Loading and splitting code files

RETRIEVAL AUGMENTED GENERATION (RAG) WITH LANGCHAIN

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Machine Learning Engineer

More document loaders...

````
# 🦜️🔗 LangChain

⚡ Build context-aware reasoning applications ⚡

[![Release Notes](https://img.shields.io/github/release/langchain-ai/langchain?style=flat-square)](https://github.com/langchain-ai/langchain/rele
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remote.remote-containers/cloneInVolume?url=https://github.com/langchain-ai/langchain)
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To help you ship LangChain apps to production faster, check out [LangSmith](https://smith.langchain.com).
[LangSmith](https://smith.langchain.com) is a unified developer platform for building, testing, and monitoring LLM applications.
Fill out [this form](https://www.langchain.com/contact-sales) to speak with our sales team.

## Quick Install

With pip:
```bash
pip install langchain
```
````

🦜🔗 LangChain

⚡ Build context-aware reasoning applications ⚡

release langchain-core==0.2.41 | CI passing | license MIT | downloads 19M/month | stars 93k | open issues 598

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Looking for the JS/TS library? Check out LangChain.js.

To help you ship LangChain apps to production faster, check out LangSmith. LangSmith is a unified developer platform for building, testing, and monitoring LLM applications. Fill out this form to speak with our sales team.

Quick Install

With pip:

```
pip install langchain
```

Loading Markdown files (.md)

```python
from langchain_community.document_loaders import UnstructuredMarkdownLoader


loader = UnstructuredMarkdownLoader("README.md")
markdown_content = loader.load()
print(markdown_content[0])
```

```
Document(page_content='# Discord Text Classification ![Python Version](https...'
         metadata={'source': 'README.md'})
```

Loading Python files (.py)

```python
from abc import ABC, abstractmethod

class LLM(ABC):
  @abstractmethod
  def complete_sentence(self, prompt):
    pass

...
```

- Integrated into RAG applications for writing or fixing code, creating docs, etc.
- Imports, classes, functions, etc.

```python
from langchain_community.document_loaders \
    import PythonLoader

loader = PythonLoader('chatbot.py')

python_data = loader.load()
print(python_data[0])
```

```
Document(page_content='from abc import ABC, ..

class LLM(ABC):
  @abstractmethod
...',
metadata={'source': 'chatbot.py'})
```

Splitting code files

```
python_splitter = RecursiveCharacterTextSplitter(
    chunk_size=150, chunk_overlap=10
)

chunks = python_splitter.split_documents(python_data)
for i, chunk in enumerate(chunks[:3]):
    print(f"Chunk {i+1}:\n{chunk.page_content}\n")
```

```
Chunk 1:
from abc import ABC, abstractmethod

class LLM(ABC):
  @abstractmethod
  def complete_sentence(self, prompt):
    pass

Chunk 2:
class OpenAI(LLM):
  def complete_sentence(self, prompt):
    return prompt + " ... OpenAI end of sentence."

class Anthropic(LLM):

Chunk 3:
def complete_sentence(self, prompt):
    return prompt + " ... Anthropic end of sentence."
```

Splitting by language

- `separators`
  - `["\n\n", "\n", " ", ""]`
  - `["\nclass ", "\ndef ", "\n\tdef ", "\n\n", " ", ""]`

```
from langchain_text_splitters import RecursiveCharacterTextSplitter, Language

python_splitter = RecursiveCharacterTextSplitter.from_language(
    language=Language.PYTHON, chunk_size=150, chunk_overlap=10
)

chunks = python_splitter.split_documents(data)

for i, chunk in enumerate(chunks[:3]):
    print(f"Chunk {i+1}:\n{chunk.page_content}\n")
```

```
Chunk 1:
from abc import ABC, abstractmethod

Chunk 2:
class LLM(ABC):
  @abstractmethod
  def complete_sentence(self, prompt):
    pass

Chunk 3:
class OpenAI(LLM):
  def complete_sentence(self, prompt):
```

Let's practice!

RETRIEVAL AUGMENTED GENERATION (RAG) WITH LANGCHAIN

Advanced splitting methods

RETRIEVAL AUGMENTED GENERATION (RAG) WITH LANGCHAIN

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Limitations of our current splitting strategies

1. Splits are naive (not context-aware) → `SemanticChunker`
    - Ignores context of surrounding text
2. Splits are made using characters vs. **tokens** → `TokenTextSplitter`
    - Tokens are processed by models
    - Risk exceeding the **context window**

Splitting on tokens

How is text split into tokens?

