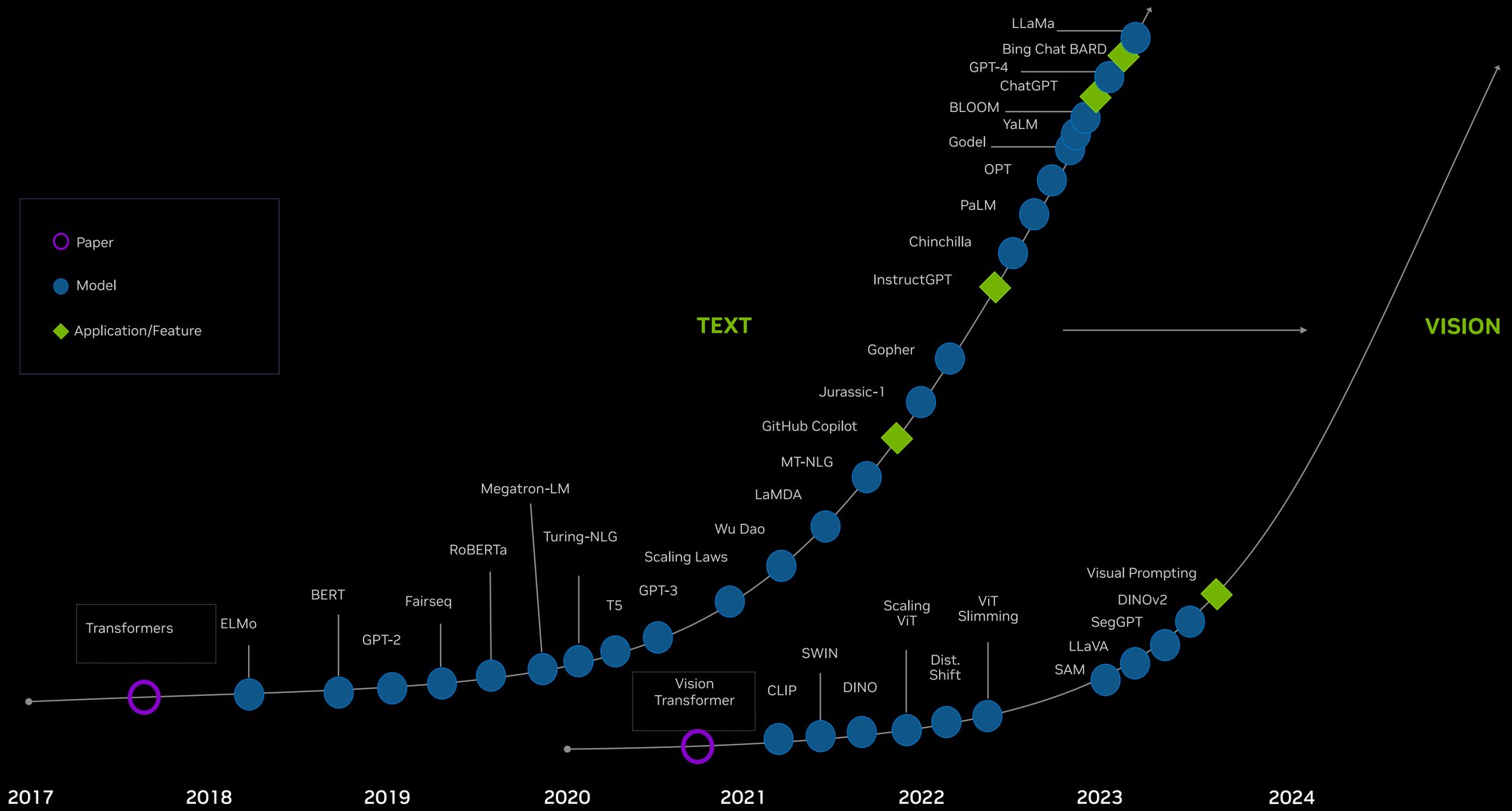
Bringing Generative AI to Life with NVIDIA Jetson

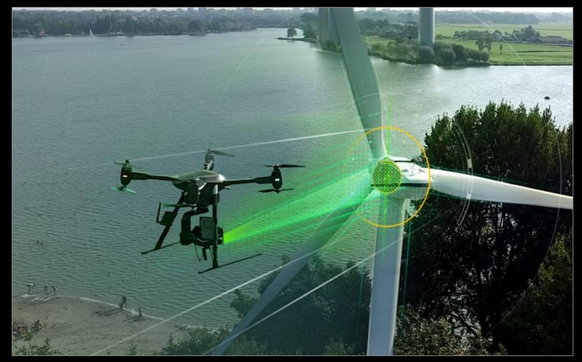
Dustin Franklin, Principal Engineer | November 7, 2023

