seeed studio
the AI hardware partner

Eric Pan

2024. 5

TinyML devices enabling phyiscal GPT

About us

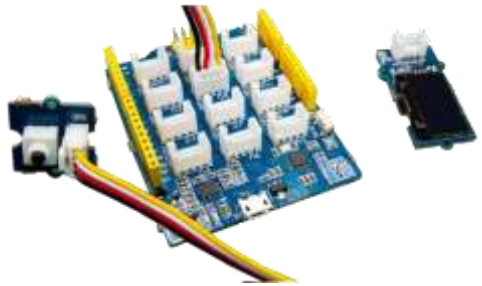
the AI hardware partner

Seeed Studio has been a leading Open Hardware company since 2008, empowering half a million direct users to create real-world digital solutions. Through relentless efforts and earned trust, our ever-growing product lines now form around emerging AI scenarios:

- Sensor networks to fetch extensive real-time data
- Edge computing to push intelligence to new frontiers

We provide industrial-ready modules and devices, and open up the capability of prototype, produce, and promote as Fusion service. Innovators from different vertical domains co-create with us to make their creations widely availalbe for diversified markets.

By embracing open source, community building and integrated software suites like SenseCraft, we are proactively lowering the tech barriers and including users with diverse expertise for glocalized matters.



From possibilities to productivities

From Technology to Industry

Technologies

- Open Source Hardware
- Machine Learning
- Advanced Sensors
- Home Assistant
- Wireless. DePIN
- LLM

Applications

- Asset Tracking
- Smart Building
- Industrial space
- Smart City
- Smart Agriculture
- Smart Energy
- Tech for good
- Open Science

Arduino

Beaglebone

Home Assistant

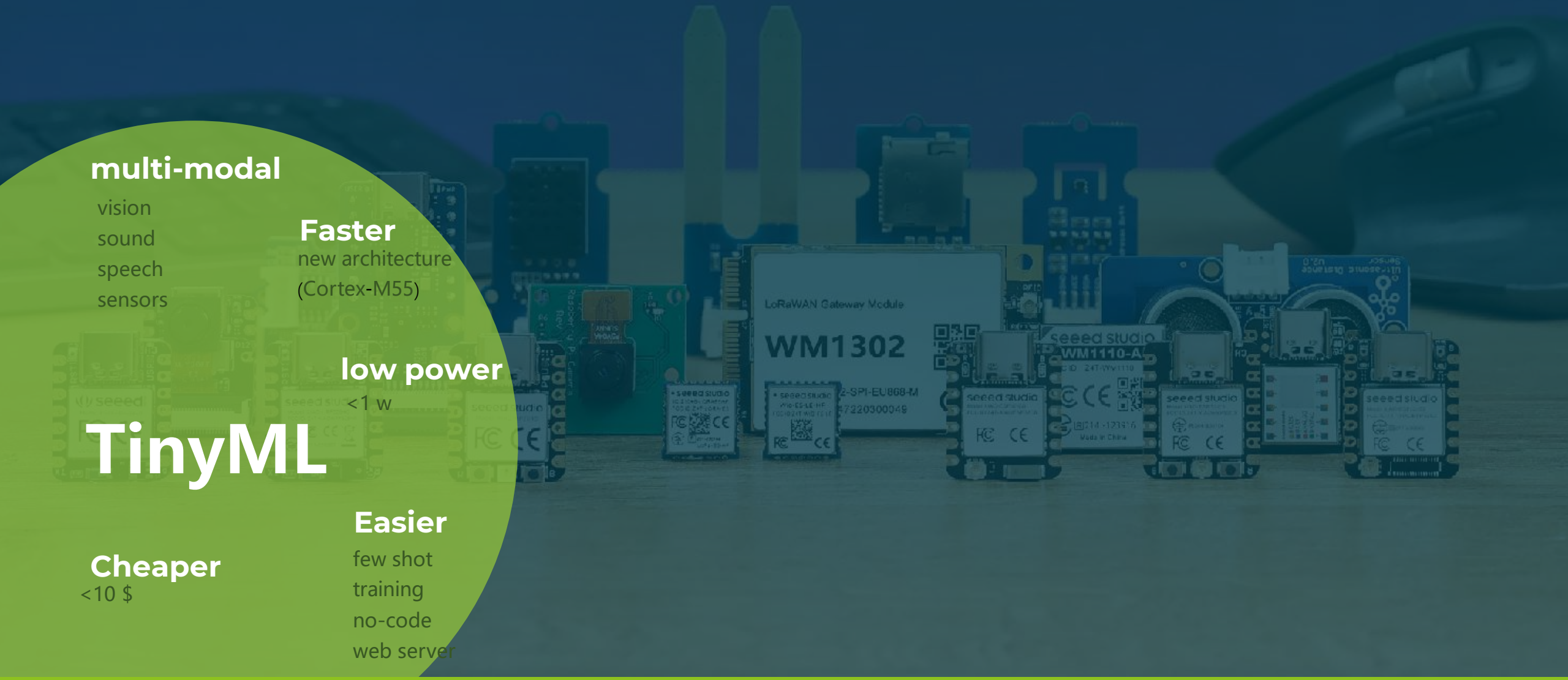
NVIDIA® Jetson

Raspberry Pi

SenseCAP

TinyML

Adding AI to almost anything



multi-modal

vision
sound
speech
sensors

Faster

new architecture
(Cortex-M55)

low power

<1 w

TinyML

Easier

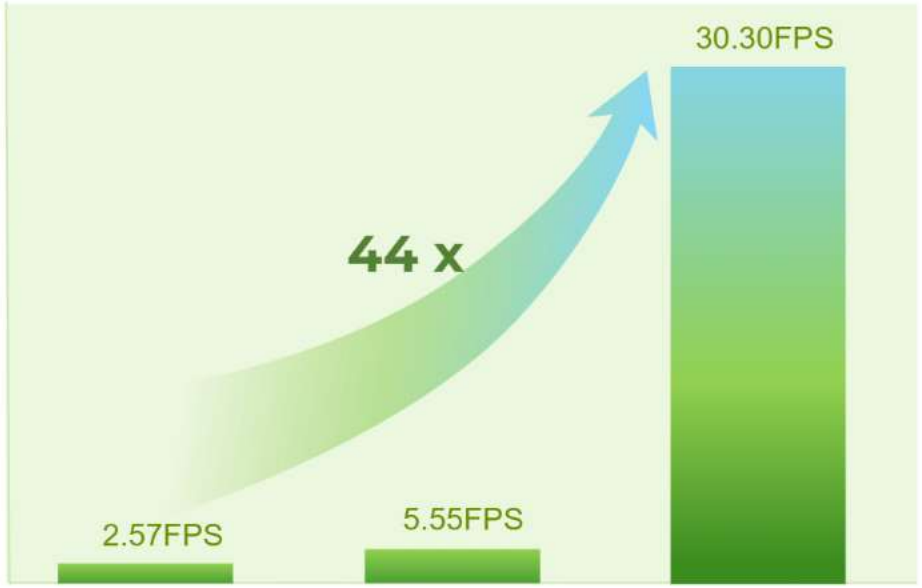
few shot
training
no-code
web server

Cheaper

<10 $

Faster and Lower power

Refresh Rate

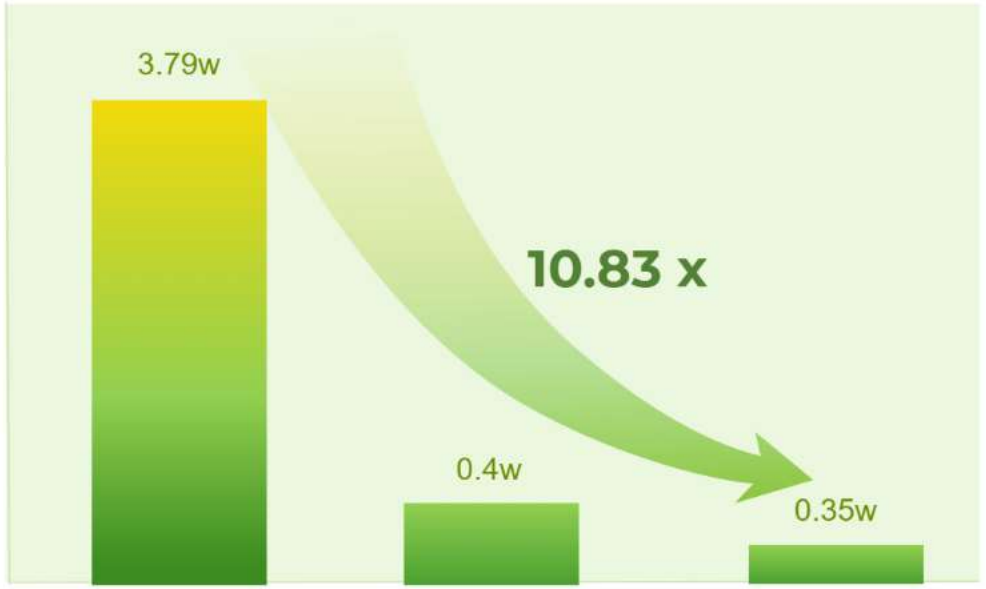


Grove Vision AI v1

XIAO ESP32S3

Grove Vision AI v2
(M55 + U55 AI addon)

Energy Efficiency



Raspberry Pi 4B

Grove Vision AI v1

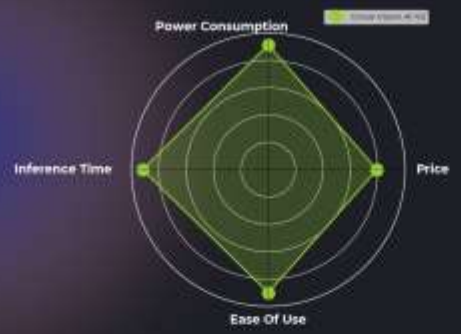
Grove Vision AI v2
(M55 + U55 AI addon)