RecursiveCharacter
TextSplitter

chunk_size=5
chunk_overlap=2

['How', 'is', 'text', 'spli', 'lit', 'into', 'toke', 'kens?']

Splitting on tokens

How is text split into tokens?

RecursiveCharacter TextSplitter

['How', 'is', 'text', 'spli', 'lit', 'into', 'toke', 'kens?']

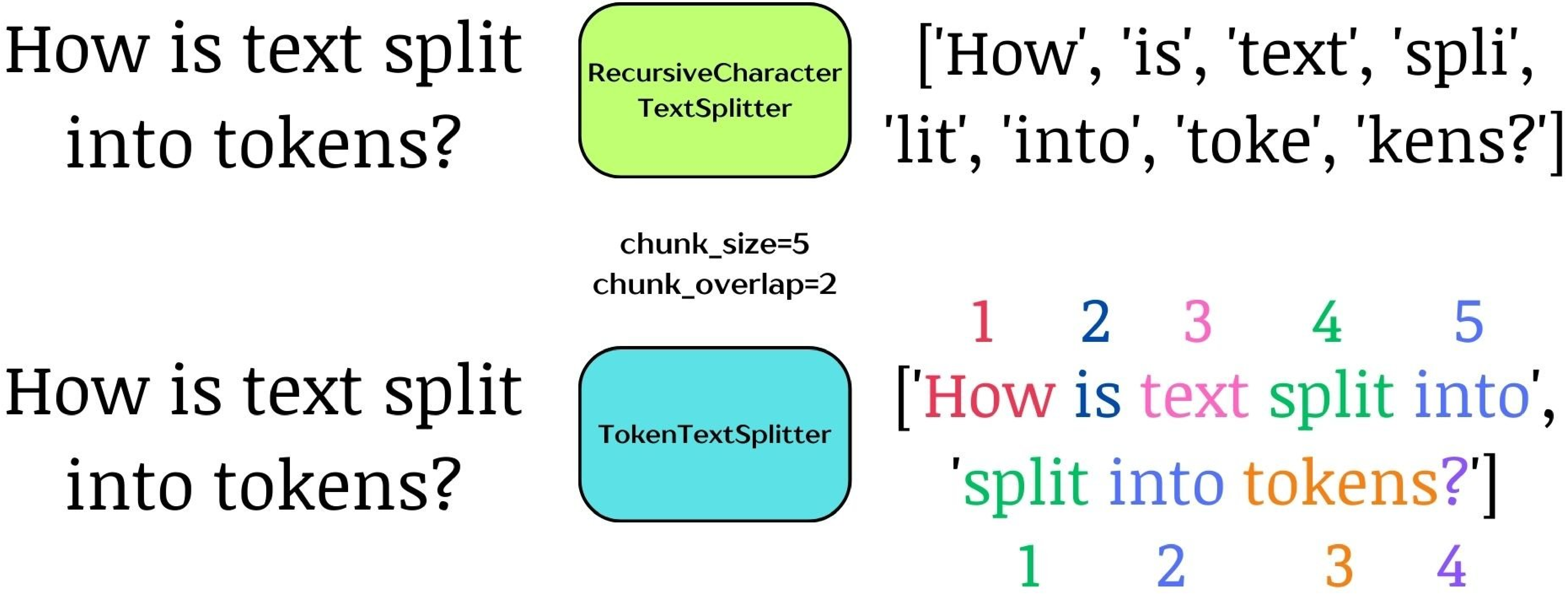
chunk_size=5
chunk_overlap=2

How is text split into tokens?

TokenTextSplitter

['How is text split into', 'split into tokens?']

Splitting on tokens



Splitting on tokens

```python
import tiktoken
from langchain_text_splitters import TokenTextSplitter
example_string = "Mary had a little lamb, it's fleece was white as snow."

encoding = tiktoken.encoding_for_model('gpt-4o-mini')
splitter = TokenTextSplitter(encoding_name=encoding.name,
                             chunk_size=10,
                             chunk_overlap=2)

chunks = splitter.split_text(example_string)

for i, chunk in enumerate(chunks):
    print(f"Chunk {i+1}:\n{chunk}\n")
```

Splitting on tokens

```
Chunk 1:
Mary had a little lamb, it's fleece


Chunk 2:
 fleece was white as snow.
```

Splitting on tokens

```
for i, chunk in enumerate(chunks):
    print(f"Chunk {i+1}:\nNo. tokens: {len(encoding.encode(chunk))}\n{chunk}\n")
```

```
Chunk 1:
No. tokens: 10
Mary had a little lamb, it's fleece was


Chunk 2:
No. tokens: 6
 fleece was white as snow.
```

Semantic splitting

RAG applications has numerous use cases, but are most frequently deployed in chatbots. Domestic dogs are descendants from an extinct population of Pleistocene wolves over 14,000 years ago.

