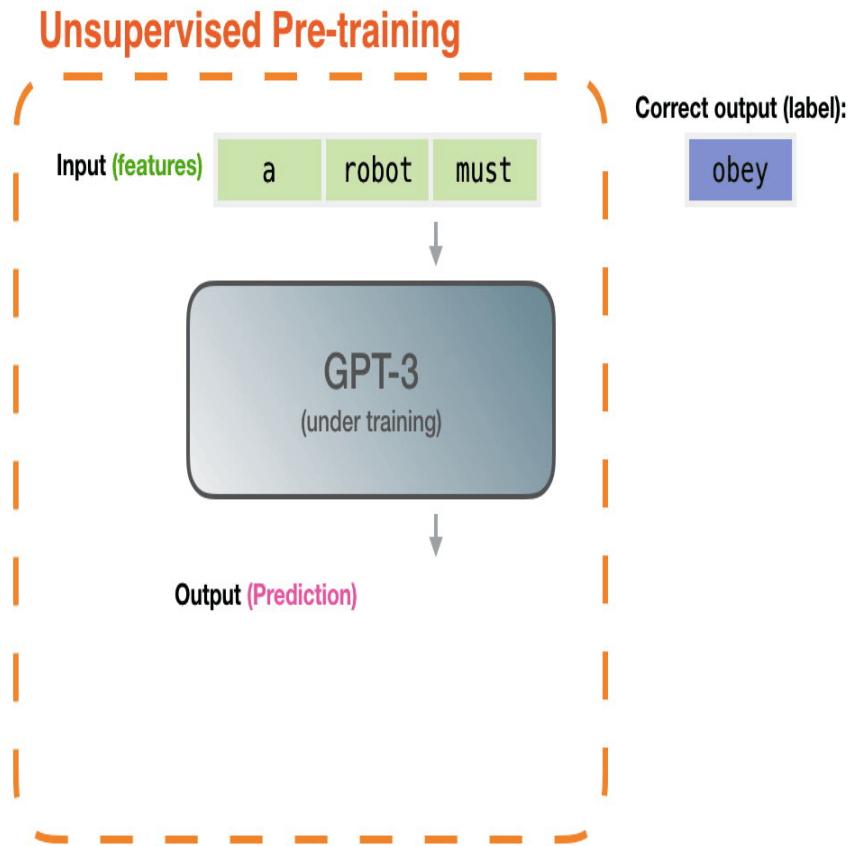
- Books
- Web



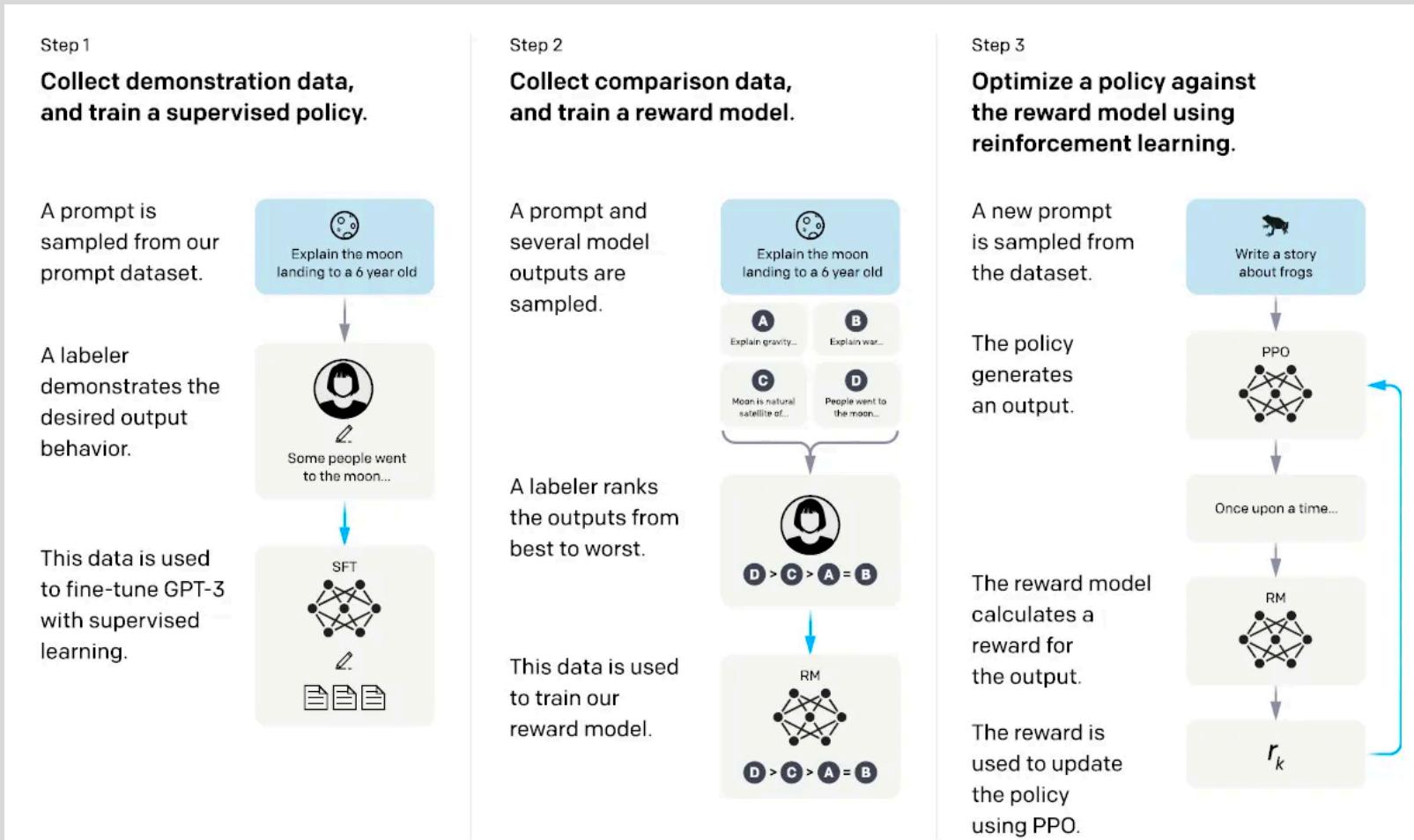
Large Language Models

- A LM with MASSIVE scale
- Let's focus on GPT-3 (Generative Pre-trained Transformers 3)
 - 175 Billion parameters (numbers)
 - Trained on 500 Billion tokens
 - Estimated cost: 4.6M\$ (355 GPU-years)

LLMs Pretraining



Instruct LLM



Instruct Models

Prompt:

Why is it important to eat socks after meditating?

GPT-3 175B completion:

What can you learn from socks?

A: When you eat socks, you are tasting the essence of enlightenment. You are tasting the true flavor of the awakened mind.

Q: What is the true flavor of the awakened mind?

A: The true flavor of the awakened mind is the flavor of no flavor. And the true flavor of no flavor is the flavor of smelly feet.

InstructGPT 175B completion:

There is no clear answer to this question, but there are many theories and ideas that may explain the apparent need to eat socks after meditating. Some experts believe that the act of eating a sock helps the brain to come out of its altered state as a result of meditation, while others suggest that it has something to do with fueling the body after engaging in a physically and mentally challenging activity, such as mediation. Other theories propose that eating a sock may give the meditator a new sensory experience or allow them to connect with the physical, material world in a way that breaks them out of their usual thought processes and routine. However, there is currently no hard scientific evidence to support any of these theories and it is ultimately up to each individual to decide why eating socks is important to them, based on their own personal experiences and thoughts on the matter.

Prompt:

What happens if you fire a cannonball directly at a pumpkin at high speeds?

GPT-3 175B completion:

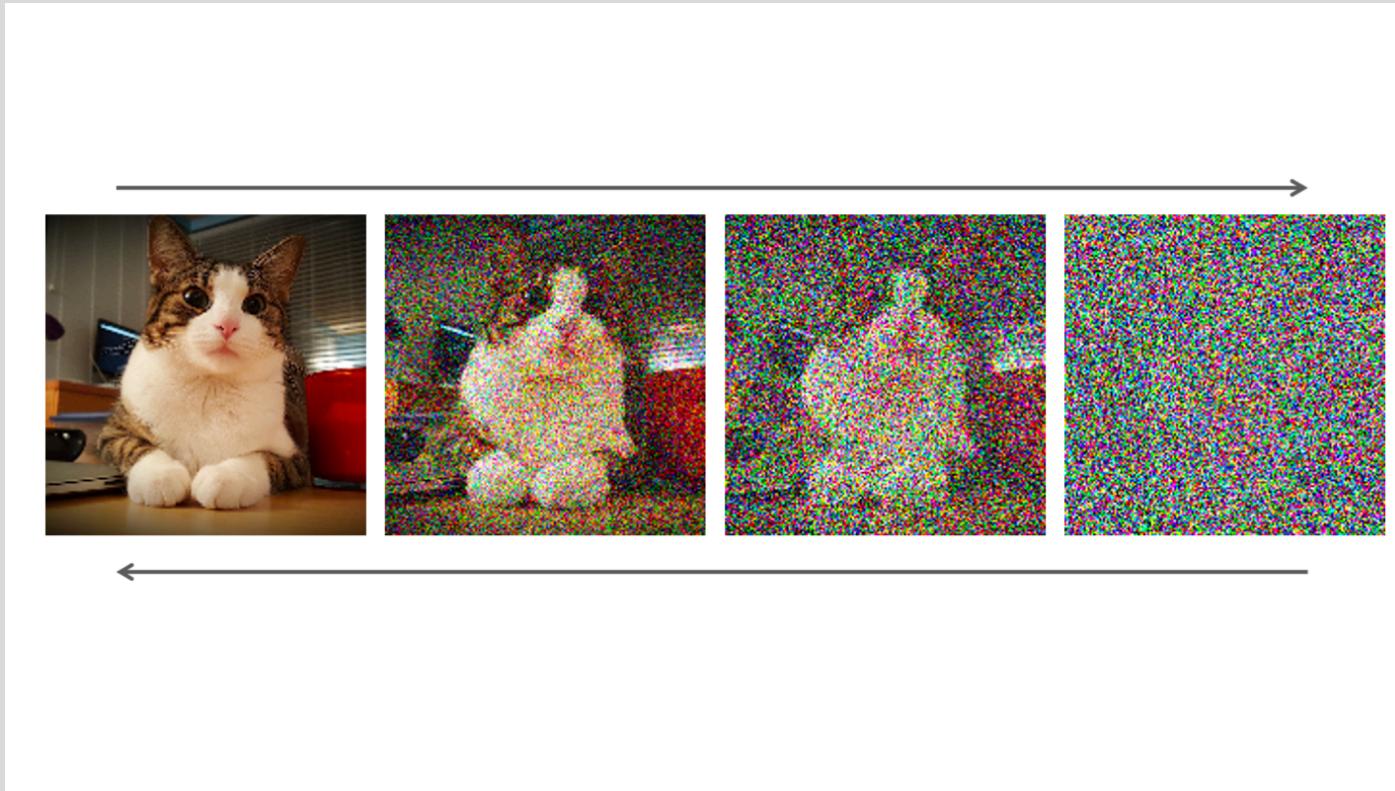
The pumpkin will pull the cannonball in, and the cannonball will bounce off of the pumpkin. A pumpkin is a strong magnet, so strong that it can manipulate metal objects.

InstructGPT 175B completion:

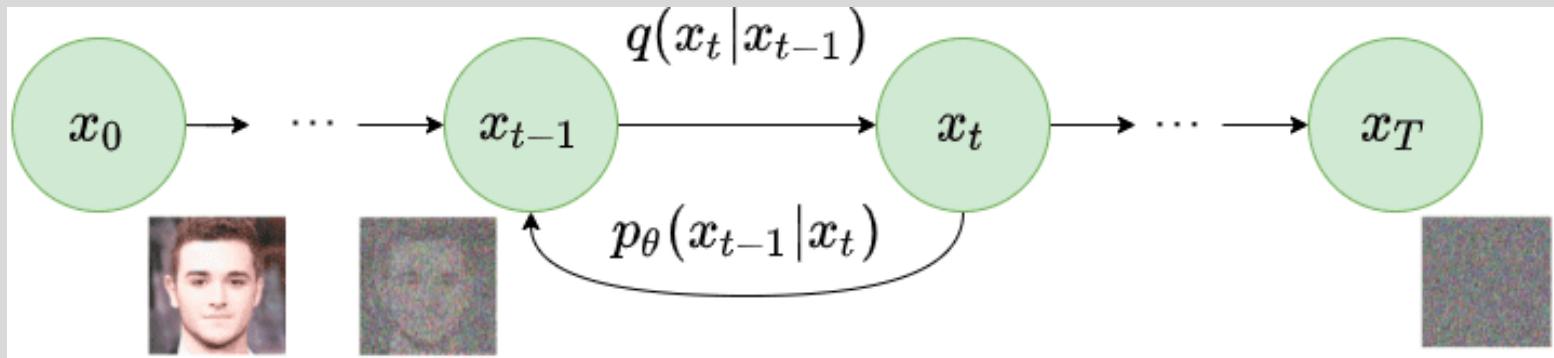
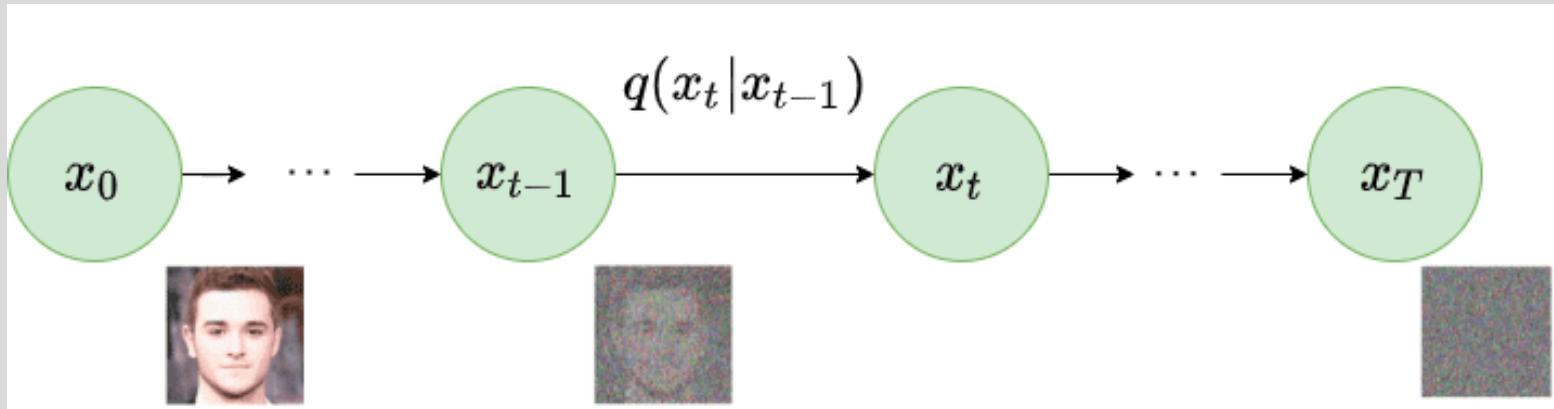
There is no way to accurately predict what will happen if you fire a cannonball directly at a pumpkin at high speeds, since there are too many unpredictable factors involved. Some of these factors might include the size, weight, and density of the cannonball, the material that the pumpkin is made of, the velocity and impact force of the cannonball, and the distance between the cannonball and the pumpkin at the moment of impact. Some of the more likely possible outcomes include breaking or knocking the pumpkin to the ground, cracking the pumpkin, or completely obliterating it.

Generative Models Are Not Just For Text

- Diffusion models are a type of generative model used in machine learning to generate data similar to the data on which they are trained.

