GETTING STARTED WITH EDGE AI ON JETSON

DUSTIN FRANKLIN, CHITOKU YATO

JETSON POWERS THE EDGE AI REVOLUTION

AMR	RETAIL	SMART CITY	AGRICULTURE/ CONSTRUCTION	SERVICES	LOGISTICS	MANUFACTURING	HEALTHCARE
serve	MALONG		KOMATSU	CISCO	6 RIVER SYSTEMS	FANUC	NANOPORE
MiR	Proppos	brain corp	JOHN DEERE	Alerion	okamura	Musashi	Kogniz
	simbe	No Traffic	SMARTAG	TOYOTA	京东X事业部	UNIVERSAL ROBOTS	TOYOTA
Geek+	fellow ROBOTS	Vivacity	HARVEST CROO ROBOTICS	Hudl	IAMROBOTICS	FRANKA EMIKA	

1,000,000+ Developers

WHY AI AT THE EDGE

BANDWIDTH

1 billion+ cameras worldwide
10’s of petabytes per day

LATENCY

Safety-critical services
Realtime decisions

PRIVACY

Data Redaction + Confidentiality
Private cloud or on-premises storage

CONNECTIVITY

50% of populated world < 8mbps
Bulk of uninhabited world no 3G+

JETSON AGX ORIN DEVELOPER KIT

Server-Class AI Performance at the Edge

200 TOPS

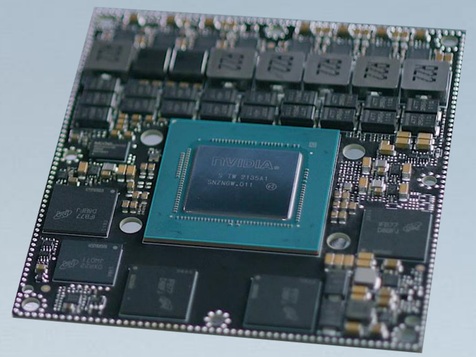
2048-core Ampere GPU

12x ARM A78 CPU

2x NVDLA 2.0

JetPack 5.0

Available Q1



JETSON AGX ORIN DEVELOPER KIT

Ser

200
204
12x
2x
Jet

Ava

NVIDIA Jetson: Introducing AGX Orin, Next-Level AI Performance for Next-Gen Robotics and Edge AI [S41957]

Join this session to learn about NVIDIA's Jetson platform for deploying AI at the edge for advanced robotics and autonomous machines in the fields of manufacturing, logistics, retail, service, agriculture, smart city, and healthcare and life...

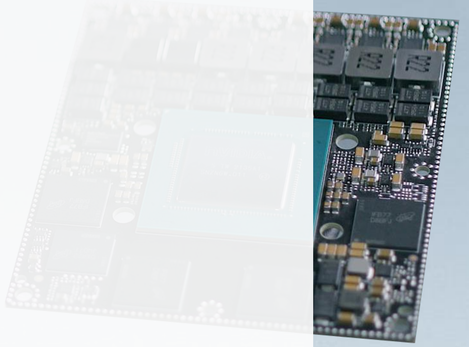
Leela Subramaniam Karumbunathan, Hardware Product Manager , NVIDIA

Industry Segment: All Industries

Primary Topic: Autonomous Machines - Robotics

ADD TO SCHEDULE **Tuesday, March 22 | 1:00 PM - 1:25 PM EDT**

Show more



JETSON DEVELOPER KITS

for Engineers, Makers, and Learners

JETSON NANO

5W | 10W
0.5 TFLOPS (FP16)

JETSON XAVIER NX

10W | 15W
21 TOPS (INT8)

JETSON AGX XAVIER

10W | 15W | 30W
32 TOPS (INT8)

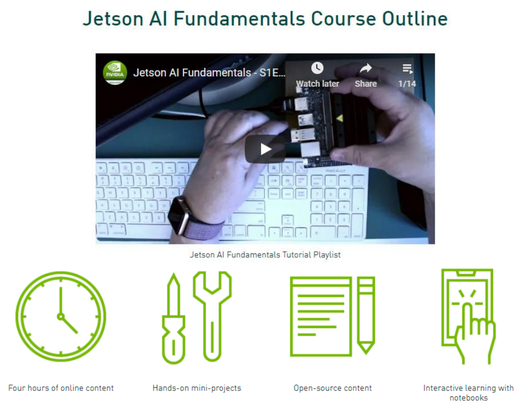
JETSON AGX ORIN

15W | 30W | 50W
200 TOPS (INT8)

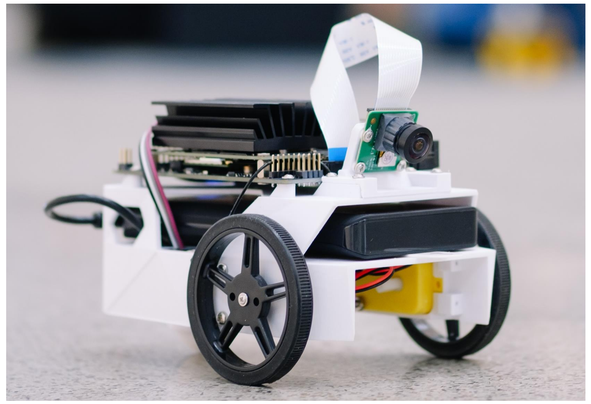
Multiple developer kits - Same software

Full specs at developer.nvidia.com/jetson

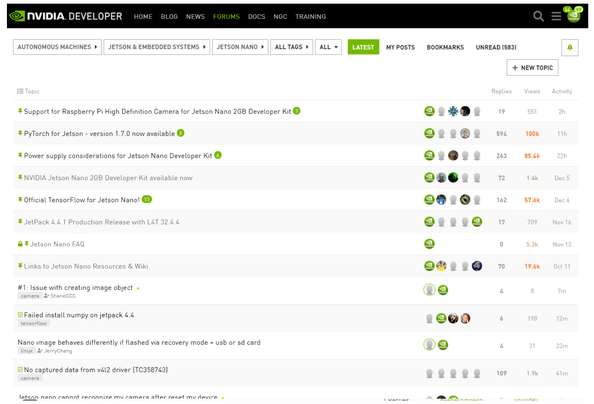
JETSON COMMUNITY RESOURCES



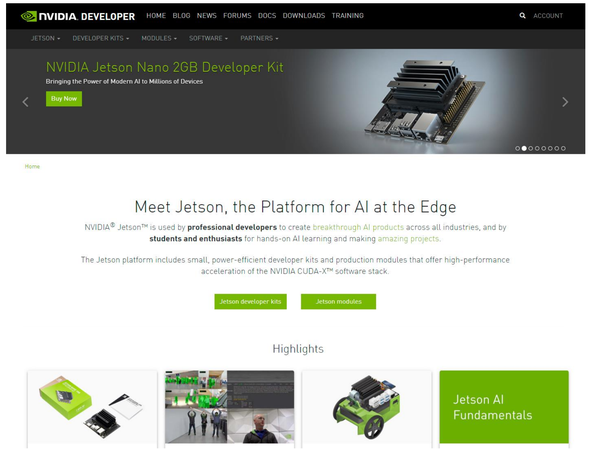
Training & Tutorials



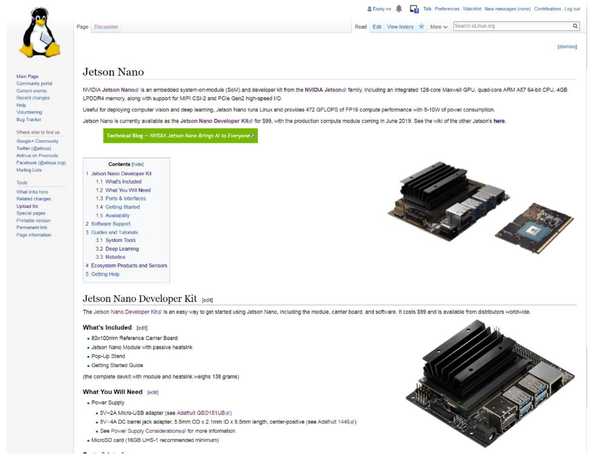
Projects



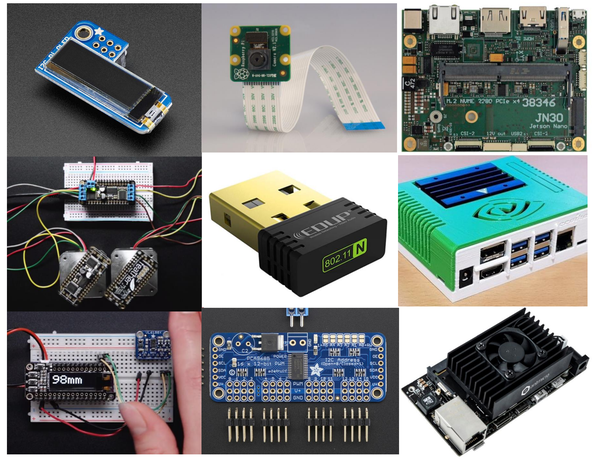
Developer Forums



Jetson Developer Zone



eLinux Wiki



Accessories

Jetson Community Projects

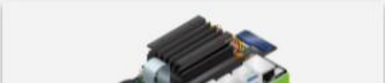
Explore and learn from Jetson projects created by us and our community. These have been created for Jetson developer kits. Scroll down to see projects with code, videos and more.

JetsonTV

This is a collection of cool projects, applications, and demos that use NVIDIA Jetson platform. For more inspiration, code and instructions, scroll below.