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Domestic dogs are descendants from an extinct population of Pleistocene wolves over 14,000 years ago.

Semantic splitting

```
from langchain_openai import OpenAIEmbeddings
from langchain_experimental.text_splitter import SemanticChunker

embeddings = OpenAIEmbeddings(api_key="...", model='text-embedding-3-small')

semantic_splitter = SemanticChunker(
    embeddings=embeddings,
    breakpoint_threshold_type="gradient",
    breakpoint_threshold_amount=0.8
)
```

[1] https://api.python.langchain.com/en/latest/text_splitter/langchain_experimental.text_splitter.SemanticChunker.html

Semantic splitting

```
chunks = semantic_splitter.split_documents(data)
print(chunks[0])
```

```
page_content='Retrieval-Augmented Generation for\nKnowledge-Intensive NLP Tasks\ Patrick Lewis,
Ethan Perez,\nAleksandra Piktus, Fabio Petroni, Vladimir Karpukhin, Naman Goyal, Heinrich
Küttler,\nMike Lewis, Wen-tau Yih, Tim Rocktäschel, Sebastian Riedel, Douwe Kiela\nFacebook AI
Research; University College London;New York University;\nplewis@fb.com\nAbstract\nLarge
pre-trained language models have been shown to store factual knowledge\nin their parameters,
and achieve state-of-the-art results when ?ne-tuned on down-\nstream NLP tasks. However, their
ability to access and precisely manipulate knowl-\nedge is still limited, and hence on
knowledge-intensive tasks, their performance\nlags behind task-specific architectures.'
metadata={'source': 'rag_paper.pdf', 'page': 0}
```

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Optimizing document retrieval