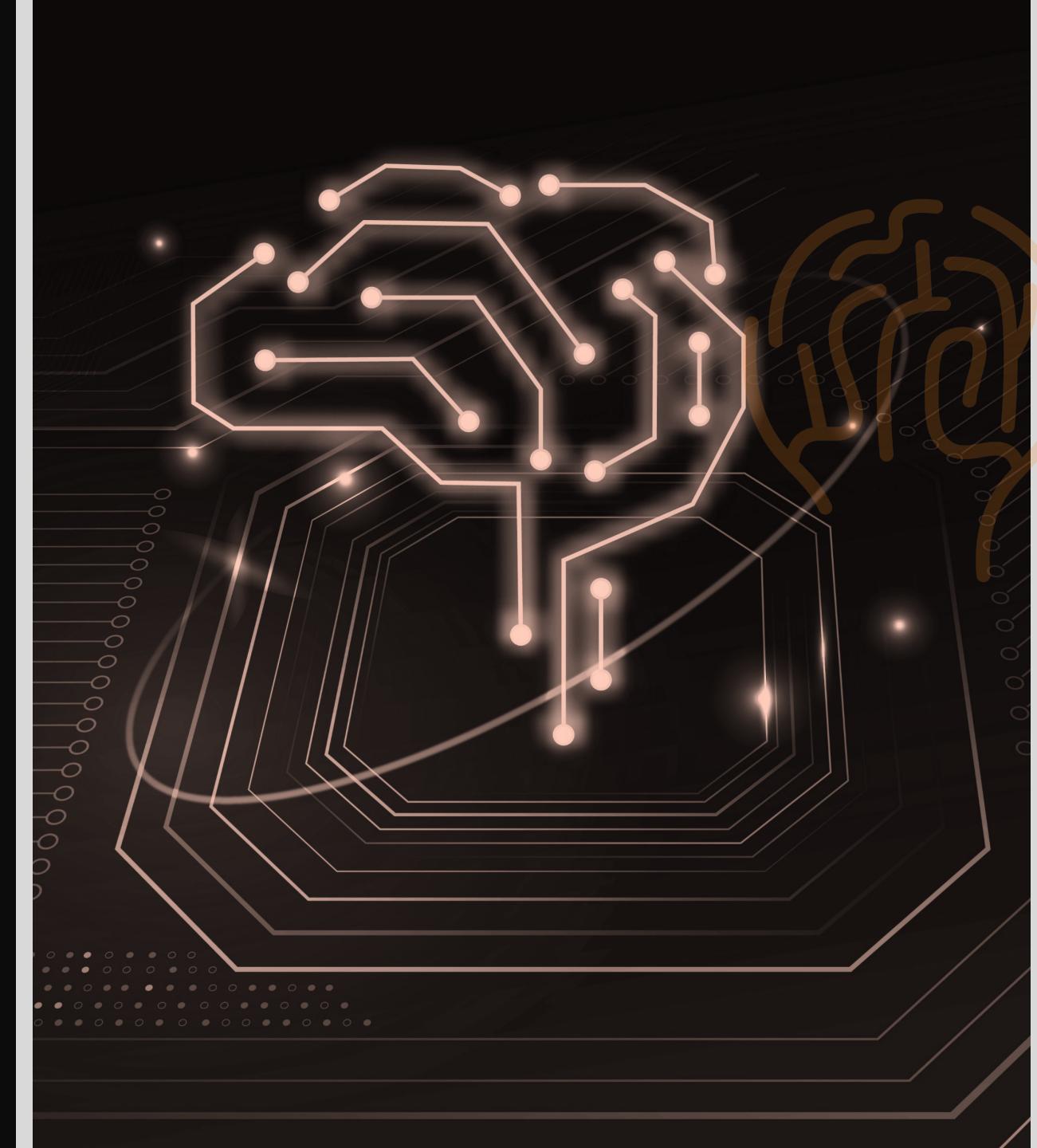


Forward/Reverse Diffusion

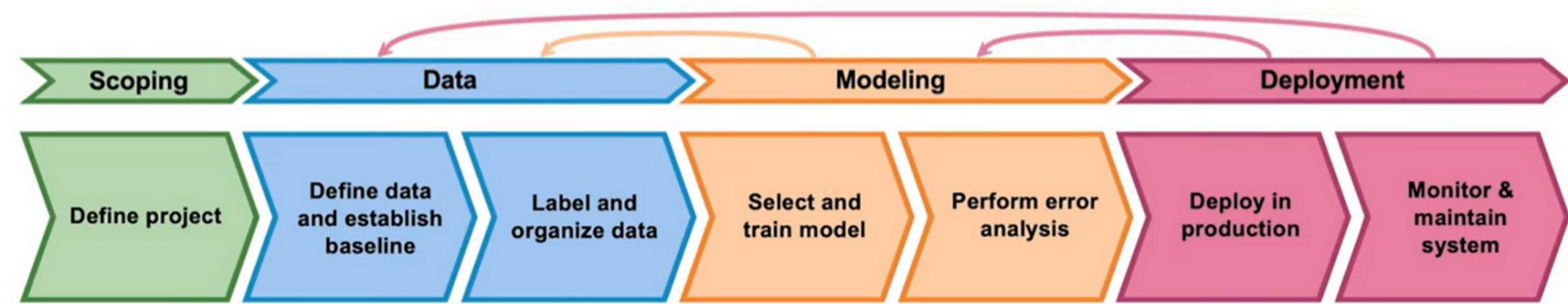


03

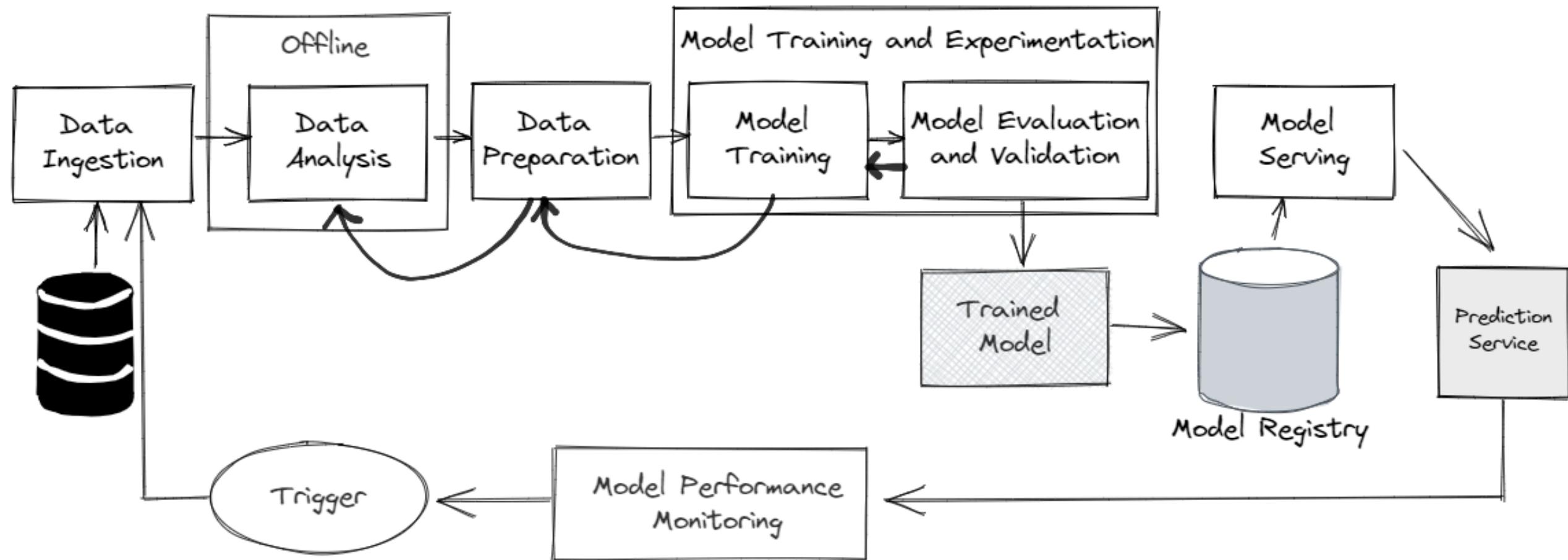