Faster

2024 MCU AI Vision Boards: Performance Comparison

Power Consumption: 0.40W
Inference Time: 389.0ms
Frame Rate: 2.57FPS
Ease of Use: 8.0
Price: $25.99

Grove Vision AI
Himax HX6537-A (ARC EM9D DSP) 400 MHz



Power Consumption: 0.35W
Inference Time: 33.0ms
Frame Rate: 30.30FPS
Ease of Use: 9.0
Price: $23.89

Grove Vision AI V2
Himax WiseEye2 HX6538 (Cortex-M55 + Ethos-U55)
400 MHz + 400MHz (M55) + 400MHz (U55)

(Based on OpenMV)
Power Consumption: 0.59W
Inference Time: 178.89ms
Frame Rate: 5.59FPS
Ease of Use: 6.0
Price: $115.00

Arduino Nicla Vision
STM32H747AII6 (ARM® Cortex® M7/M4)
480MHz (M7) + 240MHz (M4)

Power Consumption: 0.46W
Inference Time: 180.0ms
Frame Rate: 5.55FPS
Ease of Use: 4.0
Price: $45.00

ESP32-S3-EYE
ESP32S3 (Dual-Core Tensilica LX6) 240 MHz

Power Consumption: 0.45W
Inference Time: 180.0ms
Frame Rate: 5.55FPS
Ease of Use: 9.0
Price: $13.99

XIAO ESP32S3 Sense
ESP32S3 (Dual-Core Tensilica LX6) 240 MHz

Power Consumption: 3.79W
Inference Time: 8.83ms
Frame Rate: 113.21FPS
Ease of Use: 1.0
Price: $55

Raspberry Pi 4B
Broadcom BCM2711 (Cortex-A72 ARM V8) 1.5GHz

How I conduct the test

1. flash the same test model on board - Swift-YOLO Tiny 96x96
2. feed the camera with the same human face picture under the same condition
3. record their performance

Notes:

1. Raspberry Pi 4B is Included for perspective on CPU vs. MCU performance, despite its difference from MCU boards

2. Nicla Vision: Due to compatibility issues with the test model, it is tested with an alternative method; results are not directly comparable with other boards.

3. The inclusion of these 2 boards is intended to offer a broader perspective on processing capabilities across different hardware platforms. Their results are color-highlighted for clear distinction.

Scan the code to read the article

*The larger the colour block area, the better the combination.

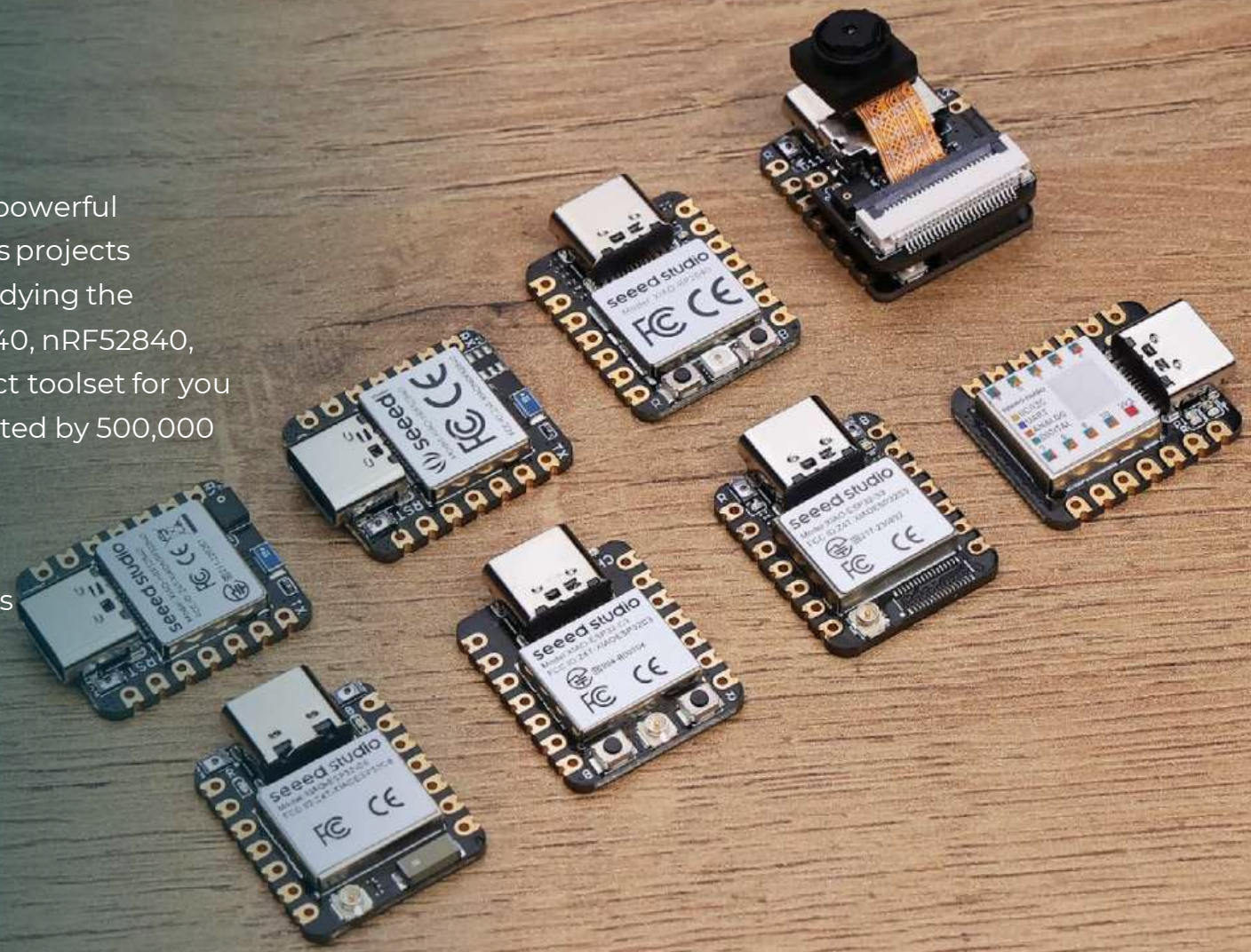
Smaller and cheaper

XIAO - tinyML MCUs

Add AI to Almost Everything

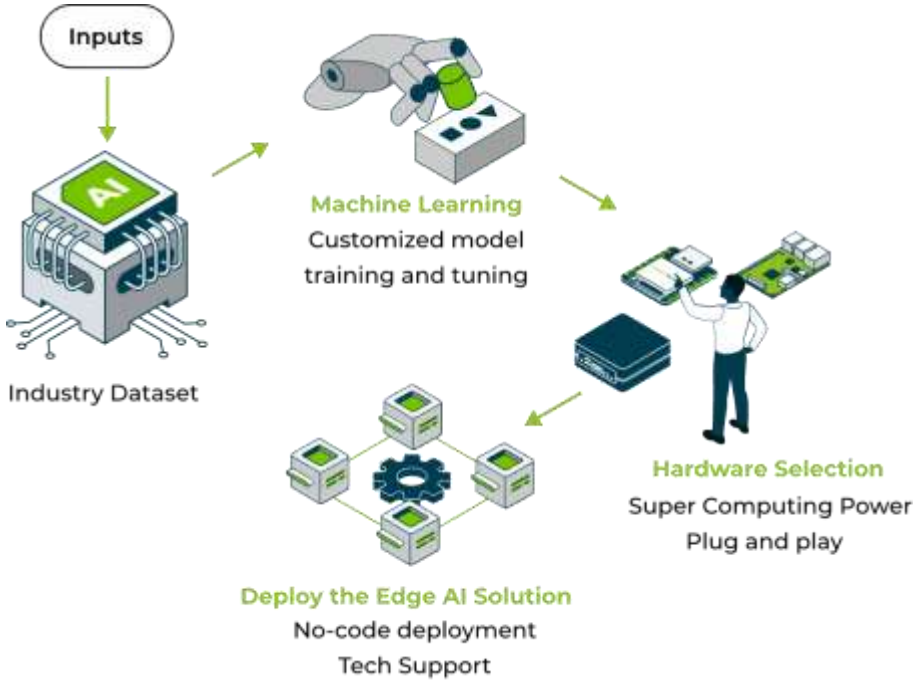
The Seeed Studio XIAO Series is a collection of thumb-sized, powerful microcontroller units (MCUs) tailor-made for space-conscious projects requiring high performance and wireless connectivity. Embodying the essence of popular hardware platforms such as ESP32, RP2040, nRF52840, and SAMD21, the Arduino compatible XIAo series is the perfect toolset for you to embrace tiny machine learning (tinyML) on the Edge. Trusted by 500,000 developers globally!