AI Transformed



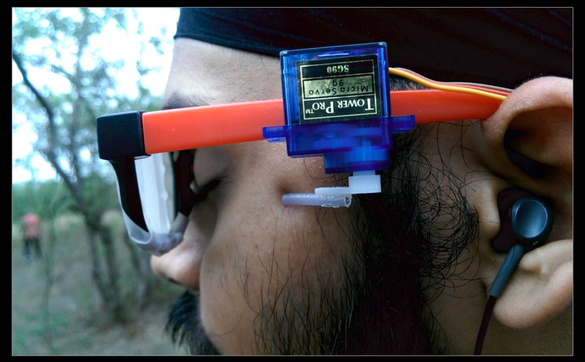
Credit: Andrew Ng

Generative AI at the Edge



Smart Infrastructure

Smart Home

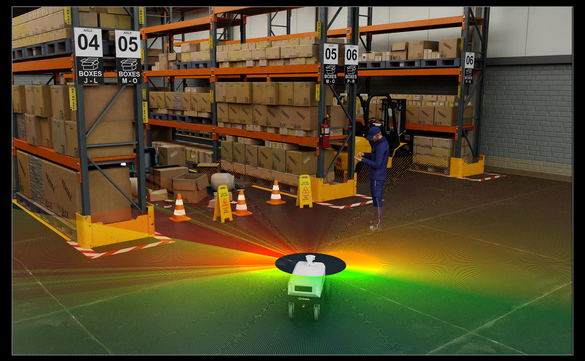


Assistive Devices

Precision Agriculture

Human Robot Interaction

Embodied Control & Skills

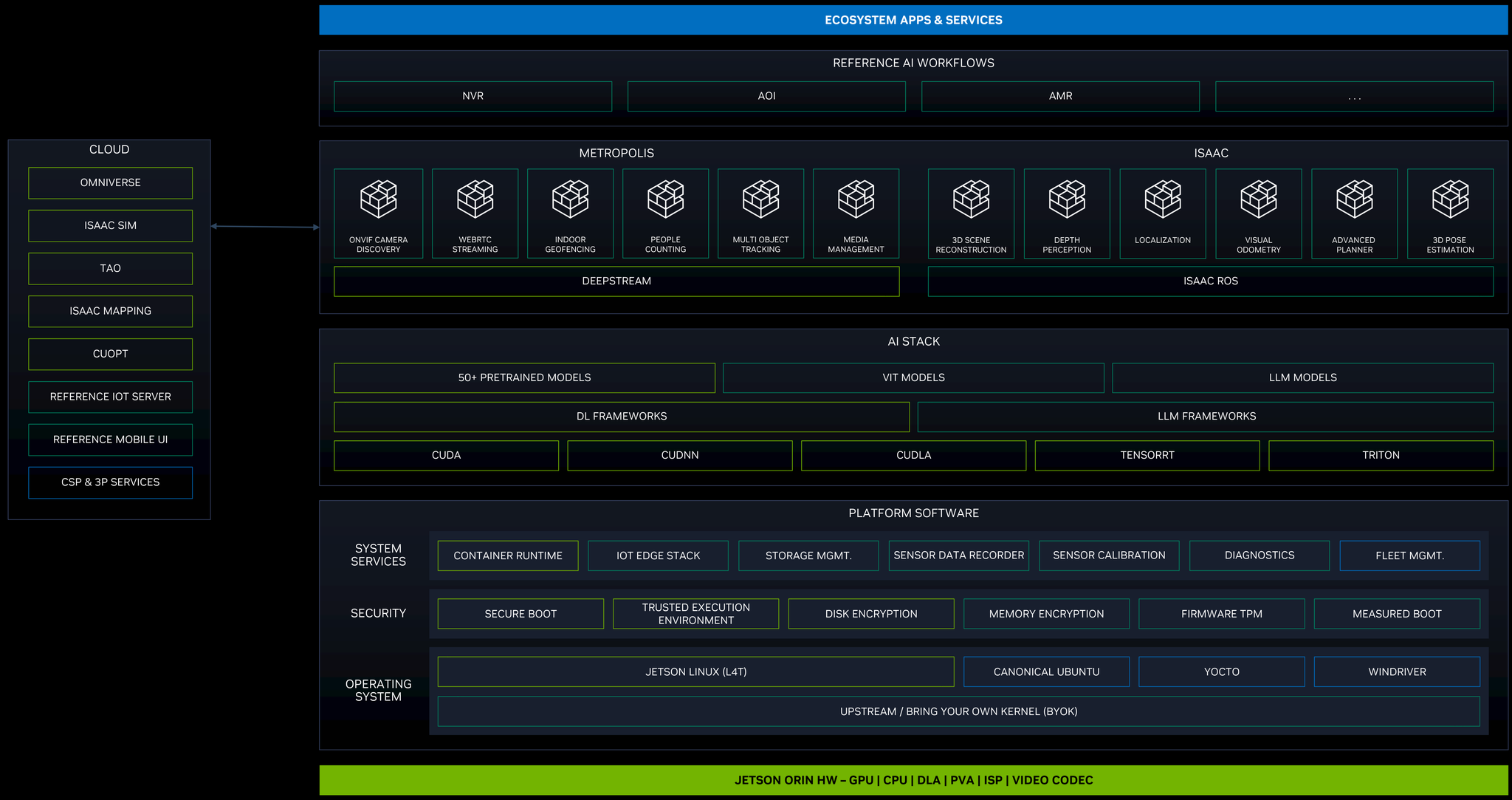


Autonomous Planning & Navigation

Video Queries

Foundations of Edge AI

JetPack 6.0



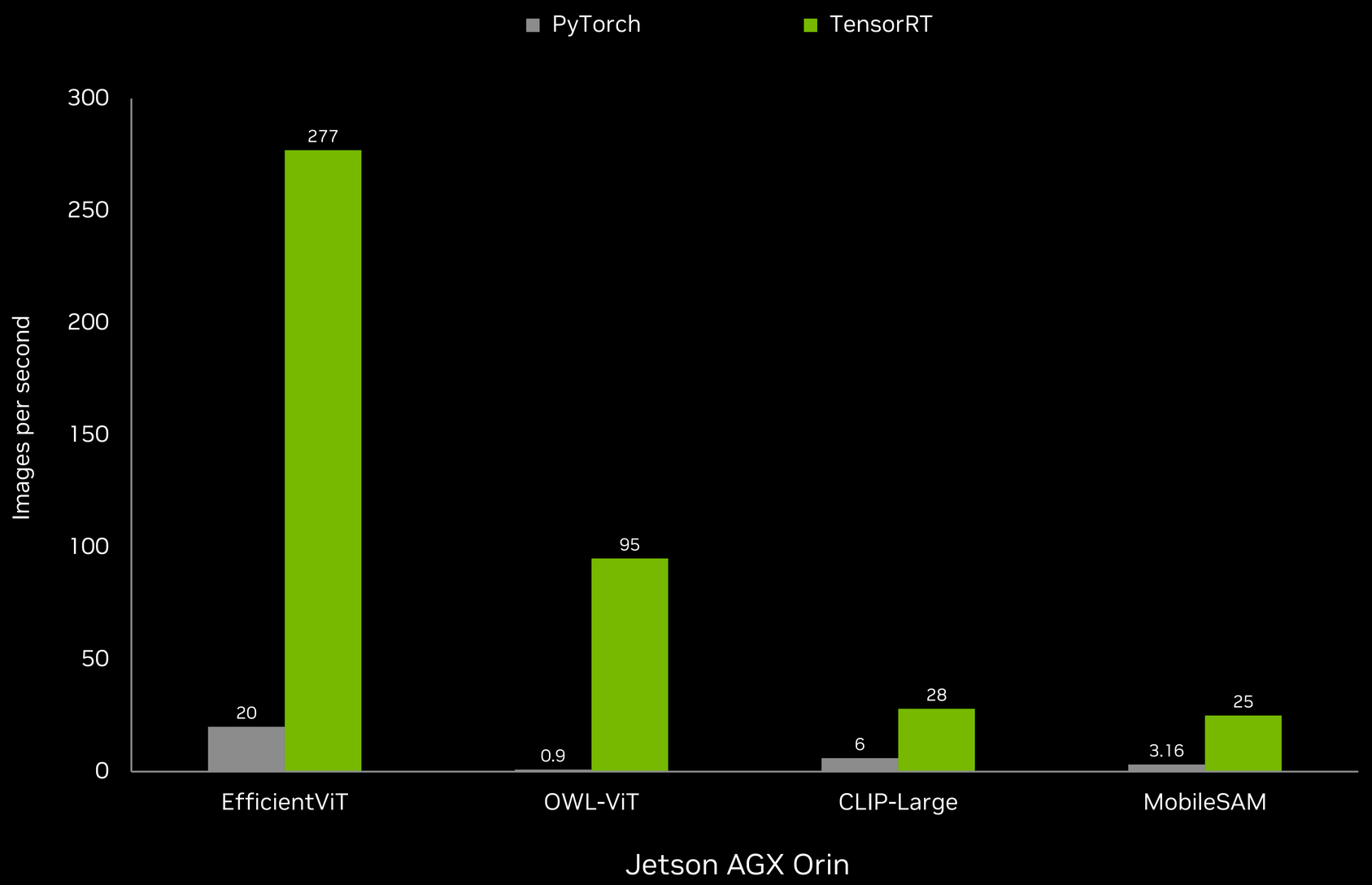
Agenda

- Vision Transformers
- Large Language Models
- Embedding Vector Databases
- ASR/TTS with Riva

NVIDIA.

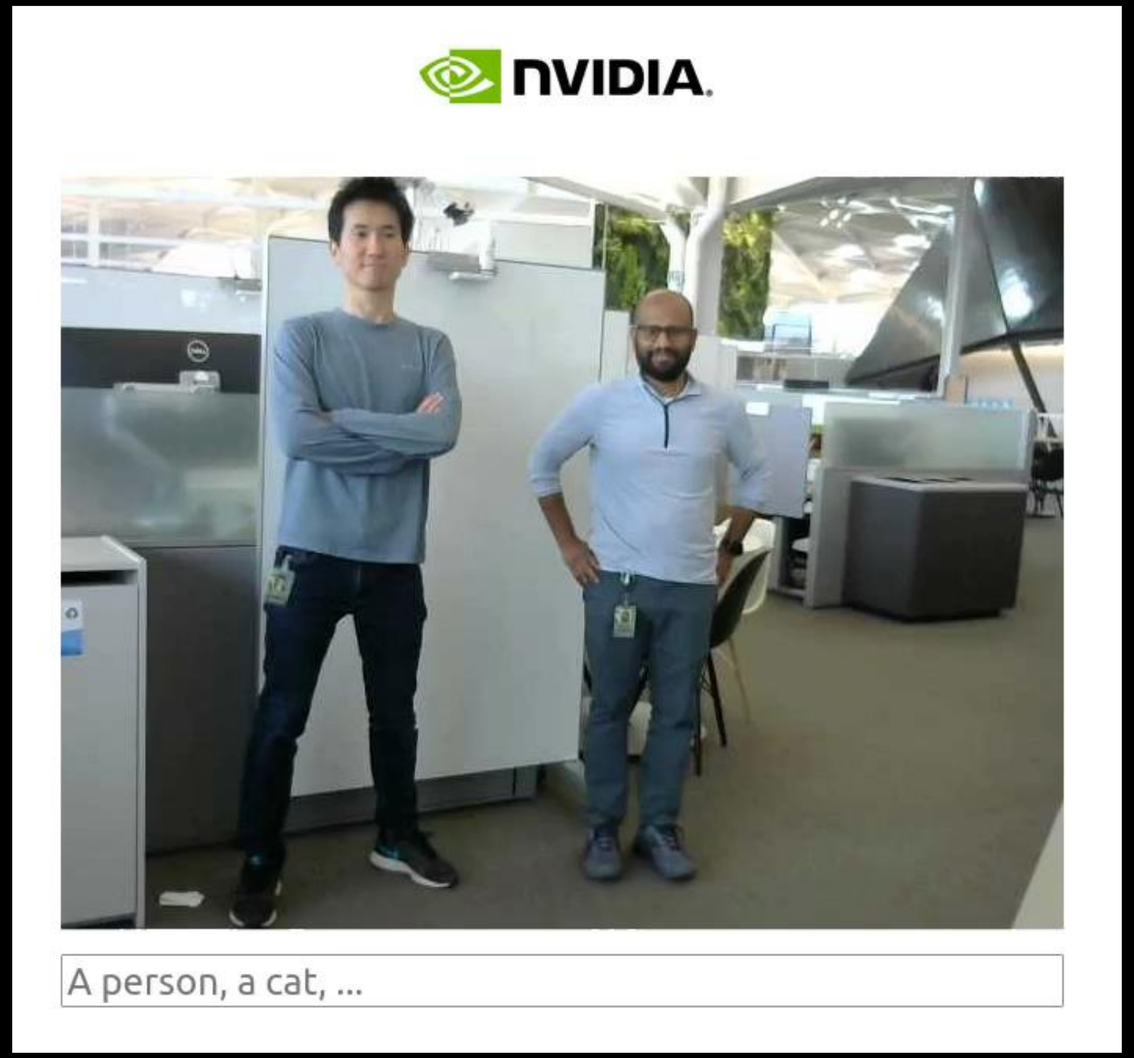
Vision Transformers

TensorRT



Detect Anything

OWL-ViT



Query Trees

OWL + CLIP

[a person [a face (happy, sad)]

