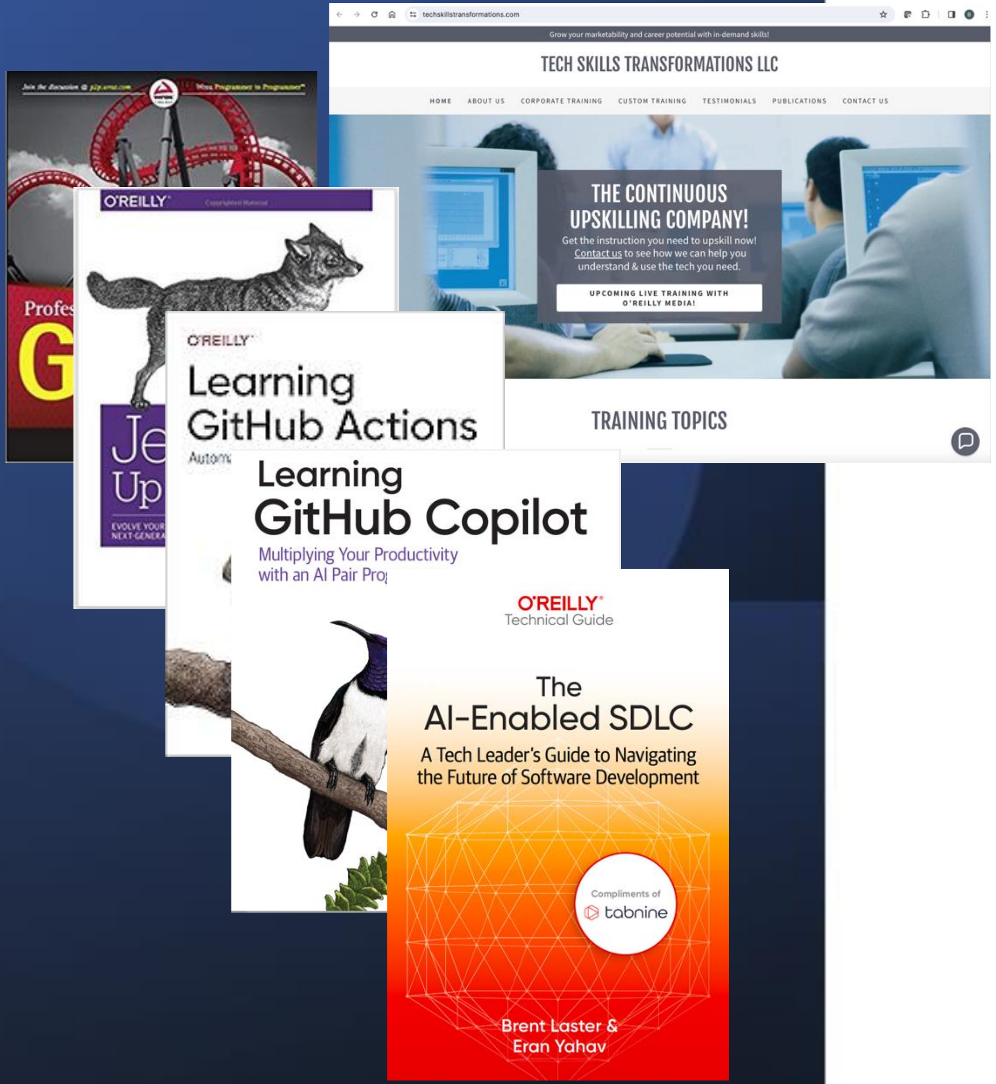
AI 3-in-1: Agents, RAG, and Local Models

Presented by Brent Laster &

Tech Skills Transformations LLC

About me



- Founder, Tech Skills Transformations LLC
- https://getskillsnow.com
- info@getskillsnow.com
- Long career in corporate as dev, manager, and director in DevOps and other areas
- Author
  - O'Reilly "reports"
  - Books
    - Professional Git
    - Jenkins 2 – Up and Running
    - Learning GitHub Actions
    - Learning GitHub Copilot
    - AI-Enabled SDLC
- Speaker
- Social media

❑ **LinkedIn: brentlaster**

❑ **X: @BrentCLaster**

❑ **Bluesky: brentclaster.bsky.social**

❑ **GitHub: brentlaster**

GitHub, git, CI/CD, HELM, TEKTON, GitLab, GitHub Copilot, Visual Studio Code, ChatGPT

LISTED BELOW ARE A FEW OF THE TECHNOLOGIES FOR WHICH WE OFFER HANDS-ON TRAINING. THESE CAN BE CUSTOMIZED FOR ANY SIZE TEAM FROM 1-100 AND FOR ANY LEVEL FROM BEGINNER TO ADVANCED.

- ArgoCD
- Containers
- Docker
- Gerrit
- Git
- GitHub Actions
- GitHub Codespaces
- GitHub Copilot
- GitHub Foundations
- GitHub Security
- GitLab
- GitOps
- Gradle
- Grafana
- Helm
- Jenkins
- Kubernetes
- Kustomize
- LLMs
- Prometheus
- Tekton
- VS Code

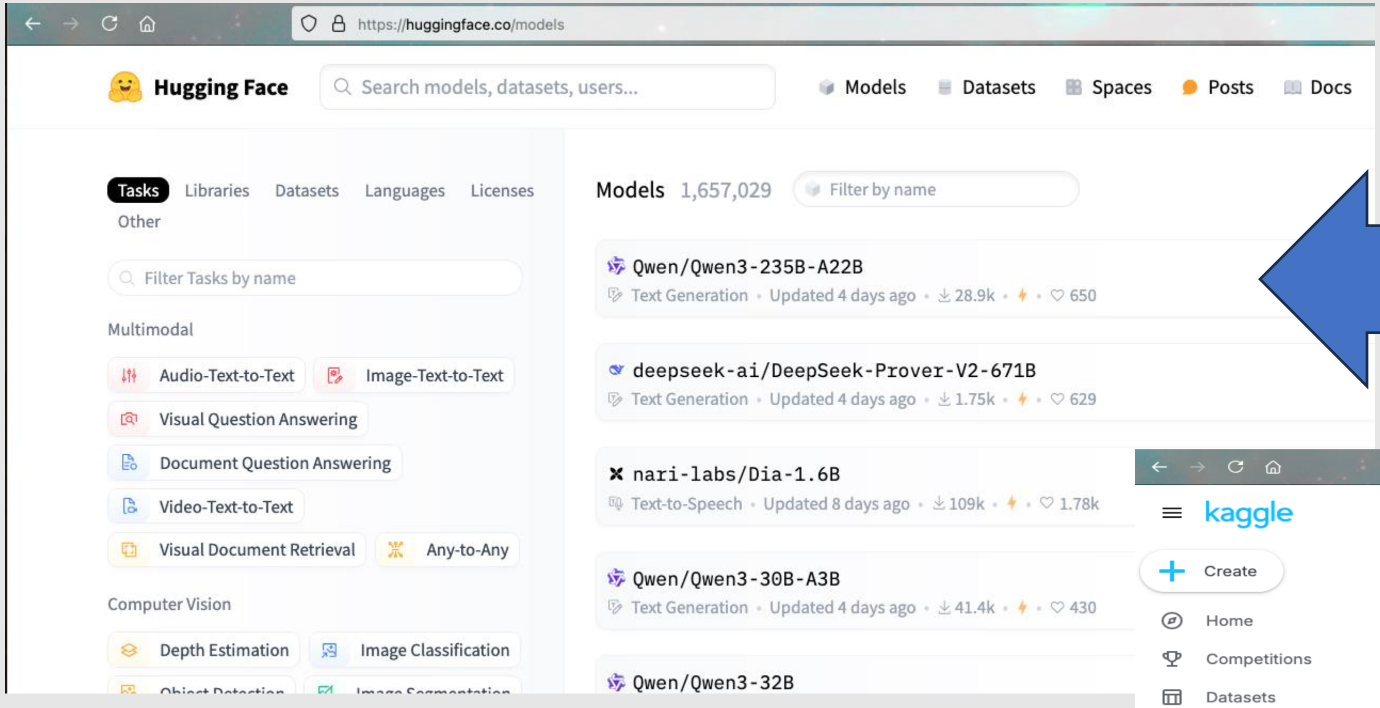
kubernetes, argo, Prometheus, Grafana, docker, GitHub Actions, Jenkins, Security

Running models locally

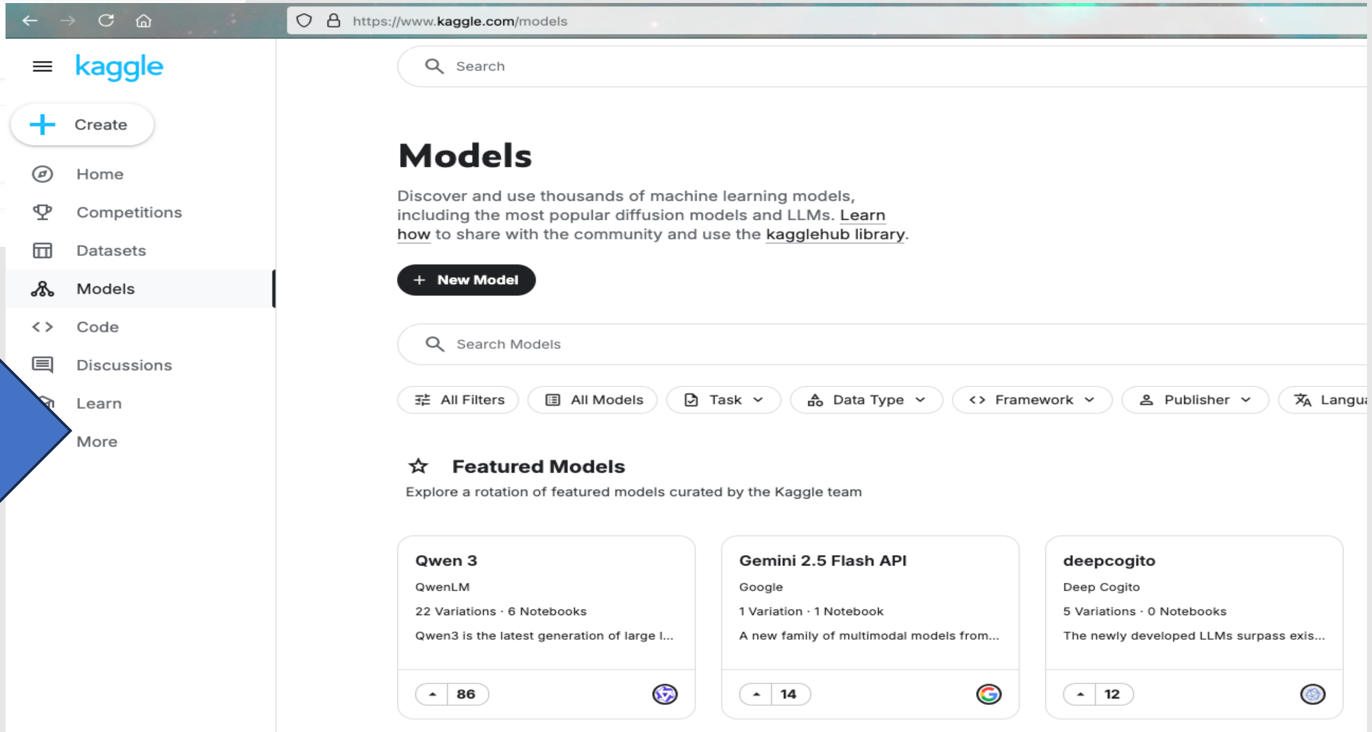
Why run models locally?

- Privacy - no need to share data
- Gives you control over setup, configuration, and customization options
  - Can tailor LLM to your needs, experiment with settings, integrate into your infra
- Can easily swap between different models for different tasks
- Work in offline mode
- Cost savings
  - No charges for subscriptions or API calls
- No censoring of results