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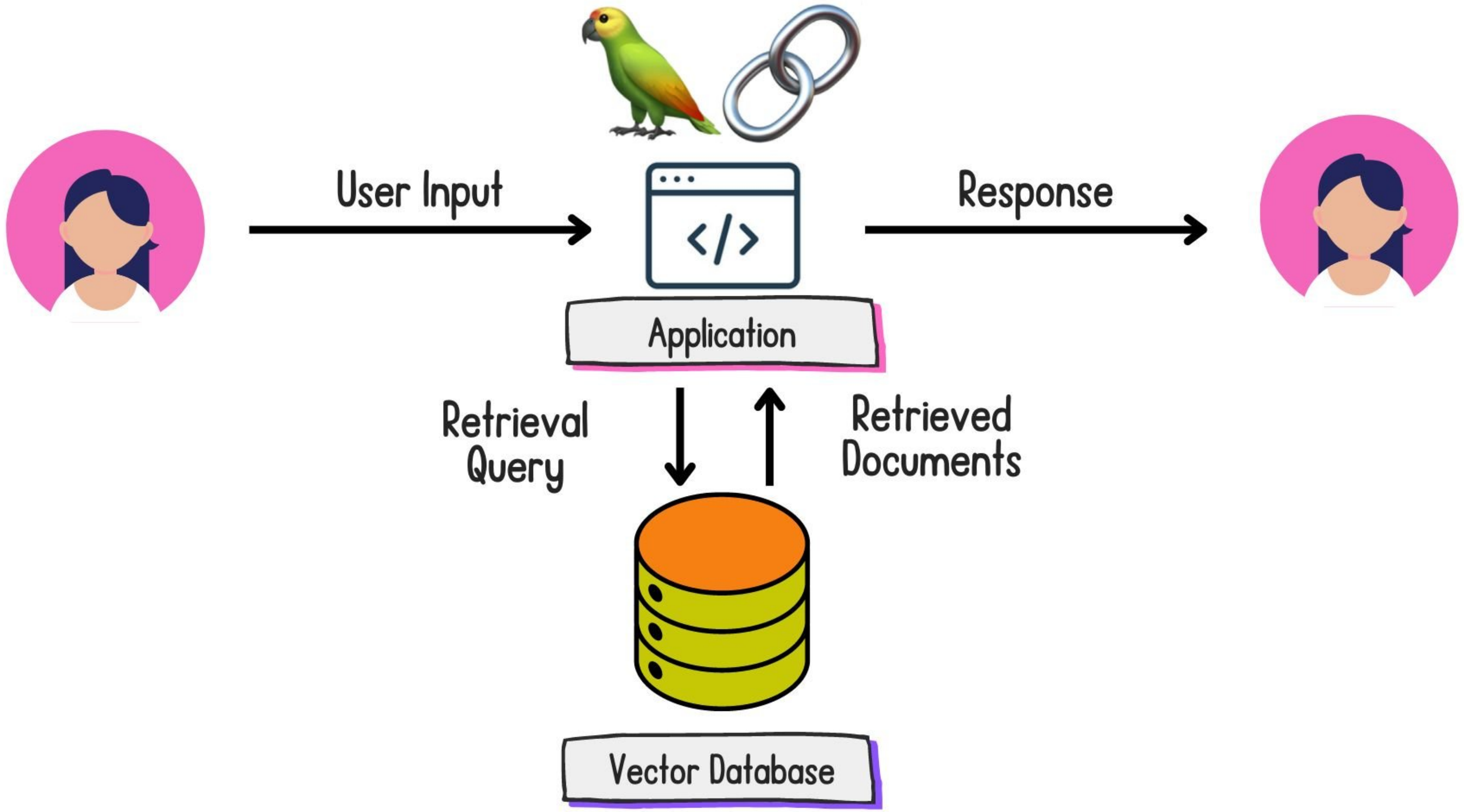
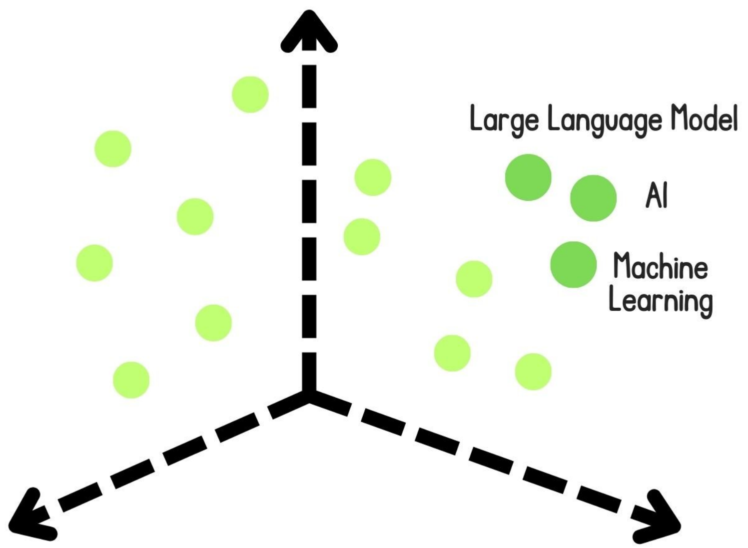
Putting the R in RAG...



Dense

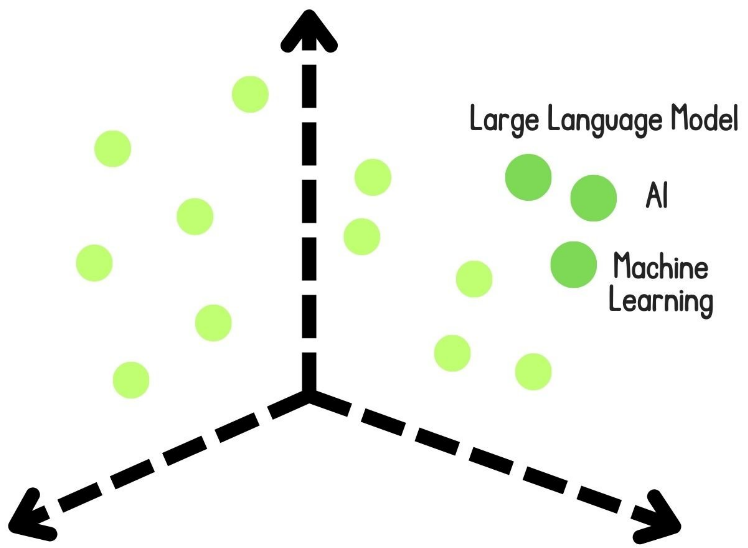
*Encode chunks as a single vector with **non-zero** components*