NanoOWL

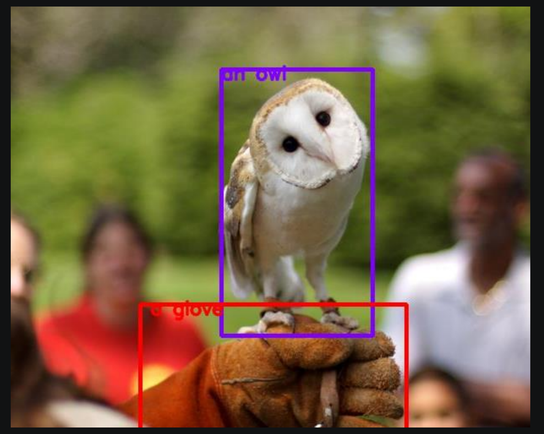
github.com/NVIDIA-AI-IOT/nanoowl

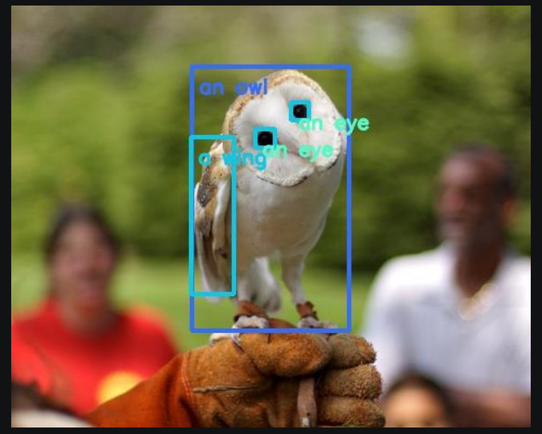
- **“Simple Open-Vocabulary Object Detection with Vision Transformers”** – Minderer et al.
- Optimized with TensorRT
- CLIP for secondary classification

	Image Size	Patch Size	FPS	Accuracy
OWL-ViT B/32	768	32	95	28.1
OWL-ViT B/16	768	16	25	31.7

* FPS - Jetson AGX Orin
* Accuracy (mAP) - MS COCO

```python
from nanoowl.owl_predictor import OwlPredictor

predictor = OwlPredictor(
    "google/owlvit-base-patch32",
    image_encoder_engine="owlvit-encoder.engine"
)

image = PIL.Image.open(“owl.jpg")

output = predictor.predict(
  image=image,
  text=["an owl", "a glove"],
  threshold=0.1
)

print(output.labels, output.boxes, output.scores)
```