Where to get models +



http://huggingface.co/models



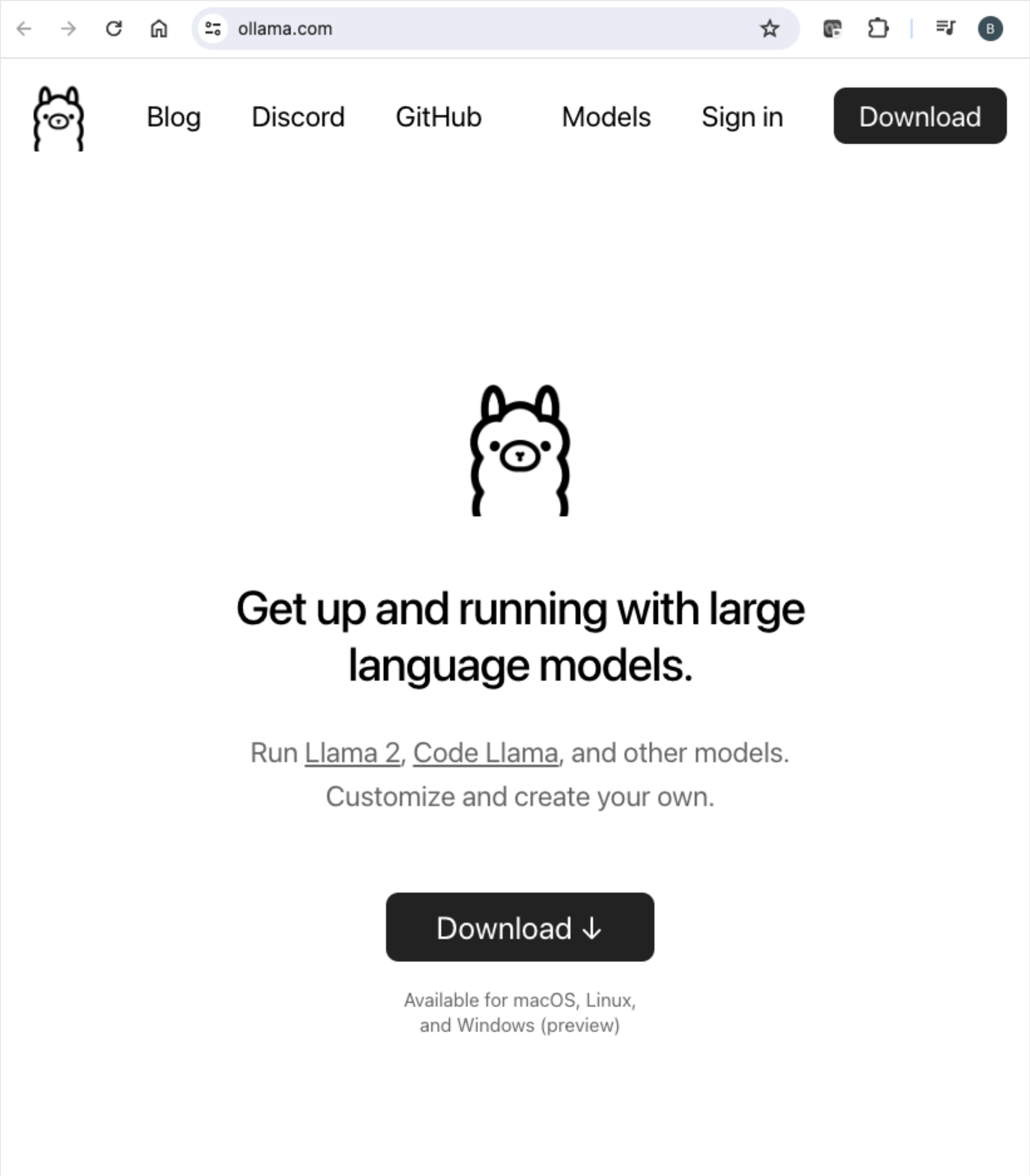
http://kaggle.com/models

Options for running LLMs locally

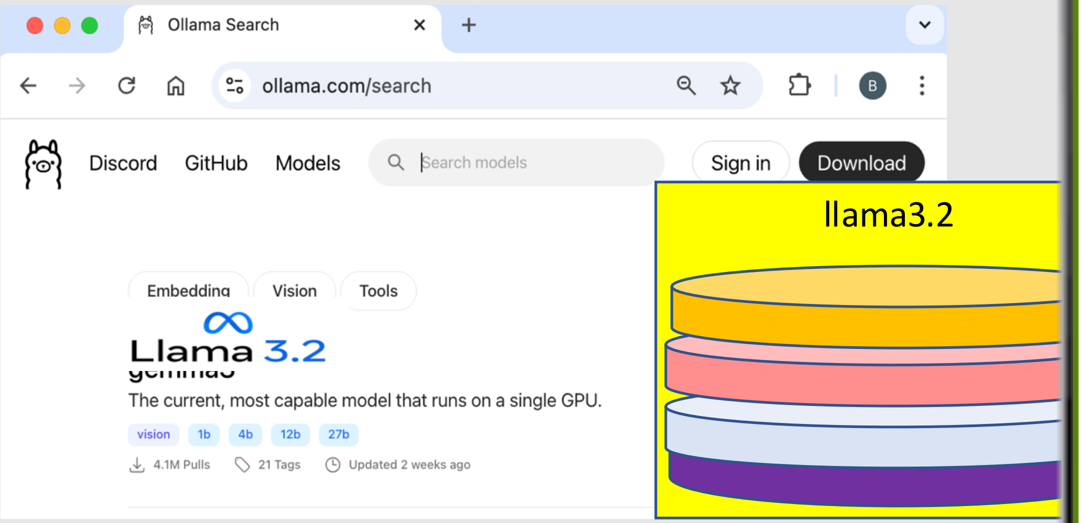
- GPT4All - https://github.com/nomic-ai/gpt4all
- LM Studio - https://lmstudio.ai
- Jan AI - https://jan.ai
- llama.cpp - https://github.com/ggerganov/llama.cpp
- LlamaFile - https://github.com/Mozilla-Ocho/llamafile
- Ollama - https://ollama.com/
- HuggingFace Transformers - https://huggingface.co/docs/transformers
- More!

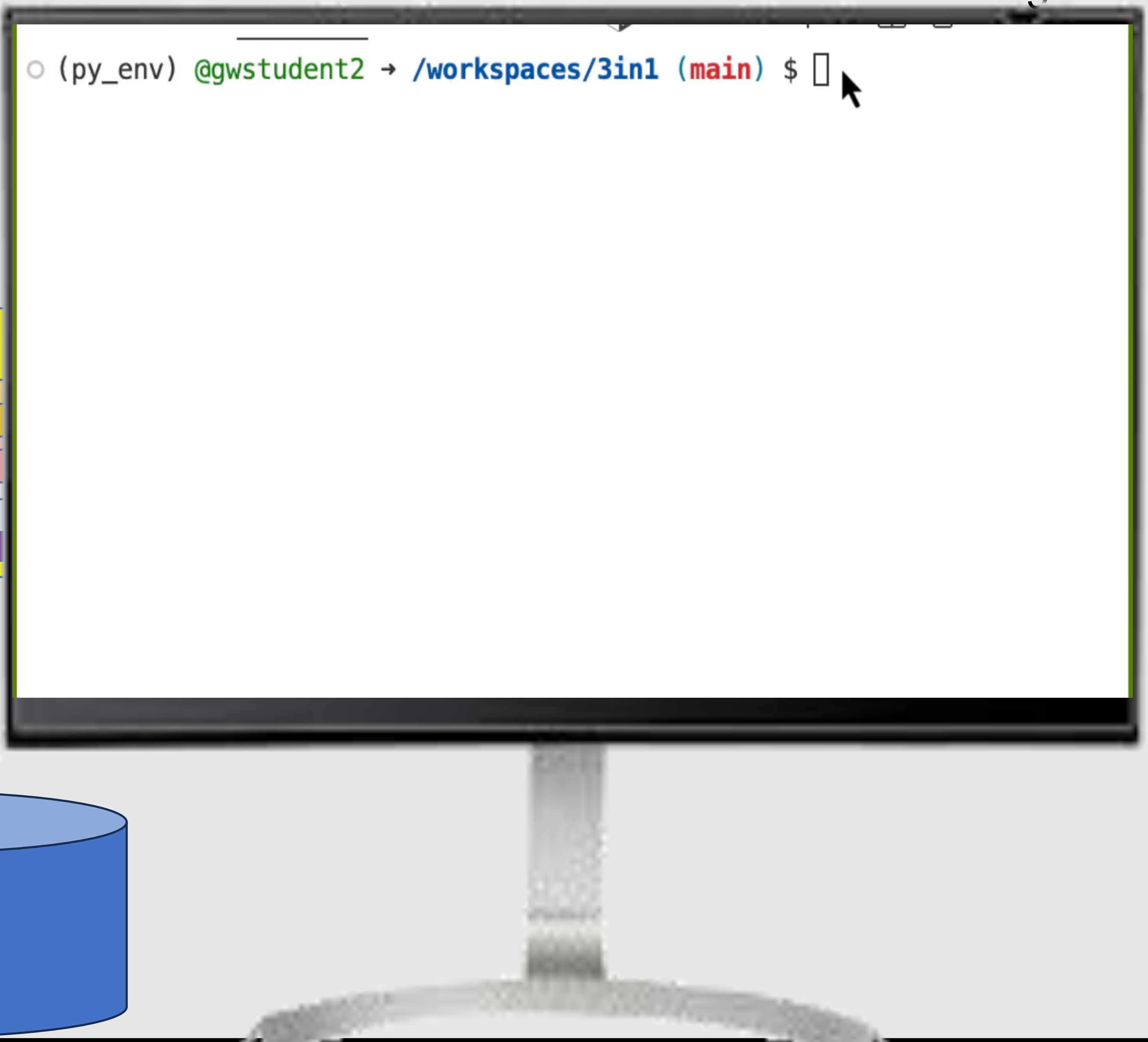
Ollama

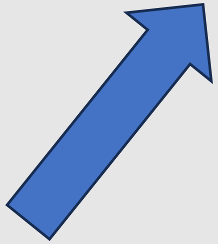
- Command line tool for downloading, exploring and using LLMs on local machine
- open source
- supports most of Hugging Face's popular models
- allows uploading new ones
- Links:
  - main site: https://ollama.com
  - GitHub: https://github.com/ollama/
- Advantages
  - speeds up and simplifies
    - model selection and download
    - configuring endpoints
    - integration with Python or JavaScript codebase



Working with Ollama #1

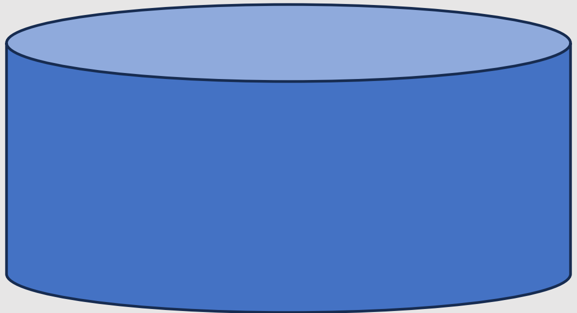






ollama pull

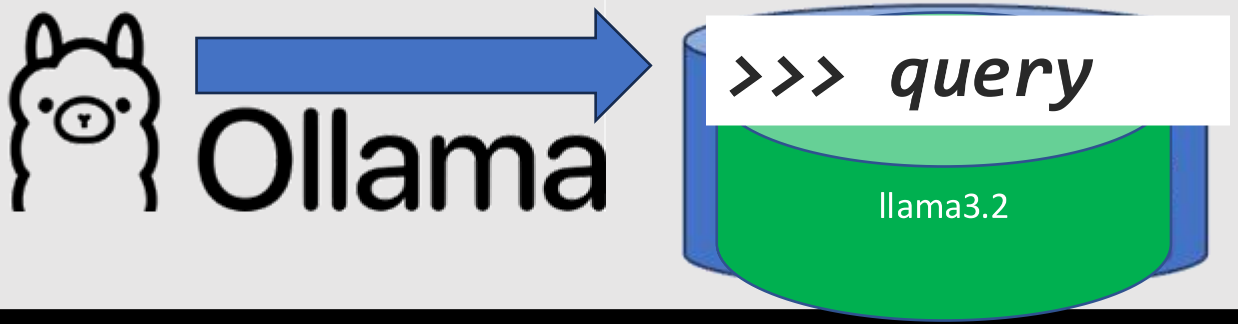
Ollama

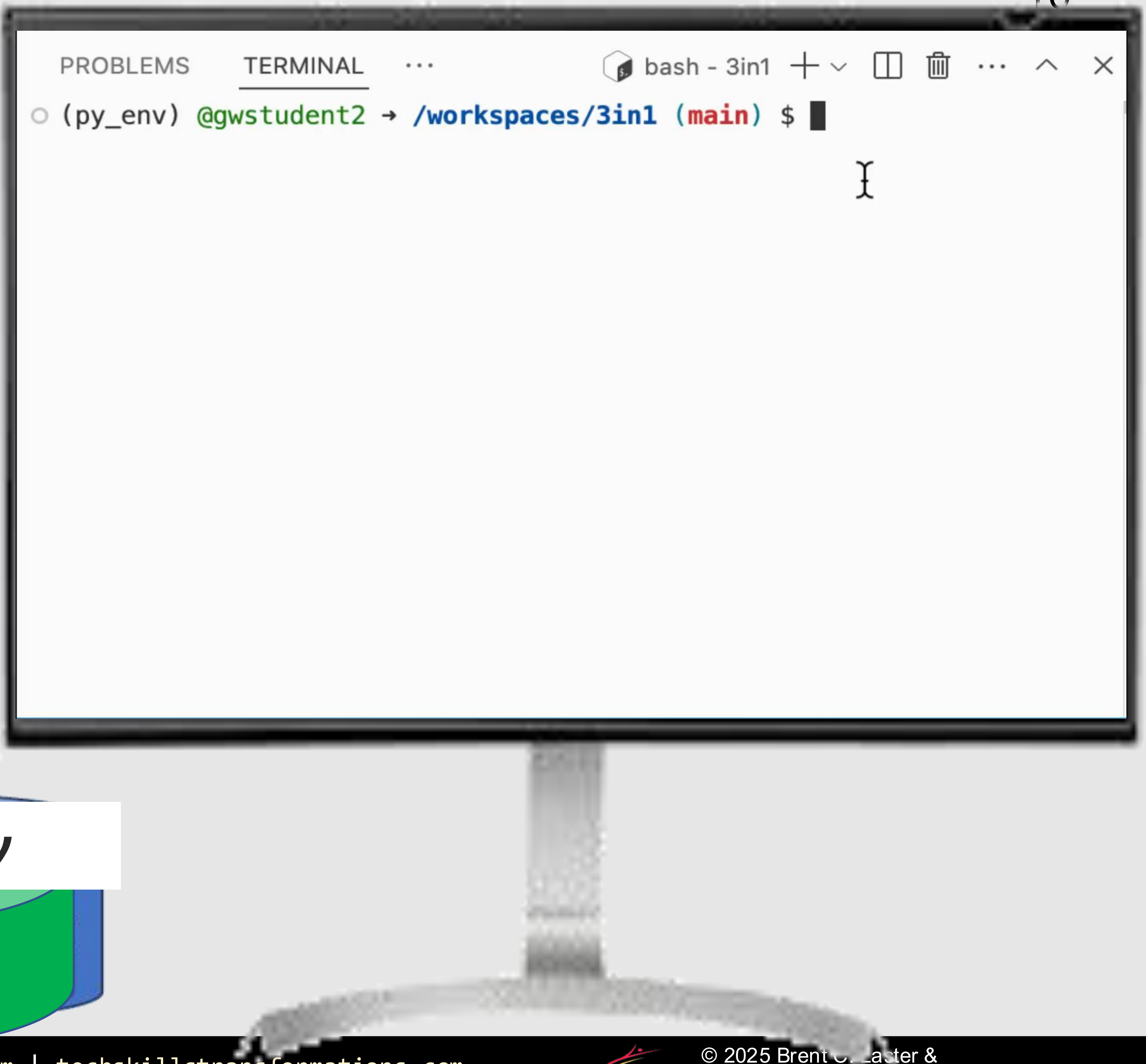


Working with Ollama #2

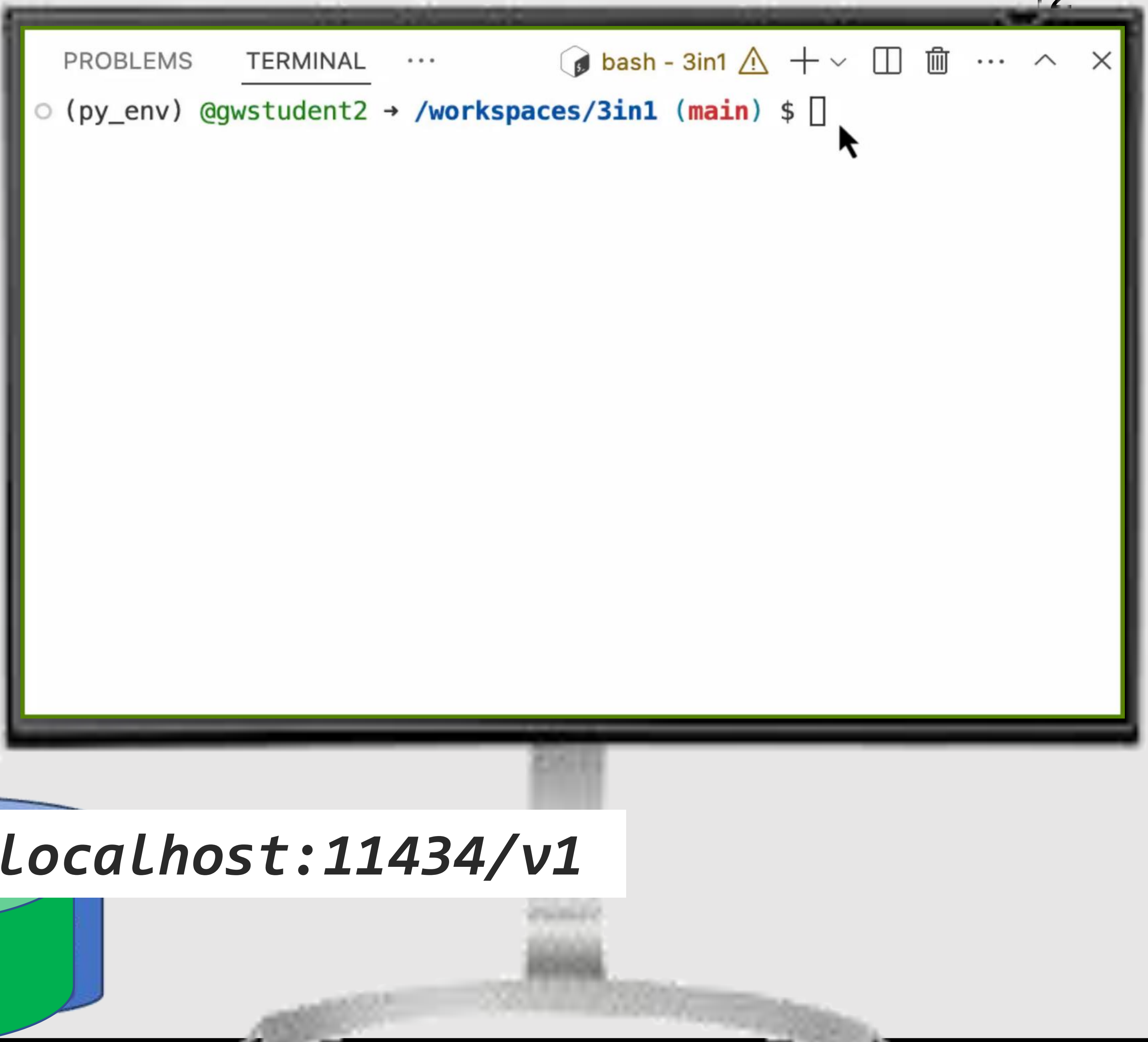
`>>> Briefly explain what an AI model is`

