Introducing large language models

INTRODUCTION TO LLMS IN PYTHON

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What are large language models (LLMs)?

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Translate

What are large language models (LLMs)?

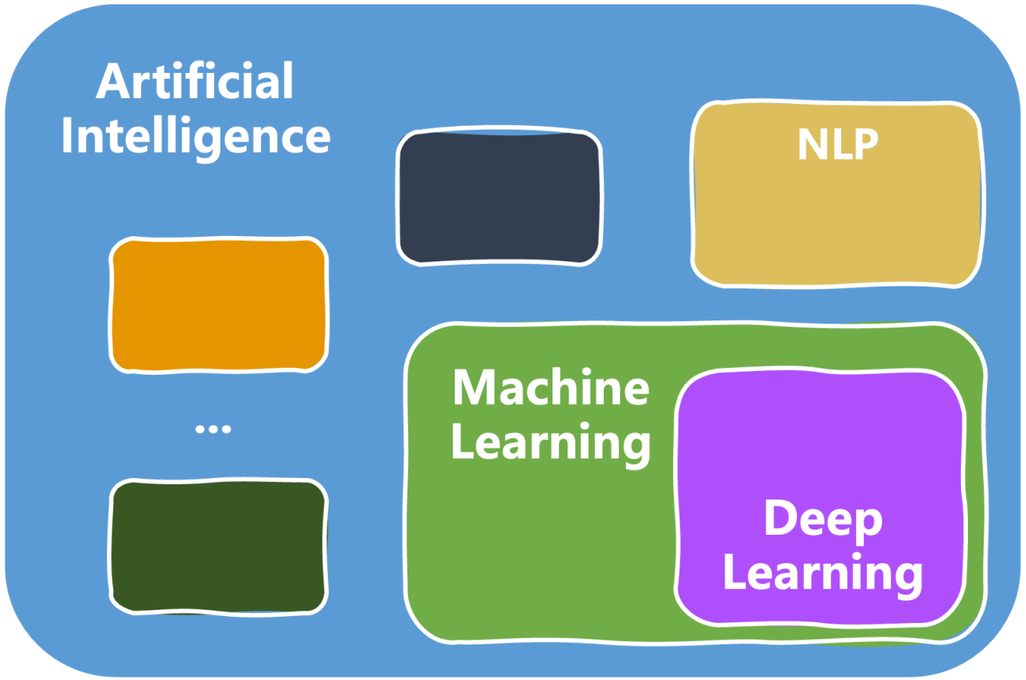
LLM: AI system able to **understand and generate human-like text** for addressing various complex **language tasks.**

- **Popular LLMs:** GPT, BERT, LLaMA, etc.

What are large language models (LLMs)?

Key characteristics of LLMs

- Based on *deep learning* architectures, most commonly **transformers**.
  - Capture complex patterns in text data.
- Significant advances in **NLP tasks**:
  - Text generation, summarization, translation, question-answering, etc.