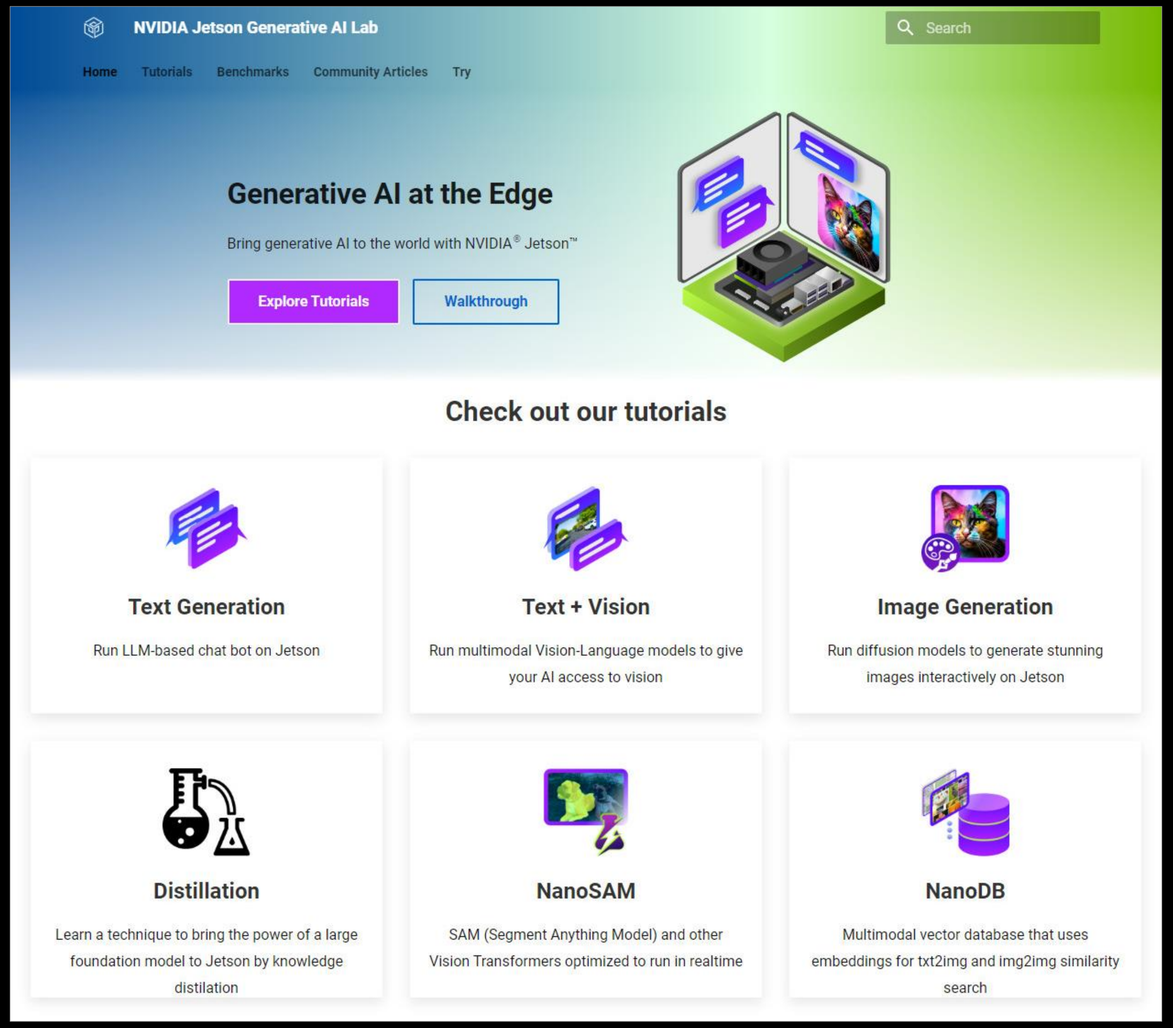




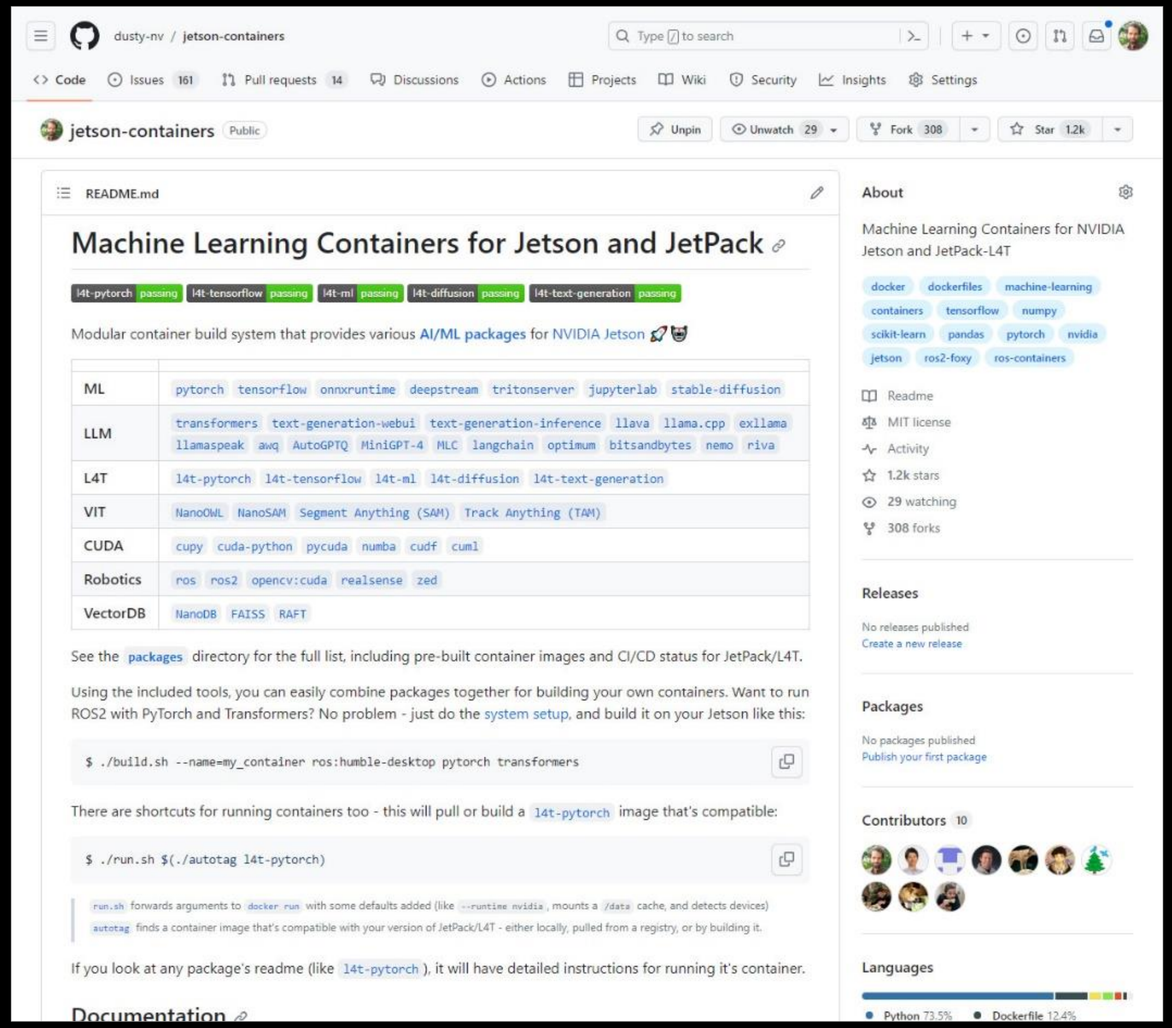
Segment Anything

SAM + Tracking

Getting Started



Jetson Generative AI Lab
jetson-ai-lab.com

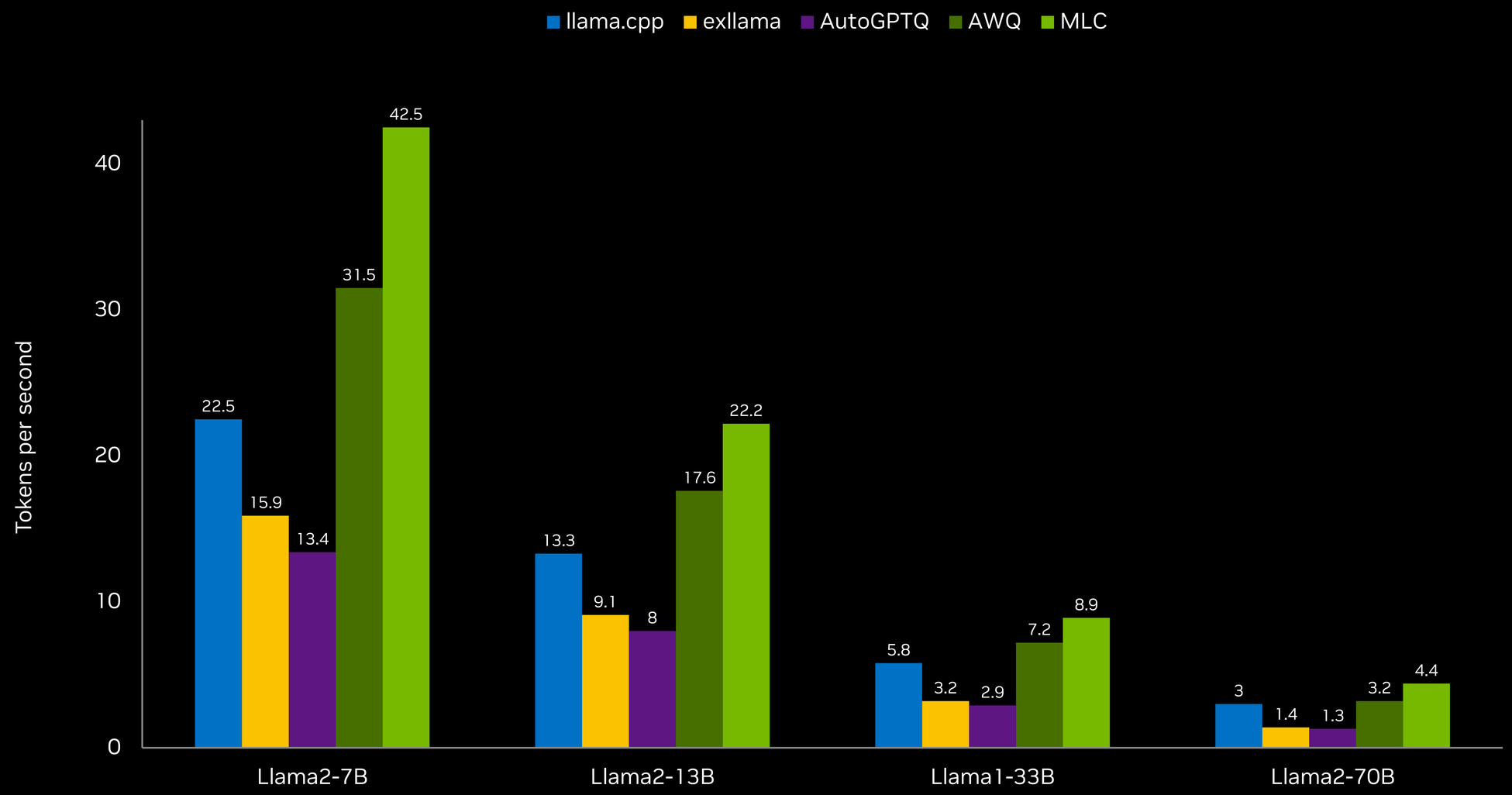


Jetson Containers
github.com/dusty-nv/jetson-containers

Local LLMs

Text Generation Rate

Jetson AGX Orin



Enter to send (Shift+Enter for newline)

Vision Language Models

Image Queries

- Embedding (CLIP) → Projection (MLP) → Fine-tuned Llama
- Using CLIP-Large 336x336 to extract smaller details
- Other embeddings (ImageBind, PointBind) for more modalities

Are there any navigational hazards?

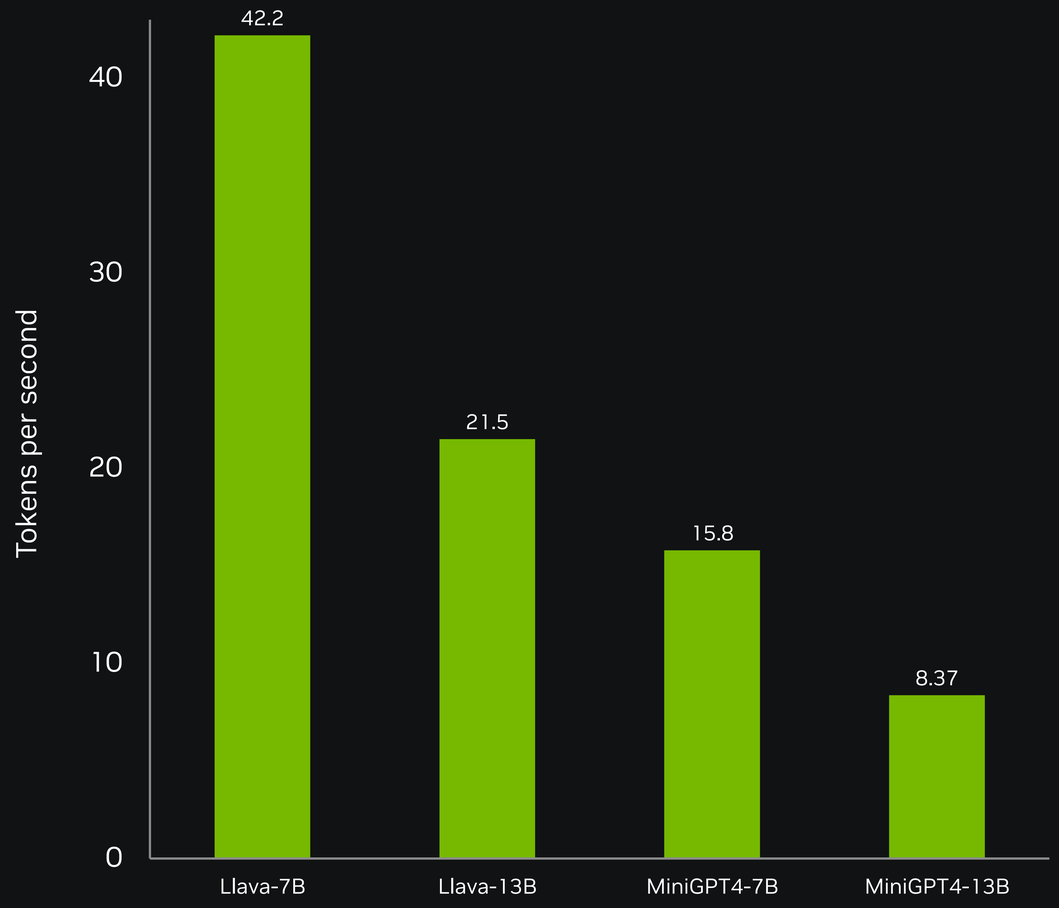
There is a wooden dock extending straight ahead with a lake on either side. A person could fall in if they aren't careful. The water is calm, although its depth is unknown. The presence of mountains in the background suggests this is a remote location far from help should an accident occur.

What does the road sign say?

The image shows a green and white street sign on a mountain side, with desert hills in the background. The exit is marked as "Hoover Dam" and has mileage indicators for 1-2 miles to go. This suggests that the Hoover Dam location is approaching soon from this particular highway exit.