`ollama run`





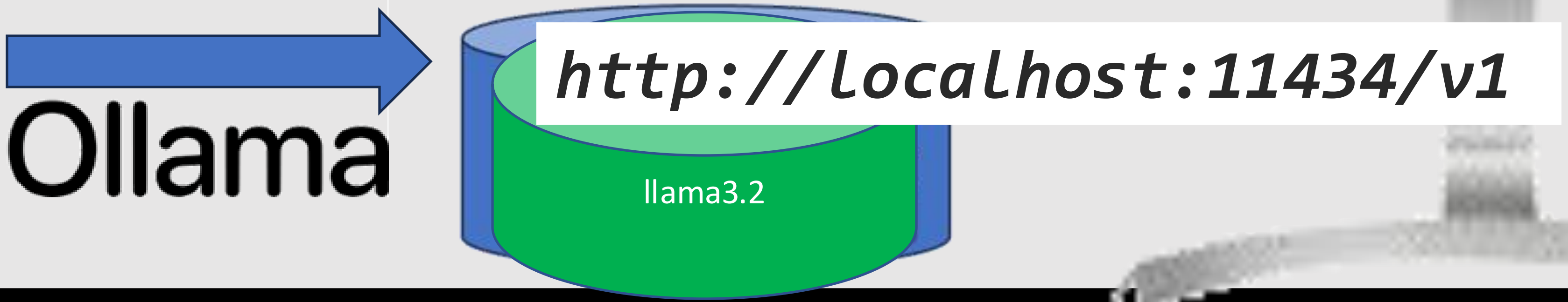
Working with Ollama #3




```python
from openai import OpenAI

# Initialize the client to talk to your local Ollama server
client = OpenAI(
    base_url="http://localhost:11434/v1",
    api_key="n-a"
)

# Send a chat completion request
completion = client.chat.completions.create(
    model="llama3.2",
    messages=[
        {"role": "system", "content": "Always answer in 3 bullet points."},
        {"role": "user",   "content": "Tell me what AI is."}
    ],
    temperature=0.7,
)

# Print out the assistant's reply
print(completion.choices[0].message.content)
```

ollama serve

Ollama

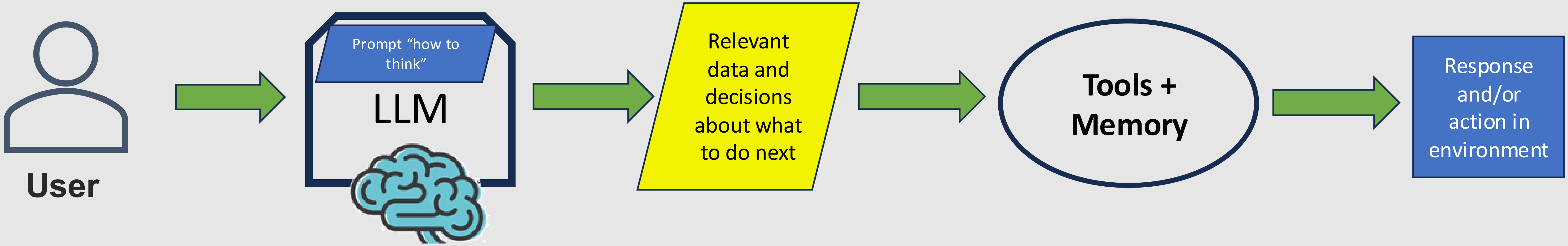


Demo #1 – Simple program to work with local model

Agents

What is an AI Agent?

- A **system** that operates within an **environment** by using **sensors** to **perceive** information, a **decision-making mechanism to process and reason about the data**, and **actuators to take actions that influence or update/respond to the environment**
- This interaction enables the agent to achieve specific goals autonomously while continuously learning and adapting over time
- Agents use LLMs to identify key data, drive decisions, and communicate naturally



Architectural Features of AI Agents

Planning

- AI autonomously outlines and executes a logical series of steps for accomplishing a given objective.
- Provides the AI with a way to dynamically adapt its approach based on real-time data and feedback..
- Might employ reflection to evaluate and improve responses
- Example: A research agent plans search → summarize → generate report.

Tool Use

- AI agents interact with external APIs, databases, and functions.
- Enhances LLMs by providing access to real-world knowledge.
- Reduces hallucinations by using retrieval-augmented generation (RAG).
- Example: Calling a Python function to perform complex calculations.

Memory

- Short-term handles tasks; long term stores knowledge and experience
- Memory ensures consistency and efficiency in multi-step decisions
- Memory recalls preferences to enhance personalization and user experience
- Example: Storing user preferences for future reference or personalized responses

system_message="""You are an AI assistant designed to help users accurately and efficiently. Your primary goal is to provide precise, helpful, and clear responses.

You have access to the following tools:

Tool Name: find_weather, Description: Get weather for a location., Arguments: latitude: float, longitude: float, Outputs: string

You should think **step by step** in order to fulfill the objective with a reasoning process divided into Thought/Action/Observation. This cycle can repeat multiple times if needed.

You should first **reflect with "Thought: {your_thoughts}"** on the current query, then (if necessary), **call a tool with the proper JSON formatting "Action: {JSON_BLOB}"**, or else print your final answer starting with the prefix "Final Answer:""""

Agent Example

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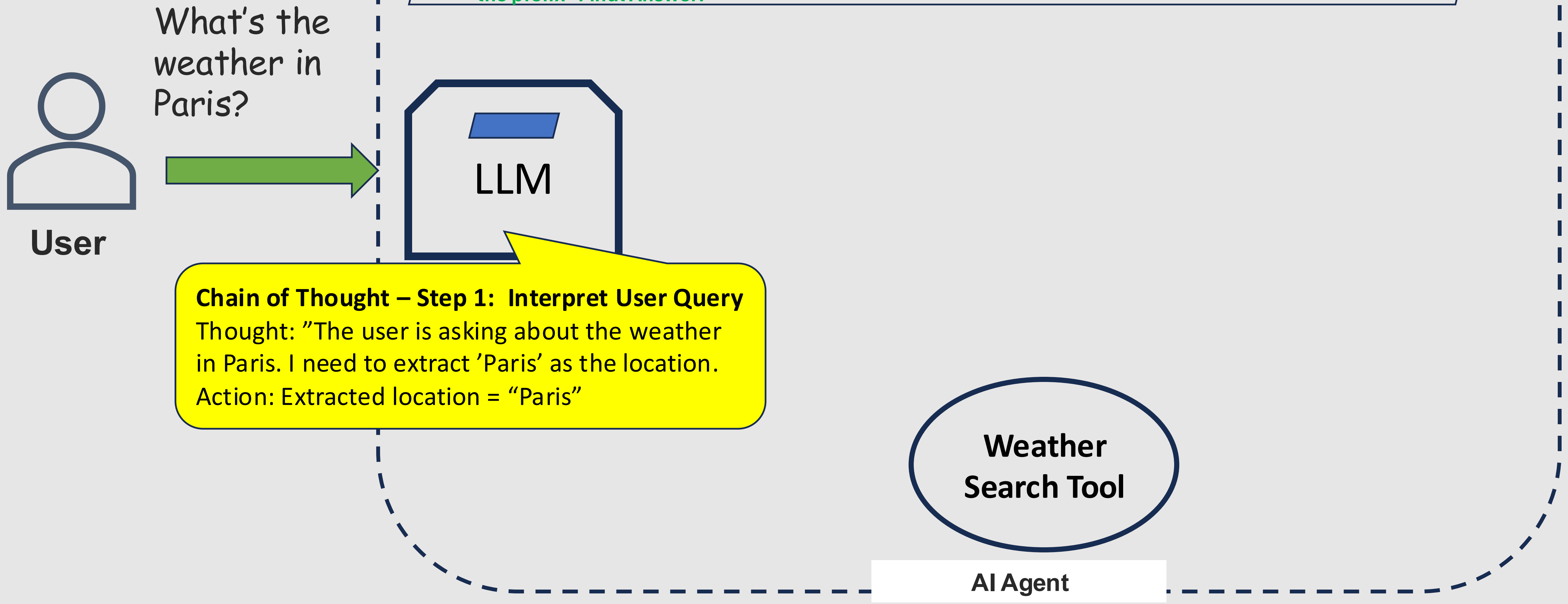

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What's the weather in Paris?

User

LLM

```
AIResponse(
      tool_calls=[{
         name:
"find_weather"
         parameters:  {
            latitude:
"48.8566",
            longitude:
"2.3522",
         },
         id:  "call_tool123",
         type:  "tool_invoke"
   }]
)
```

Chain of Thought – Step 2: Decide to use tool
Thought: "I need real-time data, so I will call the '**find_weather**' tool. First, I need to get the latitude and longitude for the tool call.

Weather Search Tool

AI Agent

Agent Example

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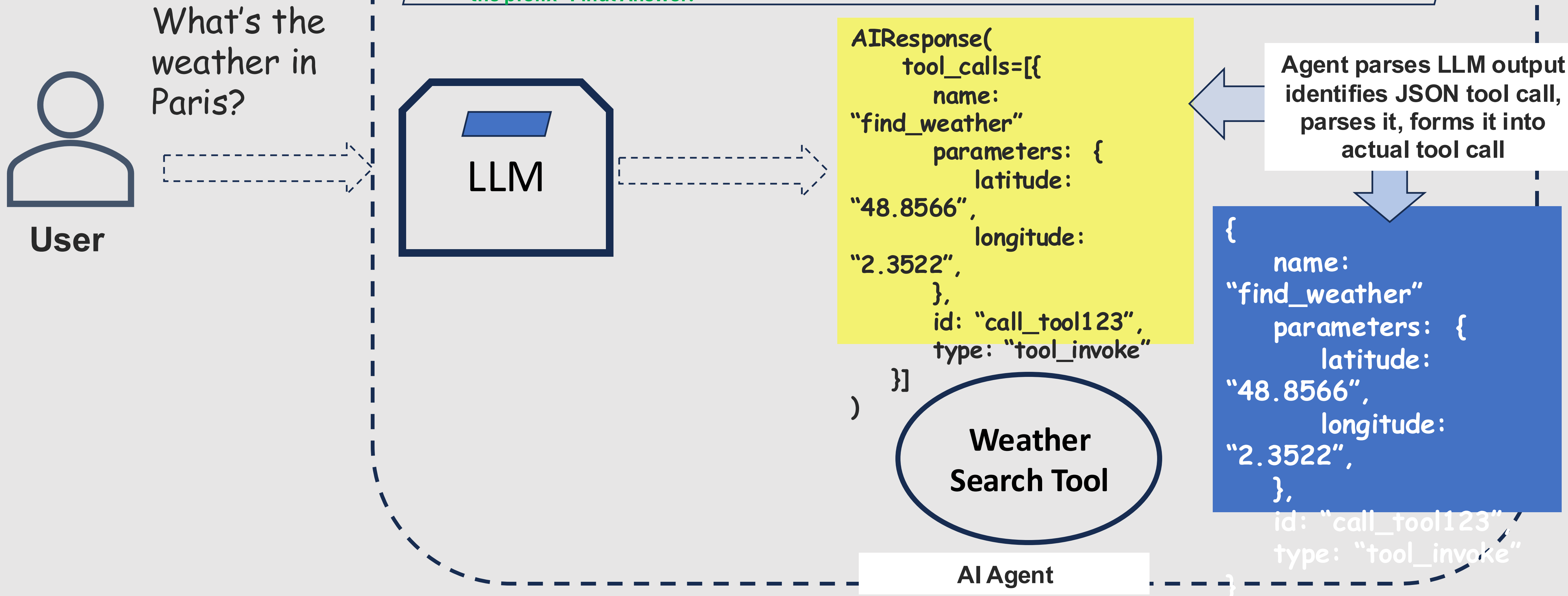