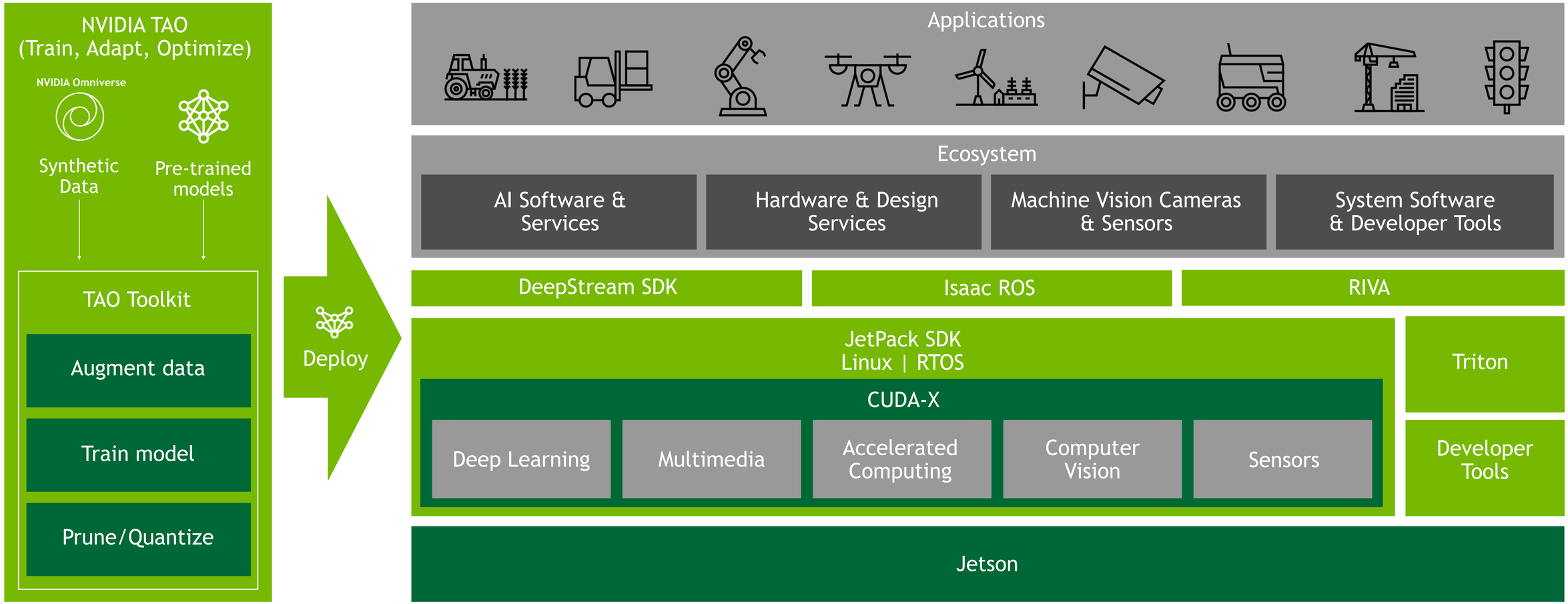
Get Started with These Projects

Modify or try out one of these projects provided by NVIDIA and jumpstart your creativity, find tips and tricks in the Community Resources page and find answers in the Jetson forum.



JETSON SOFTWARE

for AI Edge Devices



OPEN FRAMEWORK SUPPORT

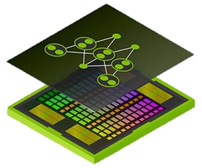
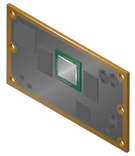
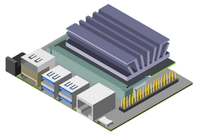
MACHINE LEARNING

PYTORCH
TensorFlow
mxnet
Caffe
Caffe2
Keras

ROBOTICS / IOT

AWS Greengrass
Azure IoT Edge
docker
MPI
ROS
AWS Robomaker
Kubernetes

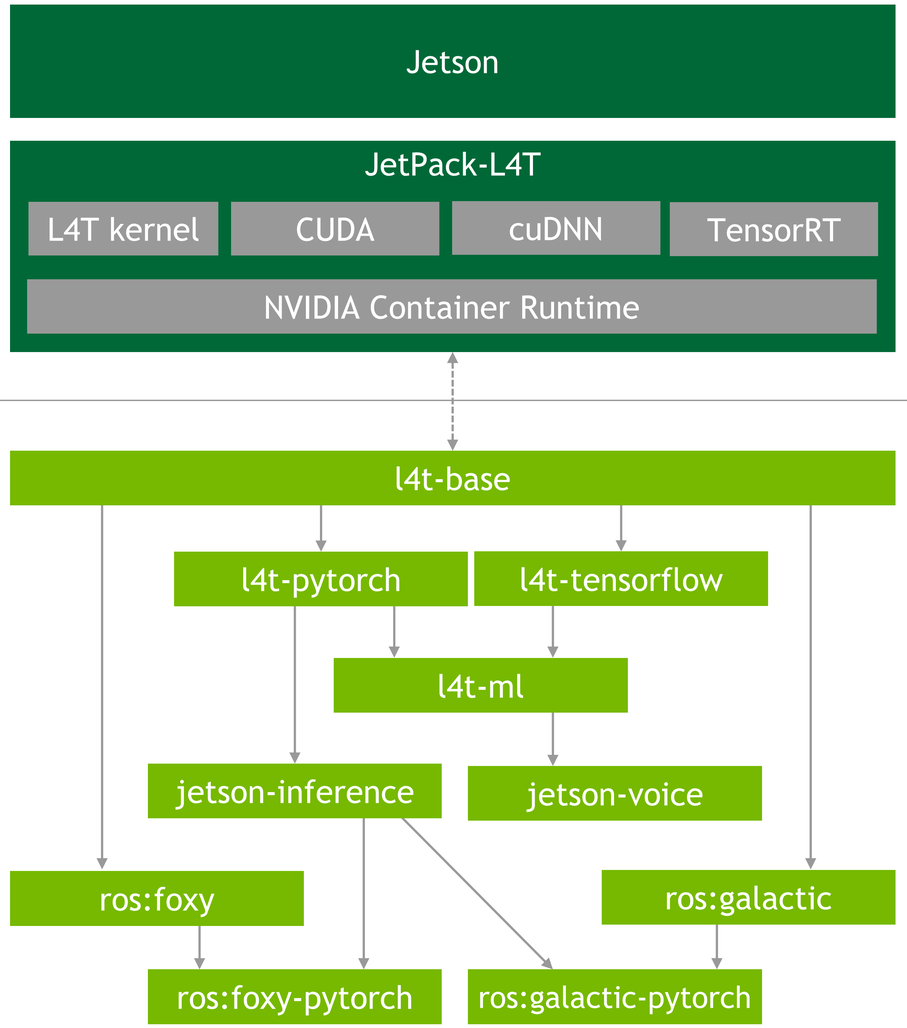
JETSON

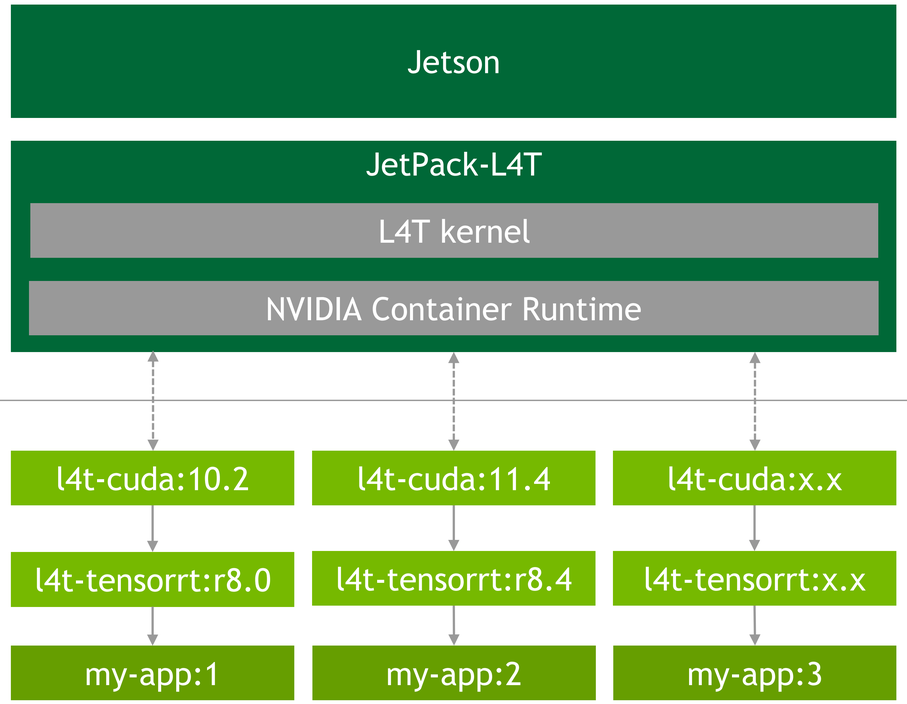
eLinux.org/Jetson_Zoo

CONTAINERS ON JETSON

SLIM CONTAINERS



FULL CONTAINERS



Device

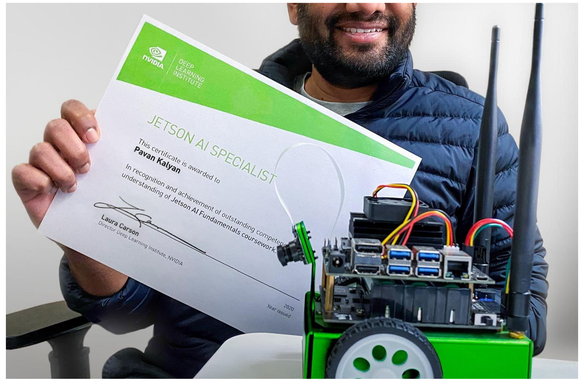
Docker

Slim containers: image size ↓
Full containers: portability ↑

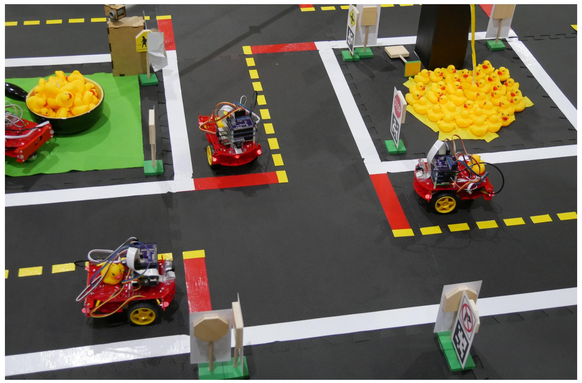
github.com/dusty-nv/jetson-containers

JETSON FOR AI EDUCATION

DLI Teaching Kits



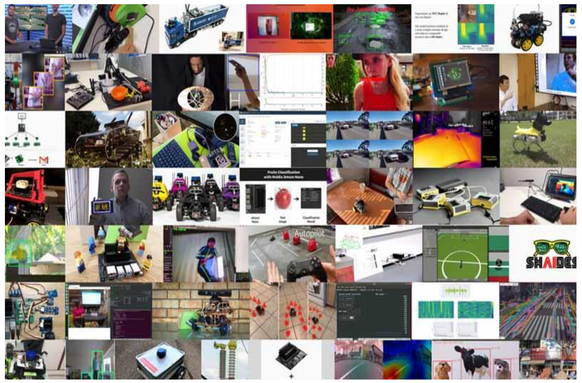
AI Certifications



Duckietown

MIT Racecar

F1TENTH



Community Projects

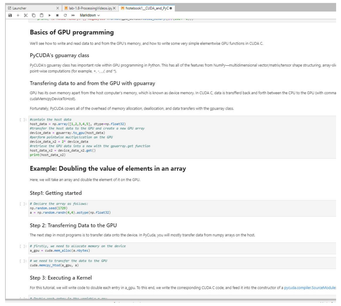
EDGE AI AND ROBOTICS TEACHING KIT

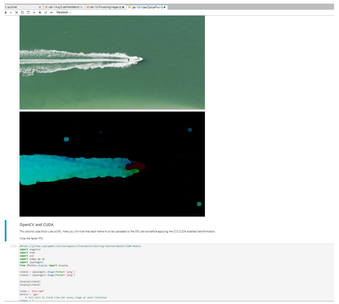
NVIDIA DEEP LEARNING INSTITUTE | UNIVERSITY OF OXFORD | UMBC

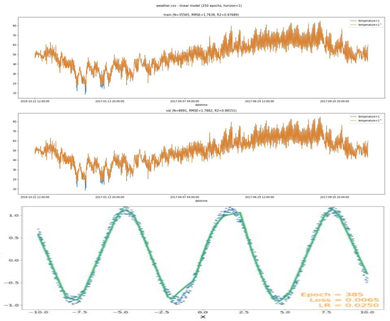
Teach fundamental and advanced topics in edge computing / IoT, video analytics, and autonomous robotics

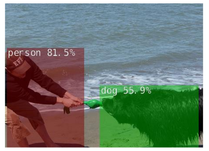
Semester-long university curriculum course material including lecture slides, labs/solutions, ect.