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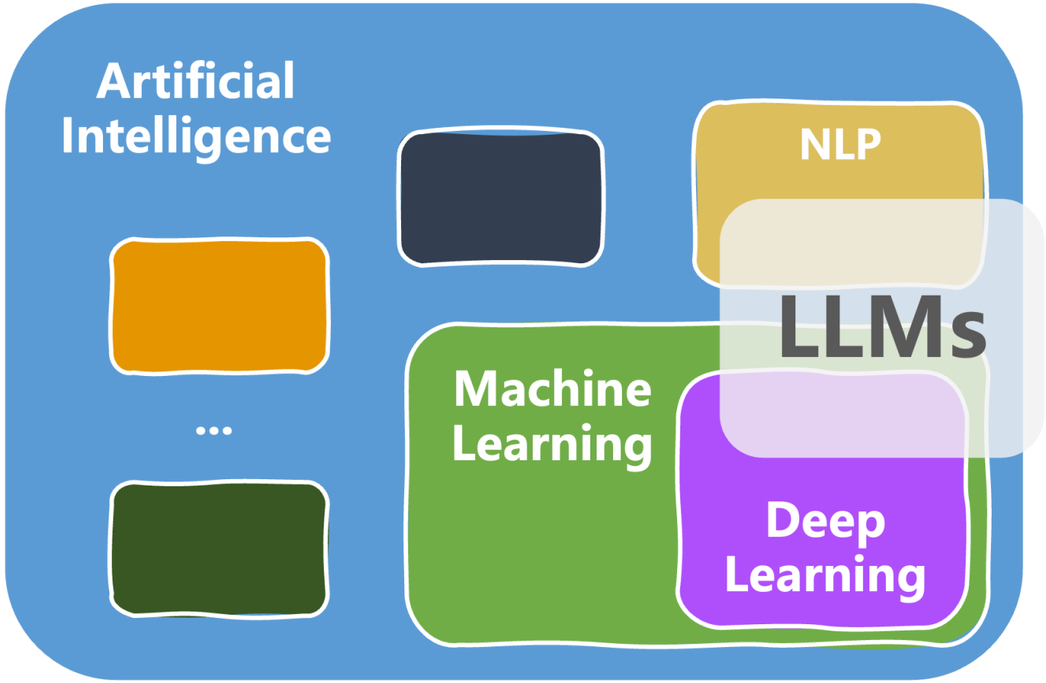
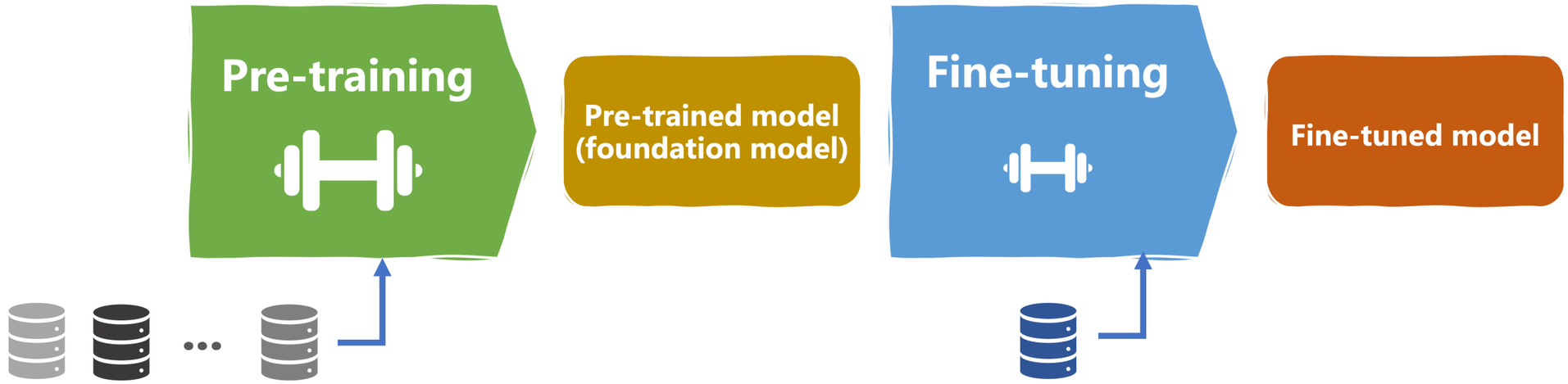
- Why "**large**"?
  - Very deep neural networks with lots of trainable weights.
  - Trained on vast text datasets.