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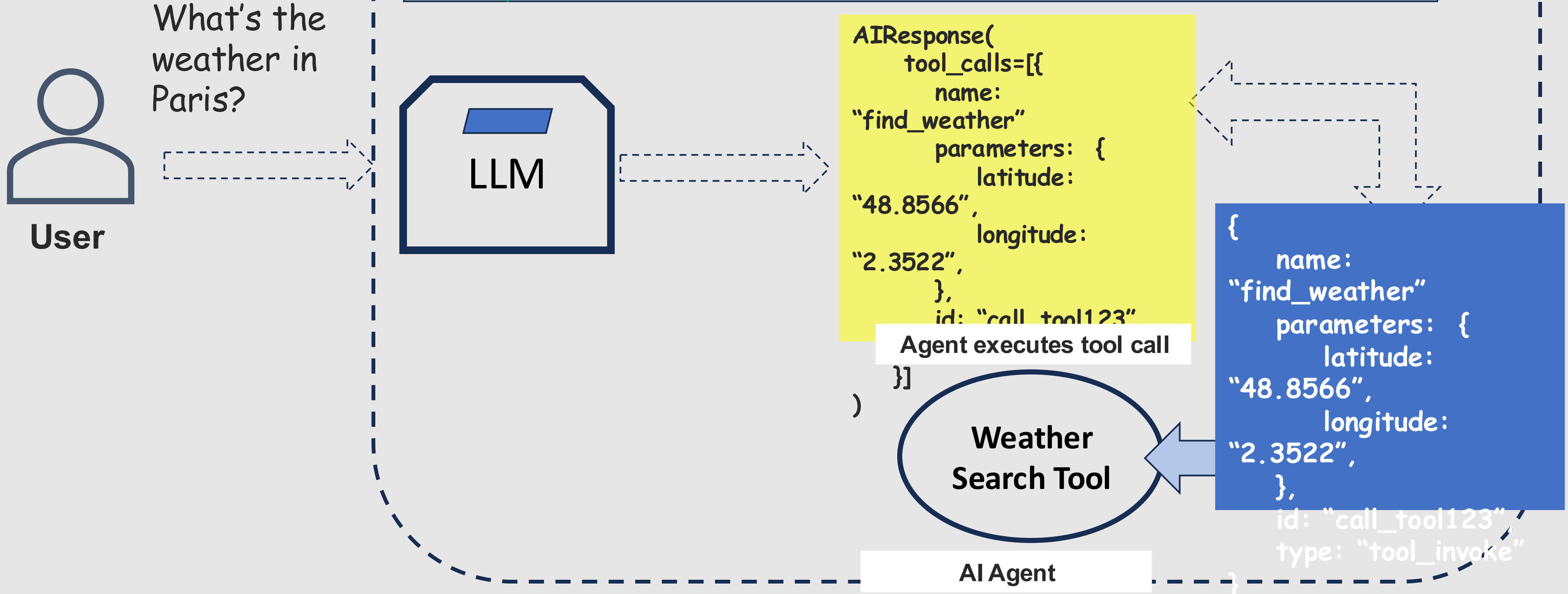

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            latitude: "48.8566",
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        id: "call_tool123",
        type: "tool_invoke"
    }]
)
```

```
{
    name: "find_weather"
    parameters: {
        latitude: "48.8566",
        longitude: "2.3522",
    },
    id: "call_tool123",
    type: "tool_invoke"
}
```

Weather tool returns result

Weather Search Tool

```
ToolResponse(
    content="53 and rainy",
    name="find_weather",
    tool_invoke_id: "call_tool123"
)
```

AI Agent

Agent Example

system_message="""You are an AI assistant designed to help users accurately and efficiently. Your primary goal is to provide precise, helpful, and clear responses.
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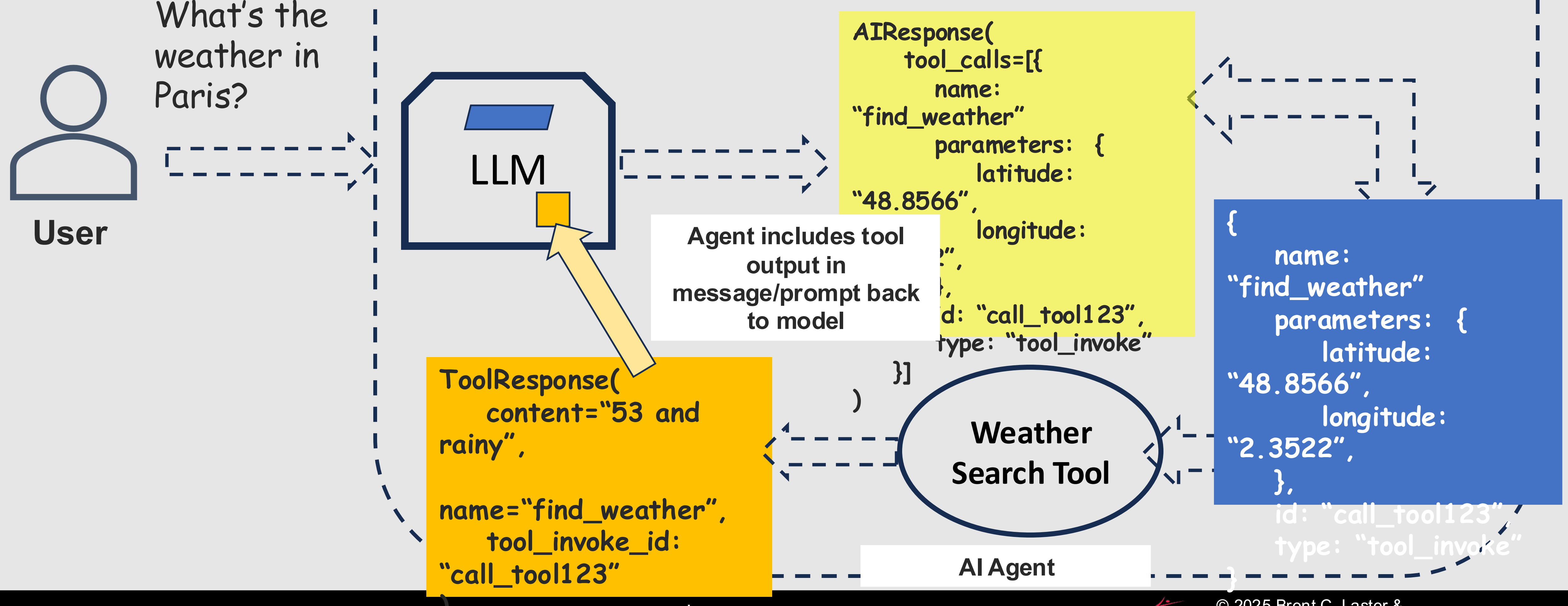

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User

LLM

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        },
        id: "call_tool123",
        type: "tool_invoke"
    }]
)
```

```
{
    name:
"find_weather"
    parameters: {
        latitude:
"48.8566",
        longitude:
"2.3522",
    },
    id: "call_tool123",
    type: "tool_invoke"
}
```

Weather Search Tool

Chain of Thought – Step 3 : Interpret JSON Response
Thought: "The tool returned weather data for Paris. I will summarize the information concisely.

```
name="find_weather",
    tool_invoke_id:
"call_tool123"
)
```

AI Agent

Agent Example

system_message="""You are an AI assistant designed to help users accurately and efficiently. Your primary goal is to provide precise, helpful, and clear responses.
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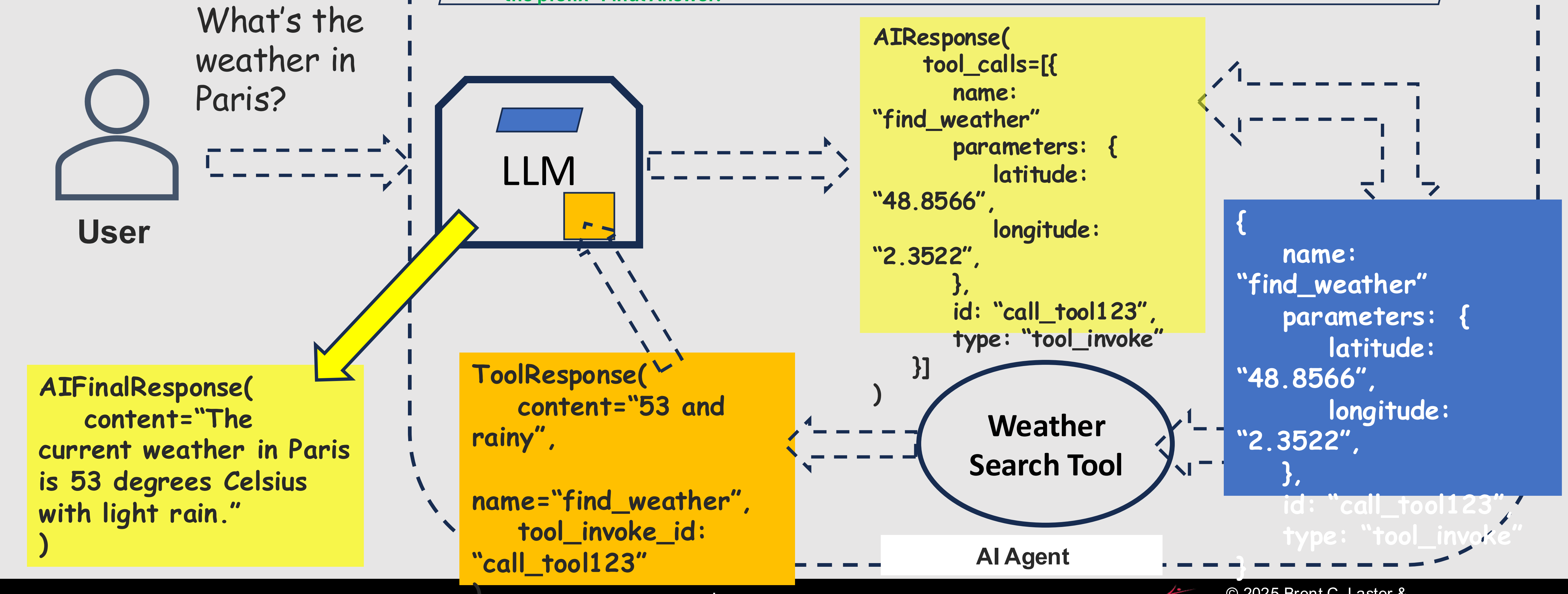

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}]
)

{
name: "find_weather"
parameters: {
latitude: "48.8566",
longitude: "2.3522",
},
id: "call_tool123",
type: "tool_invoke"
}

Weather Search Tool

ToolResponse(
content="53 and rainy",

name="find_weather",
tool_invoke_id: "call_tool123"
)

AIFinalResponse(
content="The current weather in Paris is 53 degrees Celsius with light rain."
)

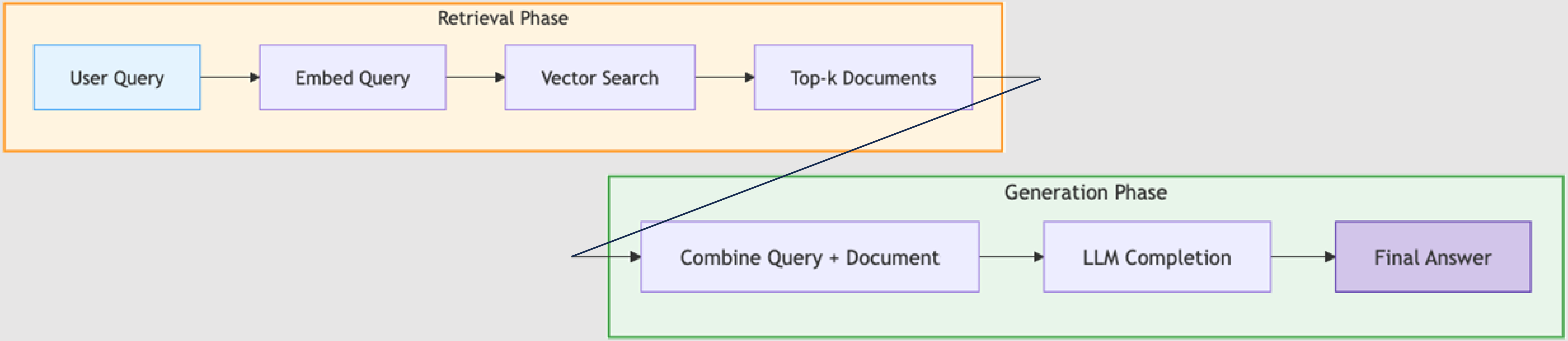
AI Agent

Demo #2 – Adding agency to our code

RAG

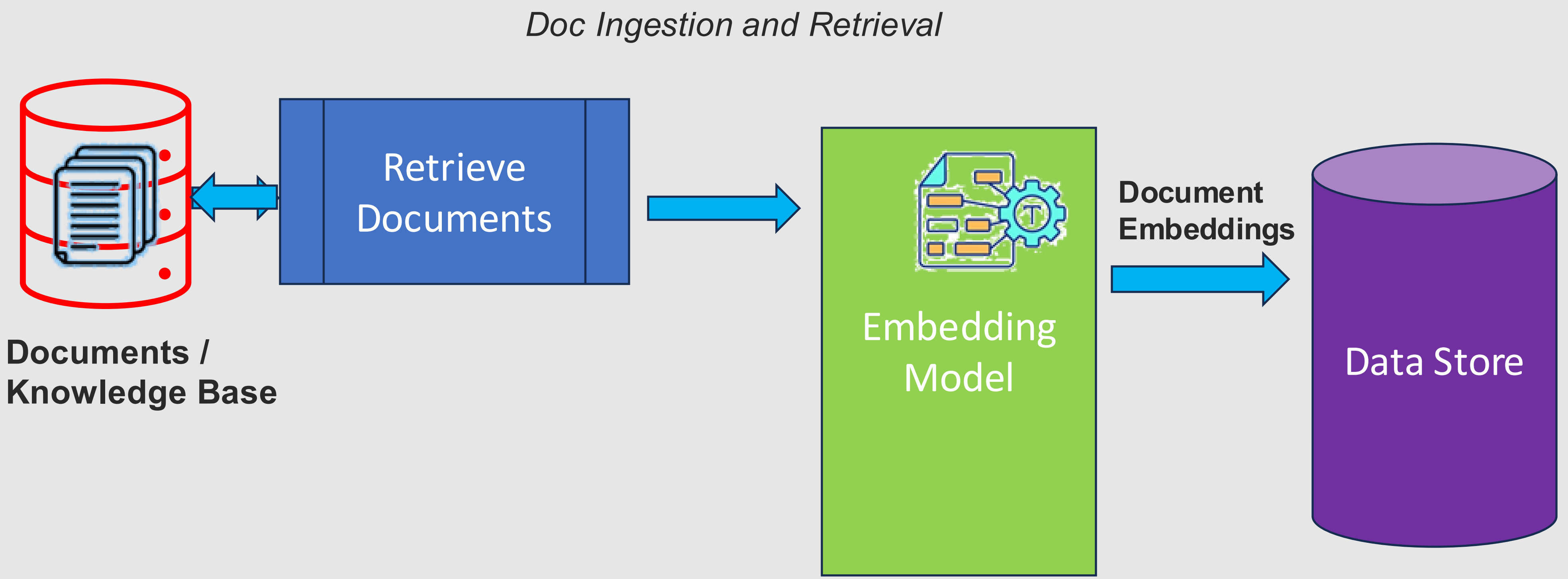
What is RAG and how does it work?

- **Combination of retrieval and generation**: RAG combines information retrieval (like a search engine) with text generation (like a language model).
- **Uses external knowledge**: Instead of relying solely on pre-trained knowledge, RAG retrieves relevant documents or data from an external source (like a database or private knowledge bases) to generate more accurate and up-to-date responses.
- **Improves factual accuracy**: By pulling in real-time data or documents, RAG reduces the risk of generating factually incorrect or outdated information.
- **Two-step process**:
  - **Retrieve**: The model searches for relevant information from a knowledge source.
  - **Generate**: It then uses the retrieved data to create a coherent, contextually accurate answer.