- **Pros:** Capturing semantic meaning
- **Cons:** Computationally expensive

Dense

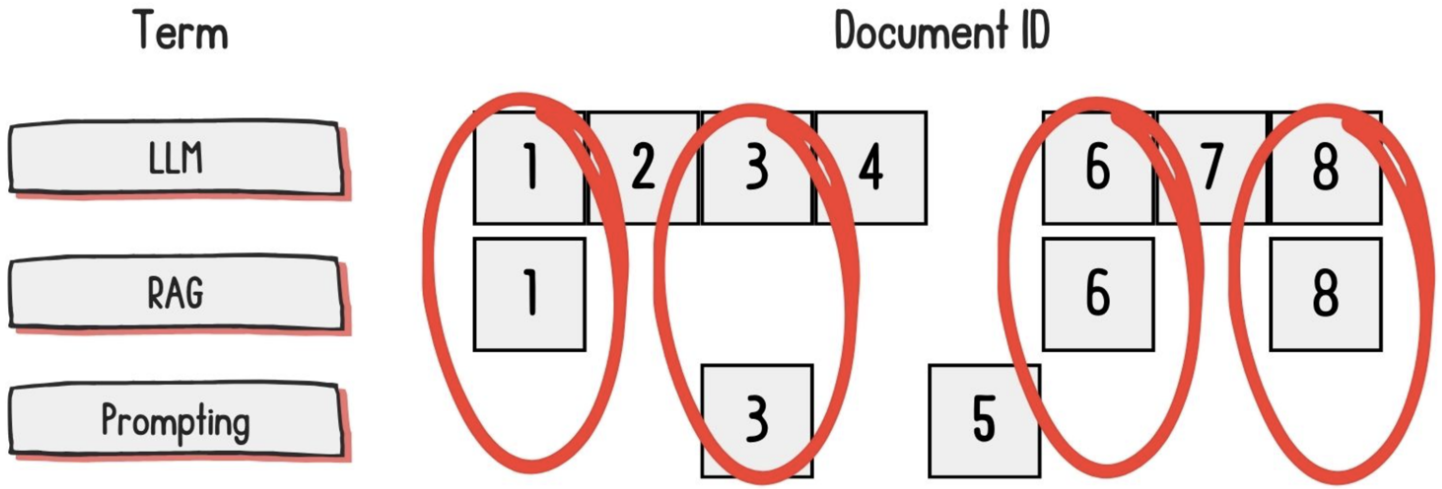
*Encode chunks as a single vector with **non-zero** components*



- **Pros:** Capturing semantic meaning
- **Cons:** Computationally expensive

Sparse

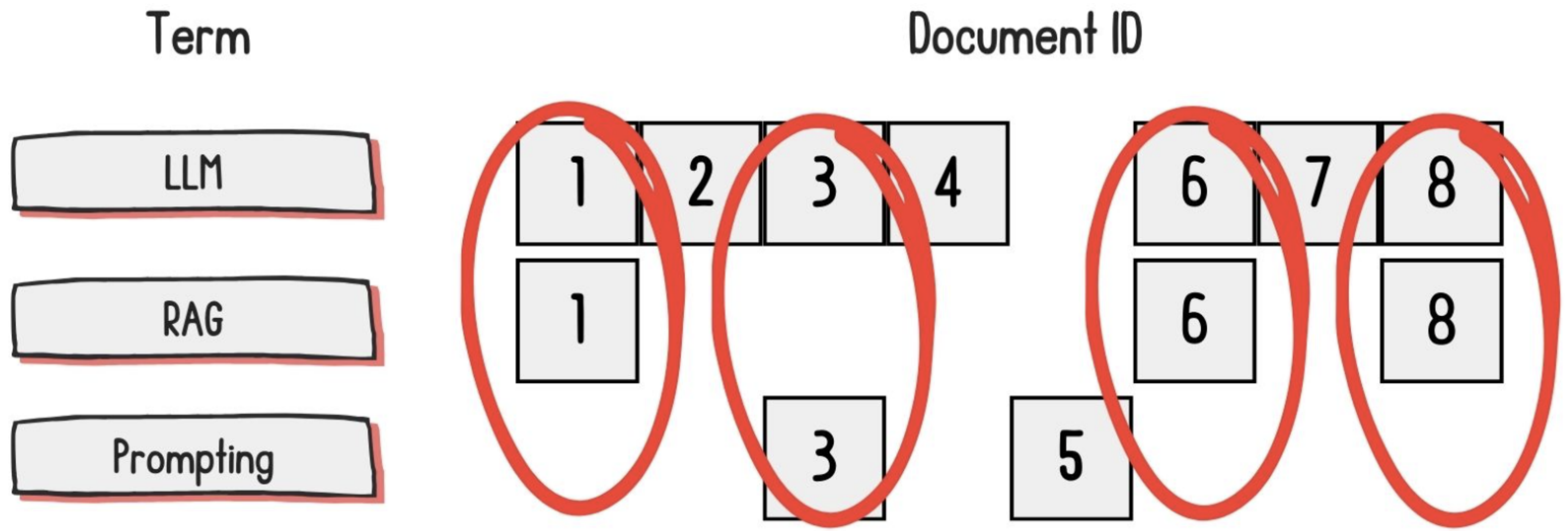
*Encode using **word matching** with mostly **zero** components*