LLMs development lifecycle

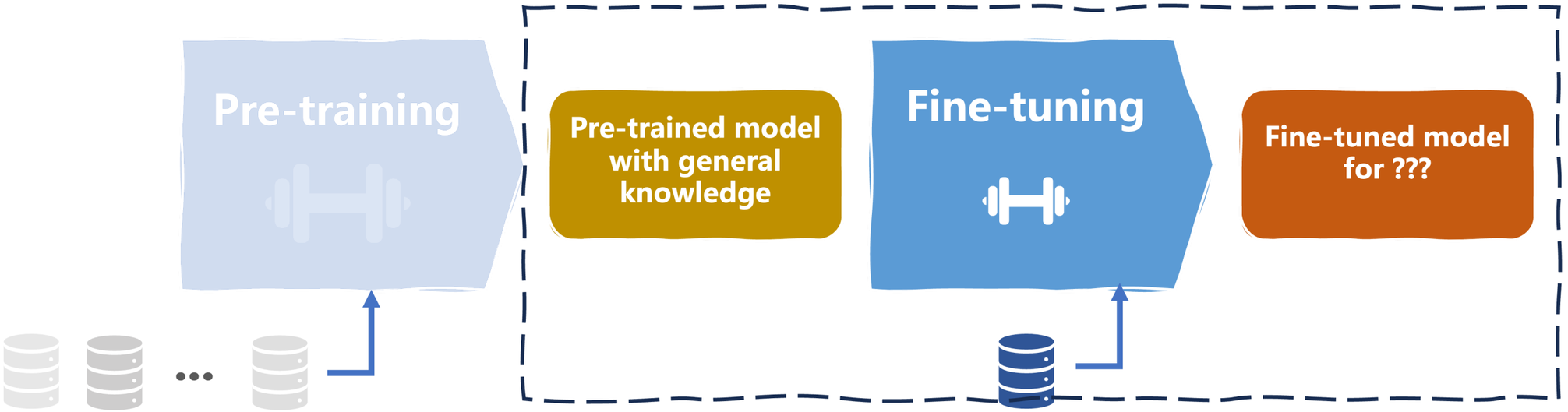
- Data ingestion and preparation.
- Model architecture design.

> **Pre-training and fine-tuning:**

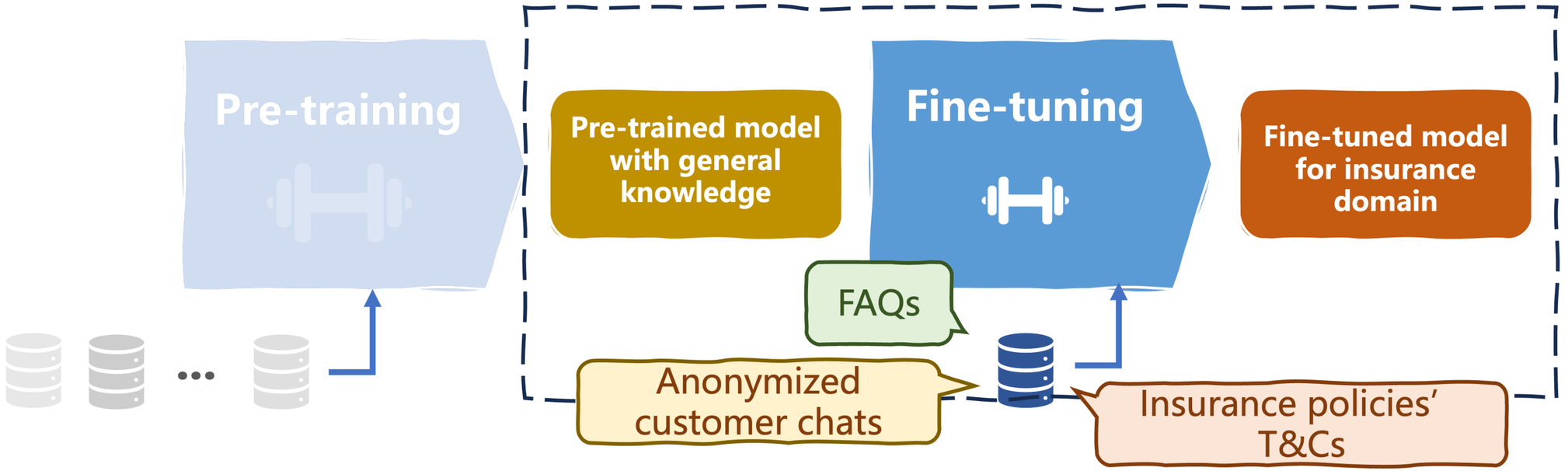


- Model evaluation, deployment, monitoring and maintenance.

Harnessing pre-trained LLMs: Hugging Face



Harnessing pre-trained LLMs: Hugging Face



Hugging Face : https://huggingface.co/

- A community hub of pre-trained LLMs and datasets ready to use.