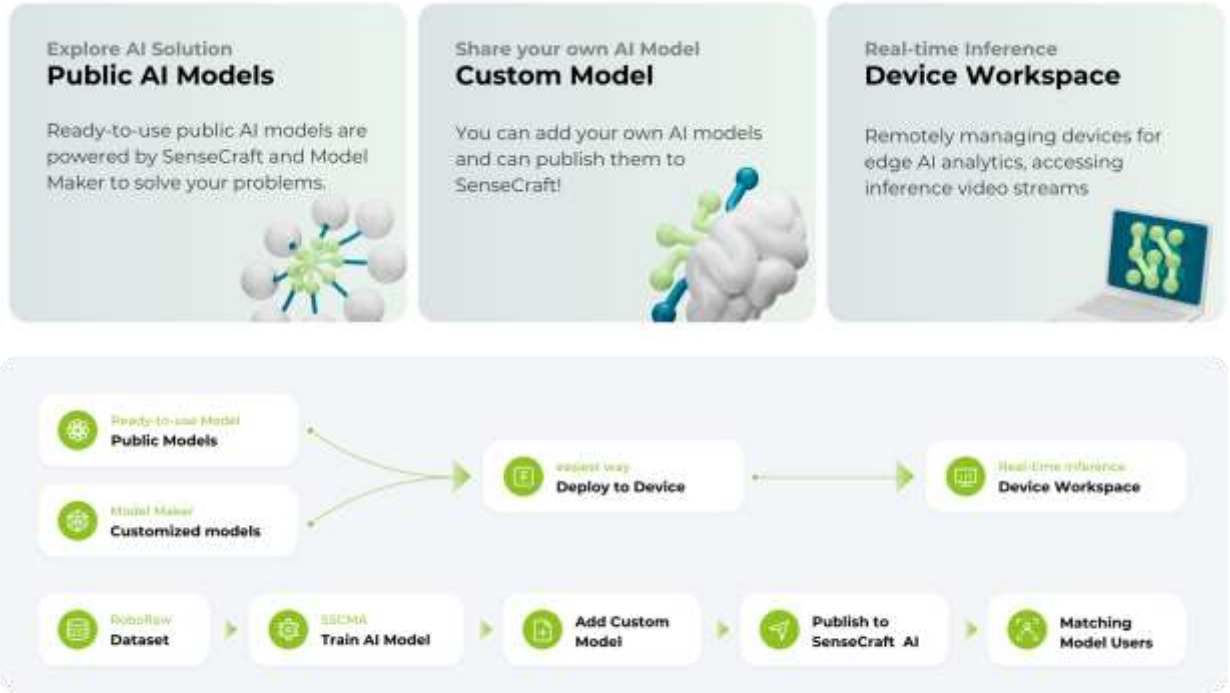
- **Module and Development Board Hybrid**
  Enabling Rapidly Prototype While Easily Integrate, Significantly Streamline Product Development Process
- **Invest for Your Future**
  Unified Form Factor Enables You to Seamlessly Upgrade or Downgrade Your Product at the Lowest Cost
- **Single-Sided Surface Mount Design**
  Effortlessly Incorporate XIAO into Other Boards for Large-Scale Manufacturing
- **Strong Ecosystem Support**
  Extensive Software Compatibility, Abundant Community Resources, and Dedicated Technical Assistance



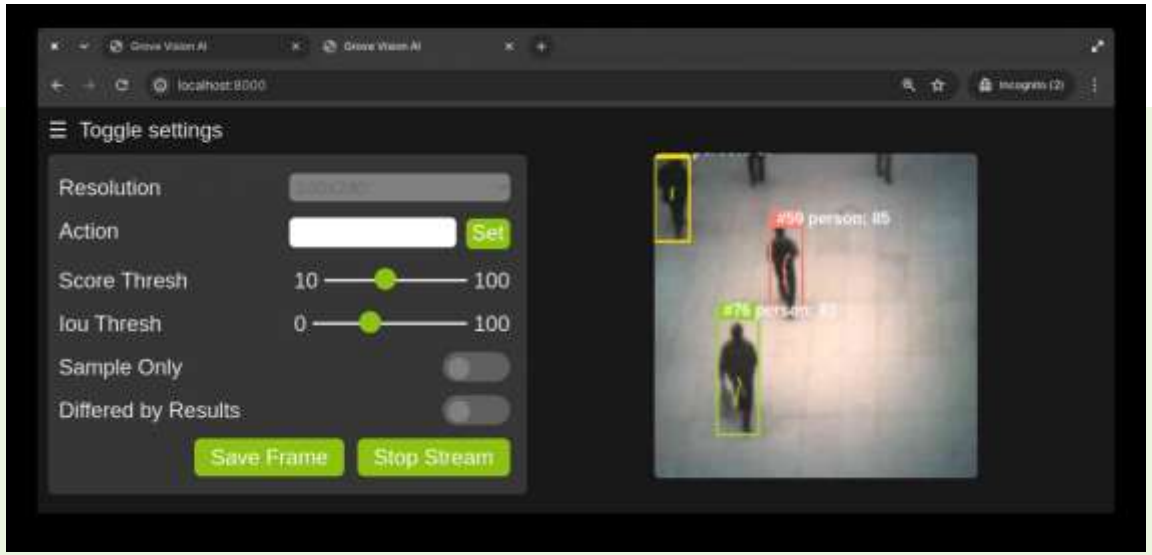
Easier - No code model MLops

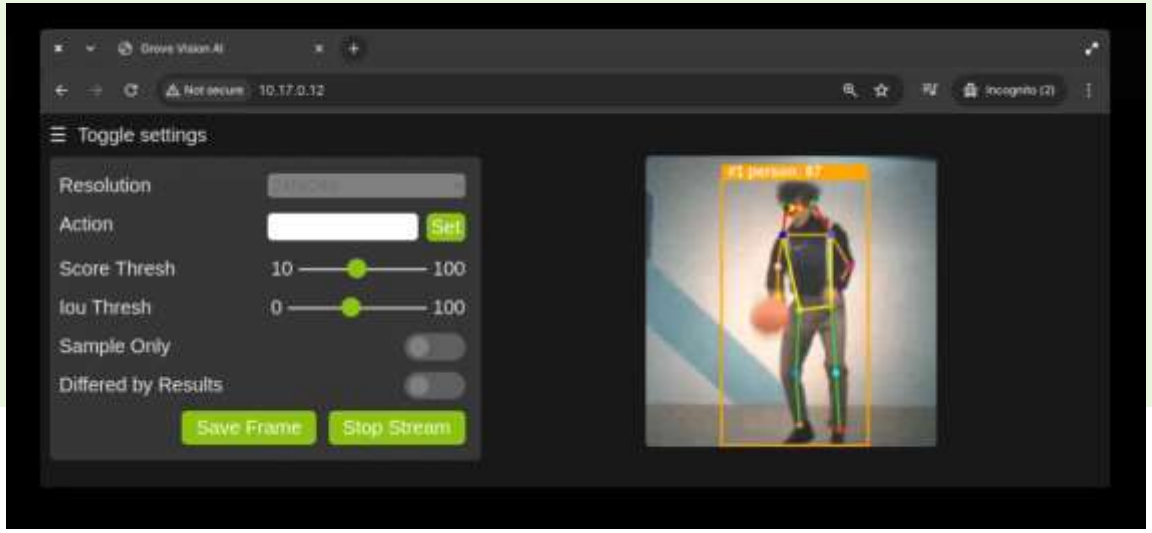
SenseCraft Model Assistant is an AI platform dedicated to simplifying the training, distribution, and deployment of AI models. With just a few clicks, you can easily deploy models and say goodbye to tedious conffguration and coding. It supports users to upload and share self-trained models, build a shared model library, and promote collaboration and innovation among AI enthusiasts. Currently supports computer vision algorithms (such as target detection, image classiffcation, image segmentation, and pose) and LLM, making it possible to realize high-speed and accurate inference on low-cost hardware, unlocking the powerful potential of AI in edge devices.