Source: https://blogs.nvidia.com/blog/what-is-retrieval-augmented-generation/

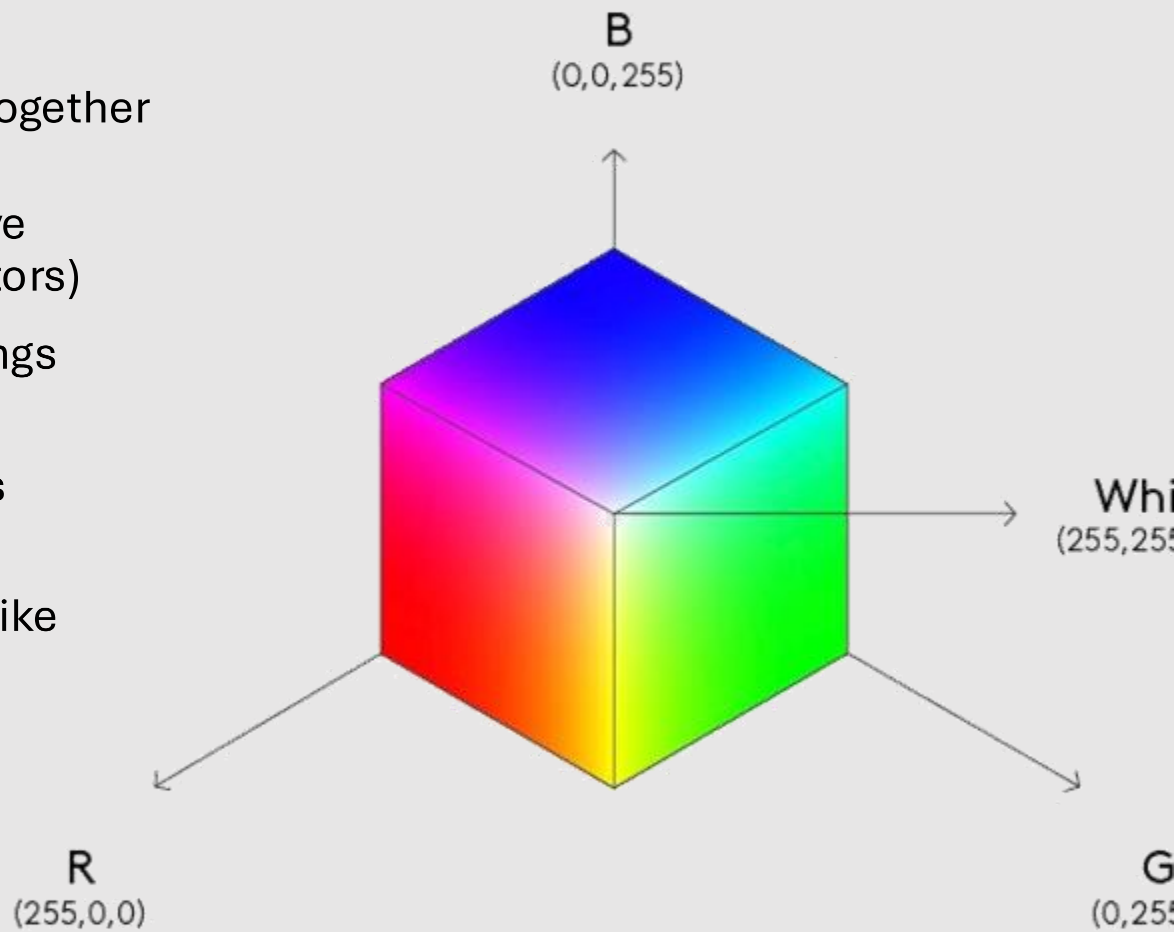
How is RAG setup?



- You provide data sources and point application to them
- Info is retrieved from the data sources and tokenized, embedded and stored in a data store
- For queries/prompts, application gathers results (most relevant ones) from the vector database with your data

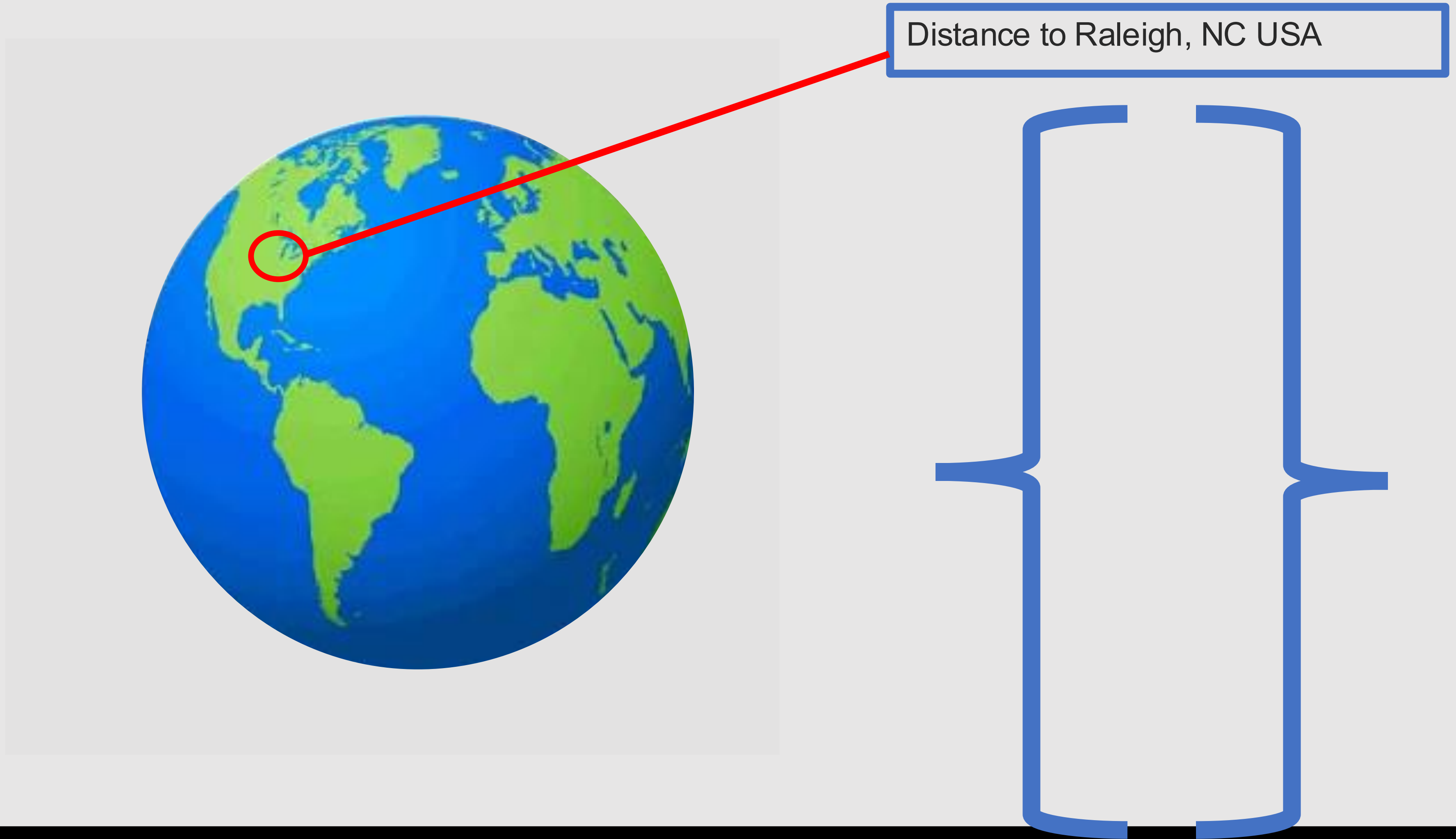
Embeddings

- Embeddings represent text as sets of numeric data - tensors (lots of dimensions)
- Each dimension stores some info about the text's meaning, context, or syntactical aspects
- Words or sentences with similar meanings are stored closer together in the vector space
  - If two pieces of text are similar syntactically, they will have similar embeddings (smaller distance between their vectors)
- During training, models learn to place text with similar meanings closer together in the embedding space
- Common pre-trained models used for generating embeddings include BERT and variants (RoBERTa, DistilBERT)
- Once you have embeddings, you can use them for NLP tasks like semantic search, text classification, sentiment analysis



Understanding vectors in AI

- Collection of data points that encapsulate an item's relationship to other items



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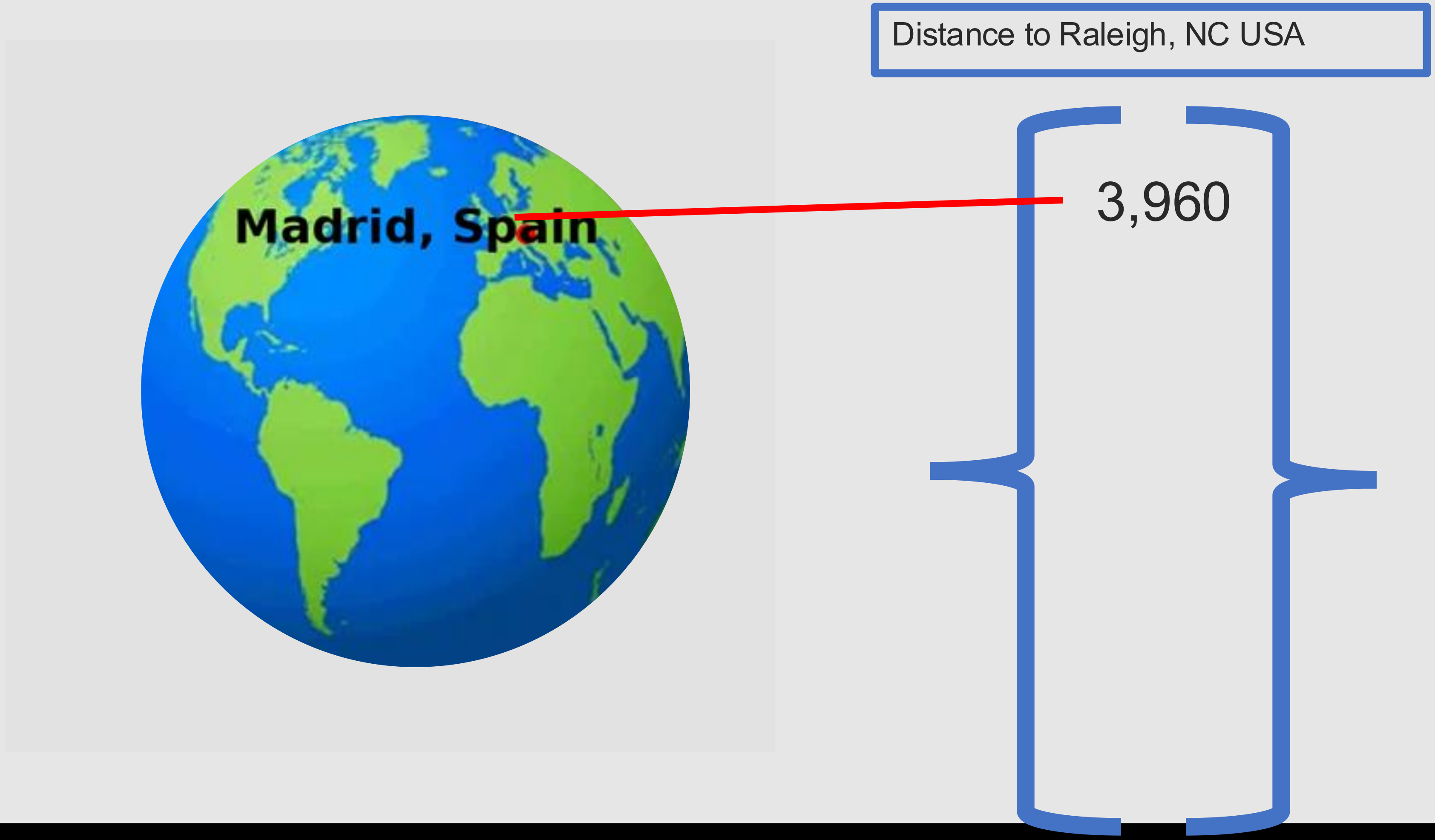

Understanding vectors in AI

- Collection of data points that encapsulate an item's relationship to other items

Distance to Raleigh, NC USA

3,960
6,609

Understanding vectors in AI

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Distance to Raleigh, NC USA

3,960
6,609
2,839.4

Understanding vectors in AI

- Collection of data points that encapsulate an item's relationship to other items

Distance to Raleigh, NC USA

$$\left\{ \begin{array}{c} 3{,}960 \\ 6{,}609 \\ 2{,}839.4 \\ 6{,}001 \end{array} \right\}$$

Understanding vectors in AI

- Collection of data points that encapsulate an item's relationship to other items

Distance to Raleigh, NC USA

$$\left\{ \begin{bmatrix} 3,960 \\ 6,609 \\ 2,839.4 \\ 6,001 \\ 507.6 \end{bmatrix} \right\}$$

Understanding vectors in AI

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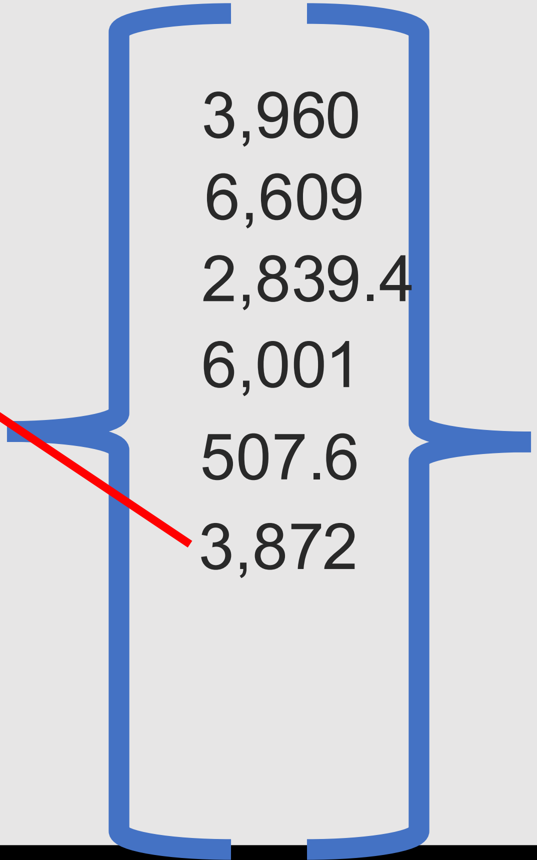
Distance to Raleigh, NC USA