"Hello World" example

- Load a sentiment classification model from **Hugging Face** hub, using **transformers library** and `pipeline()` function.
- Perform a simple sentiment prediction passing a customer review to the loaded LLM.

```
from transformers import pipeline
sentiment_classifier = pipeline("text-classification")
outputs = sentiment_classifier("""Dear seller, I got very impressed with the fast
                                  delivery and careful packaging of my order. Great
                                  experience overall, thank you!""")
print(outputs)
```

```
[{'label': 'POSITIVE', 'score': 0.9998602867126465}]
```

Let's practice!

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Tasks LLMs can perform

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Language tasks: overview

Language Generation

Language Understanding

Language tasks: overview

Language Generation

- Text generation
- Code generation

Language Understanding

Language tasks: overview

Language Generation

- Text generation
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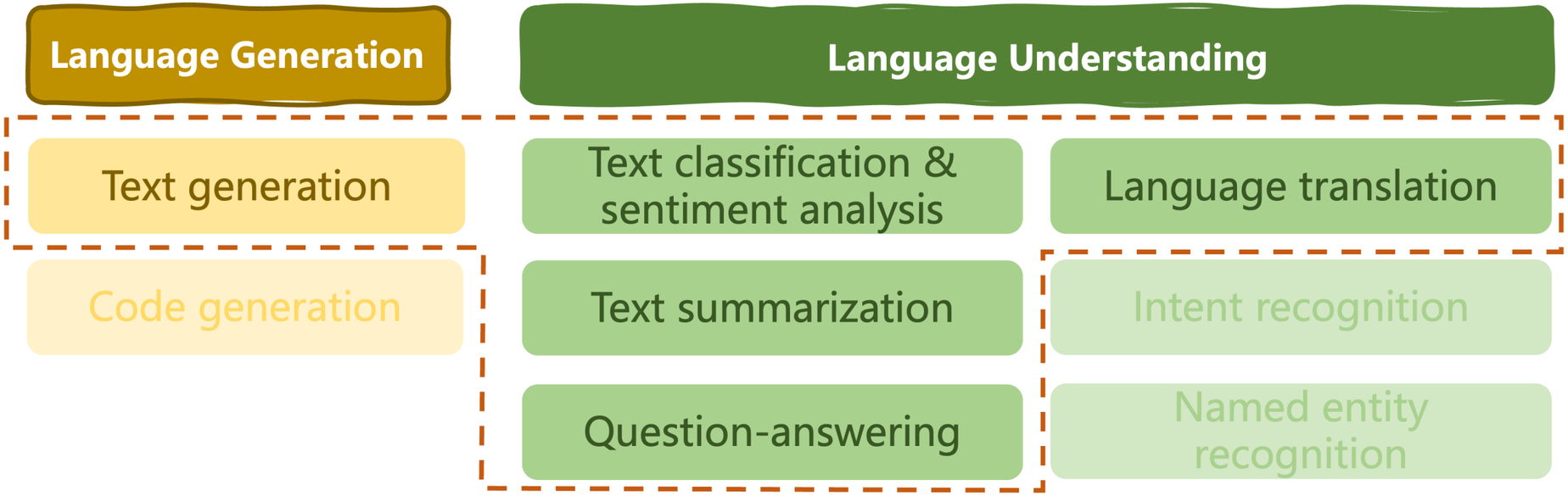
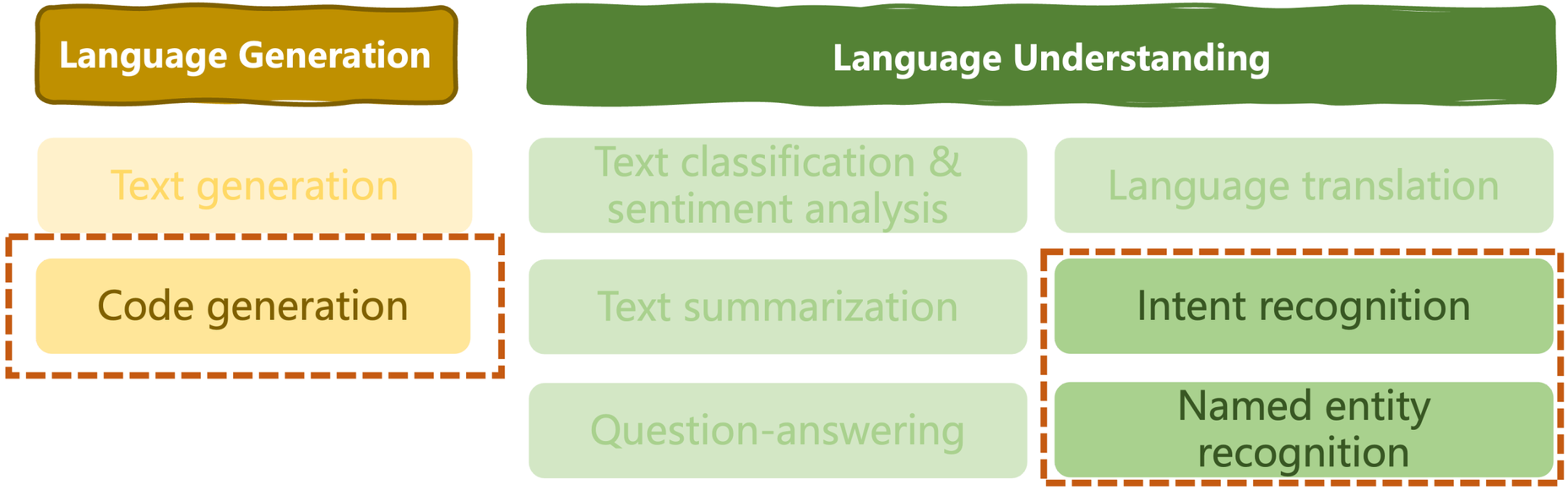
Language Understanding