- **Pros:** Precise, explainable, rare-word handling
- **Cons:** Generalizability

Sparse retrieval methods

TF-IDF: Encodes documents using the words that make the document unique



BM25: Helps mitigate high-frequency words from saturating the encoding

BM25 retrieval

```
from langchain_community.retrievers import BM25Retriever

chunks = [
    "Python was created by Guido van Rossum and released in 1991.",
    "Python is a popular language for machine learning (ML).",
    "The PyTorch library is a popular Python library for AI and ML."
]

bm25_retriever = BM25Retriever.from_texts(chunks, k=3)
```

BM25 retrieval

```
results = bm25_retriever.invoke("When was Python created?")
print("Most Relevant Document:")
print(results[0].page_content)
```

```
Most Relevant Document:
Python was created by Guido van Rossum and released in 1991.
```

- Python was created by Guido van Rossum and released in 1991."
- "Python is a popular language for machine learning (ML)."
- "The PyTorch library is a popular Python library for AI/ML."

BM25 in RAG

```
retriever = BM25Retriever.from_documents(
    documents=chunks,
    k=5
)

chain = ({"context": retriever, "question": RunnablePassthrough()}
         | prompt
         | llm
         | StrOutputParser()
)
```

[1] https://www.datacamp.com/blog/what-is-retrieval-augmented-generation-rag

BM25 in RAG

```
print(chain.invoke("How can LLM hallucination impact a RAG application?"))
```

```
The RAG application may generate responses that are off-topic or inaccurate.
```

Let's practice!

RETRIEVAL AUGMENTED GENERATION (RAG) WITH LANGCHAIN

Introduction to RAG evaluation

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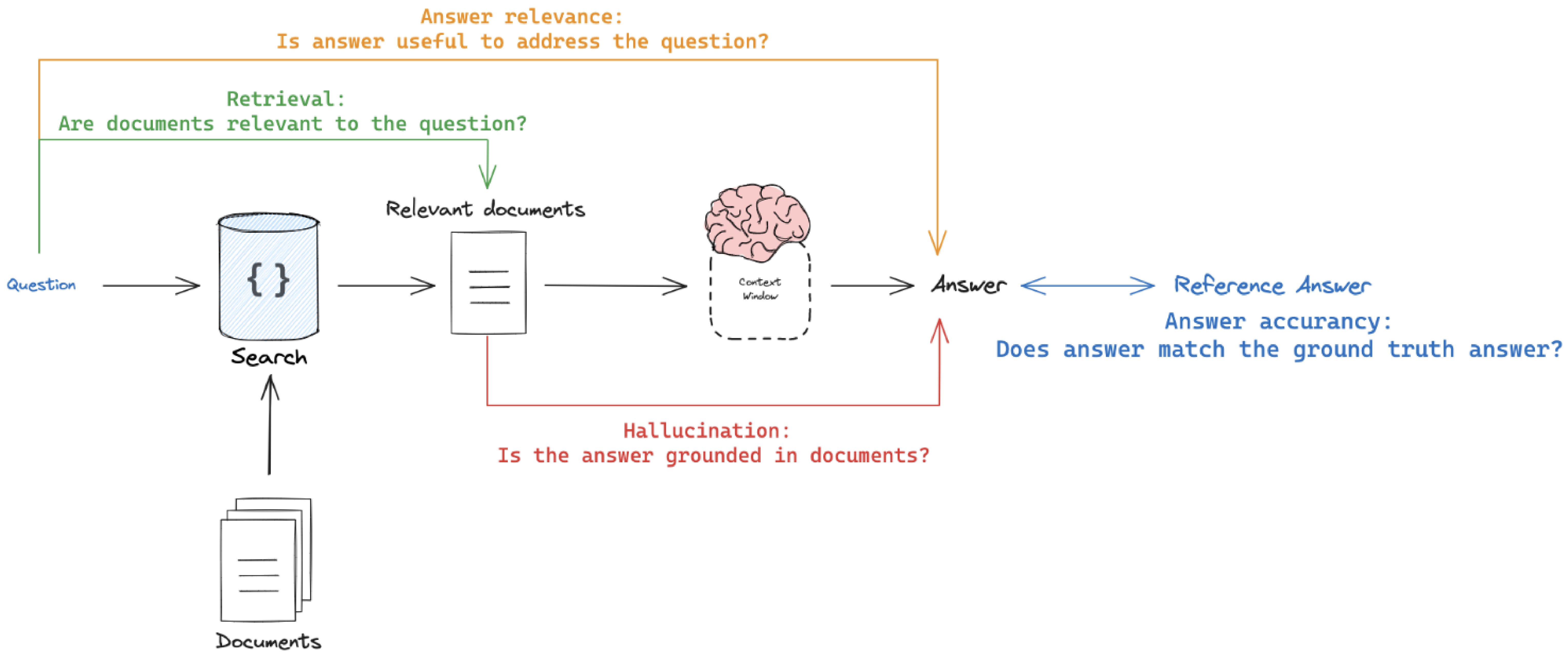
Types of RAG evaluation