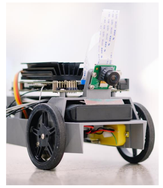
Module 1: Introduction to Edge AI	1.1: Teaching Kit Modules Overview 1.2: AI Introduction 1.3: AI Hardware 1.4: Introduction to Jetson Nano 1.5: Edge, AIoT, Big Data 1.6: Introduction to Parallel Programming 1.7: Machine Learning Fundamentals 1.8: Computer Vision **Lab: Mandelbrot CPU vs GPU** **Lab: Parallel Programming with CUDA** **Lab: Image and Video Processing** **Lab: Prediction and Classification using Machine Learning** **DLI Online Course: Getting Started with AI on Jetson Nano**
Module 2: Vision Deep Neural Networks (DNNs)	2.1: Image Classification 2.2: Object Detection 2.3: Semantic Segmentation 2.4: Pose Estimation **Lab: Hello AI World**
Module 3: Diversity, Ethics, and Security	3.1: Diversity and Bias in Datasets 3.2: Ethics and Security **Lab: Image and Video Redaction**
Module 4: Autonomous Robotics	4.1: Agent Architectures 4.2: Teaching Machines to Act 4.3: Introduction to ROS2 4.4: Robot Navigation **Lab: Obstacle Avoidance and Path Following with JetBot and Gazebo**
Module 5: Reinforcement Learning	5.1: Introduction to RL Agents 5.2: Deep RL for Vision **Lab: OpenAI Gym (Deep Q-Network)** **Lab: Robotic Arm Manipulation in Gazebo**
Module 6: Natural Language Conversational AI	6.1: Natural Language Processing (NLP) 6.2: Speech Recognition (ASR) 6.3: Text-to-Speech (TTS) **Lab: Python NLP** **Lab: ASR, NLP, TTS Chatbot**

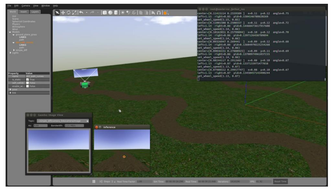


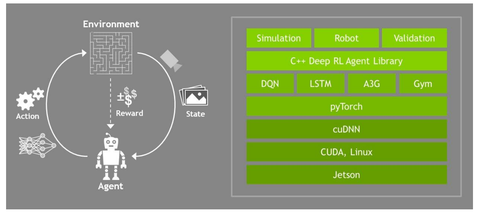


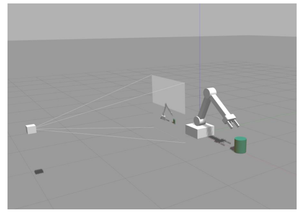


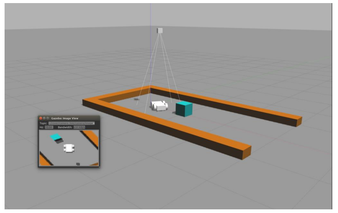












NVIDIA

JETSON AI CERTIFICATIONS

1

Get a Devkit

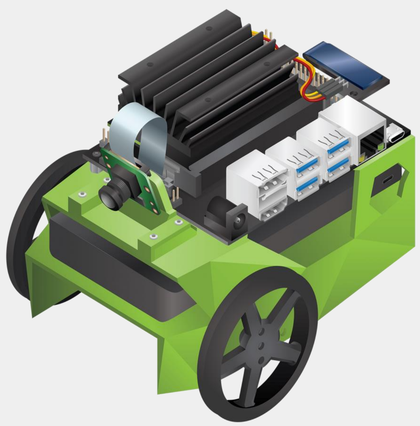
2

NVIDIA DEEP LEARNING INSTITUTE

Take Jetson AI Fundamentals Course

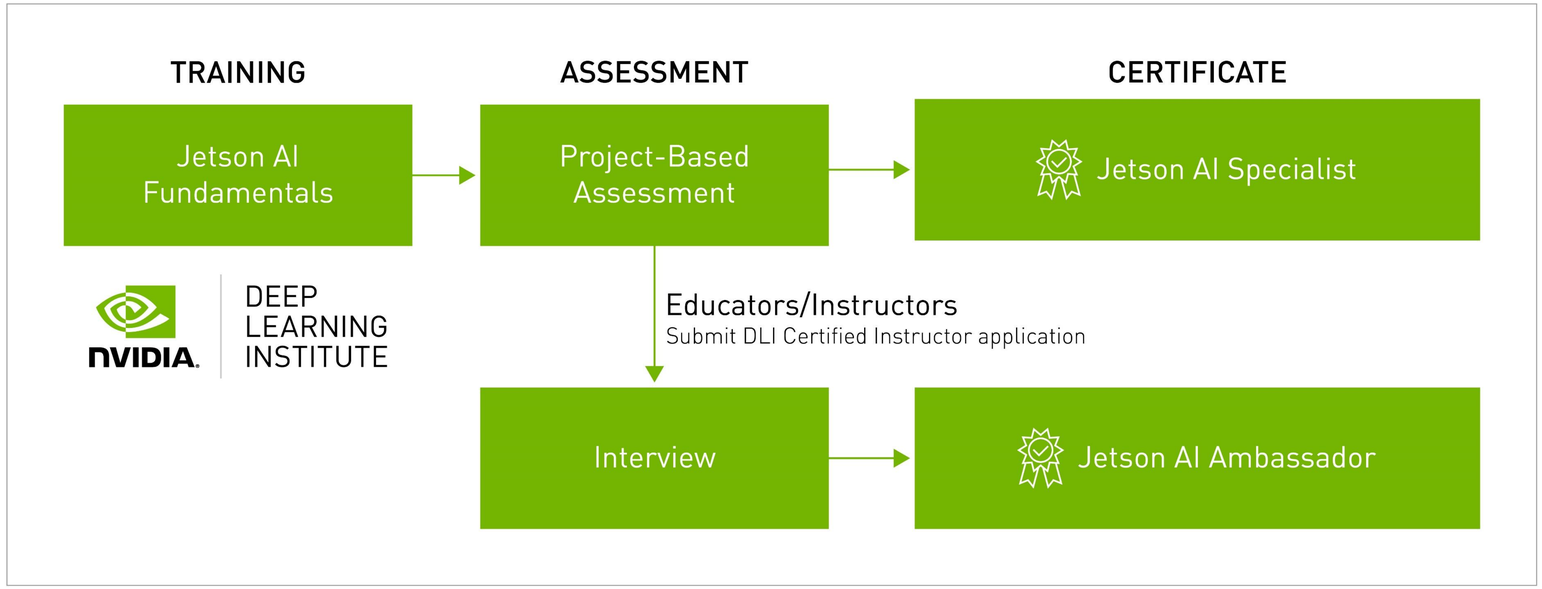
nvidia.com/jetson-ai-certification

3

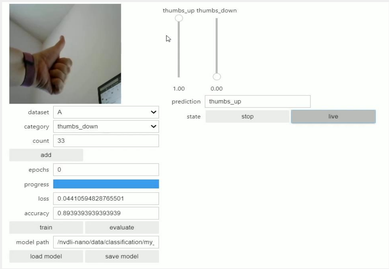


Submit a Project

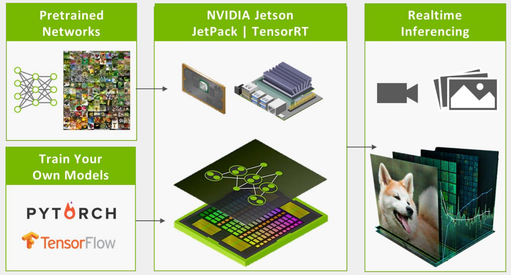
JETSON AI CERTIFICATIONS



Jetson AI Fundamentals



Getting Started with AI on Jetson Nano



Hello AI World

JetBot

nvidia.com/jetson-ai-certification

JETSON AI FUNDAMENTALS

Getting Started with AI on Jetson Nano

System Setup

Camera Capture

Classification

Regression

Hello AI World

Image Recognition

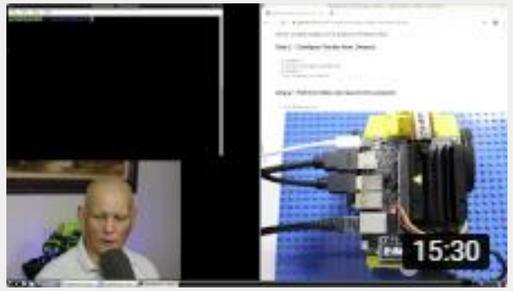
Object Detection

Data Collection + Training

Semantic Segmentation

JetBot

Hardware Setup



Software Setup

Collision Avoidance

Road Following

NVIDIA

GETTING STARTED WITH AI

on Jetson Nano

First Steps in Deep Learning

Interactive collection/training/inference

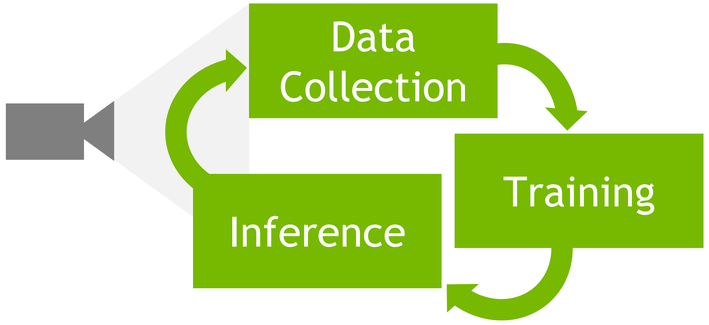
JupyterLab + PyTorch notebooks

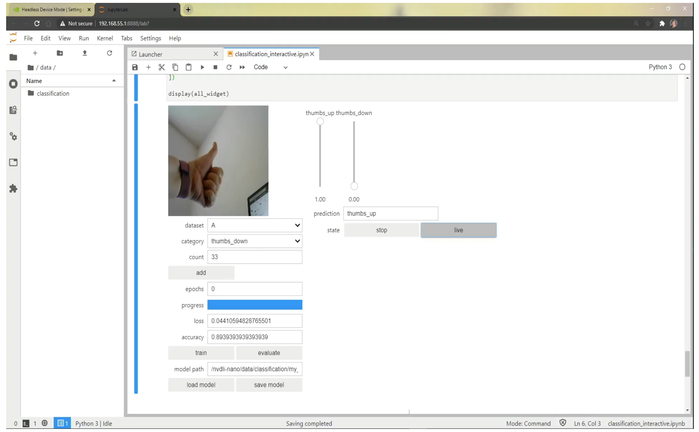
Classification (thumbs up/thumbs down)