- Text classification & sentiment analysis
- Language translation
- Text summarization
- Intent recognition
- Question-answering
- Named entity recognition

Language tasks: overview



Language tasks: overview



Language task	Goal
Code generation	Automatically generate code scripts based on requirements.
Intent recognition	Determine purpose behind a text, e.g., in chatbot enquiries.
Named entity recognition	Identify and classify named entities in text (people, places, ...).

Text classification: sentiment analysis


```
from transformers import pipeline

llm = pipeline("text-classification")
text = "Walking amid Gion's Machiya wooden houses was a mesmerizing experience"
outputs = llm(text)

print(outputs[0]['label'])
```

```
POSITIVE
```

Text generation


```
llm = pipeline("text-generation")
prompt = "The Gion neighborhood in Kyoto is famous for"
outputs = llm(prompt, max_length=100)
print(outputs[0]['generated_text'])
```

```
The Gion neighborhood in Kyoto is famous for making fish and seafood by the sea,
which made sense in the 1920s because it was the largest city of its age.
```

Text summarization


```
llm= pipeline("summarization", model="facebook/bart-large-cnn")
long_text = """Walking amid Gion's Machiya wooden houses is a mesmerizing experience. The beautifully
preserved structures exuded an old-world charm that transports visitors back in time, making them feel
like they had stepped into a living museum. The glow of lanterns lining the narrow streets add to the
enchanting ambiance, making each stroll a memorable journey through Japan's rich cultural history."""
outputs = llm(long_text, max_length=60, clean_up_tokenization_spaces=True)
print(outputs[0]['summary_text'])
```

```
Walking amid Gion's Machiya wooden houses is a mesmerizing experience. The beautifully preserved
structures exuded an old-world charm. The glow of lanterns lining the narrow streets add to the ambiance.
Each stroll is an memorable journey through Japan's rich cultural history.
```

Question-answering


```
llm = pipeline("question-answering")
context = "Walking amid Gion's Machiya wooden houses was a mesmerizing experience."
question = "What are Machiya houses made of?"
outputs = llm(question=question, context=context)
print(outputs['answer'])
```

```
wooden
```

Language translation


```
llm = pipeline("translation_en_to_es", model="Helsinki-NLP/opus-mt-en-es")
text = "Walking amid Gion's Machiya wooden houses was a mesmerizing experience."
outputs = llm(text, clean_up_tokenization_spaces=True)
print(outputs[0]['translation_text'])
```

```
Caminar entre las casas de madera Machiya de Gion fue una experiencia fascinante.
```

Let's practice!