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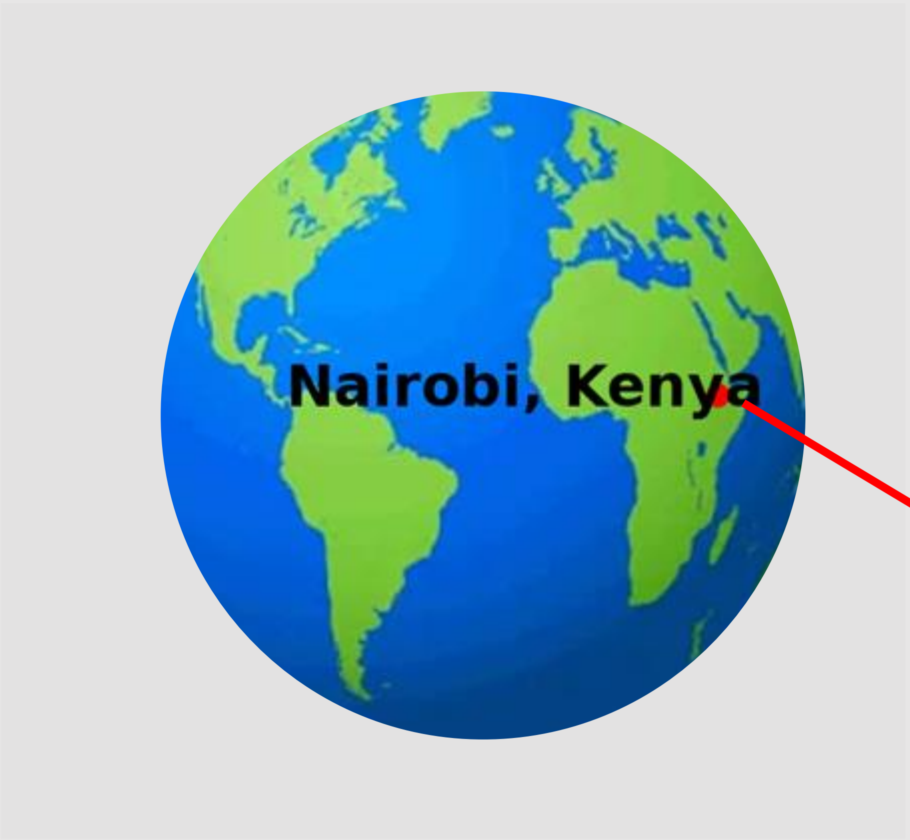

Distance to Raleigh, NC USA

3,960
6,609
2,839.4
6,001
507.6
3,872
7,679

Understanding vectors in AI

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Distance to Raleigh, NC USA

{
3,960
6,609
2,839.4
6,001
507.6
3,872
7,679
2,870.1
}

Semantic meaning / relationships

- Suppose we have 3 words
- King and Queen are more similar to each other than they are to lunch
- In order for neural net to understand the relationships, each word needs to be represented as a vector
- Suppose each word is represented by a 2-dimensional vector

King $\begin{bmatrix} -130.16 \\ 89.5 \end{bmatrix}$

Queen $\begin{bmatrix} -115.43 \\ 95.2 \end{bmatrix}$

Lunch $\begin{bmatrix} -89.5 \\ 34.3 \end{bmatrix}$

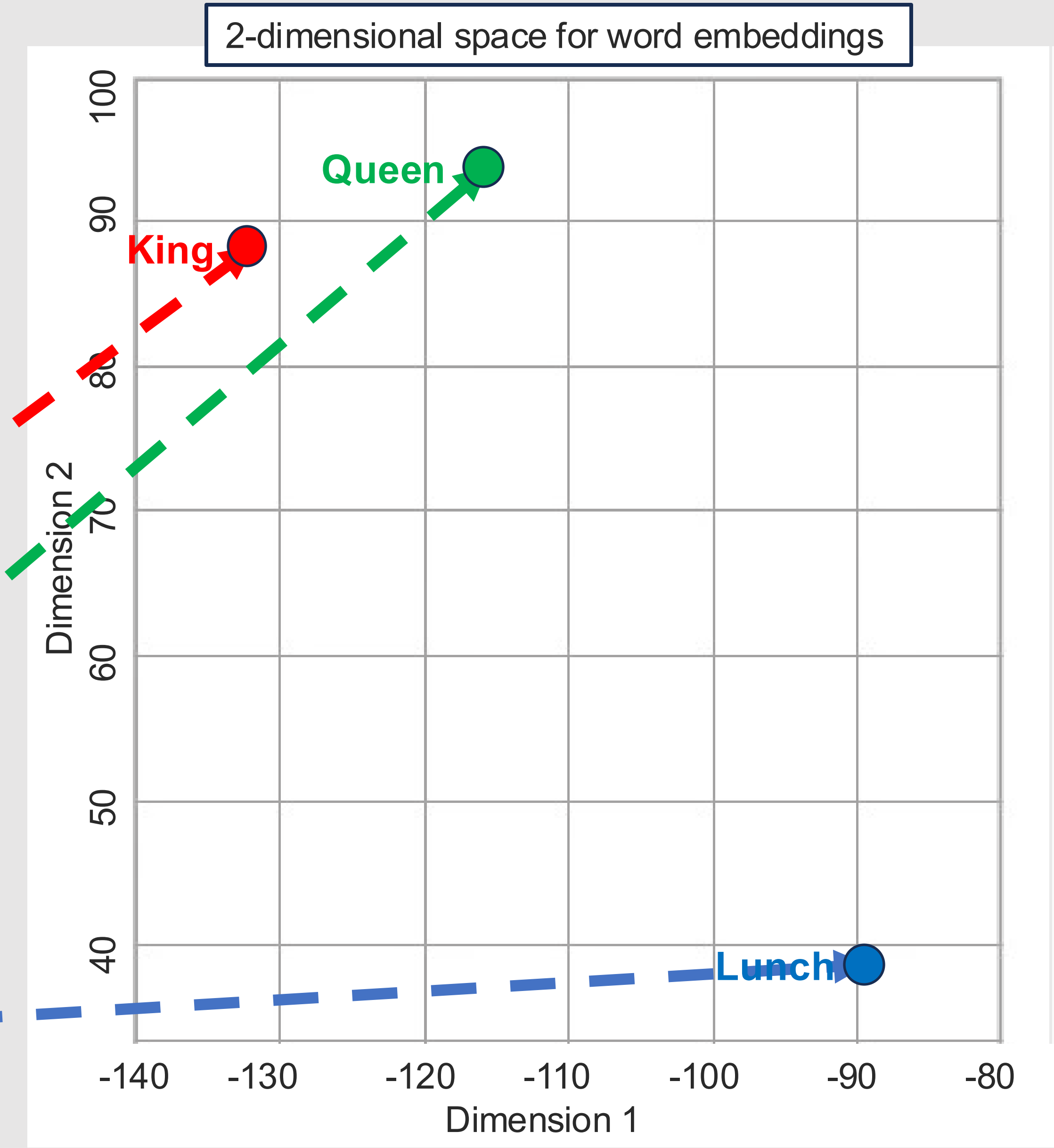
Embedding space

- Plotting in 2-dimensional embedding space shows relationships
- Way to let NN understand relationships between words
- We want the NN to learn that King and Queen are more similar to each other than they are to lunch

King $\begin{bmatrix} -130.16 \\ 89.5 \end{bmatrix}$

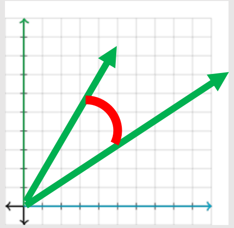
Queen $\begin{bmatrix} -115.43 \\ 95.2 \end{bmatrix}$

Lunch $\begin{bmatrix} -89.5 \\ 34.3 \end{bmatrix}$

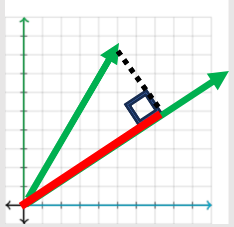


Searching for Vectors - similarity metrics

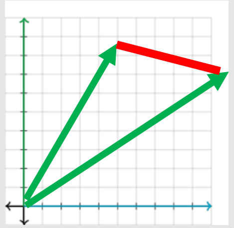
- 3 metrics commonly used to determine similarity of two vectors (2-dimensional representation)



Cosine similarity - measure the angle between two vectors; values from -1 to 1; 1 = both point in same direction; -1 point in opposite directions; 0 = orthogonal (perpendicular)



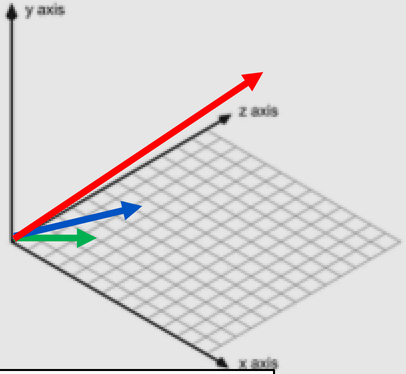
Dot product / inner product - measures how well 2 vectors align with each other; values from - ∞ to ∞; positive values indicate vectors are in same direction; negative values indicate opposite directions; 0 = orthogonal



Euclidean distance - measures the distance between two vectors; values from 0 to ∞; 0 = identical; larger numbers farther apart

imagine 3 vectors - a,b,c

$$a=\begin{bmatrix}.01\\.07\\.1\end{bmatrix}\quad b=\begin{bmatrix}.01\\.08\\.11\end{bmatrix}\quad c=\begin{bmatrix}.91\\.57\\.6\end{bmatrix}$$



Cosine similarity

$$sim(u,v) = \frac{u \cdot v}{\|u\|\|v\|} = \frac{\sum_{i=1}^{n} a_n b_n}{\sqrt{\sum_{i=1}^{n} u_n^2}\sqrt{\sum_{i=1}^{n} v_n^2}}$$

$$sim(a,b) = \frac{(a_1 * b_1) + (a_2 * b_2) + (a_3 * b_3)}{\sqrt{a_1^2 + a_2^2 + a_3^2}\sqrt{b_1^2 + b_2^2 + b_3^2}}$$

$$= \frac{(0.01 * 0.01) + (0.07 * 0.08) + (0.1 * 0.11)}{\sqrt{0.01^2 + 0.07^2 + 0.1^2}\sqrt{0.01^2 + 0.08^2 + 0.11^2}}$$

0.0141

Dot product / inner product

$$u \cdot v = |u||v|cos\theta = \sum_{i=1}^{n} a_n b_n$$

Dot product formula

$$a \cdot b = (a_1 b_1) + (a_2 b_2) + (a_3 b_3)$$
$$= (0.01 * 0.01) + (0.07 * 0.08) + (0.1 * 0.11)$$