Generative Models In Practice



General AI Project Lifecycle



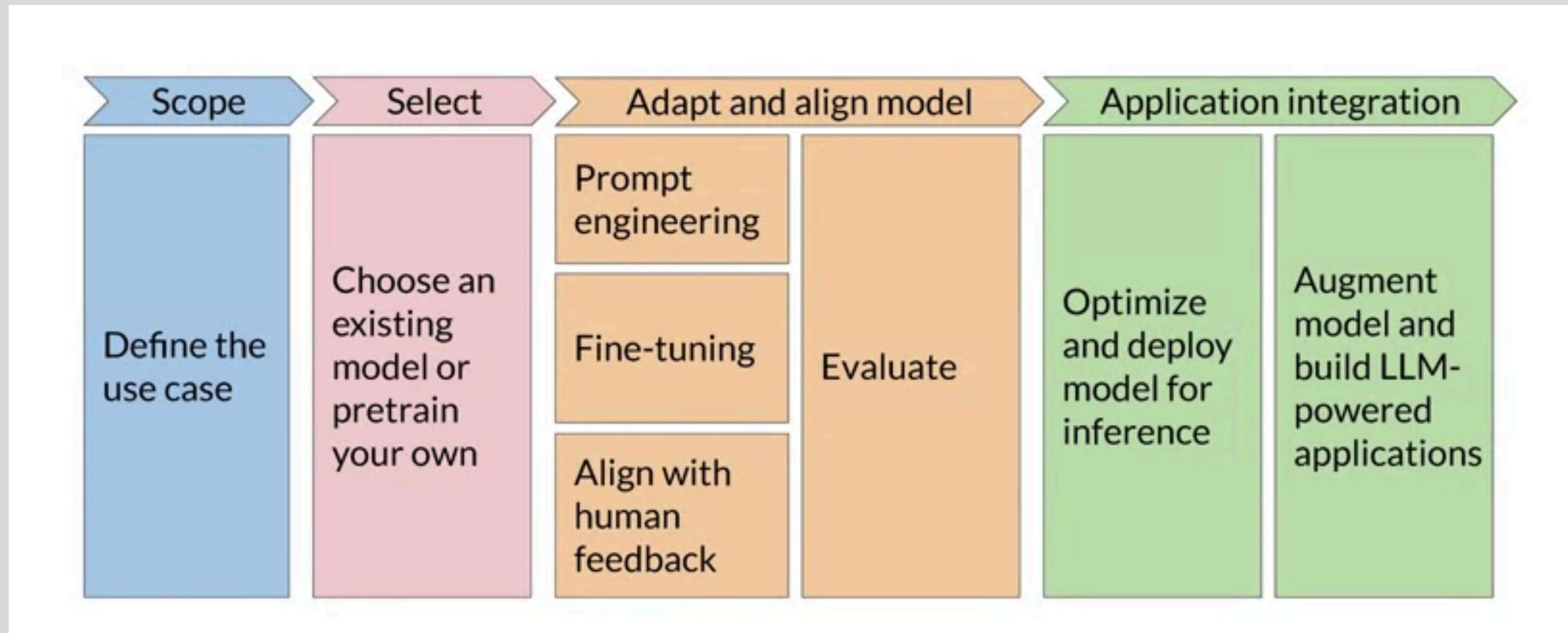
Machine Learning System Before GPT



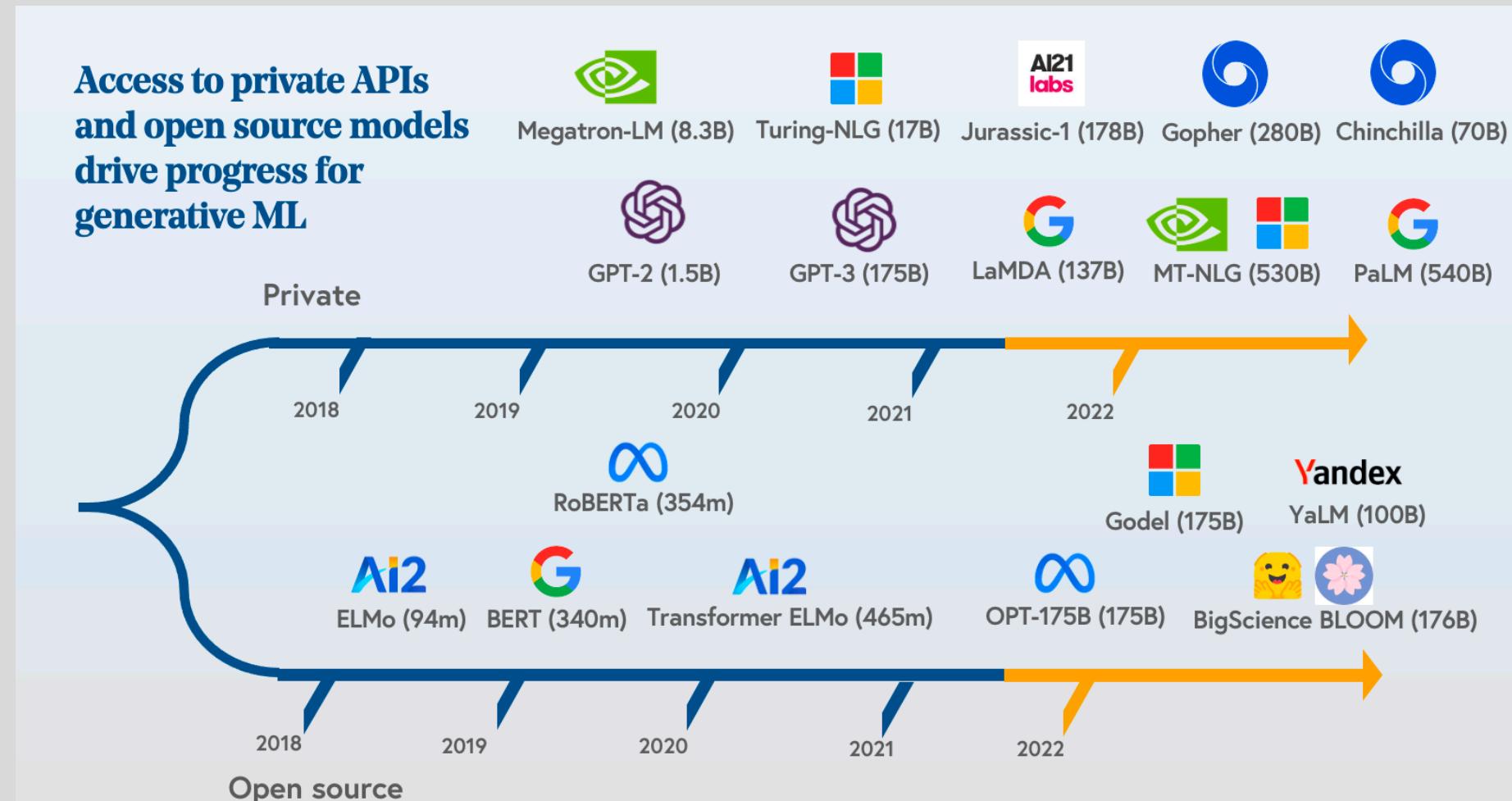
Training Model From Scratch

- Not Usually recommended
 - Enormous data requirement
 - Computationally expensive
 - Training such large models has many engineering challenges