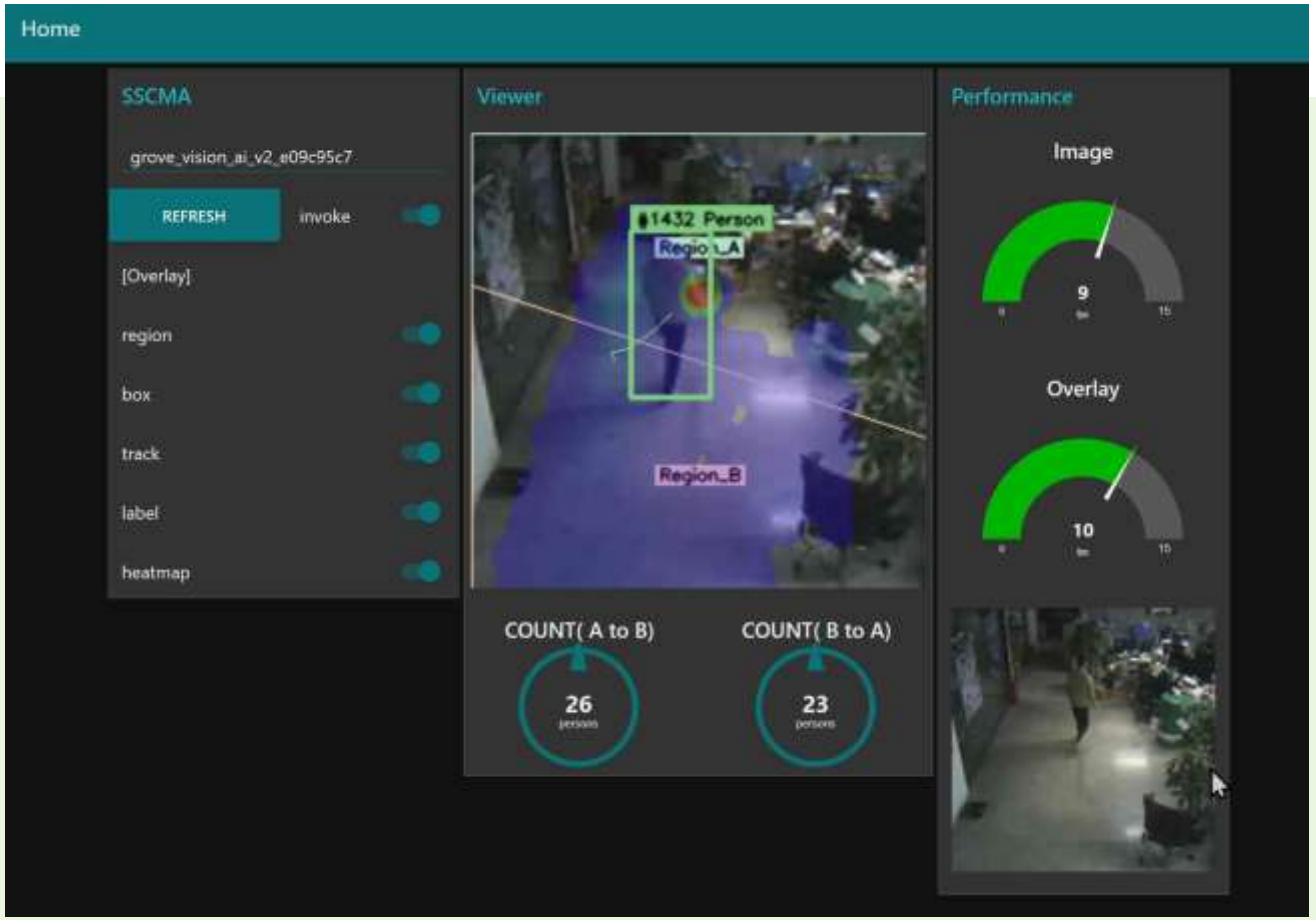




Easier - No code model MLops

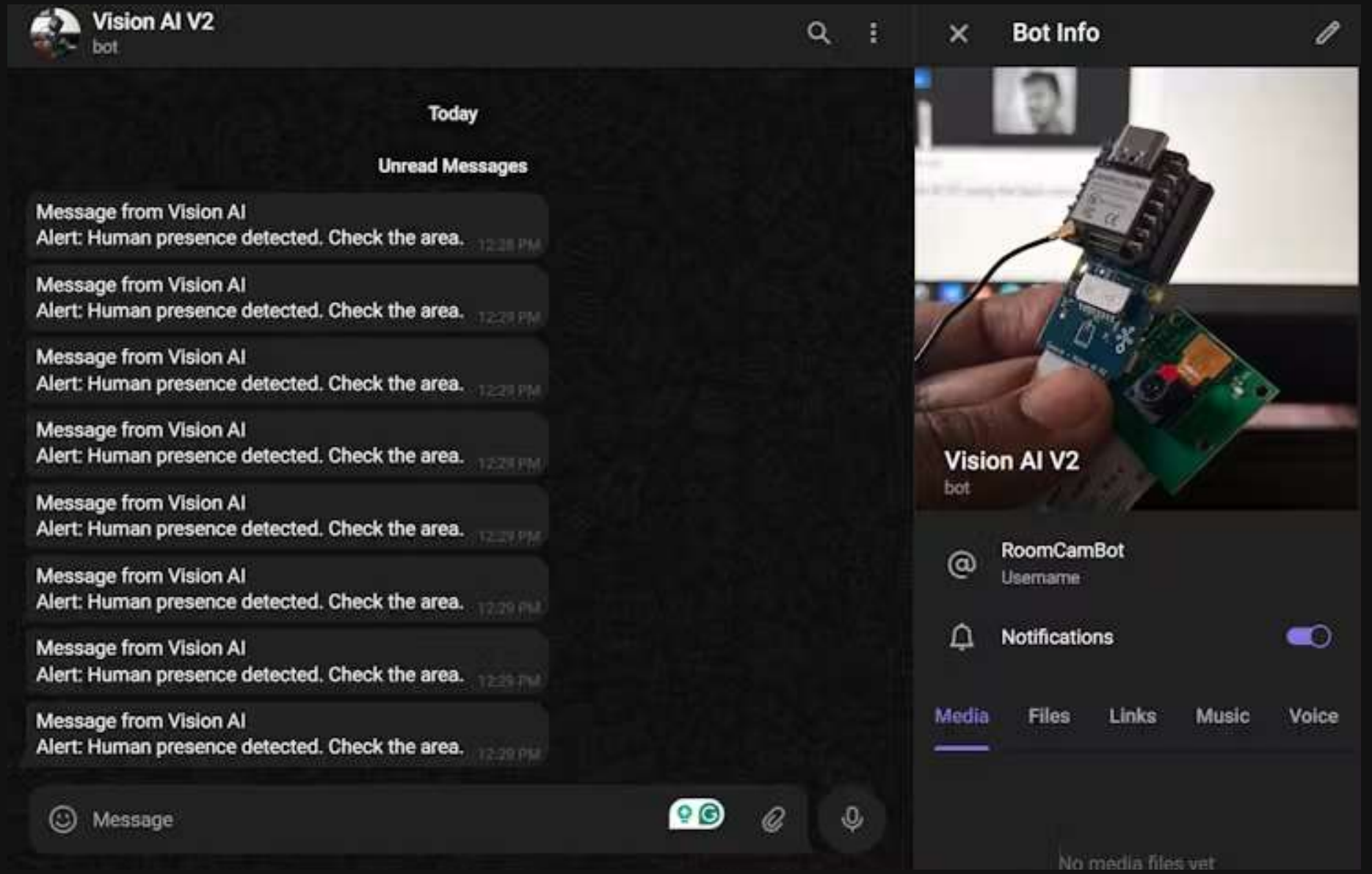






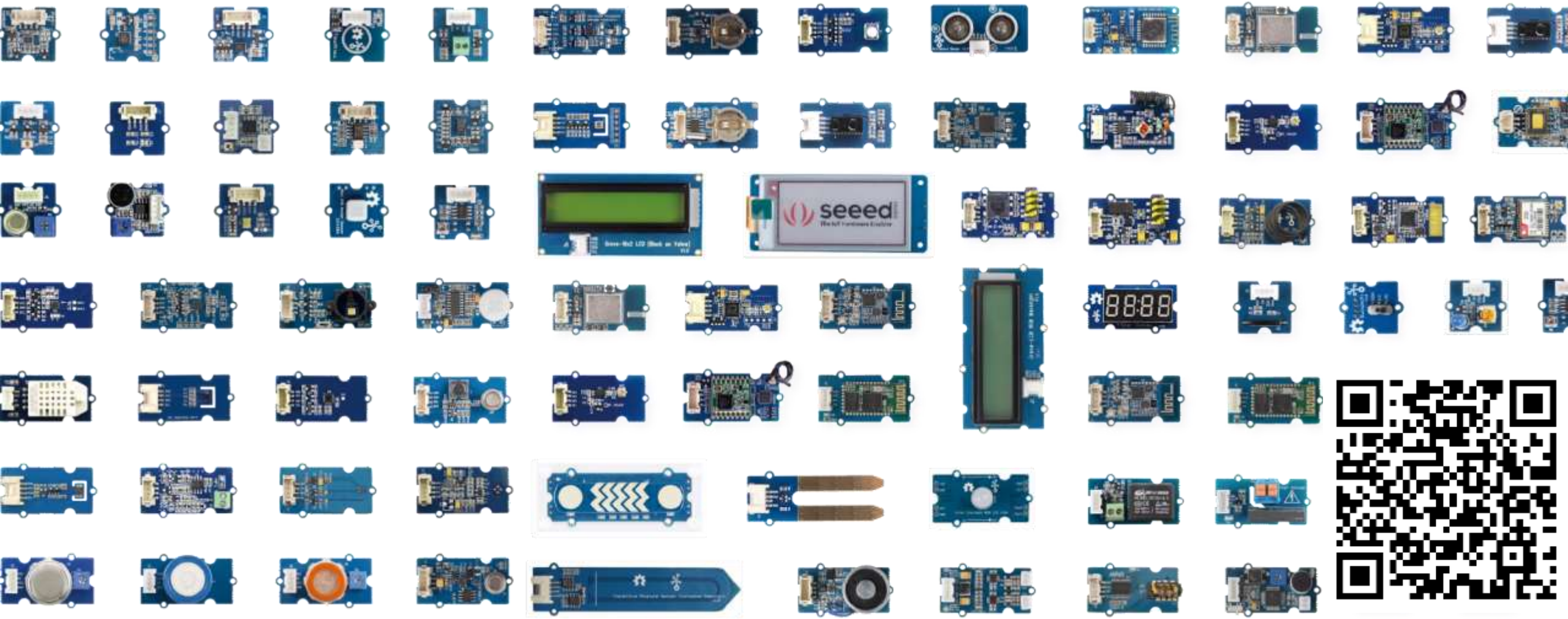
https://github.com/Seeed-Studio/Seeed_Arduino_SSCMA/tree/main/examples/camera_web_server