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The transformer architecture

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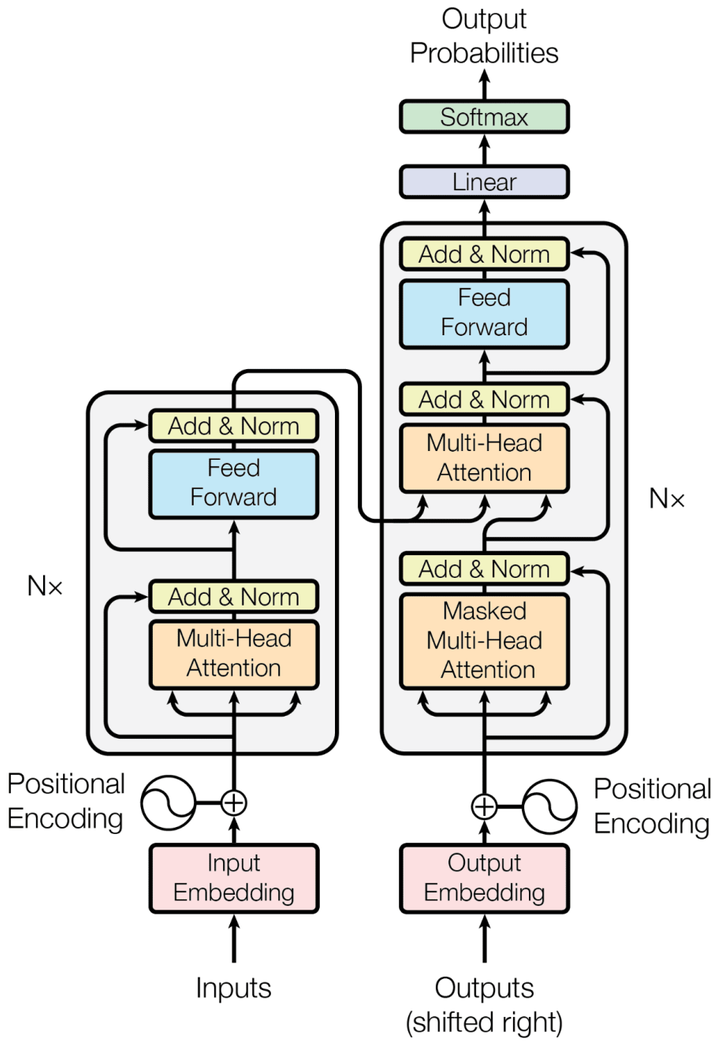
What is a transformer?

- **Deep learning** architecture for **text processing, understanding**, and **generation.**
- Foundation behind popular LLMs: **BERT, GPT, T5**, etc.

Characteristics:

- No recurrent (RNN) architecture.
- Capture **long-range dependencies** in text.
  - **Attention mechanisms + positional encoding.**
- Tokens are handled simultaneously
  - **Efficient:** faster training and inference.

The original transformer architecture



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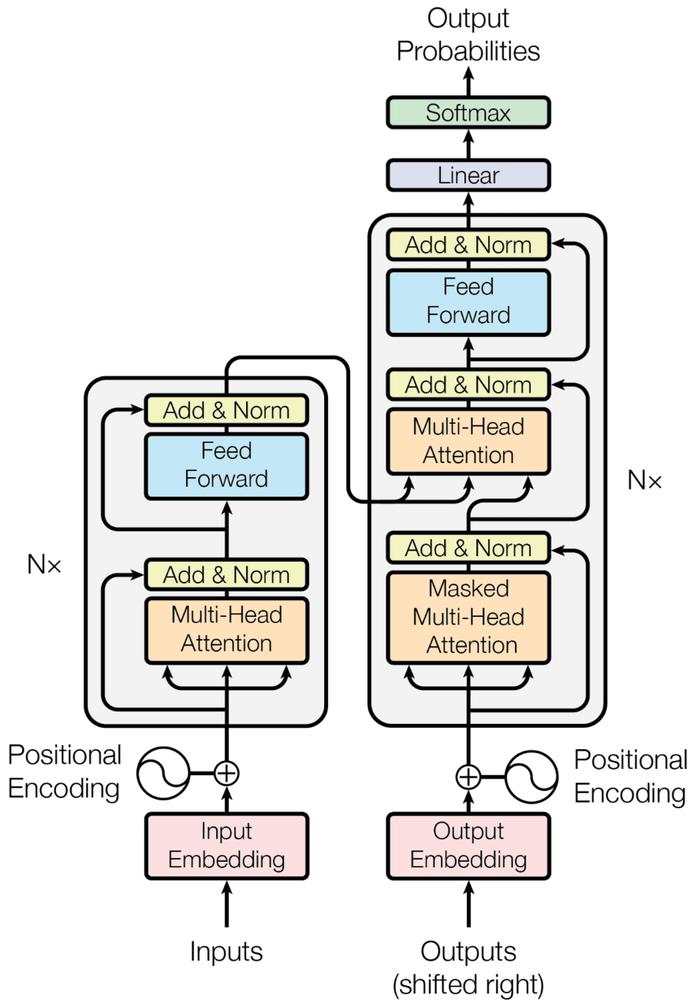