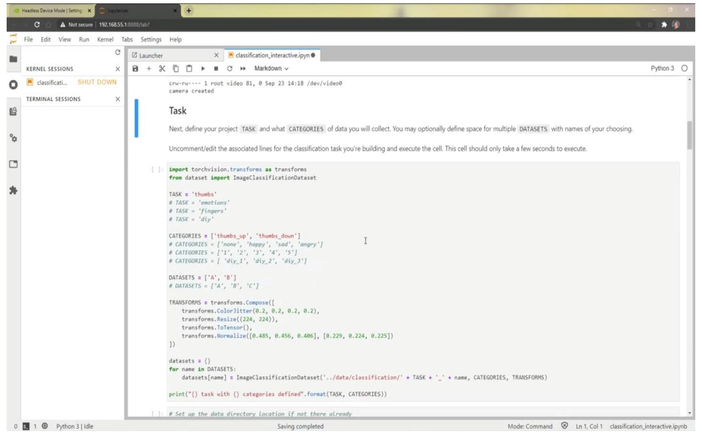
Regression (facial features)

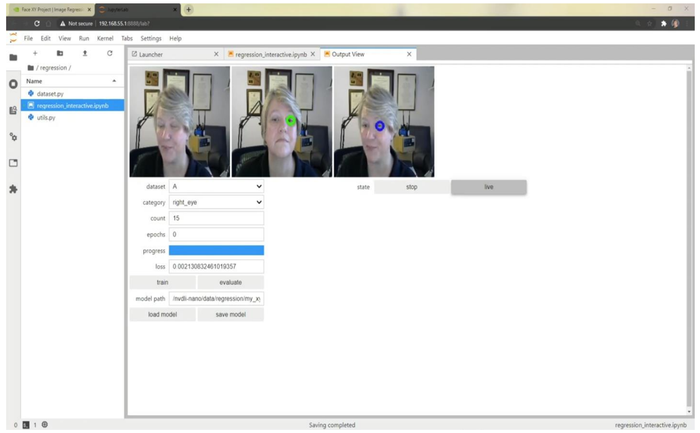
Runs entirely onboard Nano

Fully containerized









DEEP LEARNING INSTITUTE

BUILDING VIDEO AI APPLICATIONS AT THE EDGE

on Jetson Nano

Intelligent Video Analytics with DeepStream

Using DeepStream Python APIs

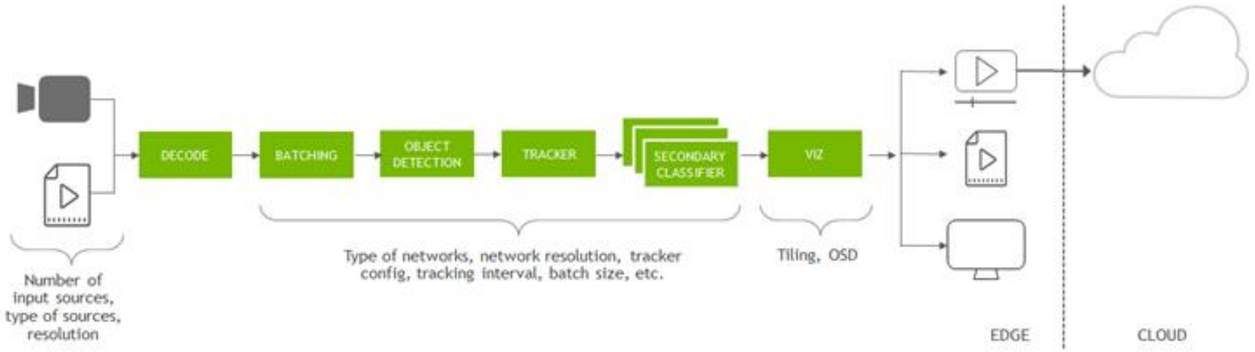
JupyterLab notebooks

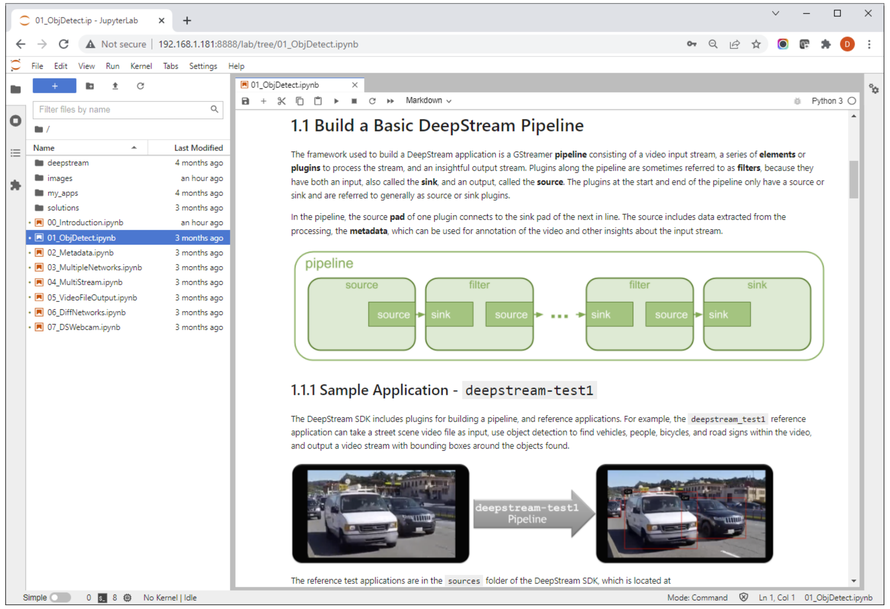
Metadata analysis

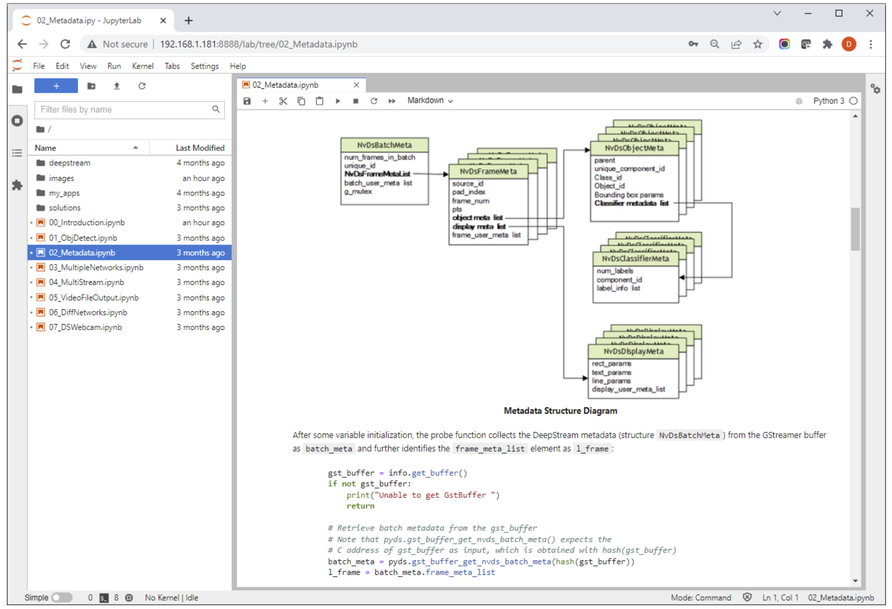
Multiple streams / networks

Object detection & tracking

Live camera streaming







DEEP LEARNING INSTITUTE

HELLO AI WORLD

Create Your Own AI Project

Comes with 40+ pretrained networks

Vision Libraries for Python and C++

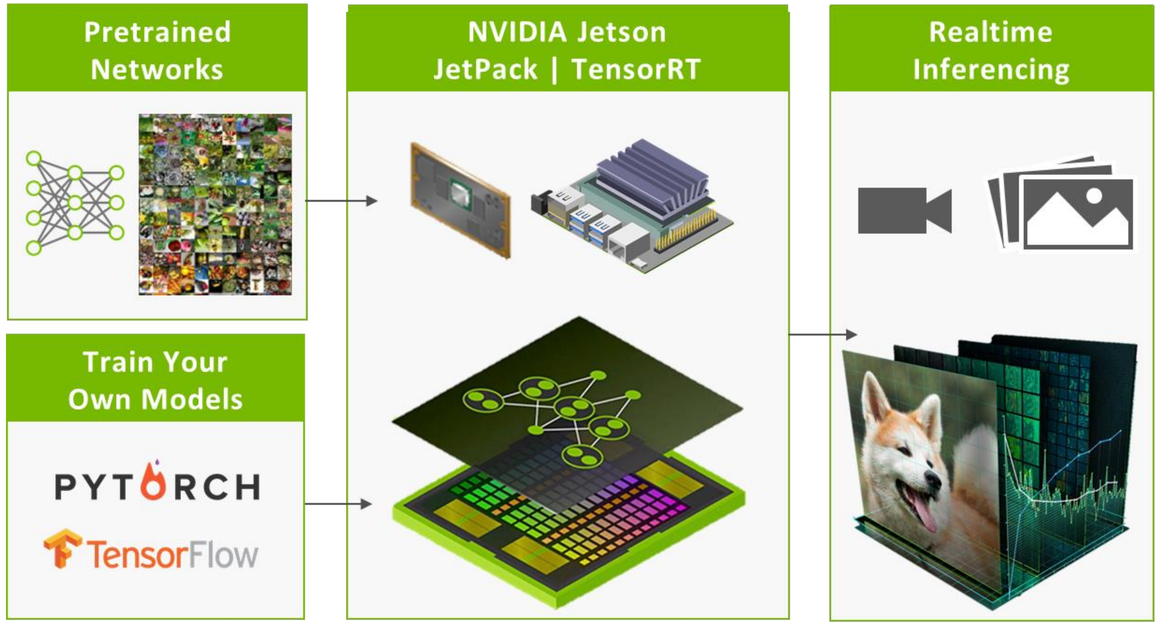
Realtime performance and camera streaming