Easier - chat with TinyML



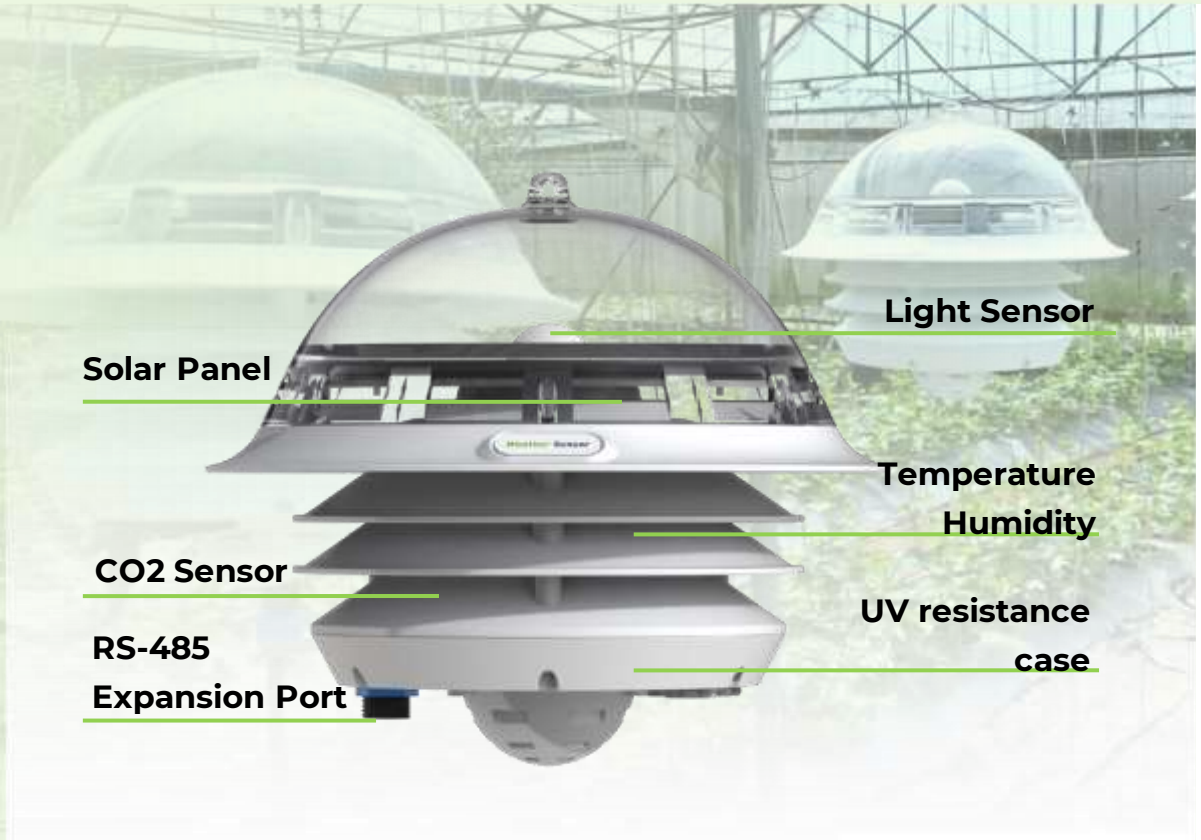
Atlas of Sensors

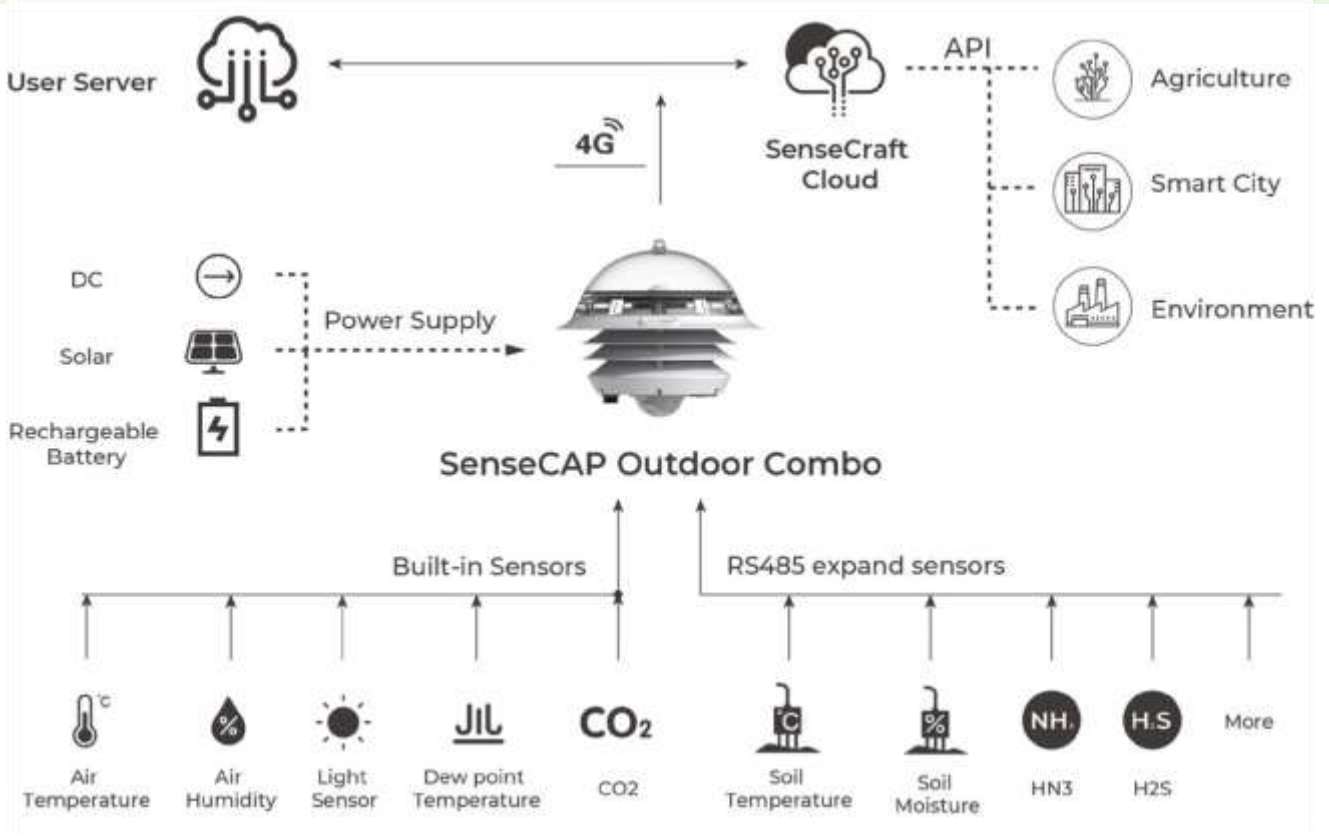
Nerve endings of the digital world



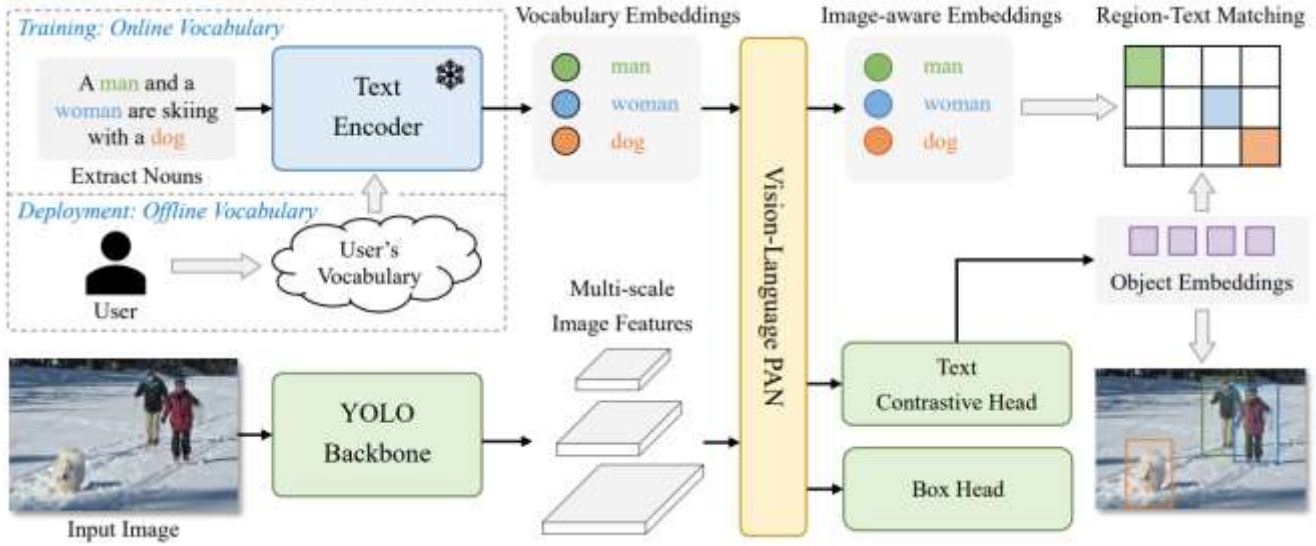
Scan code to download

Multi-modal


Light Sensor
Solar Panel
Temperature
Humidity
CO2 Sensor
UV resistance case
RS-485 Expansion Port


User Server
4G
SenseCraft Cloud
API
Agriculture
Smart City
Environment
DC
Solar
Rechargeable Battery
Power Supply
SenseCAP Outdoor Combo
Built-in Sensors
RS485 expand sensors
Air Temperature
Air Humidity
Light Sensor
Dew point Temperature
CO2
Soil Temperature
Soil Moisture
HN3
H2S
More

what's next: few shot training?