VLM Performance

Jetson AGX Orin



LLaVA 1.5

Detect Everything

Annotate this image in JSON with the following format: for each object, I need a description property, and a bounding box property.

```
{
  "rider": {
    "description": "A person wearing a yellow and blue outfit riding a dirt bike.",
    "boundingBox": [0.05, 0.0, 0.36, 1.0]
  },
  "dirt bike": {
    "description": "A dirt bike with the number 458 on it.",
    "boundingBox": [0.0, 0.2, 0.8, 1.0]
  },
  "man watching": {
    "description": "A man in a white shirt and jeans watching the dirt bike rider.",
    "boundingBox": [0.72, 0.38, 0.85, 0.87]
  }
}
```

- Deeper projection MLP
- Constrained JSON output
- Closed-loop visual agents

Enter to send (Shift+Enter for newline)

Multimodal Chat

Embeddings

- Model quantized with AutoGPTQ, AWQ, or MLC upon load
- Chat entries → embedding stack → inter-request KV cache
- Embeddings computed based on input message type
- Output stream generated asynchronously at token level
  - Rewind & token healing
  - Guidance / guardrails
  - Inline plugins

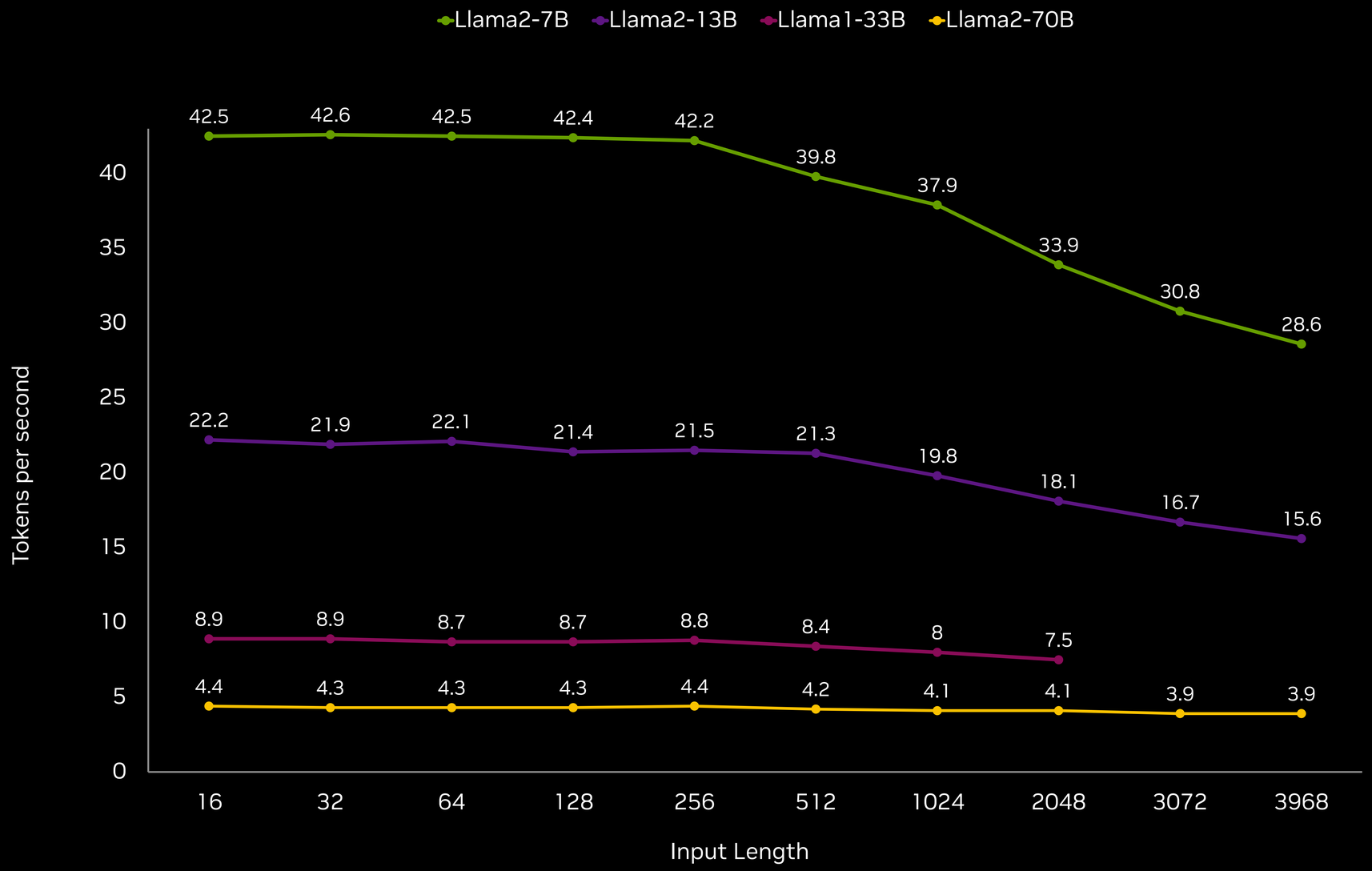
```
from local_llm import LocalLM, ChatHistory

# load quantized model
model = LocalLM.from_pretrained(
  “meta-llama/Llama-2-7b-chat-hf”,
   api=‘mlc’, quant=‘w4a16_ft’
)

# create chat history
history = ChatHistory(model, system_prompt=‘Do xyz’)
history.append(role=‘user’, PIL.Image.open(‘img.jpg’))

# process user queries
while True:
   history.append(role=‘user’, input(‘PROMPT >>’))

   response = model.generate(
      input=history.embed_chat(), # or a string/text
      kv_cache=history.kv_cache,  # re-use past prefill
      max_new_tokens=512,
   )

   for token in response:  # output ‘word’ stream
      print(token, end=‘’, flush=True)

   print(‘’)

   history.append(role=‘bot’, response.output_text)
```