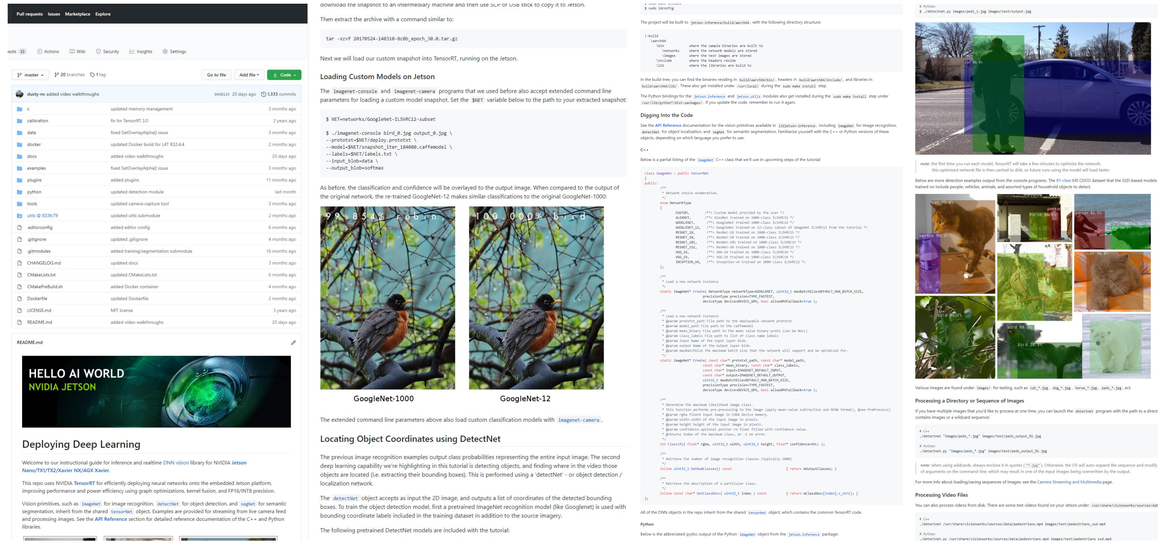
On-device training with PyTorch

Data collection & annotation tool

Ready-to-run Docker container

Step-by-step guides and coding tutorials

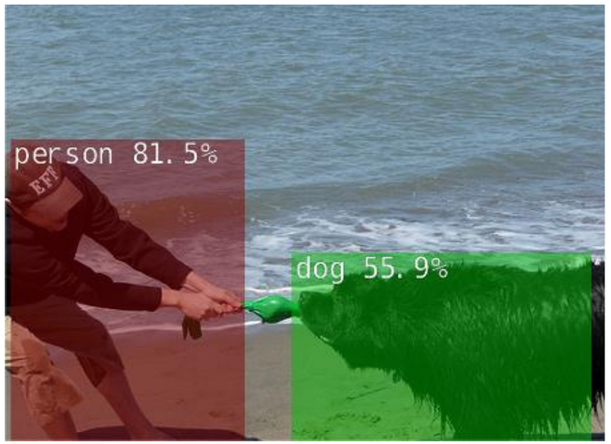




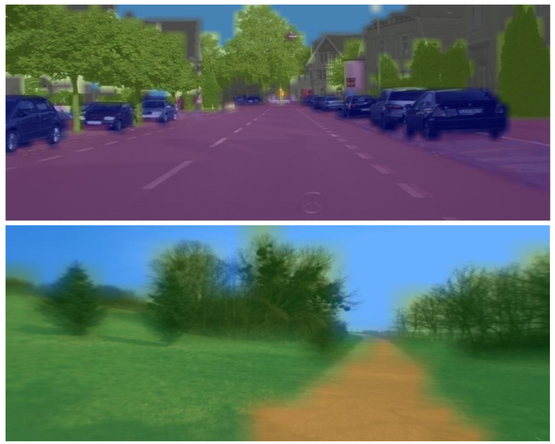
github.com/dusty-nv/jetson-inference

HELLO AI WORLD

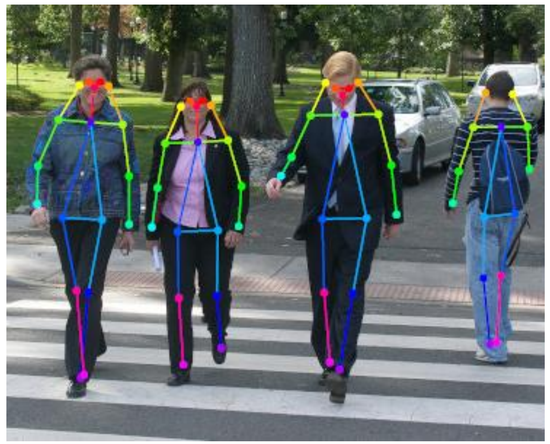
Image Classification



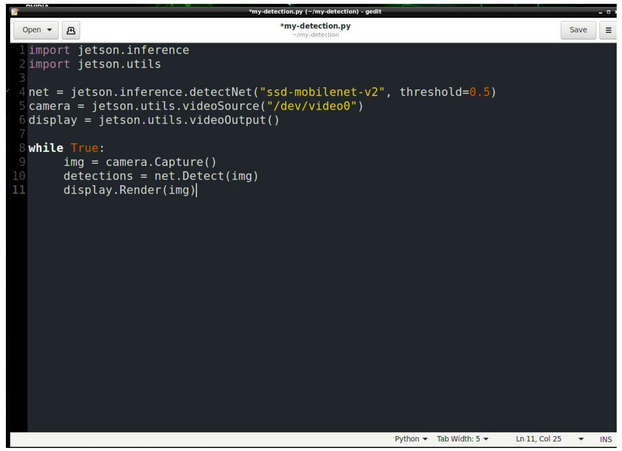
Object Detection



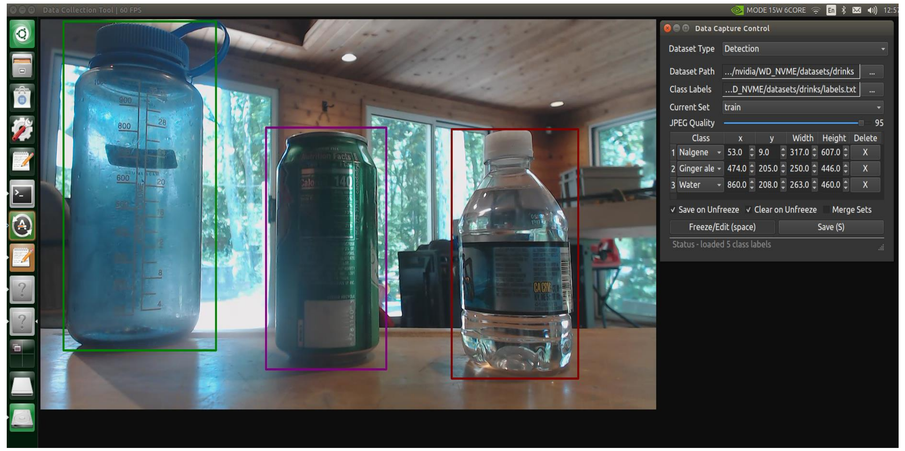
Semantic Segmentation



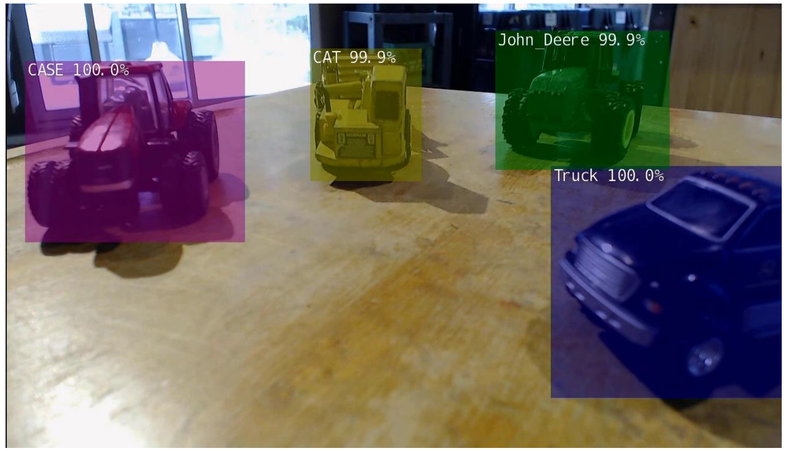
Pose Estimation



Code Your Own Programs
(Python / C++)



Collect Your Own Datasets



Train Your Own Models

JETSON VOICE

ASR / NLP / TTS

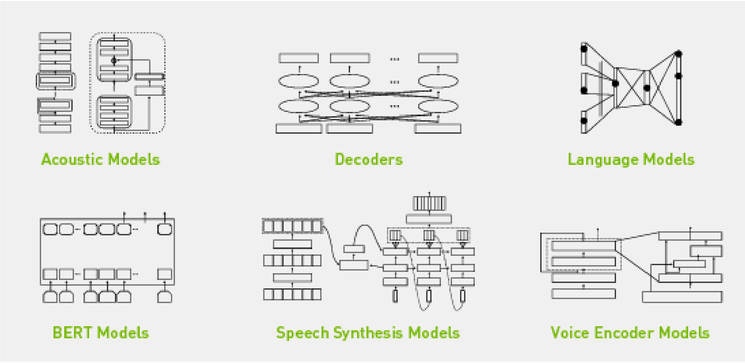
- Streaming ASR
  - Transcription: QuartzNet, Citrinet
  - Classification: Matchboxnet, Marblenet
- NLP (BERT / DistilBERT)
  - Joint Intent/Slot Classification
  - Question Answering (QA)
  - Text Classification (Sentiment Analysis)
  - Token Classification (Named Entity Recognition)
- TTS (FastPitch / HiFi-GAN)

TensorRT-optimized runtime

Models trained with NeMo / PyTorch

Containerized for Jetson

github.com/dusty-nv/jetson-voice



jetson-voice

jetson-voice is an ASR/NLP/TTS deep learning inference library for Jetson Nano, TX1/TX2, Xavier NX, and AGX Xavier. It supports Python and JetPack 4.4.1 or newer. The DNN models were trained with NeMo and deployed with TensorRT for optimized performance. All computation is performed using the onboard GPU.

Currently the following capabilities are included:

- Automatic Speech Recognition (ASR)
  - Streaming ASR (QuartzNet)
  - Command/Keyword Recognition (MatchboxNet)
  - Voice Activity Detection (VAD Marblenet)
- Natural Language Processing (NLP)
  - Joint Intent/Slot Classification
  - Text Classification (Sentiment Analysis)
  - Token Classification (Named Entity Recognition)
  - Question/Answering (QA)
- Text-to-Speech (TTS)

The NLP models are using the DistilBERT transformer architecture for reduced memory usage and increased performance. For samples of the text-to-speech output, see the TTS Audio Samples section below.