https://huggingface.co/spaces/stevengrove/YOLO-World

Generative AI expand to real world

multi-modal
imagie
Speech
Sensors

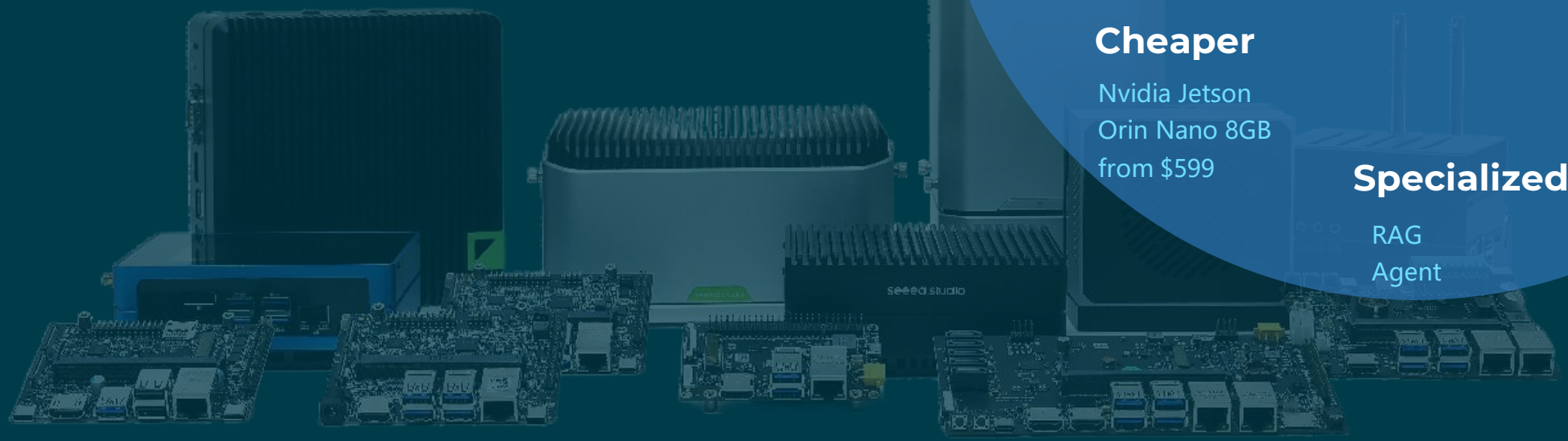
Stronger
> 40T

Distributed
Locally deployed

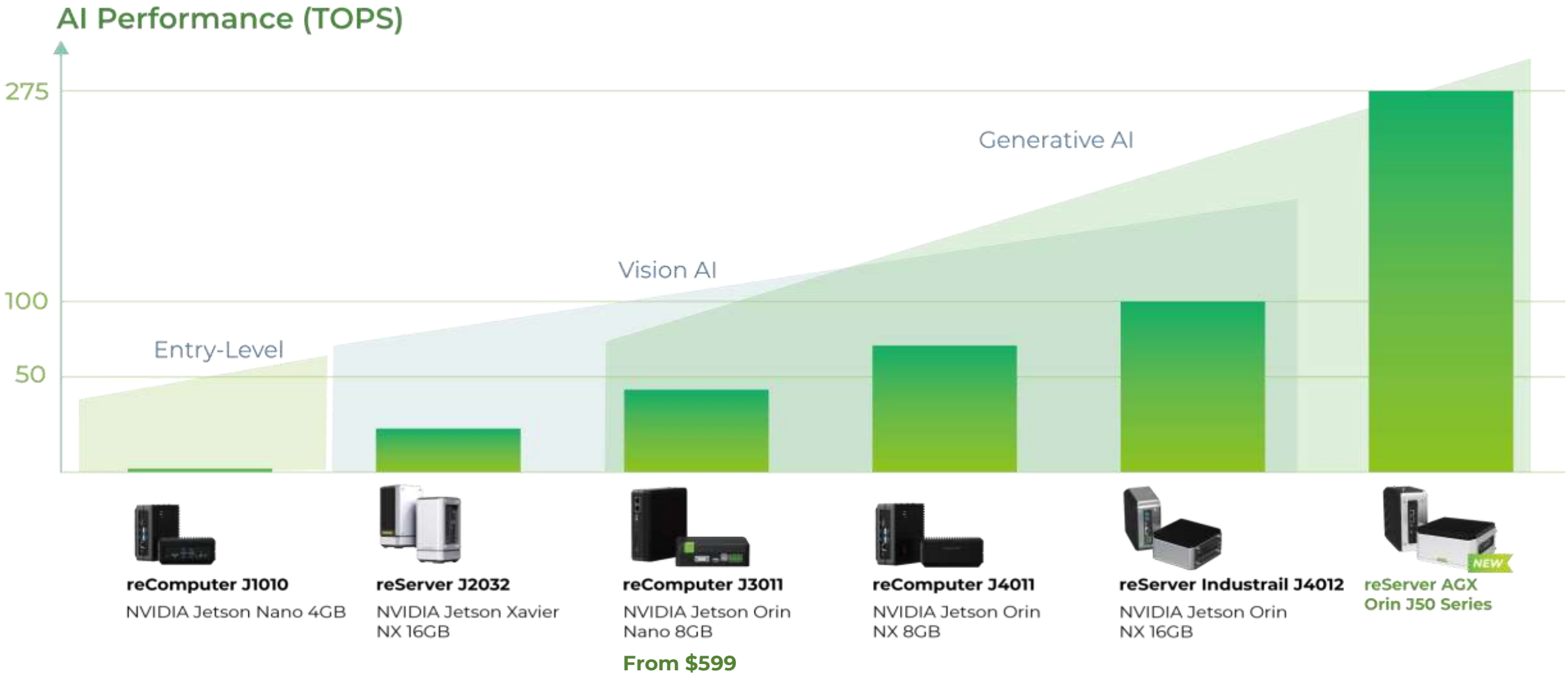
Generative AI

Cheaper
Nvidia Jetson
Orin Nano 8GB
from $599

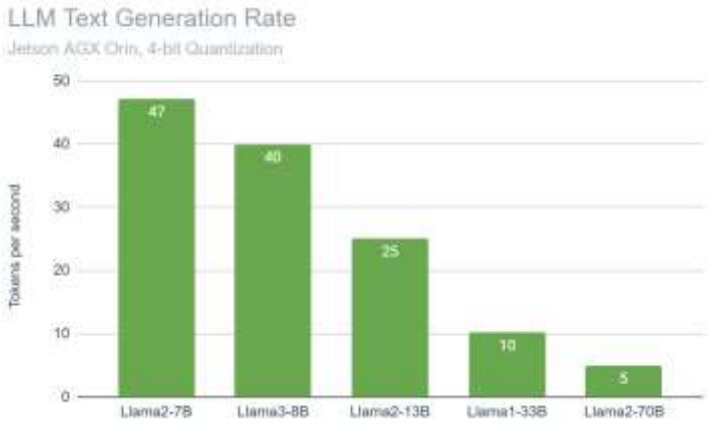
Specialized
RAG
Agent



Evolving edge AI capability



Generative AI at the Edge

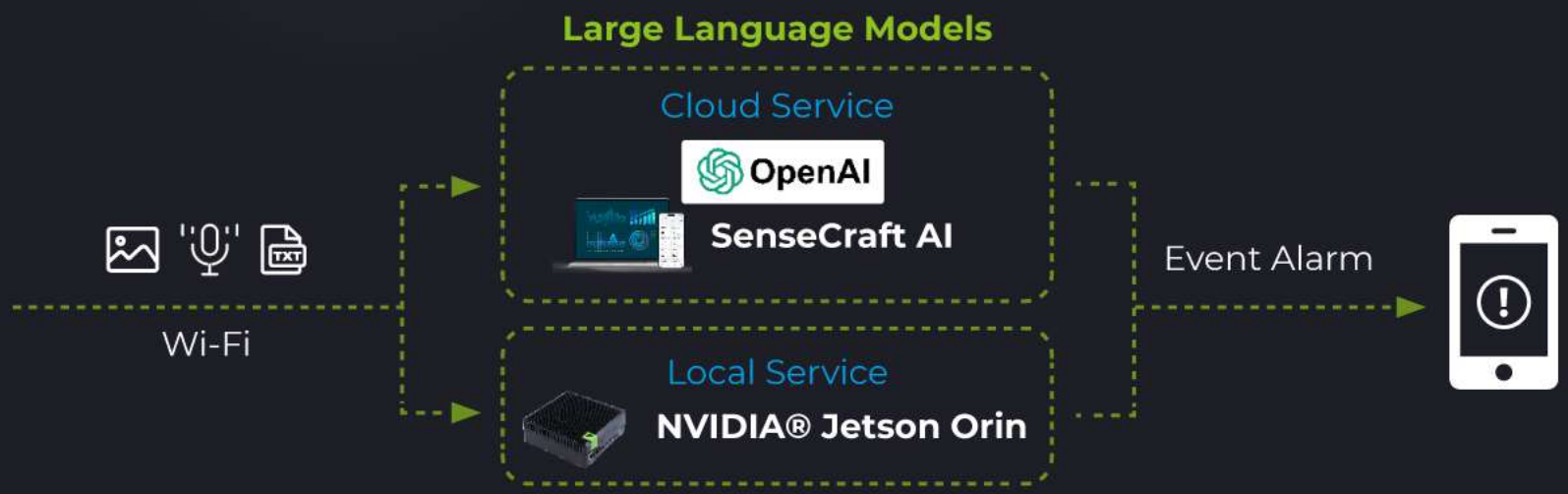


https://www.jetson-ai-lab.com/

Cost comparison of Open AI vs Local LLM

5 Years Usage of Solution

	Times/day	Times for 5years	Jetson Solution Cost	OpenAI Solution Cost/year	Number of months to break-even
(24h) 1 request per day	1	1825	899	1.825	5993.33
(24h) 1 request per hour	24	43800	899	43.8	249.72
(24h) 1 request per 30min	48	87600	899	87.6	124.86
(24h) 1 request per 15min	99	180675	899	**903.4**	60.83
(24h) 1 request per 60s	1440	2628000	899	2628	4.16
(24h) 1 request per 10s	14400	26280000	899	26280	0.42