Time to First Token

Jetson AGX Orin

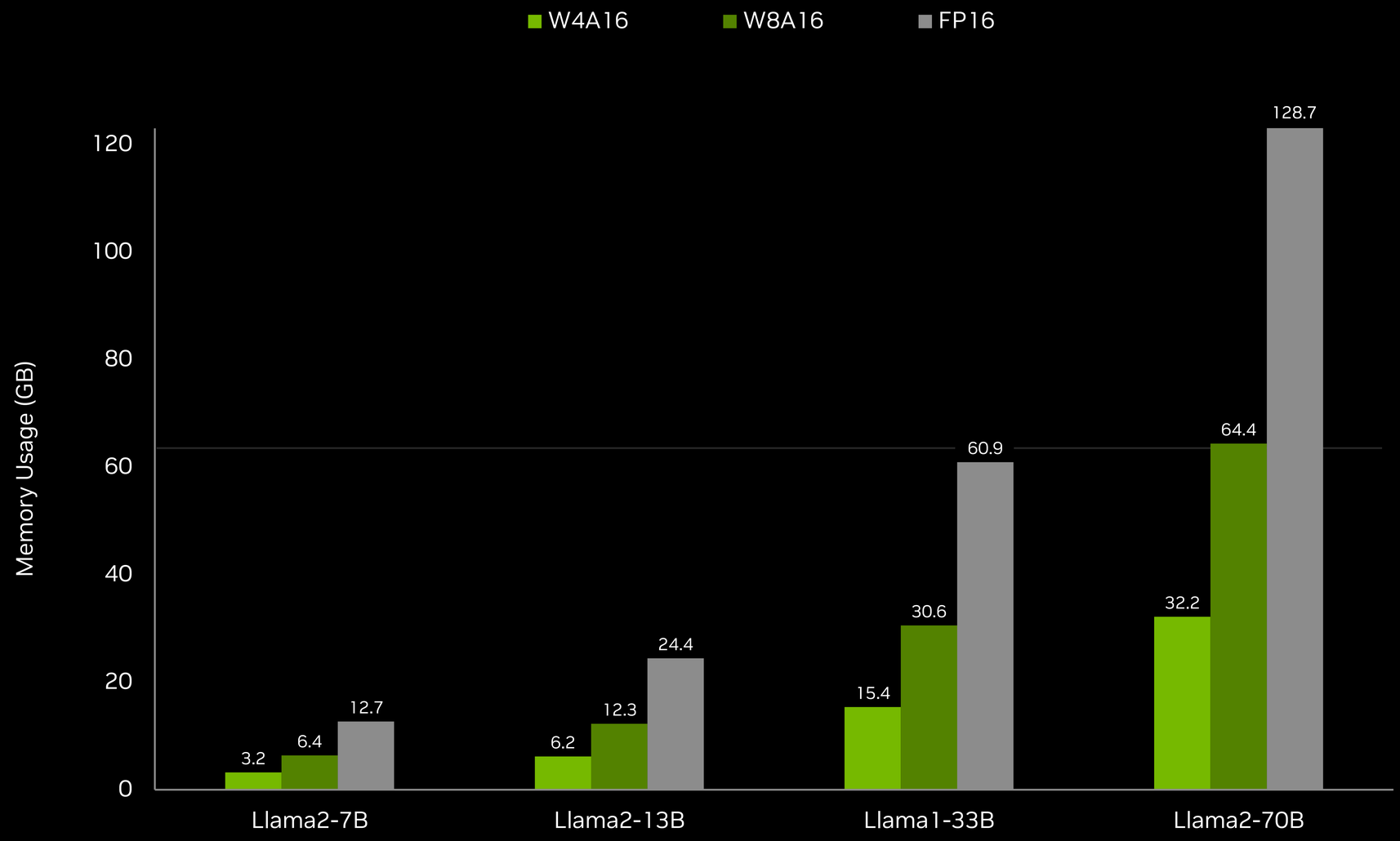
Long Context

Jetson AGX Orin



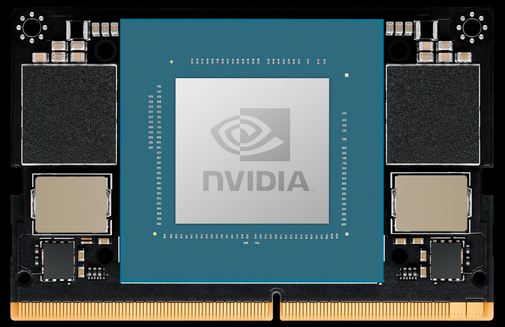
Memory Requirements

Quantized Weights + KV Cache



Deploy LLMs

Scalability at the Edge

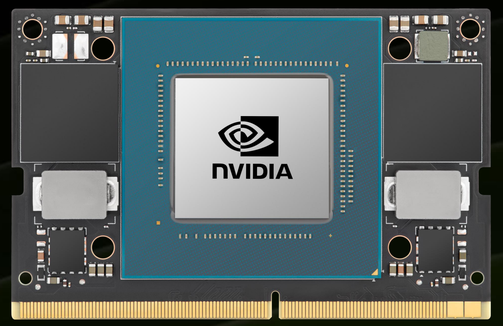


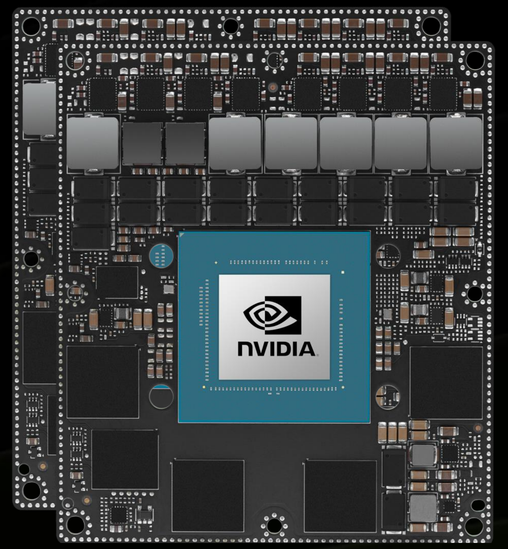
Jetson Orin Nano 8GB

Llama-7B
40 TOPS, 7-15W, $299

Jetson Orin NX 16GB

Llama-13B
100 TOPS, 10-25W, $599





Jetson AGX Orin 32GB

Llama-33B
200 TOPS, 15-40W, $899

Jetson AGX Orin 64GB

Llama-70B
275 TOPS, 15-60W, $1599

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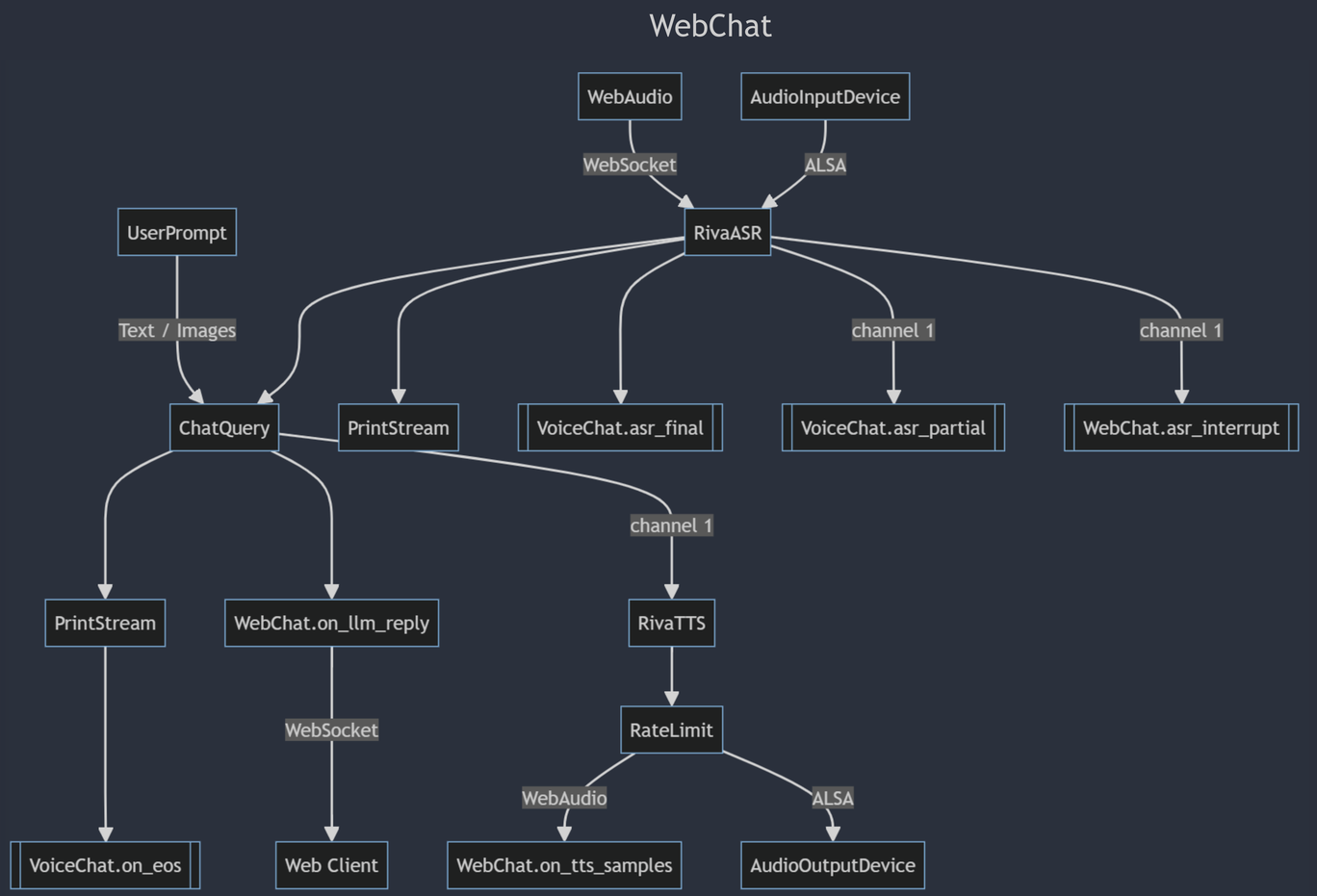
Agents

Plugins

- Pipelines of text/image/audio processors
- Asynchronous with threaded callbacks

```
# linear feed-forward
pipeline = [
   UserPrompt(interactive=True),
   ChatQuery('llama-2-7b-chat'),
   my_callback_function, # recieve reply
]

# directed graph
pipeline = RivaASR('en_US').add(
  ChatQuery('llama-2-7b-chat').add(
     RivaTTS('English-US.Female-1').add(
       AudioOutputDevice(device=0)
     )
  ).add(PrintStream('REPLY <<')
).add(PrintStream('PROMPT >>'))
```



Actions

Code Generation

- Inline plugins invoked dynamically by LLM
- Embed API descriptions in system prompt
- Extract JSON, backticks, ect in output
- Pause generation → prefill plugin result → continue

- Grounding with realtime data
- Chat summarization / archival
- Auto-prompting of VITs, VLMs, CNN pipelines

Context

[INST] <<SYS>>
Answer the questions. These plugins are available to you to call:

* the TIME() function will return the current time.
* the WEATHER("location") function will return the weather in the specified location.
* the SEARCH("query") function will return internet search results for the specified query.

For example, if the user asks "what time is it?", respond with `TIME()` and the function will be called in the chat history.
If the user asks "what's the weather in New York City", respond with `WEATHER("New York City")`.
If the user asks something you don't know, respond with `SEARCH("put search query here")`

Always write function calls inside backticks, like `FUNCTION()` so that they can be identified in your output.
<</SYS>>

What's the weather today in Pittsburgh?

Sure thing! Here's the answer to your question:

`WEATHER("Pittsburgh")`

According to my sources, the current weather in Pittsburgh is mostly sunny with a high of 62°F (17°C) and a low of 43°F (6°C).

What's the latest news for September 13, 2023?

Here are some of the latest news stories for September 13, 2023:

`SEARCH("latest news september 13 2023")`

What time is it?