Running the Container

jetson-voice is distributed as a Docker container due to the number of dependencies. There are pre-built containers images available on DockerHub for JetPack 4.4.1 and JetPack 4.5/4.5.1:

```
dustynv/jetson-voice:r32.4.4    # JetPack 4.4.1 (L4T R32.4.4)
dustynv/jetson-voice:r32.5.0    # JetPack 4.5 (L4T R32.5.0) / JetPack 4.5.1 (L4T R32.5.1)
```

To download and run the container, you can simply clone this repo and use the `docker/run.sh` script:

```
$ git clone --branch dev https://github.com/dusty-nv/jetson-voice
$ cd jetson-voice
```

Natural Language Processing (NLP)

There are two samples included for NLP:

- `examples/nlp.py` (intent/slot, text classification, token classification)
- `examples/nlp_qa.py` (question/answering)

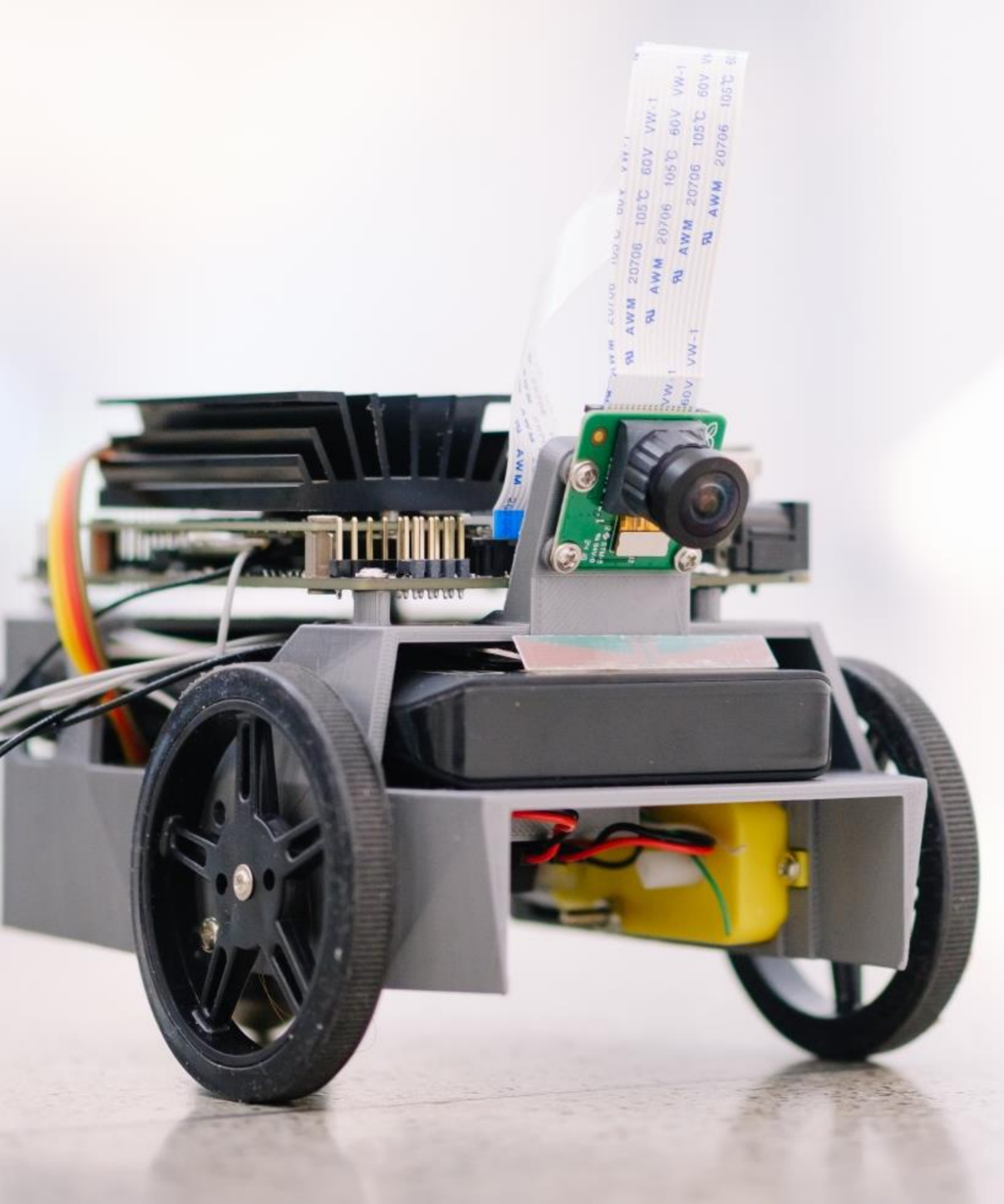
These each use a DistilBERT model which has been fined-tuned for it's particular task. For information about using the NLP APIs, please refer to `jetson_voice/nlp.py` and see the samples above.

Joint Intent/Slot Classification

Joint Intent and Slot classification is a task of classifying an Intent and detecting all relevant Slots (Entities) for this Intent in a query. For example, in the query: `What is the weather in Santa Clara tomorrow morning?`, we would like to classify the query as a `weather` Intent, and detect `Santa Clara` as a location slot and `tomorrow morning` as a date_time slot.

Intents and Slots names are usually task specific and defined as labels in the training data. The included intent/slot model was trained on the NLU-Evaluation-Data dataset - you can find the various intent and slot classes that it supports here. They are common things that you might ask a virtual assistant:

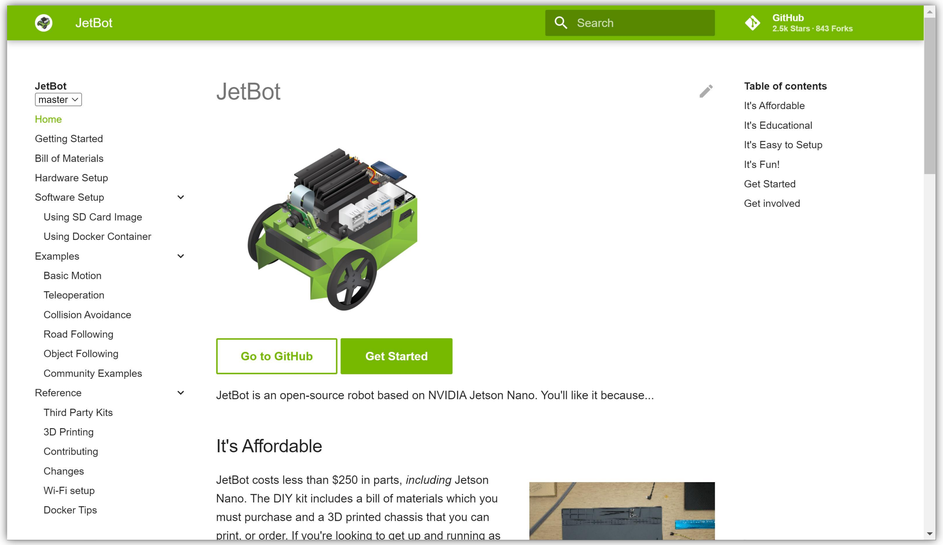
```
$ examples/nlp.py --model distilbert_intent

Enter intent_slot query, or Q to quit:

> What is the weather in Santa Clara tomorrow morning?

{'intent': 'weather_query',
 'score': 0.7165476,
 'slots': [{'score': 0.6280392, 'slot': 'place_name', 'text': 'Santa'},
           {'score': 0.61760694, 'slot': 'place_name', 'text': 'Clara'},
           {'score': 0.5439486, 'slot': 'date', 'text': 'tomorrow'},
           {'score': 0.4520608, 'slot': 'date', 'text': 'morning'}]}

> Set an alarm for 730am

{'intent': 'alarm_set',
 'score': 0.5713072,
 'slots': [{'score': 0.40017933, 'slot': 'time', 'text': '730am'}]}

> Turn up the volume
```



JETBOT

- Open-Source Autonomous Deep Learning Robotics Kit
- Programmable through Jupyter notebooks
- Workflow for creating dataset for and training image classification, image regression deep learning network
- ROS support and Gazebo simulator available