[1] Image Credit: LangSmith

Output accuracy: string evaluation

```
query = "What are the main components of RAG architecture?"
predicted_answer = "Training and encoding"
ref_answer = "Retrieval and Generation"
```

Output accuracy: string evaluation

```
prompt_template = """You are an expert professor specialized in grading students' answers to q
You are grading the following question:{query}
Here is the real answer:{answer}
You are grading the following predicted answer:{result}
Respond with CORRECT or INCORRECT:
Grade:"""

prompt = PromptTemplate(
    input_variables=["query", "answer", "result"],
    template=prompt_template
)

eval_llm = ChatOpenAI(temperature=0, model="gpt-4o-mini", openai_api_key='...')
```

Output accuracy: string evaluation

```python
from langsmith.evaluation import LangChainStringEvaluator

qa_evaluator = LangChainStringEvaluator(
    "qa",
    config={
        "llm": eval_llm,
        "prompt": PROMPT
    }
)

score = qa_evaluator.evaluator.evaluate_strings(
    prediction=predicted_answer,
    reference=ref_answer,
    input=query
)
```

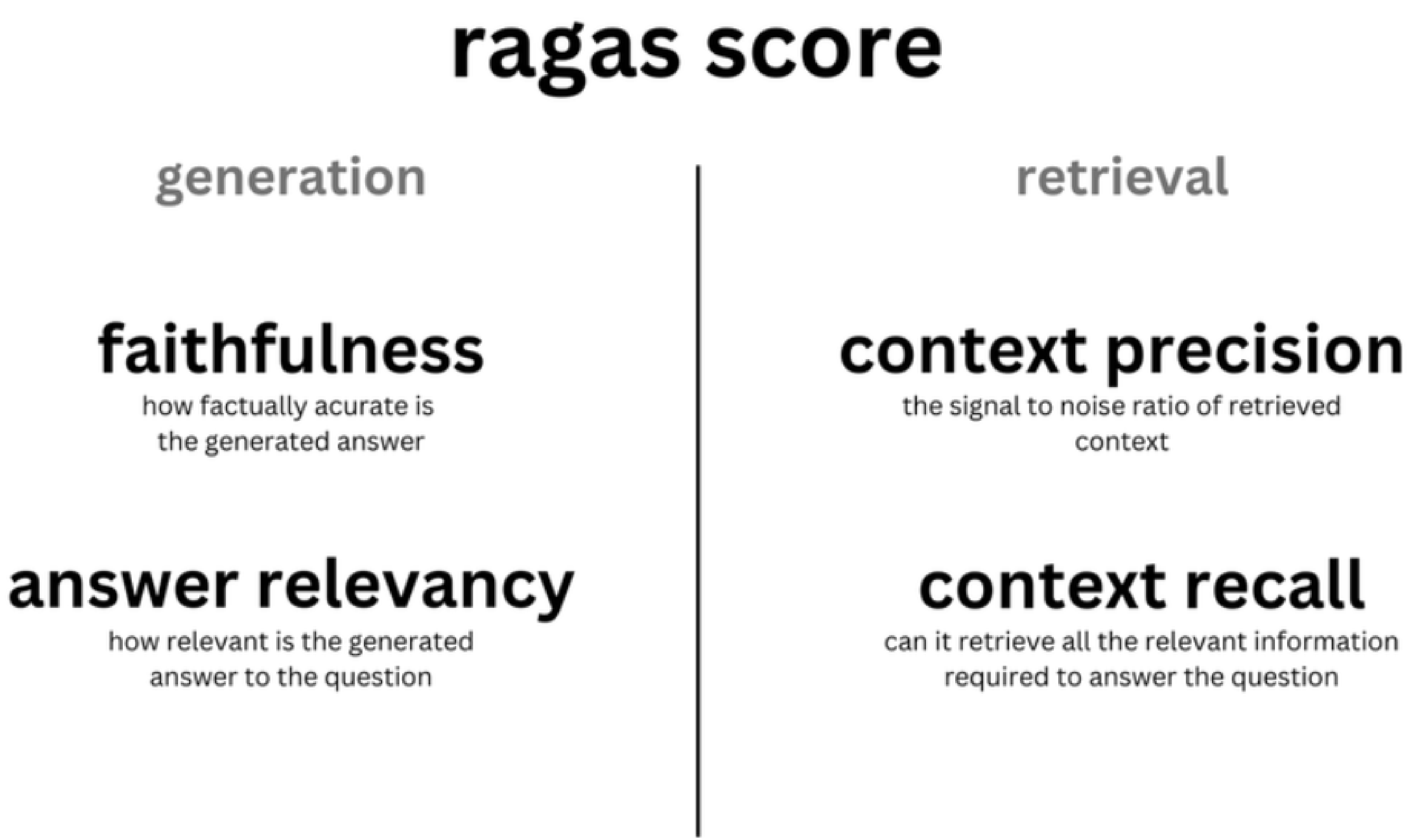
Output accuracy: string evaluation

```
print(f"Score: {score}")
```

```
Score: {'reasoning': 'INCORRECT', 'value': 'INCORRECT', 'score': 0}
```

```
query = "What are the main components of RAG architecture?"
predicted_answer = "Training and encoding"
ref_answer = "Retrieval and Generation"
```

Ragas framework



[1] Image Credit: Ragas

Faithfulness

- *Does the generated output faithfully represent the context?*

$$\text{Faithfulness} = \frac{\text{No. of claims made that can be inferred from the context}}{\text{Total no. of claims}}$$

- **Normalized** to `(0, 1)`

Evaluating faithfulness

```
from langchain_openai import ChatOpenAI, OpenAIEmbeddings
from ragas.integrations.langchain import EvaluatorChain