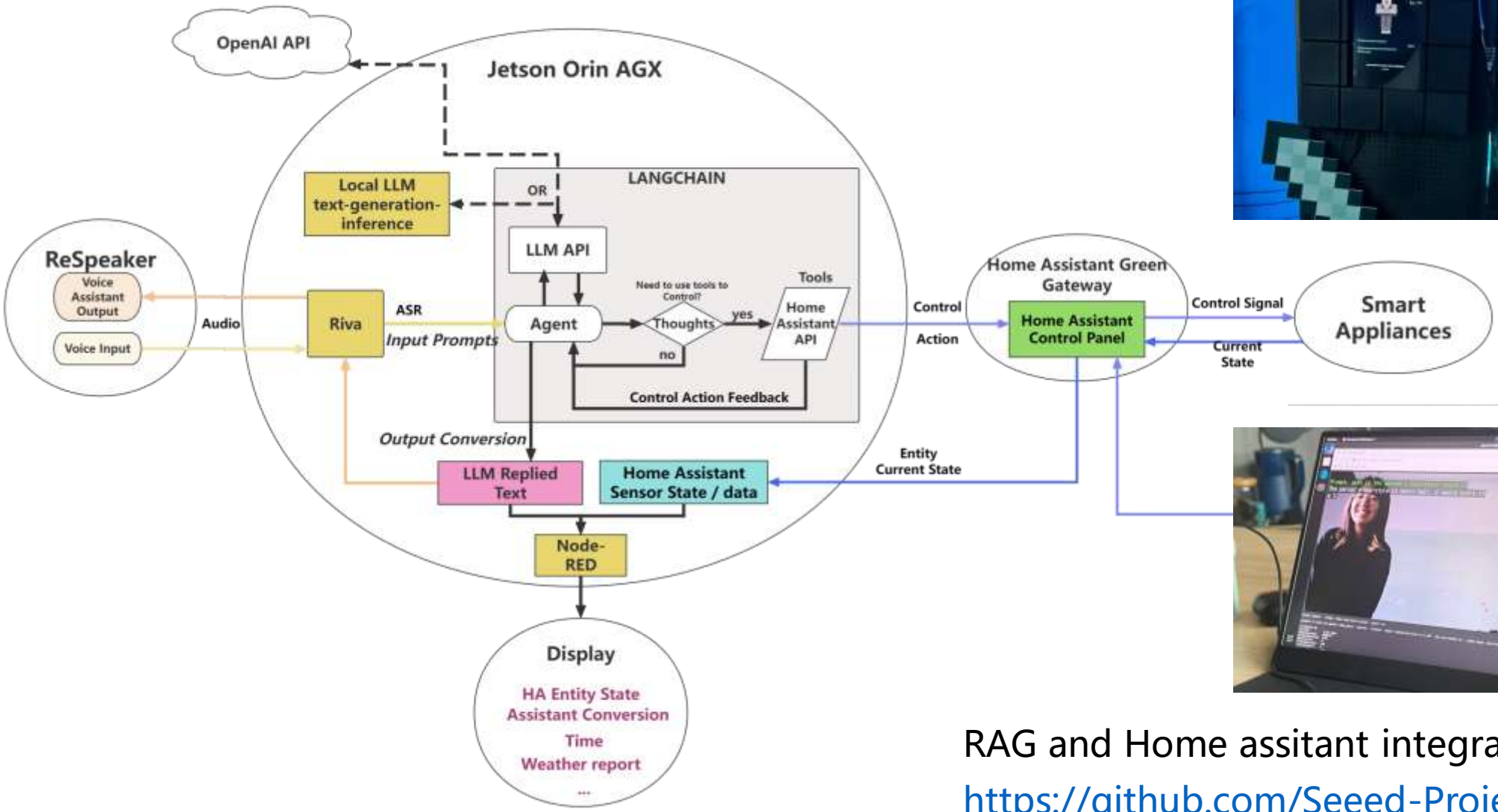
Cons:

- Privacy
- High demand, lower cost with local LLM
- Local LLM speed is network-independent

Pros:

- Low demand, lower cost with OpenAI
- OpenAI offers high accuracy

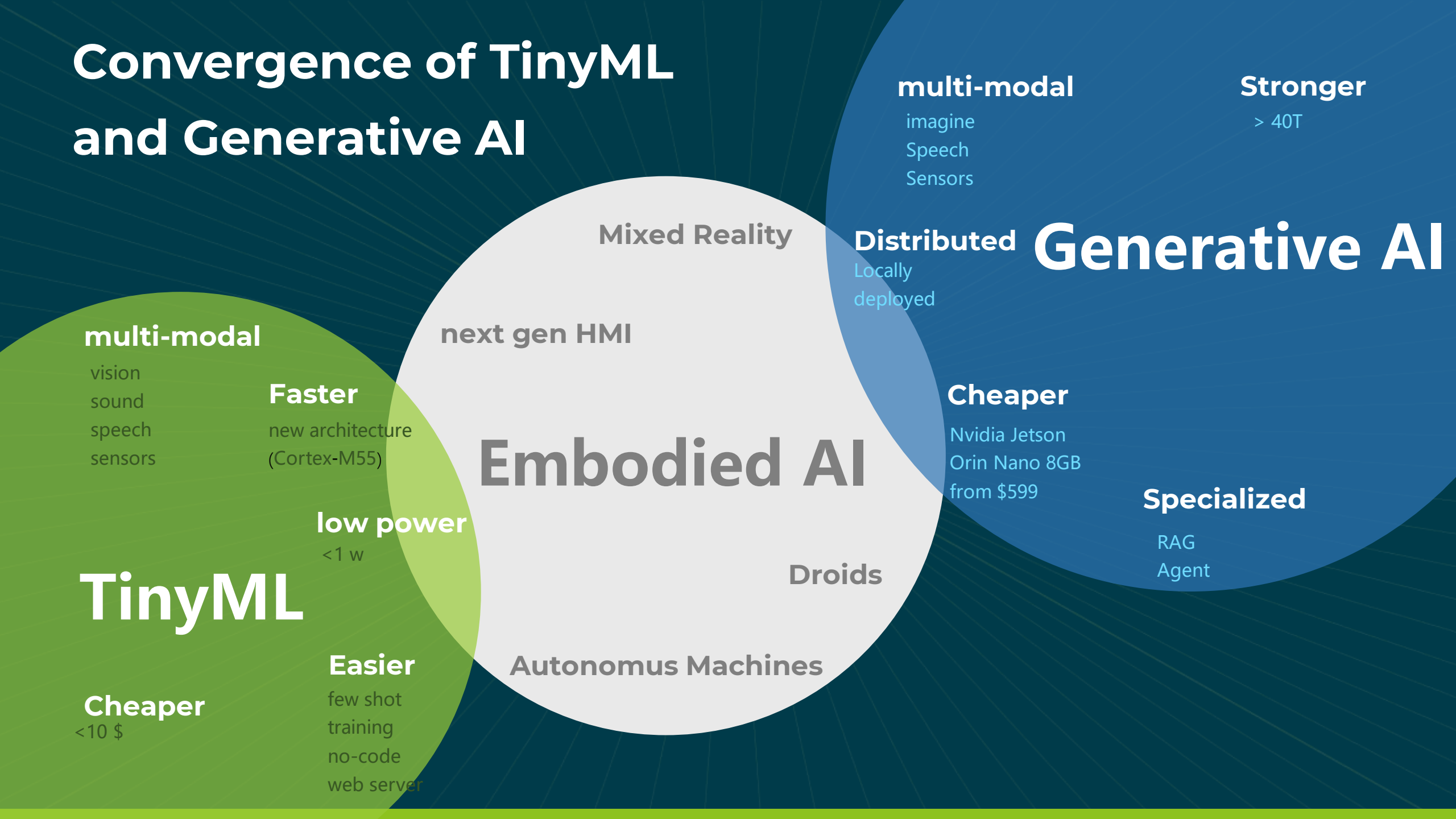
Next generation human machine interface to complex system



RAG and Home assitant integration

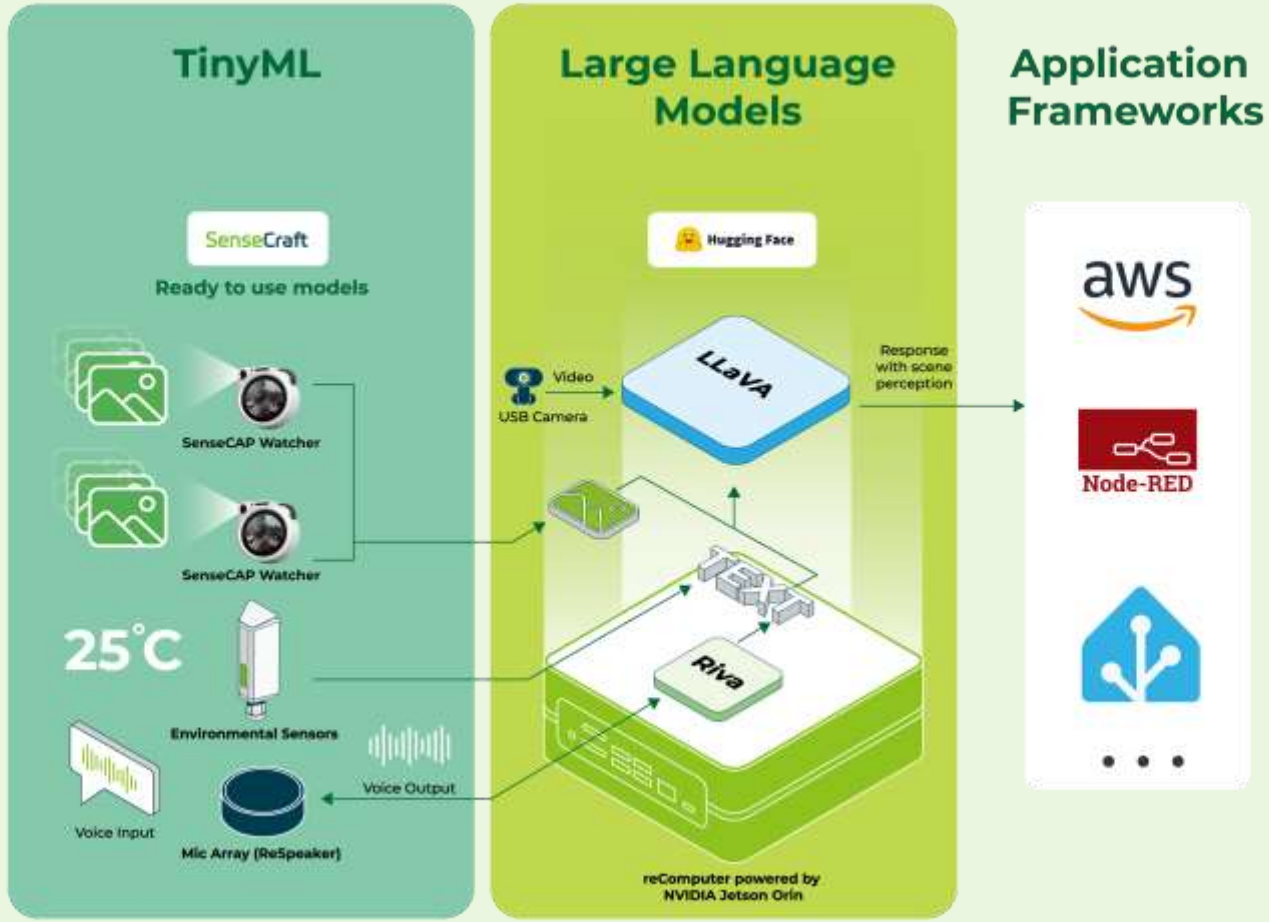
https://github.com/Seeed-Projects/LocalJARVIS