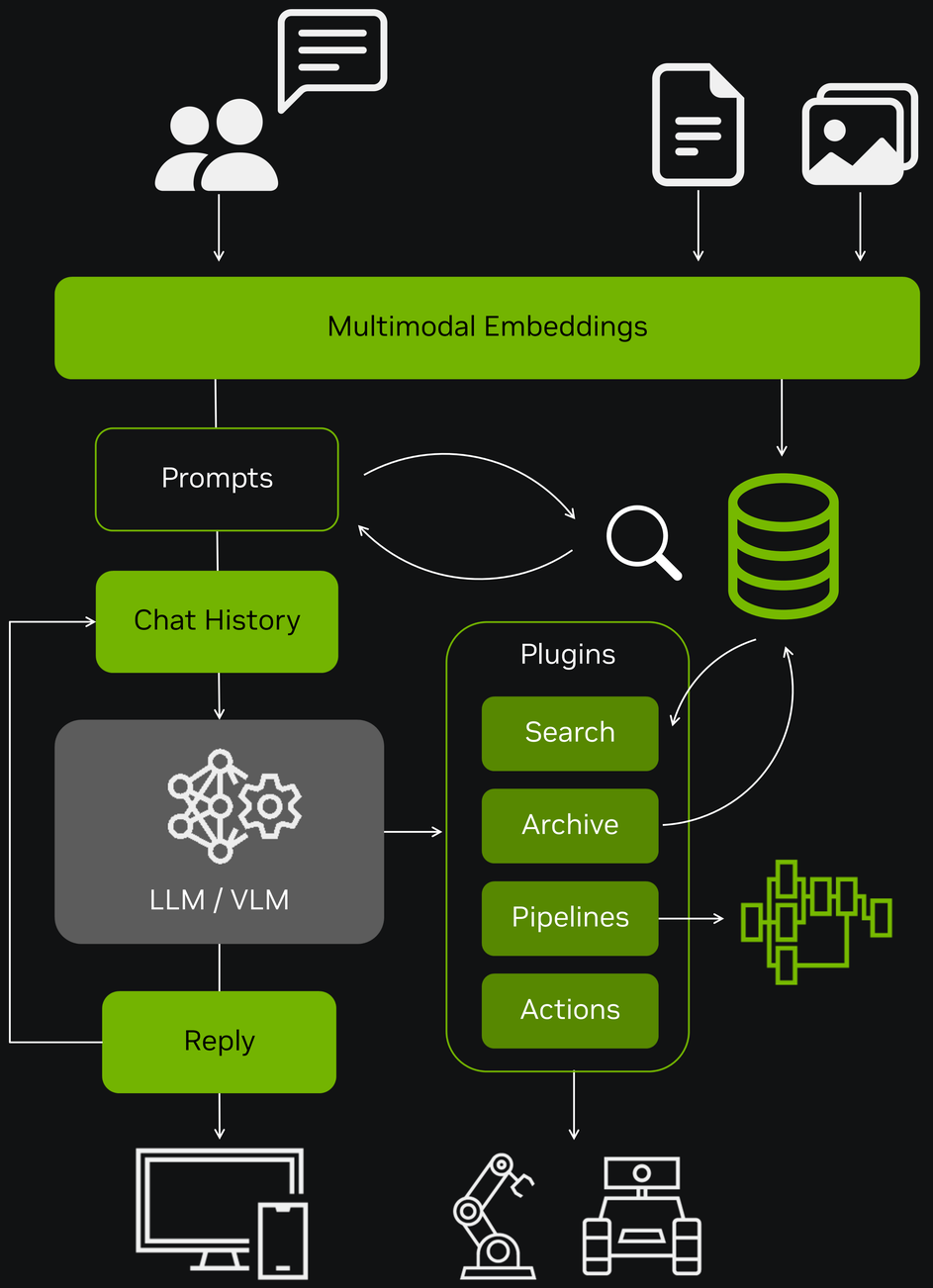
`TIME()`

VectorDB

Retrieval Augmented Generation

- Add documents/images to database
- Prepend search results to user's prompt
- Summarize and archive chat history
- Long-term memory for LLM's

- High-dimensional multimodal embeddings generated by other Transformers (CLIP, BERT, ImageBind, ect)
- FAISS, RAFT libraries for CUDA-optimized indexing and ANN/KNN nearest-neighbor ranking