- Two main stacks: **encoder** and **decoder.**
- **N encoder** (resp. decoder) **layers.**
  - Attention mechanisms + feed-forward.
- No **recurrence** nor **convolutions.**
- Intended for various **language tasks**, e.g.:
  - Translation
  - Summarization
  - Question-answering
  - etc.

[1] Image source: A. Vaswani, et al. "Attention is all you need". Arxiv, 2017: https://arxiv.org/pdf/1706.03762.pdf

Our first PyTorch transformer

Structural elements in a transformer architecture:

- `d_model` : model embedding dimension.
- `n_heads` : number of attention heads.
- `num_encoder_layers,num_decoder_layers` : number of encoder and decoder layers.

PyTorch transformer initialization.

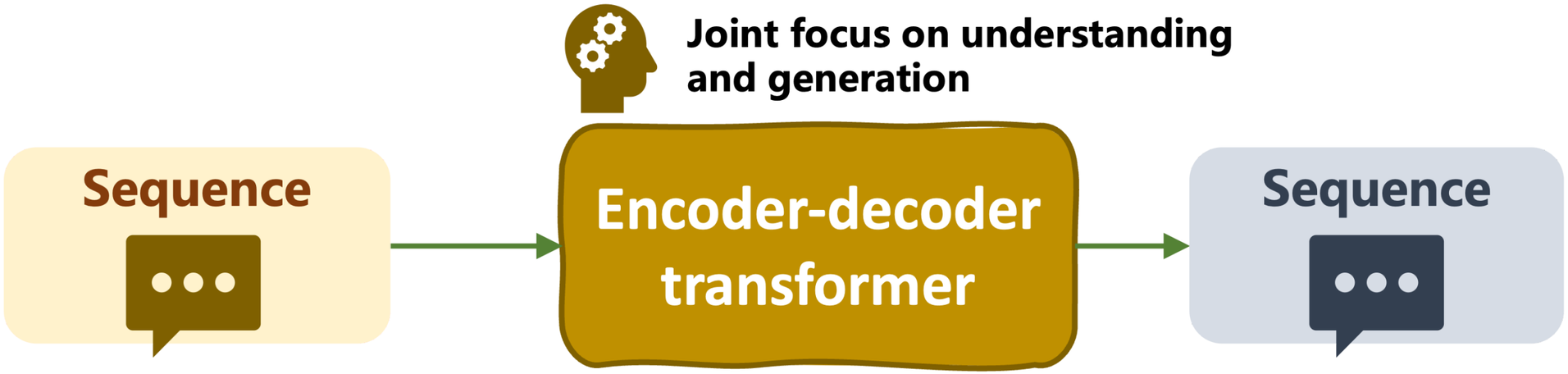
- `torch.nn.Transformer` class.

```
import torch
import torch.nn as nn

d_model = 512
n_heads = 8
num_encoder_layers = 6
num_decoder_layers = 6

model = nn.Transformer(
    d_model=d_model,
    nhead=n_heads,
    num_encoder_layers=num_encoder_layers,
    num_decoder_layers=num_decoder_layers
)
```