Generative AI Project Lifecycle



Model Selection



Prompt Engineering

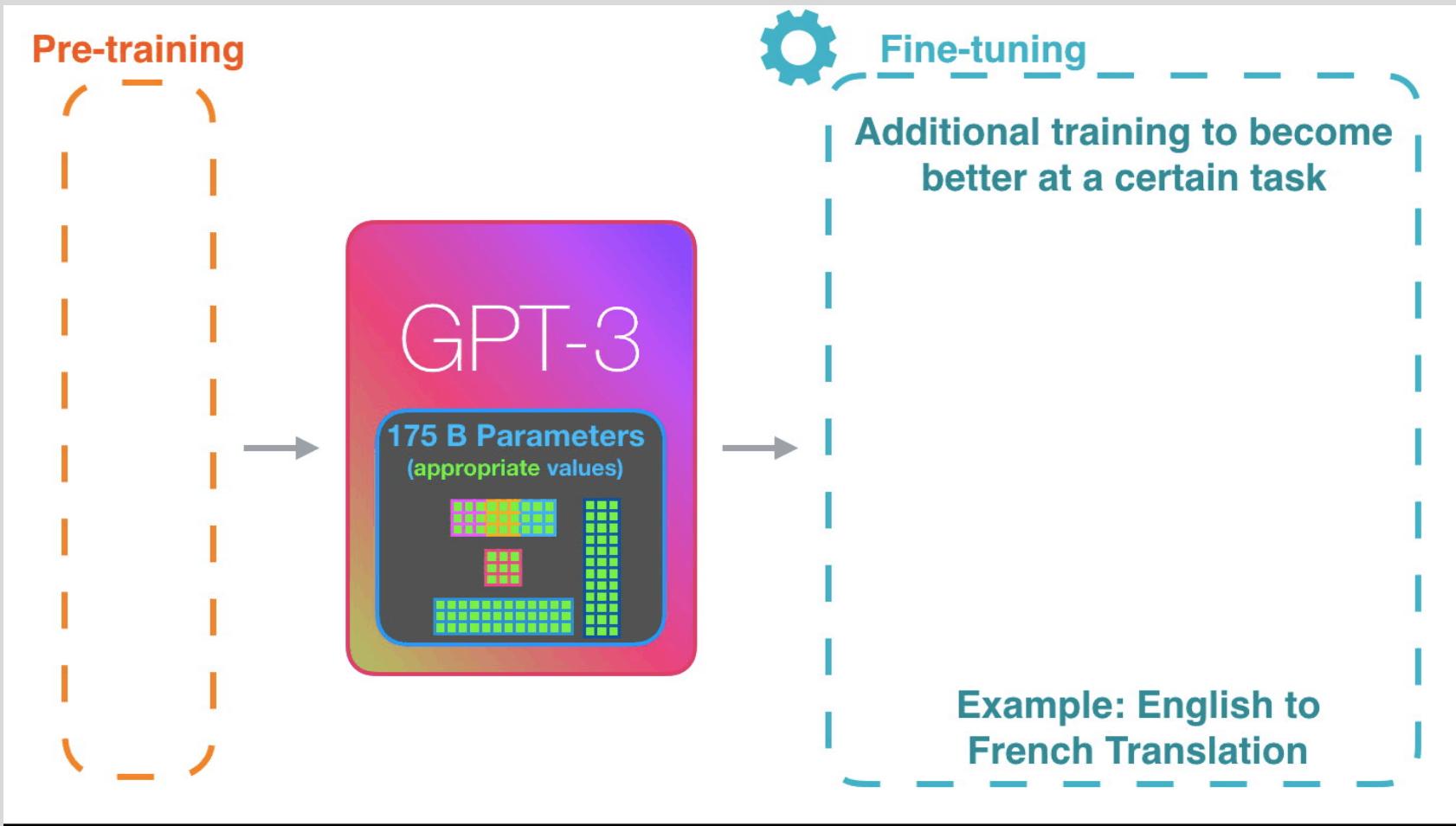
- Process of crafting effective instructions for AI models
 - Like coding: clear prompt yield accurate results
 - Efficiency: saves time by guiding model toward relevant information
- Challenges
 - Crafting prompt for complex tasks might require multiple iterations
 - Model limitations cause difficulties
 - Prompt performance heavily depends on model controlling parameters
 - Evaluating a prompt is very challenging

We will delve into this topic today ...

Fine-tuning

- Instead of random parameters, start with pre-trained parameters
- Fine-tune on specific tasks with smaller data
 - Classification
 - QA
 - Translation

Fine-tuning





thank you!
Any questions?