0.0167

Euclidean distance

$$d(u,v) = \sqrt{\sum_{i=1}^{n} (u_i - v_i)^2}$$

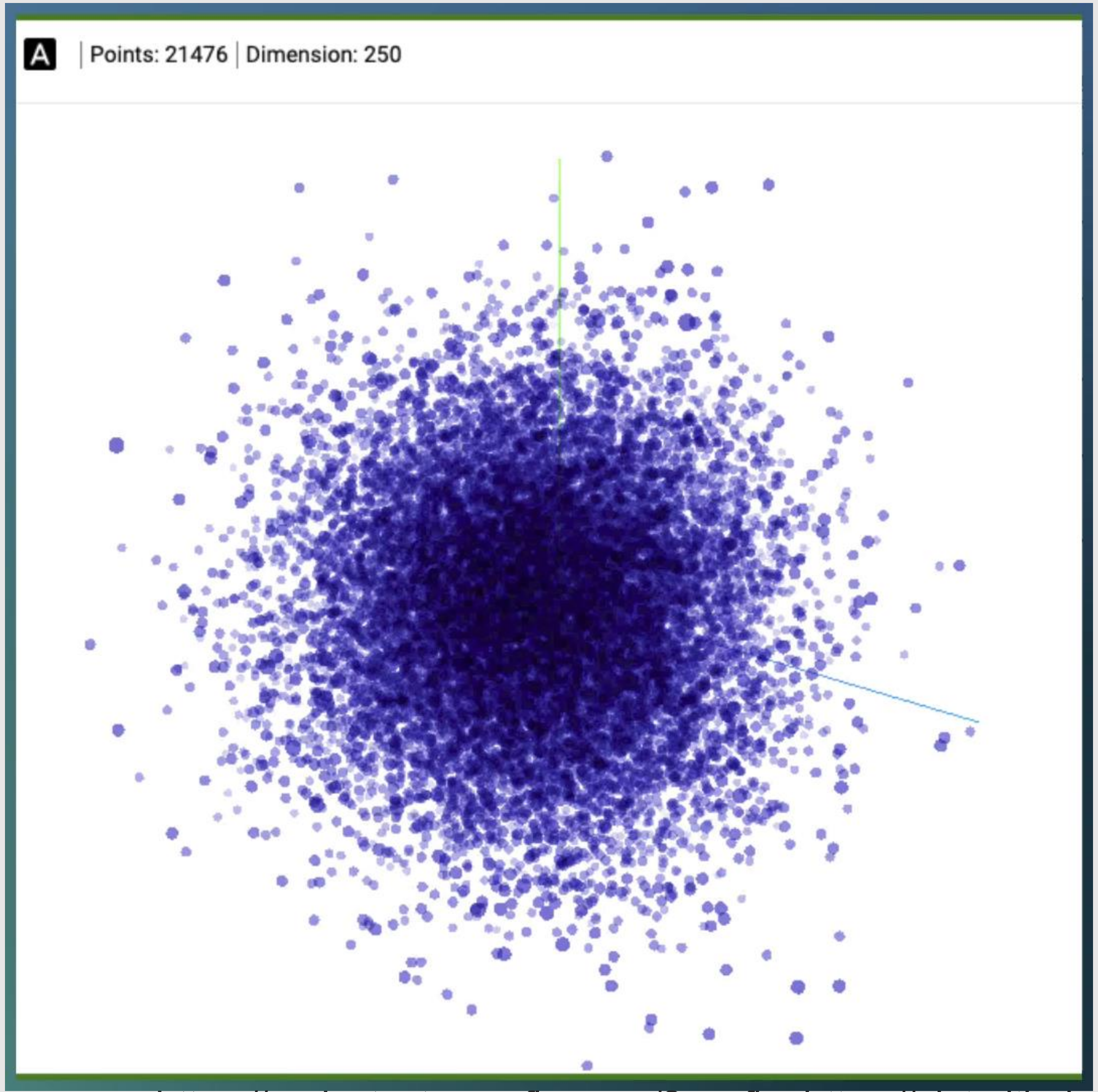
...dean distance formula

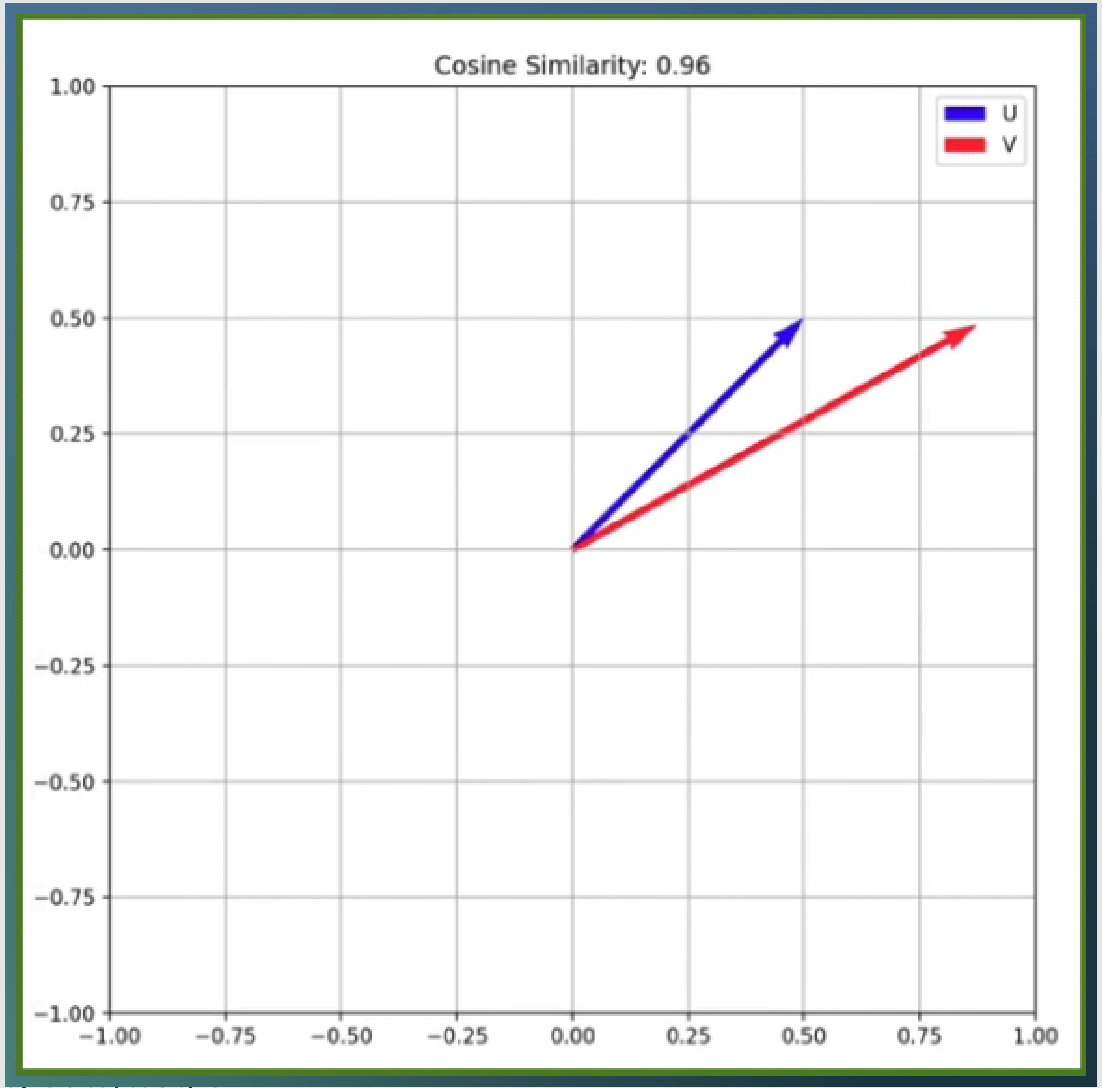
$$d(a,b) = \sqrt{(b_1 - a_1)^2 + (b_2 - a_2)^2 + (b_3 - a_3)^2}$$
$$= \sqrt{(0.01 - 0.01)^2 + (0.08 - 0.07)^2 + (0.11 - 0.1)^2}$$

0.9998

...edit: https://towardsdatascience.com/similarity-metrics-in-nlp-acc0777e234c

Visualizing Embeddings and Vector Similarity





source: https://projector.tensorflow.org/?config=https://gist.githubusercontent.com/martin-labrecque/4483ff5a104f0b56417585c3bc9a12f1/raw/57348e12a70c8d70c2c573d3dbc0122ac077556b/journaux_config.json

Vectors and relationships example

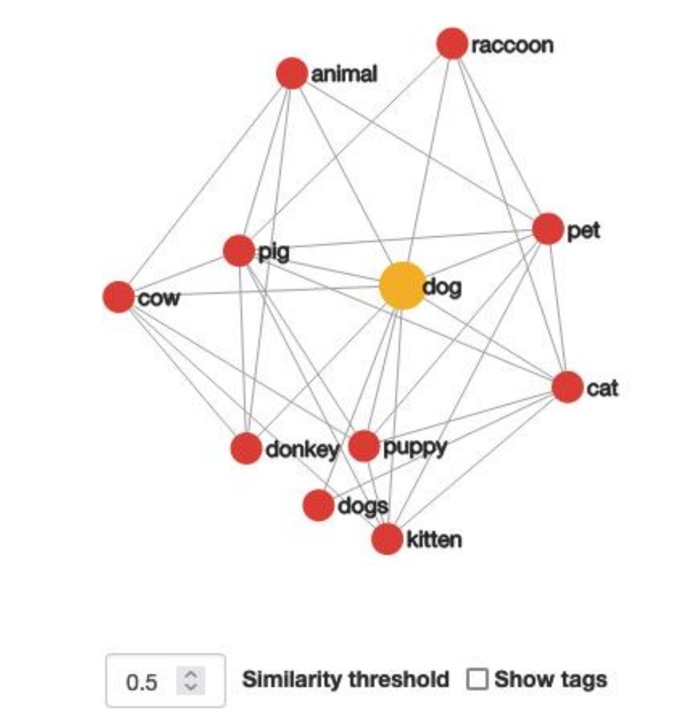
- Query - what words are related to "dog" in model "English Wikipedia"?

Word frequency

☑ High ☑ Medium ☐ Low

1. puppy NOUN 0.6909
2. cat NOUN 0.6893
3. pet NOUN 0.6779
4. pig NOUN 0.6680
5. dogs NOUN 0.6174
6. animal NOUN 0.6066
7. donkey NOUN 0.6060
8. raccoon NOUN 0.6021
9. cow NOUN 0.5953
10. kitten NOUN 0.5947

- *We show only the associates of the same part of speech as your query. All associates can be found at the Similar Words tab.*



Show the raw vector of «dog» in model MOD_enwiki_upos_skipgram_300_2_2021:

[-0.03301828354597092, 0.05134638026356697, 0.0036009703762829304,
-0.04066073149442673, 0.10361430048942566, 0.013021323829889297,
0.028161464259028435, -0.0027567853685468435, 0.03388035297393799,
-0.044882044196128845, 0.005169689189642668, -0.05818631127476692,
0.0533536821603775, 0.016616210341453552, 0.02030780538916588,
-0.008570297621190548, -0.10925538837909698, -0.0708925873041153,
0.04675082117319107, -0.03091960959136486, -0.05172094330191612,
0.04471702128648758, 0.008674593642354012, -0.01816382259130478,
0.05909318849444389, 0.10409023612737656, 0.05633684620261192,
-0.024881813675165176, 0.01872968301177025, 0.007228093687444925,
-0.023127363994717598, 0.01528552919626236, -0.0643191784620285,
-0.010359424166381359, -0.06104437634348869, -0.13868044316768646,
-0.023004498332738876, 0.0038427673280239105, -0.021551262587308884,
-0.03467748314142227, 0.010687021538615227, -0.017304275184869766,
0.026886526495218277, -0.0030398862436413765, -0.03685504570603371,
-0.06017328053712845, 0.047442398965358734, -0.10714898258447647,
0.14808930456638336, -0.06579480320215225, -0.004342162515968084,
0.06226382404565811, 0.08031187951564789, -0.055930640548467636,
-0.07030591368675232, 0.015474628657102585, 0.05367768555879593,
0.0917837843298912, 0.031899698078632355, 0.055091146379709244,
-0.025078952312469482, -0.048126623034477234, -0.09730836749076843,
-0.07128141075372696, 0.019415033981204033, -0.025872433558106422,
-0.01761292852461338, 0.015608762390911579, -0.029876720160245895,
-0.008602319285273552, 0.049825914204120636, 0.06784739345312119,
0.005586292129009962, -0.07148509472608566, -0.03097137063741684,
-0.020296750590205193, 0.05099814385175705, 0.14920306205749512,

Source: http://vectors.nlpl.eu/explore/embeddings/en/MOD_enwiki_upos_skipgram_300_2_2021/dog_NOUN/

Vector Databases

Vector Databases

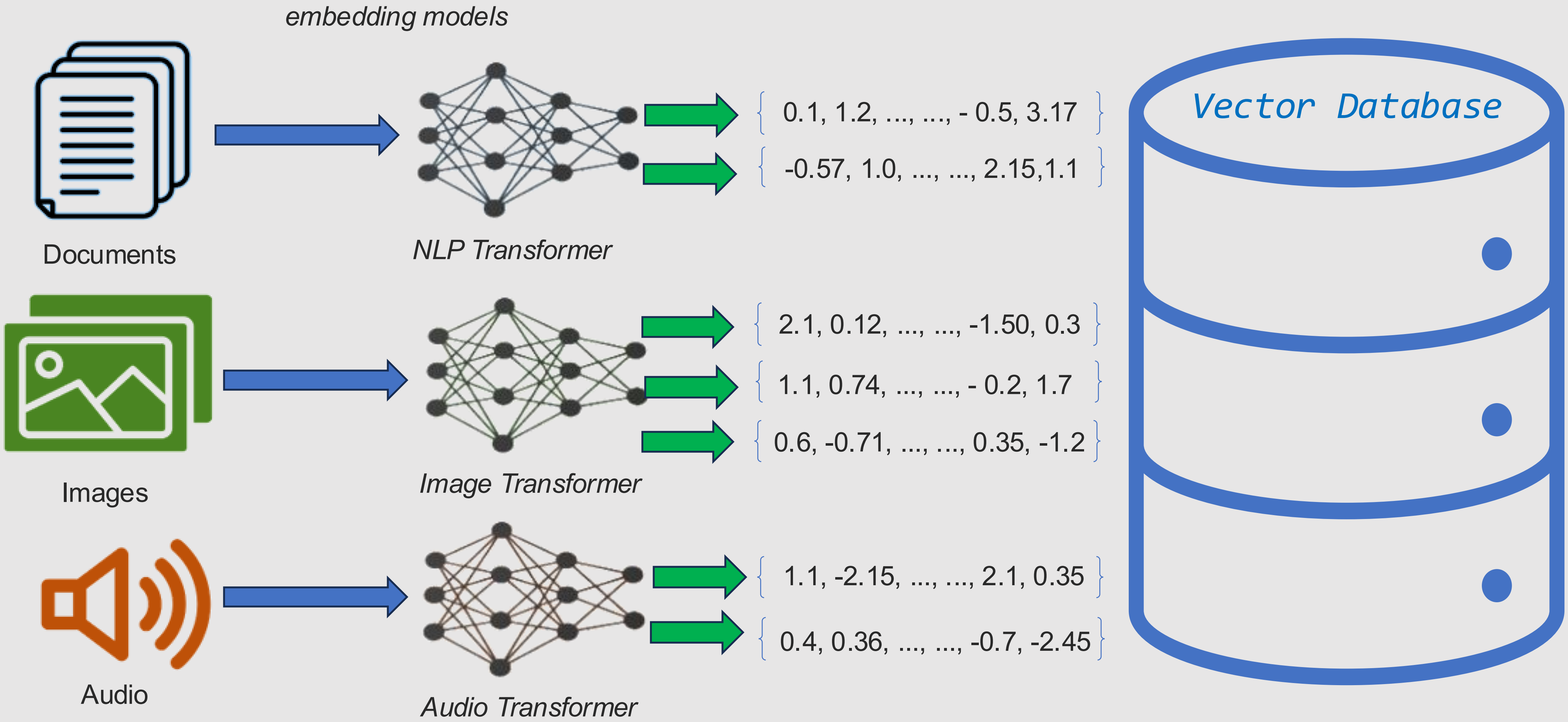
- Specialized database that index and stores *vector embeddings*
- Useful for
  - fast retrieval
  - similarity search
- Offer comprehensive data management capabilities
  - metadata storage
  - filtering
  - dynamic querying based on associate metadata

Vector Database

- Scalable and can handle large volumes of vector data
- Support real-time updates
- Play key role in AI and ML applications

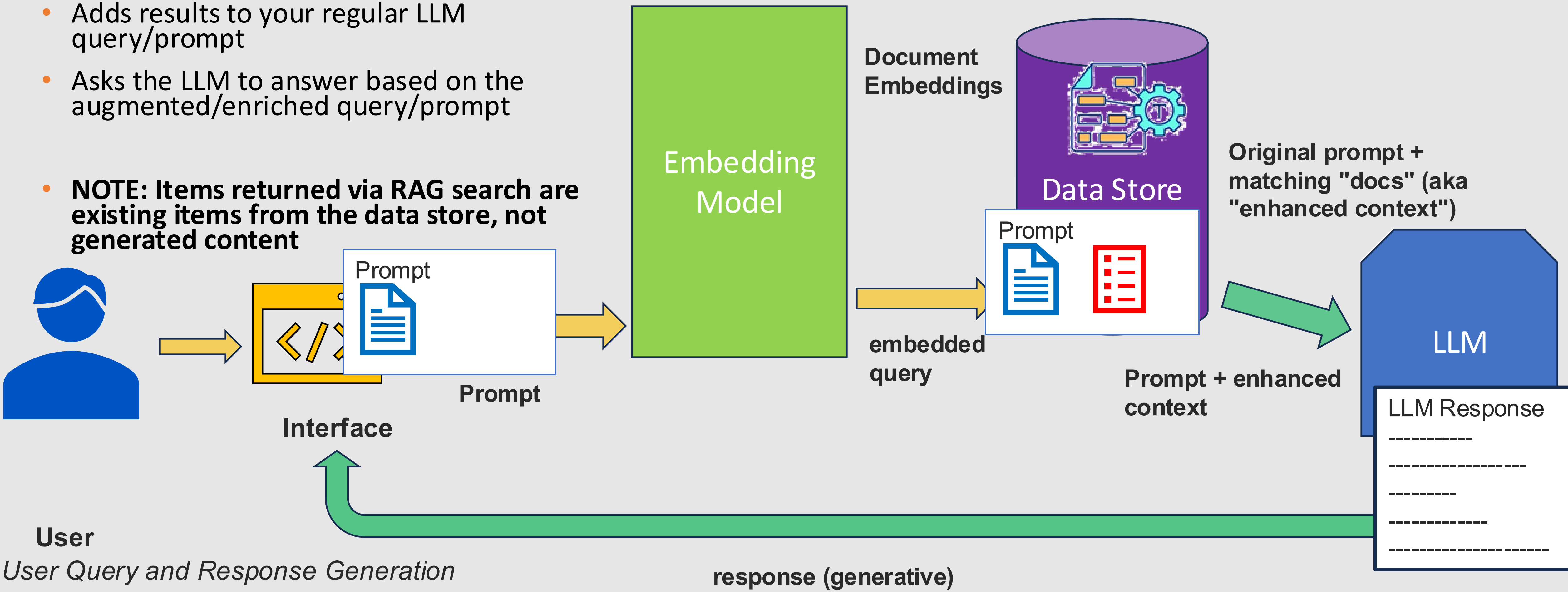
How data gets into Vector Databases

- Data is input, converted to embeddings (vectors) and stored
- Queries are input, converted to embeddings (vectors) and then **similarity metrics** are used to find results ("nearest neighbors")



How does RAG work?