Types of transformer architectures



Type	Language tasks	Notable models
Encoder-decoder	Language translation, text summarization	T5, BART
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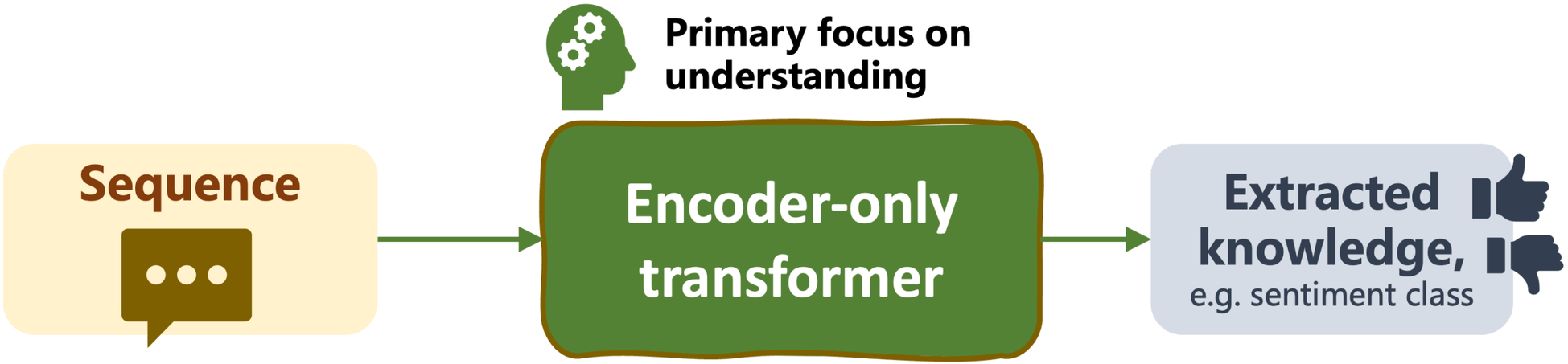
Types of transformer architectures



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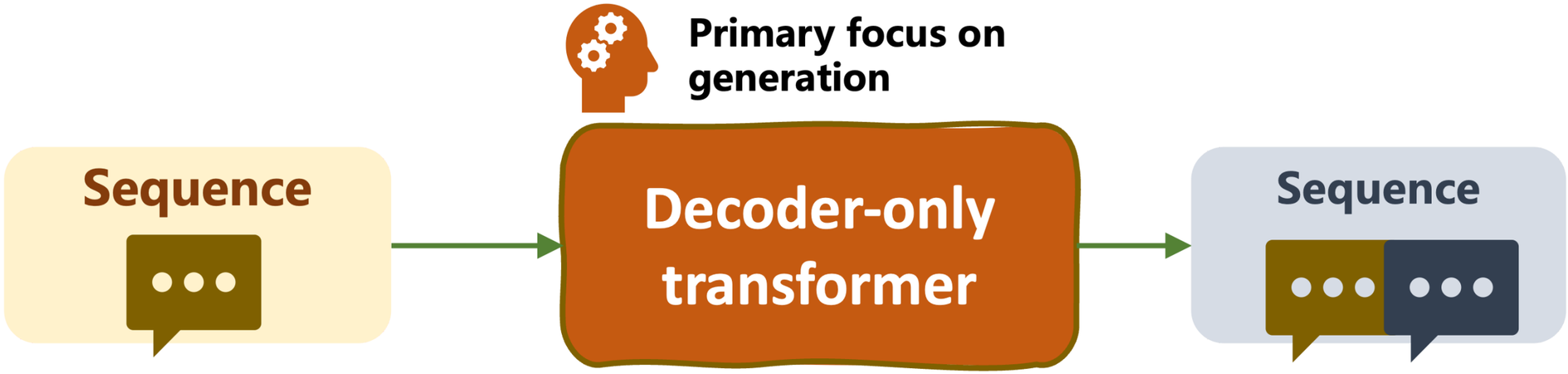

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Encoder-only	Text classification, extractive QA	BERT
Decoder-only	**Text generation, generative QA.**	**GPT**

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