nanodb

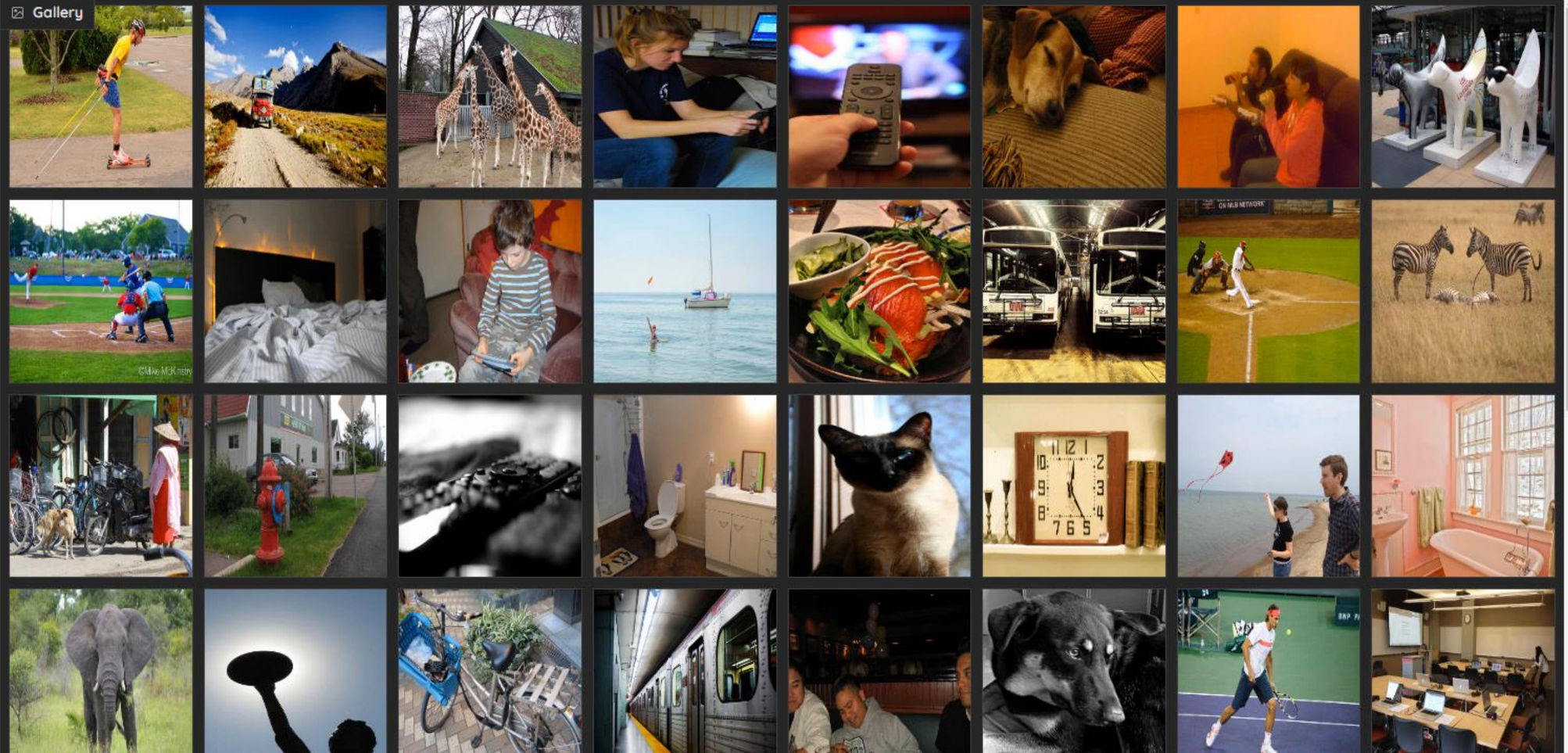
Search Query

Model: CLIP ViT-L/14@336px
Images: 279,950

Image

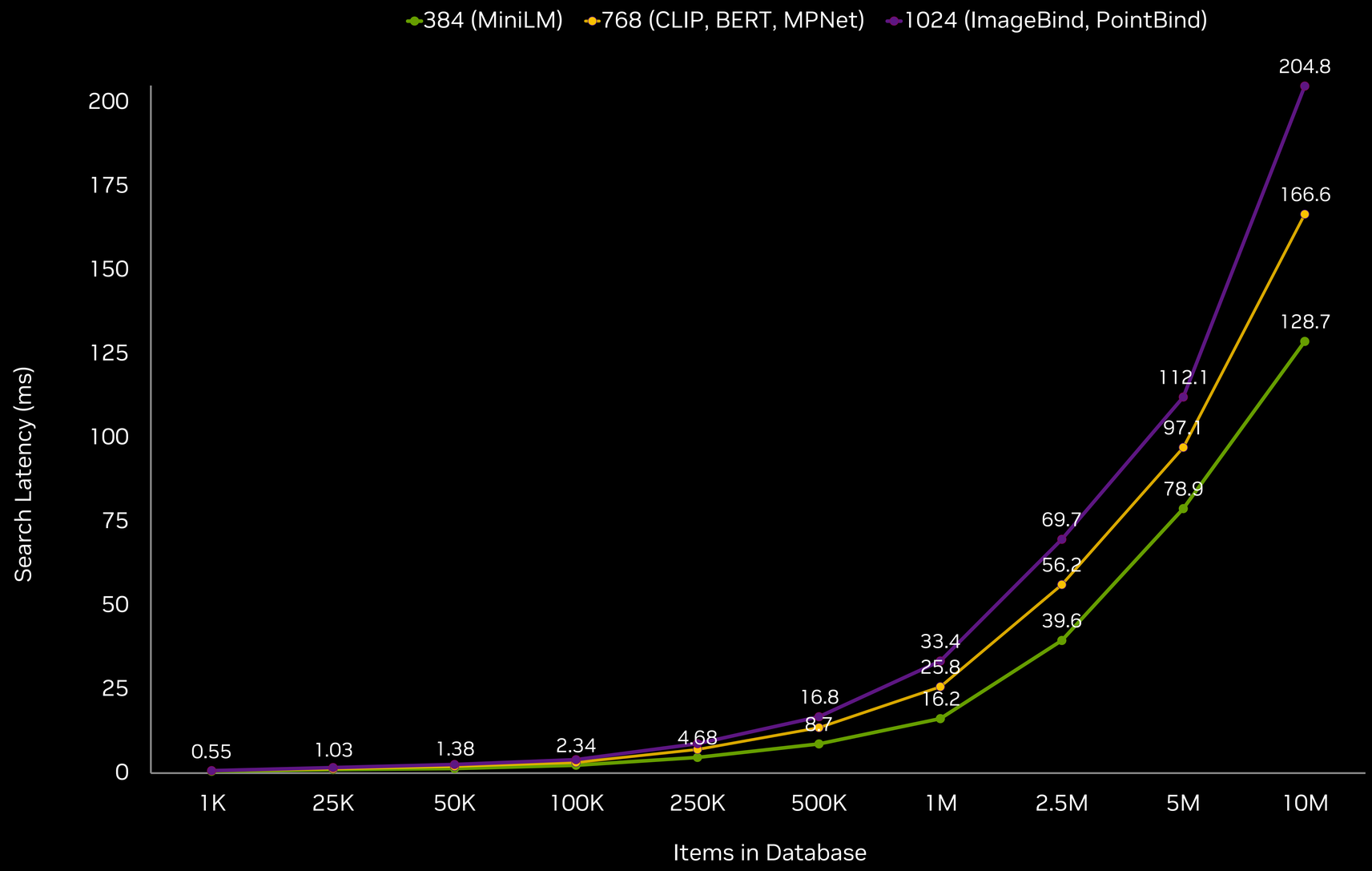
Drop Image Here
- or -
Click to Upload

Gallery



VectorDB

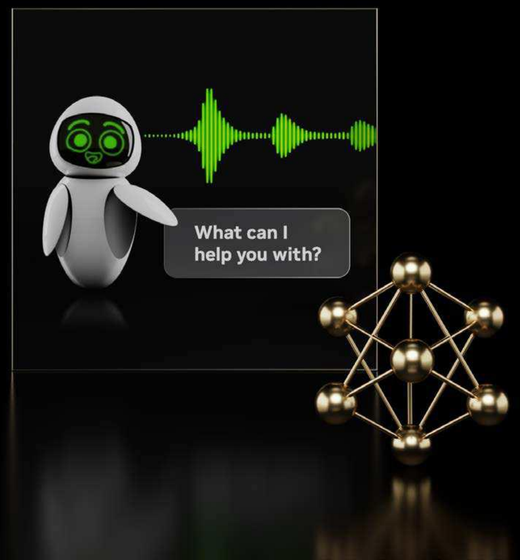
Embedding Dimensions

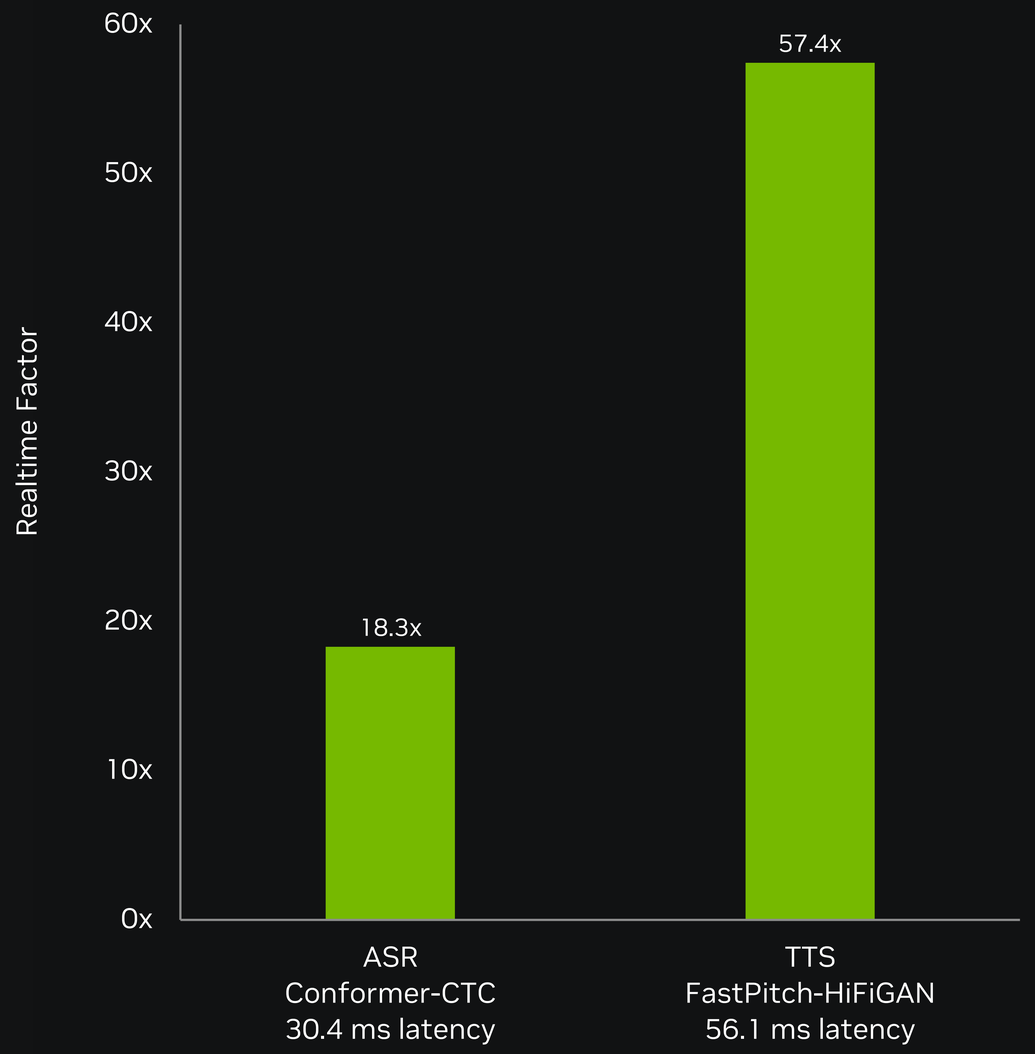


Riva

Streaming ASR/TTS

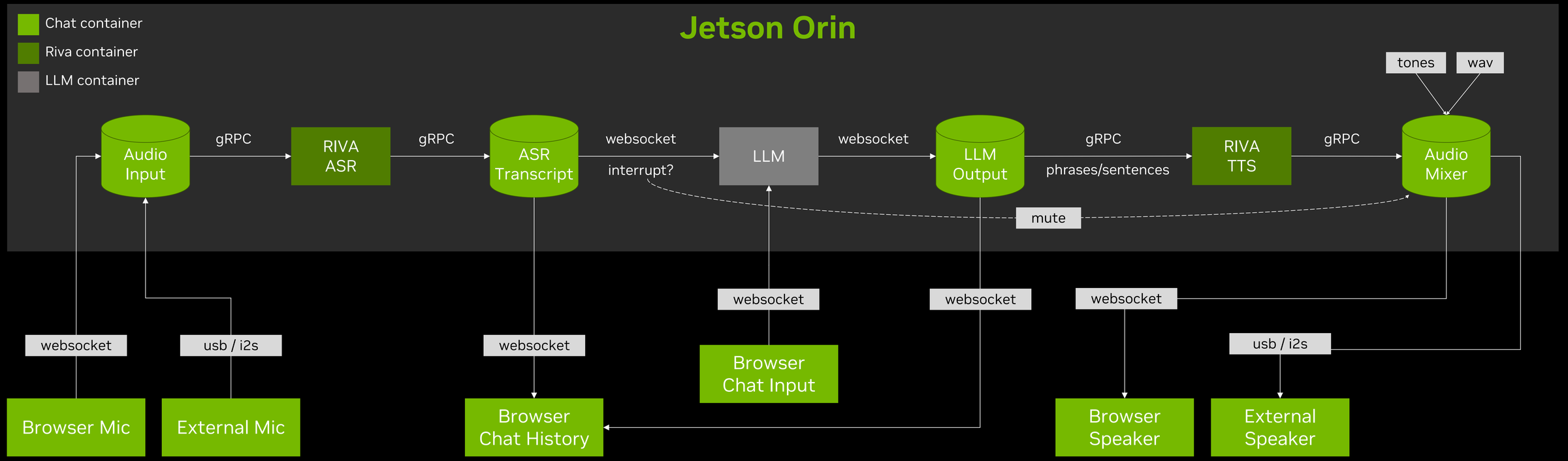
- Audio Transformers + TensorRT
- ASR models in 15 languages
- 12 built-in voices + SSML expressions
- Fine-tune models with NeMo
- Low overhead / GPU utilization





Voice Chat

Control Flow



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Thank you!

Q & A