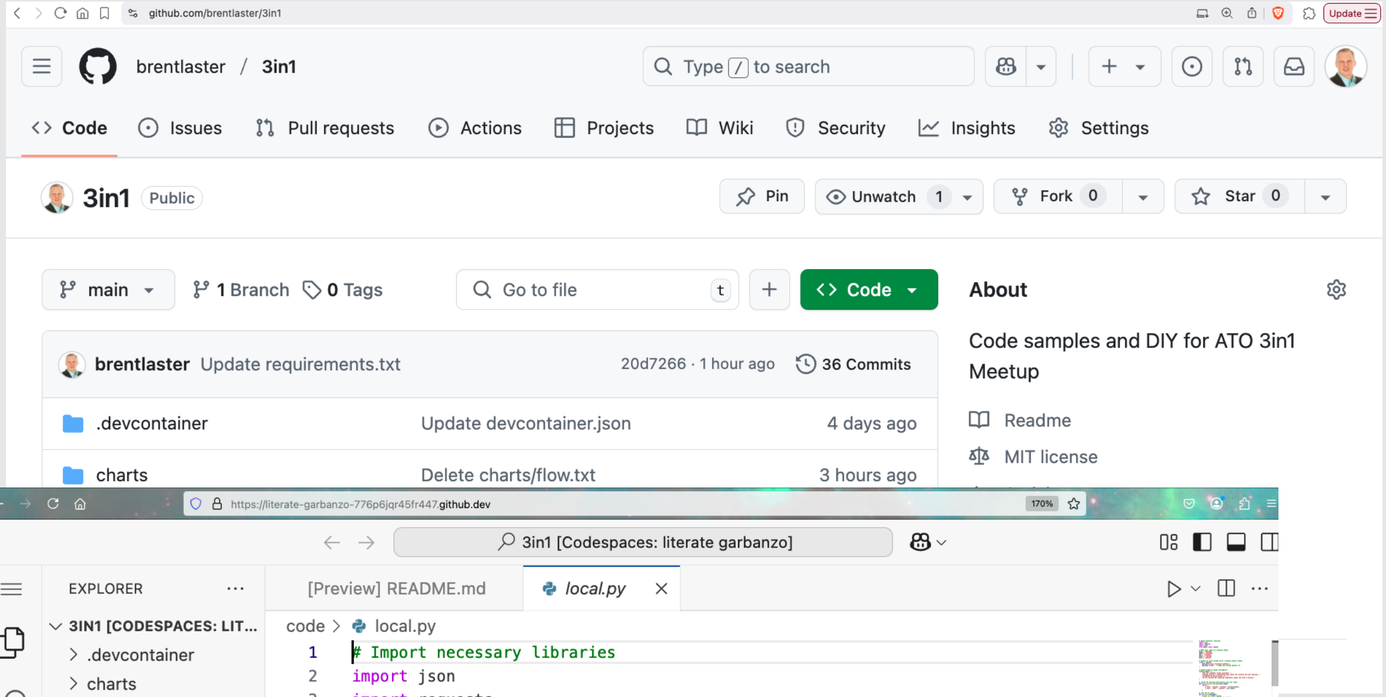
- For queries/prompts, application gathers results (most relevant ones) from the vector database with your data
- Adds results to your regular LLM query/prompt
- Asks the LLM to answer based on the augmented/enriched query/prompt
- **NOTE: Items returned via RAG search are existing items from the data store, not generated content**

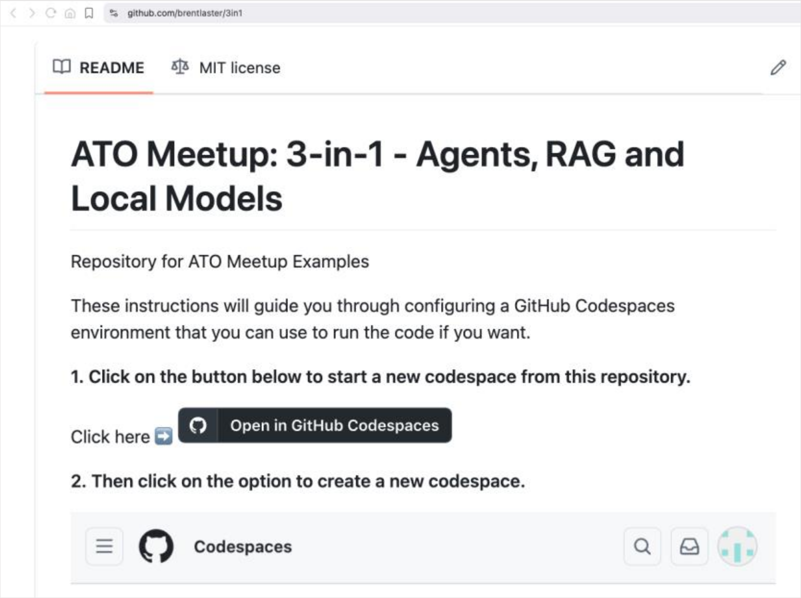


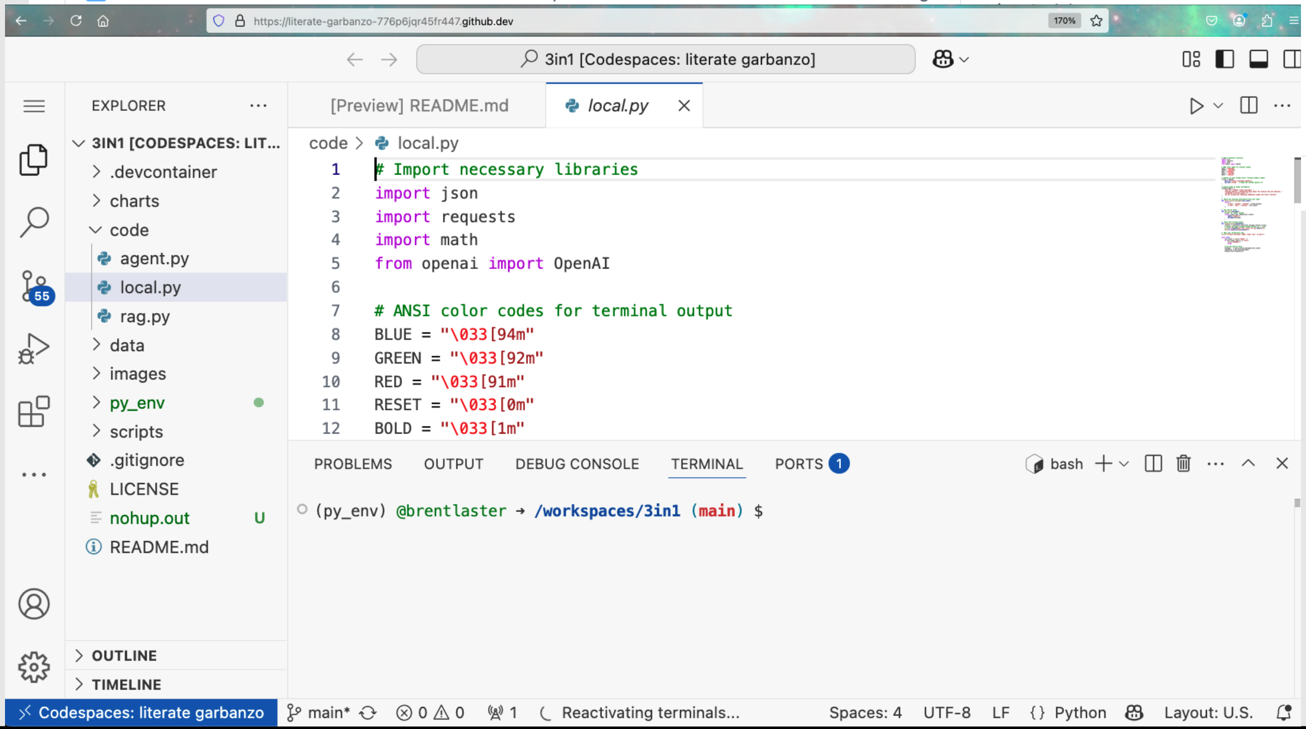
Demo #3 – Adding RAG to our code

DIY – github.com/brentlaster/3in1

- Fork if desired
- Click on button in README to start codespace
- Follow guide.md



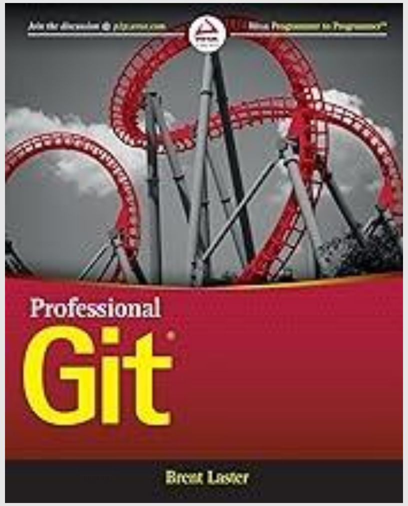


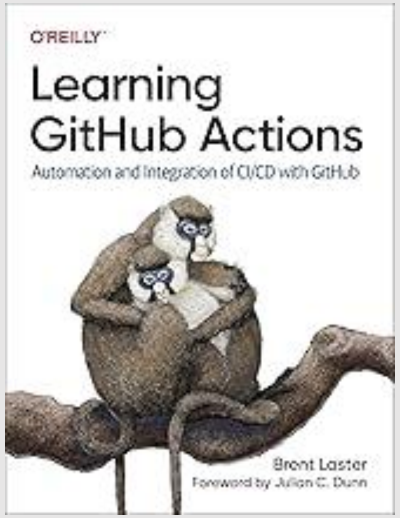


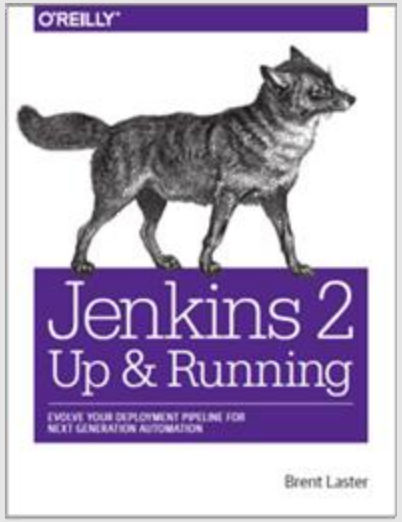
That’s all - thanks!

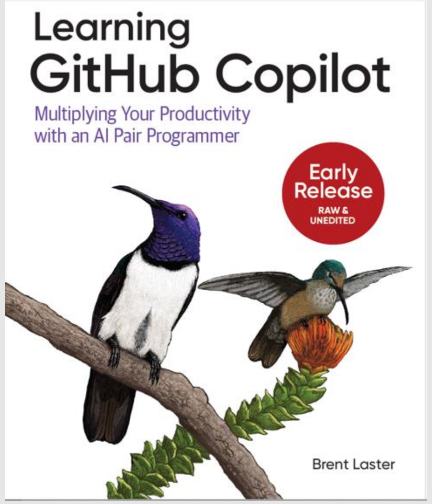
Contact: training@getskillsnow.com

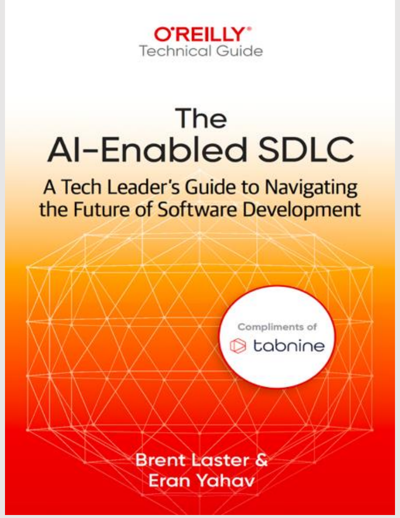
techskillstransformations.com
getskillsnow.com

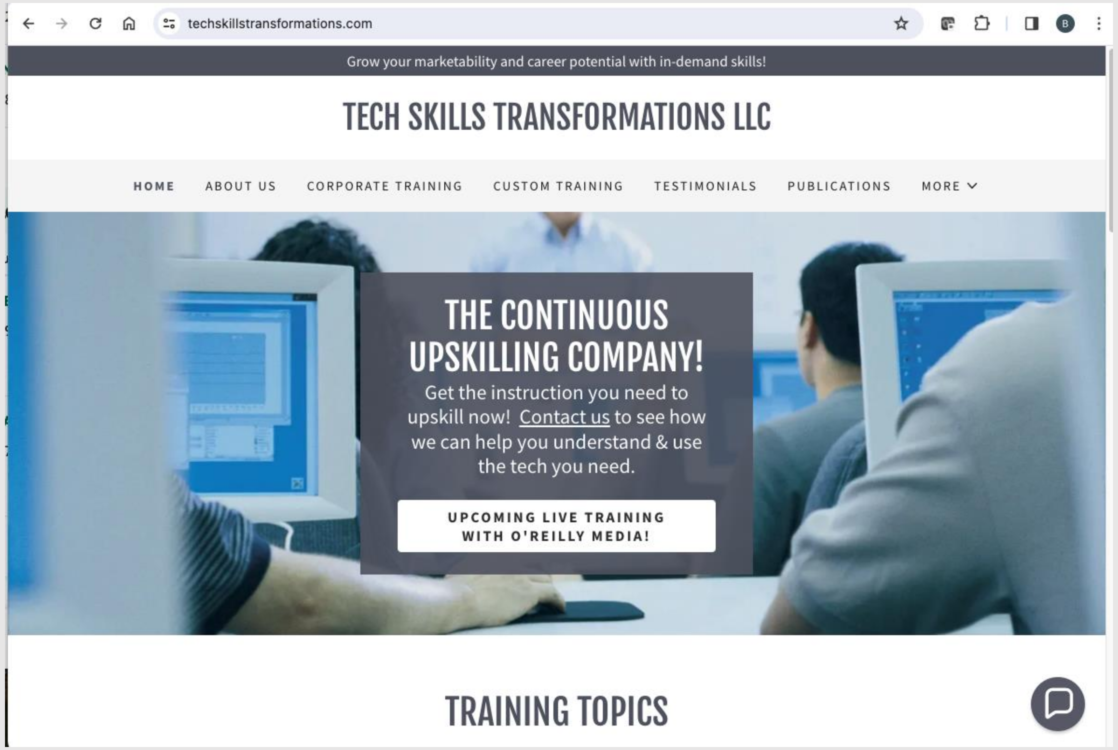












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- **X: @BrentCLaster**
- **Bluesky: brentclaster.bsky.social**
- **GitHub: brentlaster**