from ragas.metrics import faithfulness

llm = ChatOpenAI(model="gpt-4o-mini", api_key="...")
embeddings = OpenAIEmbeddings(model="text-embedding-3-small", api_key="...")

faithfulness_chain = EvaluatorChain(
    metric=faithfulness,
    llm=llm,
    embeddings=embeddings
)
```

Evaluating faithfulness

```
eval_result = faithfulness_chain({
  "question": "How does the RAG model improve question answering with LLMs?",
  "answer": "The RAG model improves question answering by combining the retrieval of documents...",
  "contexts": [
    "The RAG model integrates document retrieval with LLMs by first retrieving relevant passages...",
    "By incorporating retrieval mechanisms, RAG leverages external knowledge sources, allowing the...",
  ]
})

print(eval_result)
```

```
'faithfulness': 1.0
```

Context precision

- *How relevant are the retrieved documents to the query?*
- **Normalized** to `(0, 1)` → `1` = highly relevant

```
from ragas.metrics import context_precision

llm = ChatOpenAI(model="gpt-4o-mini", api_key="...")
embeddings = OpenAIEmbeddings(model="text-embedding-3-small", api_key="...")

context_precision_chain = EvaluatorChain(
    metric=context_precision,
    llm=llm,
    embeddings=embeddings
)
```

Evaluating context precision

```
eval_result = context_precision_chain({
  "question": "How does the RAG model improve question answering with large language models?",
  "ground_truth": "The RAG model improves question answering by combining the retrieval of...",
  "contexts": [
    "The RAG model integrates document retrieval with LLMs by first retrieving...",
    "By incorporating retrieval mechanisms, RAG leverages external knowledge sources...",
  ]
})

print(f"Context Precision: {eval_result['context_precision']}")
```

```
Context Precision: 0.99999999995
```

Let's practice!

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