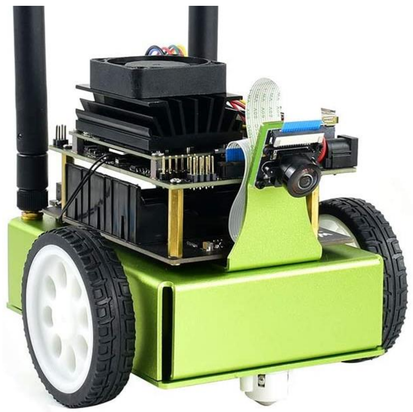
Visit the website at **jetbot.org**



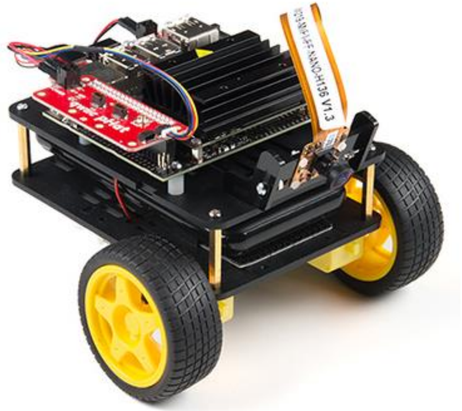
GPU TECHNOLOGY CONFERENCE
SAN JOSE McENERY CONVENTION CENTER

JETBOT KITS

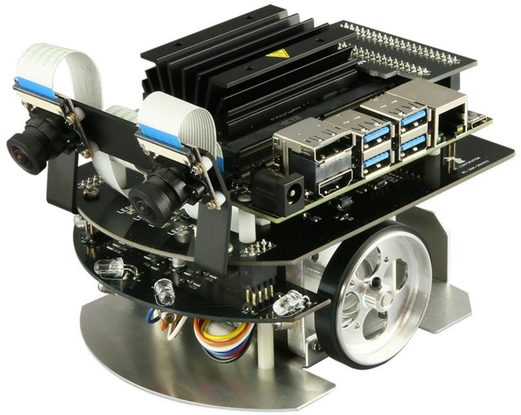
Duckietown



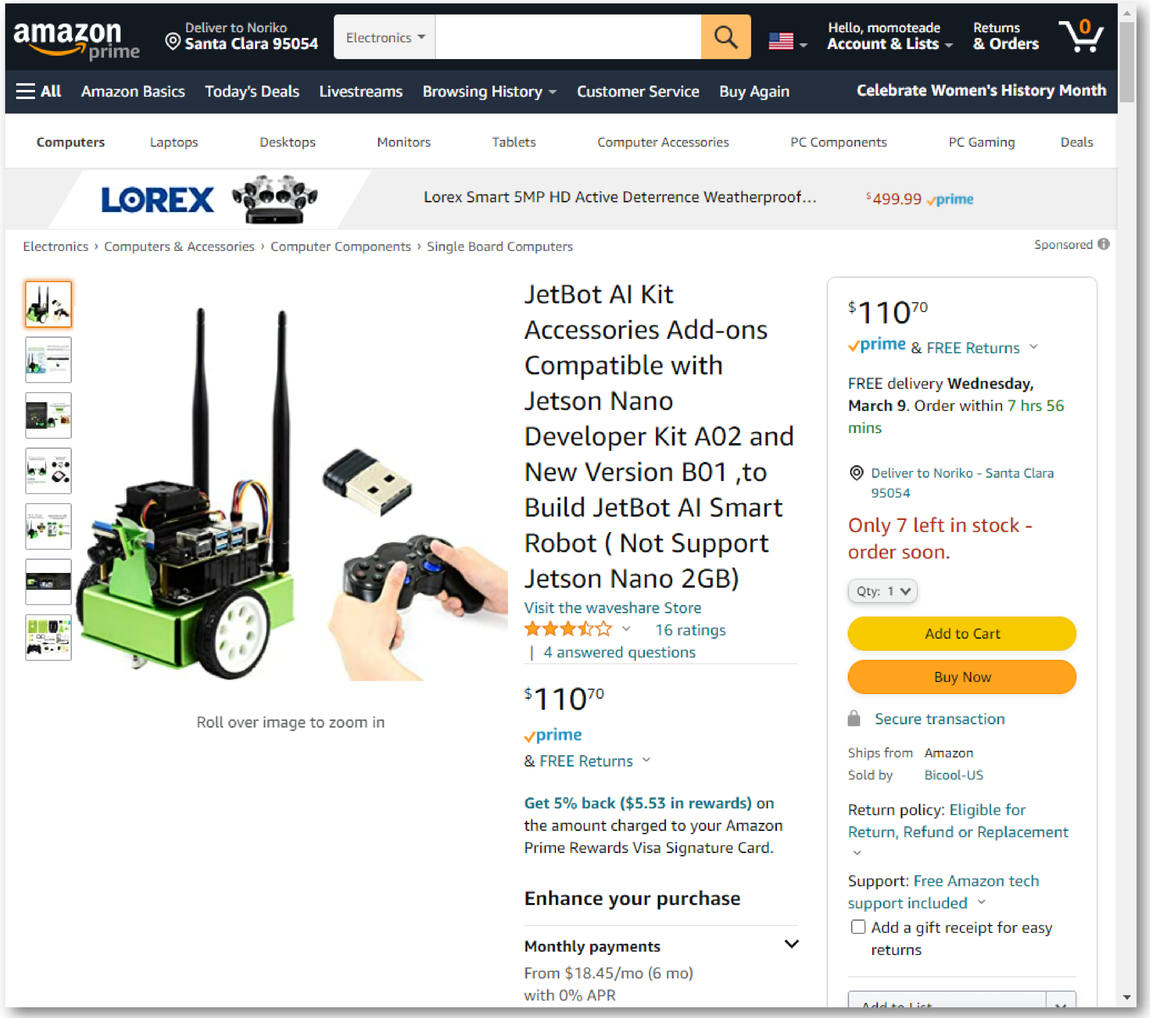
Waveshare



SparkFun



RT



NVIDIA

jetbot.org

JetBot

Search

GitHub
1.9k Stars · 649 Forks

JetBot
master

- Home
- Getting Started
- Bill of Materials
- Hardware Setup
- Software Setup
  - Using SD Card Image
  - Using Docker Container
- Examples
  - Basic Motion
  - Teleoperation
  - Collision Avoidance
  - Road Following
  - Object Following
- Reference
  - Third Party Kits
  - 3D Printing
  - Contributing
  - Changes
  - Wi-Fi setup
  - Docker Tips

JetBot

Go to GitHub | Get Started

JetBot is an open-source robot based on NVIDIA Jetson Nano. You'll like it because...

It's Affordable

JetBot costs less than $250 in parts, *including* Jetson Nano. The DIY kit includes a bill of materials which you must purchase and a 3D printed chassis that you can print, or order. If you're looking to get up and running as quick as possible, there are also many third party kits available that come pre-bundled.

It's Educational

JetBot includes a set of Jupyter notebooks which cover basic robotics concepts like programatic motor control, to more advanced topics like training a custom AI for avoiding collisions. What you'll learn isn't limited to JetBot. You'll learn concepts related to neural network data collection and training that extend as far as your imagination.

It's Easy to Setup

Table of contents

- It's Affordable
- It's Educational
- It's Easy to Setup
- It's Fun!
- Get Started
- Get involved

JETBOT-BASED ROBOTS FOR DEVELOPERS

Commercially available, ready-to-code

Jetson TX2 4GB

Double 3
by Double Robotics

$4,500~

Jetson Xavier NX Developer Kit

Create 3
by iRobot

$300

Jetson Xavier NX

Cyberdog
by Xiaomi

$?

DOUBLE 3 BY DOUBLE ROBOTICS

Complete tele-existence robot, open to developers

Cameras
- 2x CSI camera on tilt motor
- 2x RealSense depth camera

Sensors
- 2x (RealSense D430)
- 5x Ultrasonic range detectors
- Wheel encoders
- IMU (9 DoF)

Battery
- 4 hour of runtime

Audio
- Microphone array (6ch)
- Speaker (8W)

Display
- 9.7” multi-touch LCD
- Remotely adjustable height

Developer Expansion
- 2x USB 3.1 ports on back
- On-board D3-API
- Dashboard

Jetson TX2 4GB

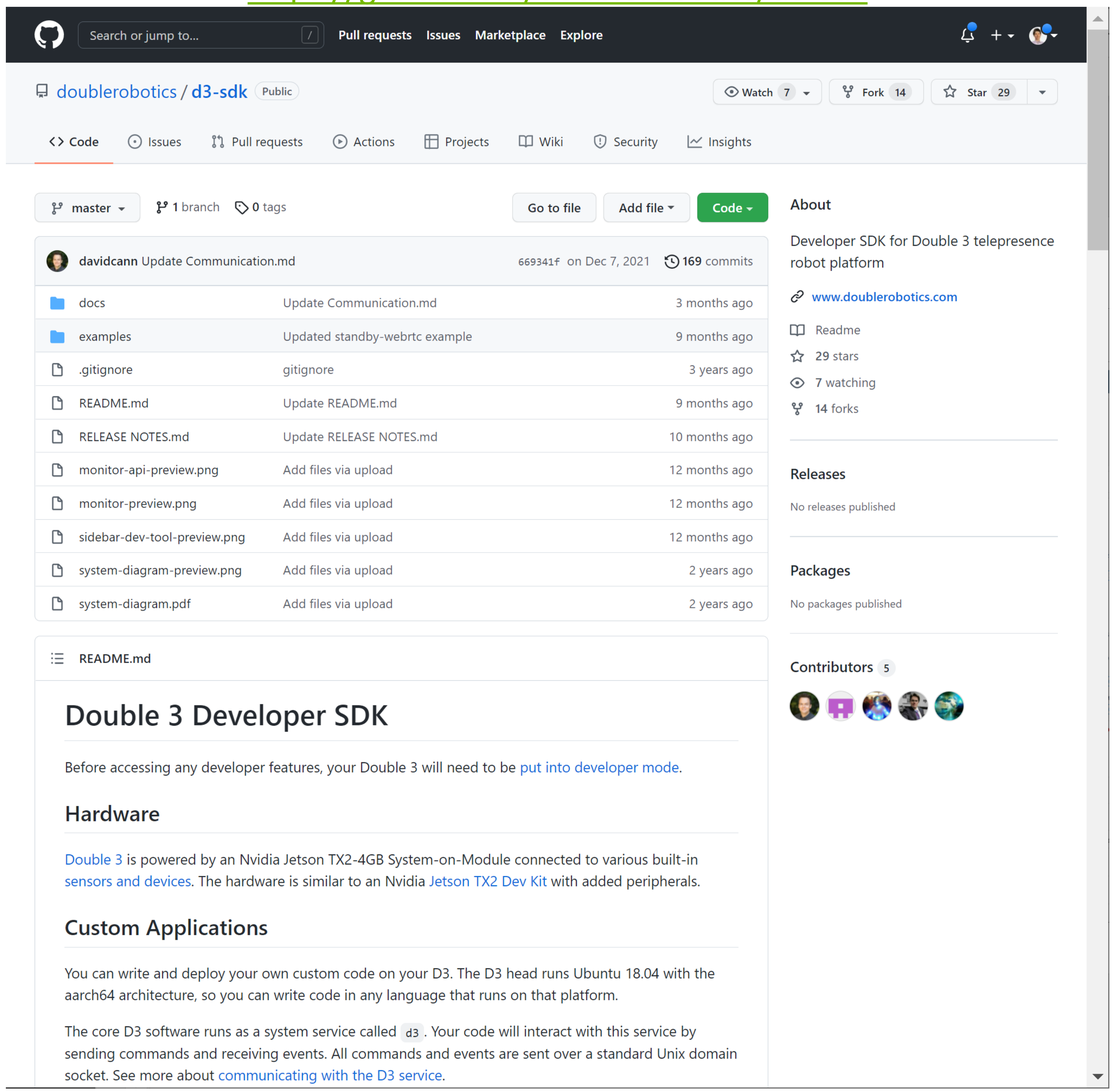
https://www.doublerobotics.com/double3.html