Convergence of TinyML and Generative AI



Convergence of TinyML and Generative AI

rhapsody of TinyML and local LLM



Physical AI agent for smarter facility and machines

Self-learning

Your agent to watch what you care

Activity · Occupany · Condition

Comprehensive Sensors

Vision · Sound

Self Learning and evolving

Capture · Train · Deploy

Local and public LLM

LLM Omnipotent

Pervasive

Low Power AI

On-device TinyML

Nature Interaction

Voice · Touch · Dial

No code setup

App

Small Size

64x68x25mm

Extensive

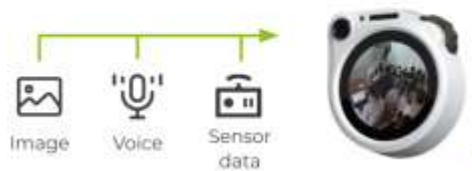
Seamlessly Integrations

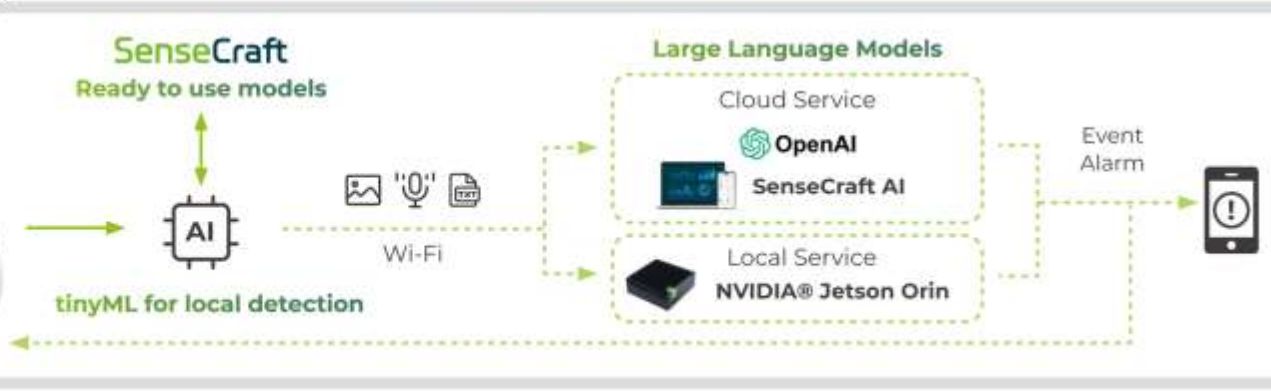
Smart Home · Powerful AI · Node-RED

Grove Extension

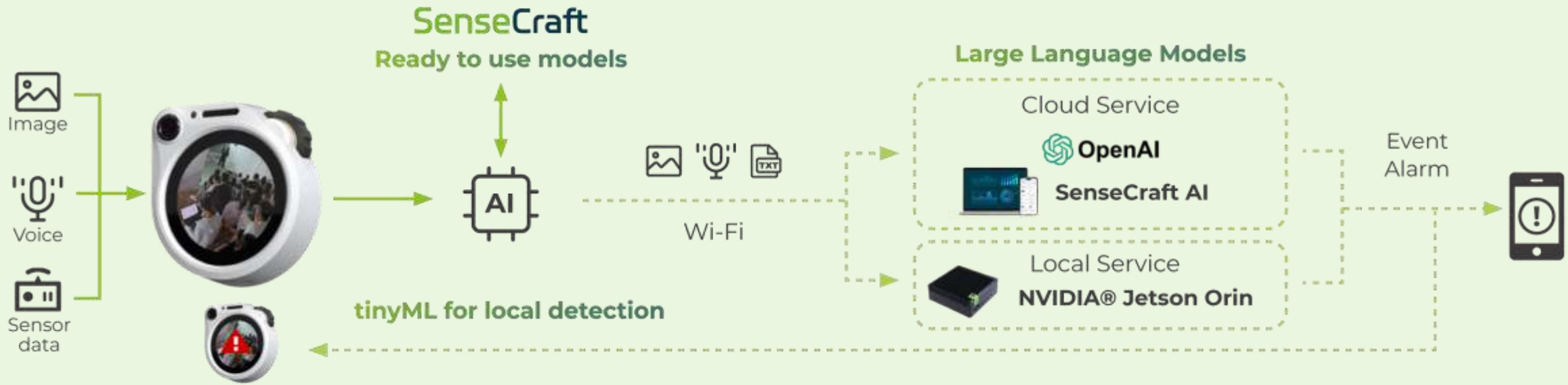
Open Source · Ready for Customization

Built-in Battery · Wi-Fi/BLE · SD Card · USB Type-C

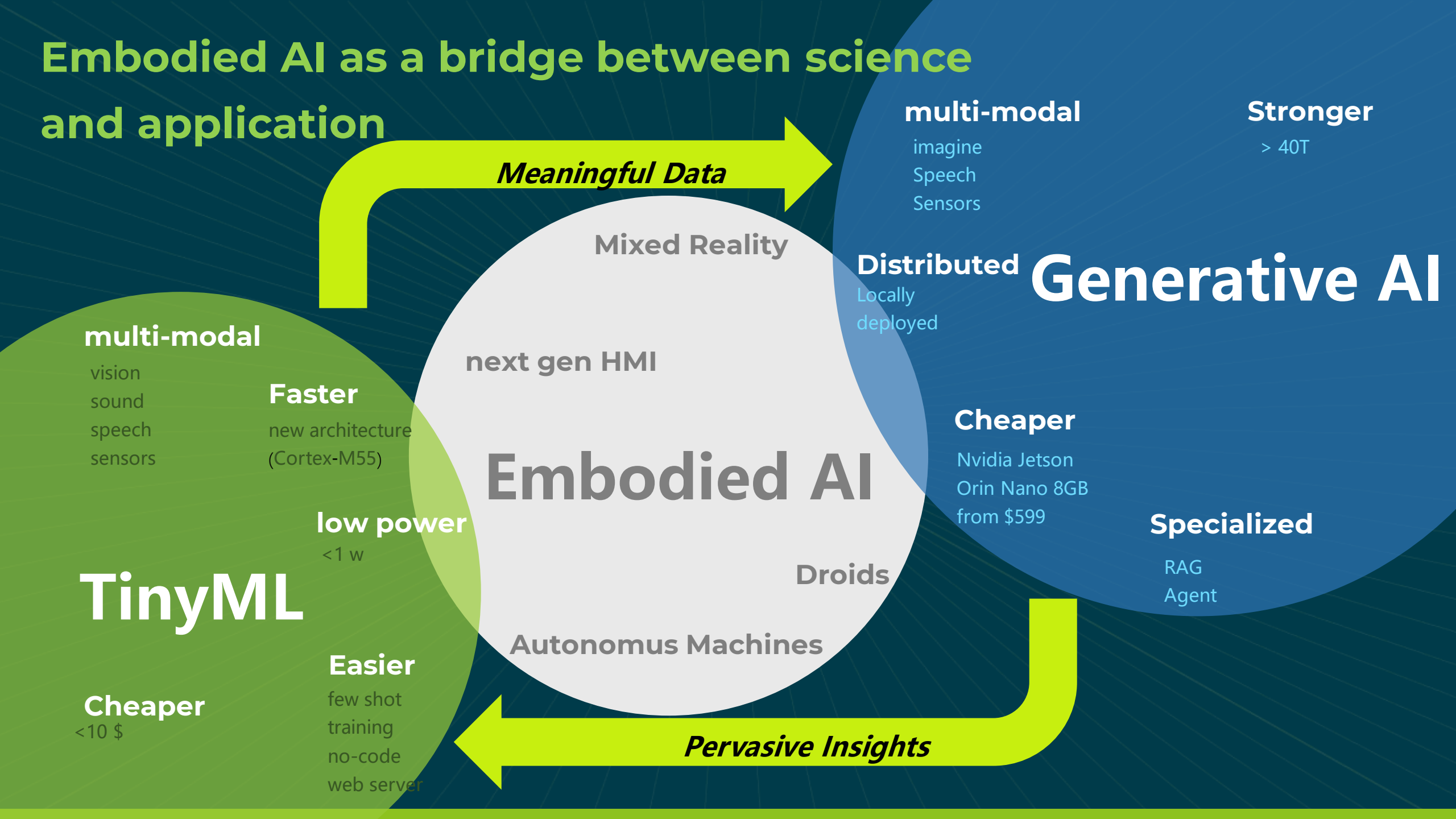




Physical AI agent for smarter facility and machines



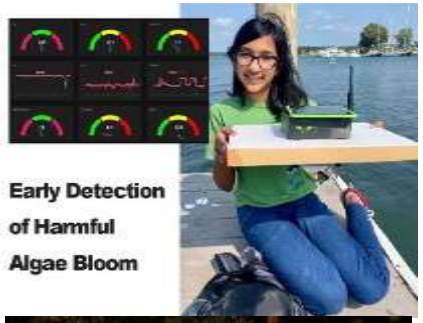
Embodied AI as a bridge between science and application



Embodied AI as a bridge between science and application

IoT2wild Contest

Website: https://www.hackster.io/contests/iotinthewild
Winner announced at Hackster Impact Summit on October 11, 2022



Embodied AI as a bridge between science and application

Co-Invent Solutions

Based on various digital transformation scenarios, we continue to develop smart devices that integrate the latest technologies, and work closely with developers and industry experts to provide software and hardware solutions for vertical industries at multiple levels.

seeed studio

IoT Devices

Non-engineer Experts

Industrial Know-How

Software, Algothrim, Industrial Insights

Solution

seeed studio

The AI Hardware Partner

Let’s talk!

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