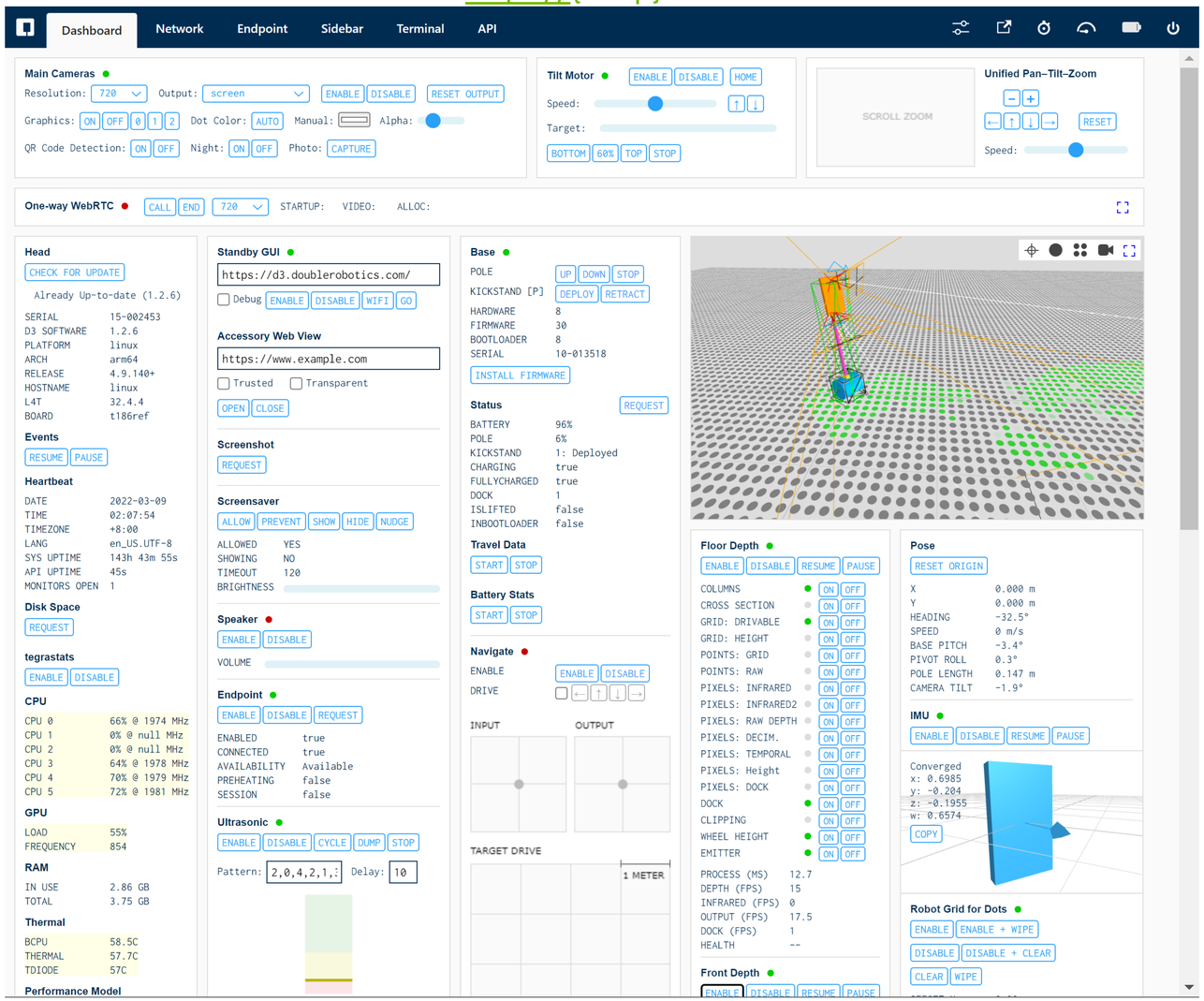
DEVELOPER-FRIENDLY

D3-API, Dashboard

https://github.com/doublerobotics/d3-sdk

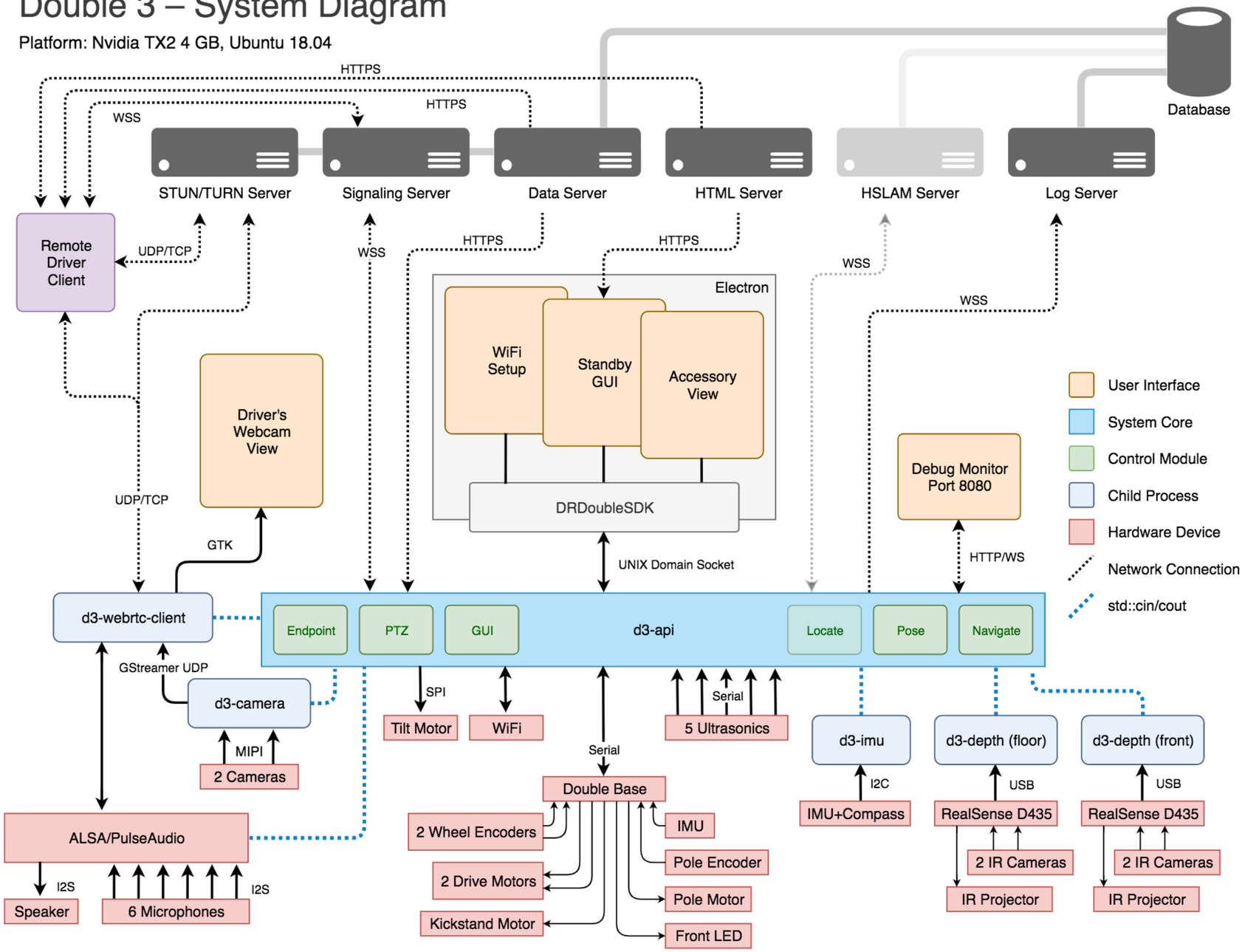
https://{d3-ip}:8080

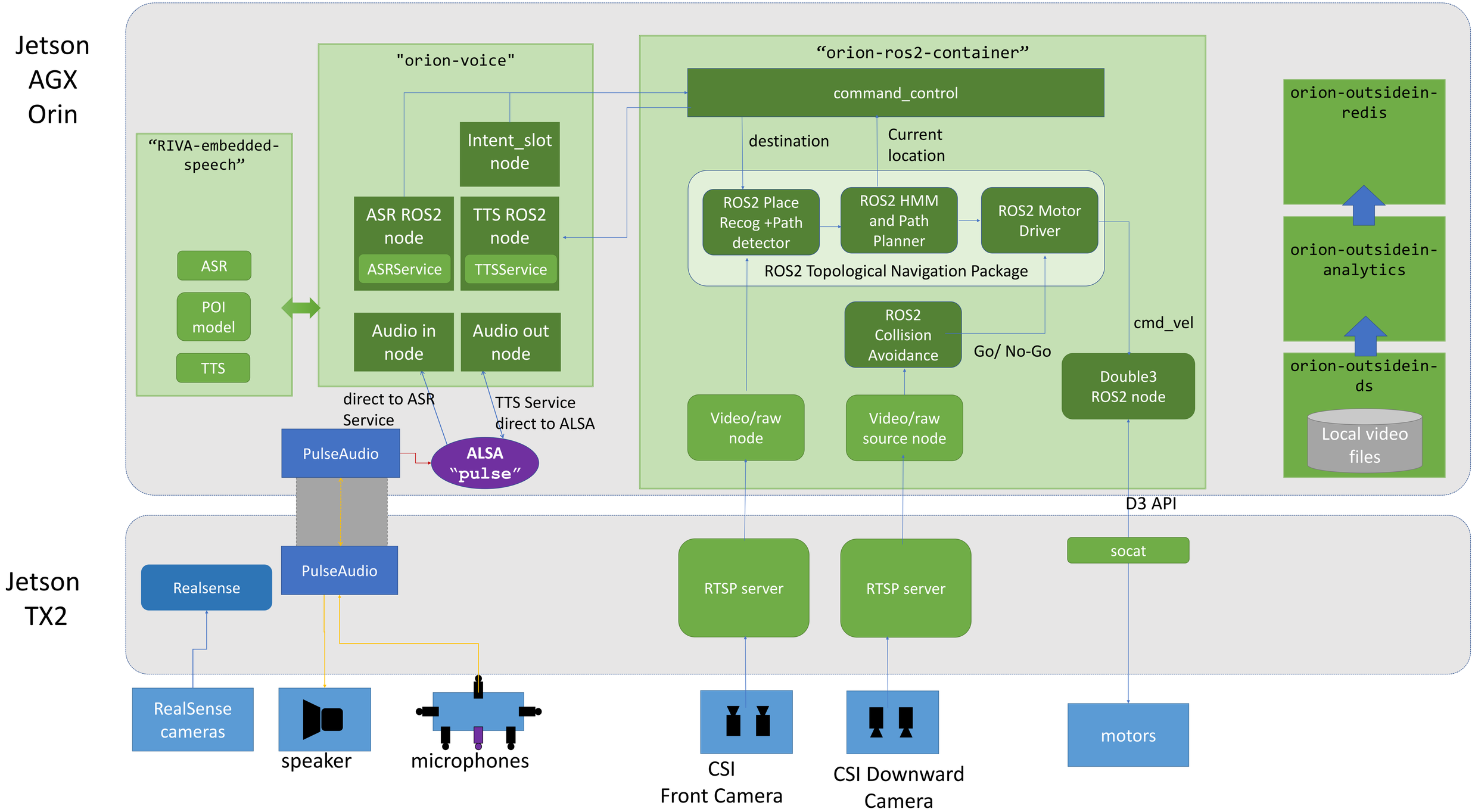




Double 3 – System Diagram

Platform: Nvidia TX2 4 GB, Ubuntu 18.04




Jetson AGX Orin
"orion-voice"
"RIVA-embedded-speech"
ASR
POI model
TTS
Intent_slot node
ASR ROS2 node
ASRService
TTS ROS2 node
TTSService
Audio in node
Audio out node
direct to ASR Service
TTS Service direct to ALSA
PulseAudio
ALSA "pulse"
"orion-ros2-container"
command_control
destination
Current location
ROS2 Place Recog +Path detector
ROS2 HMM and Path Planner
ROS2 Motor Driver
ROS2 Topological Navigation Package
ROS2 Collision Avoidance
Go/ No-Go
cmd_vel
Double3 ROS2 node
Video/raw node
Video/raw source node
orion-outsidein-redis
orion-outsidein-analytics
orion-outsidein-ds
Local video files
D3 API
socat
Jetson TX2
Realsense
PulseAudio
RTSP server
RTSP server
RealSense cameras
speaker
microphones
CSI Front Camera
CSI Downward Camera
motors

TIPS FOR DEVELOPING ON DOUBLE 3

- Camera access
  - through v4l2loopback device (`/dev/video10`)
- Use Docker containers
- Limitations
  - Storage → USB thumb-drive
  - 4GB RAM → TensorRT optimization
- USB-C battery if you are mounting Jetson AGX Orin

```
prob_blocked: {} 0.0218048095703125
prob_blocked: {} 0.092041015625
prob_blocked: {} 0.03338623046875
prob_blocked: {} 0.0411376953125
prob_blocked: {} 0.042205810546875
prob_blocked: {} 0.06268310546875
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prob_blocked: {} 0.03460693359375
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prob_blocked: {} 0.09234619140625
prob_blocked: {} 0.06390380859375
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prob_blocked: {} 0.0577392578125
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prob_blocked: {} 0.09185791015625
prob_blocked: {} 0.07330322265625
prob_blocked: {} 0.0562744140625
prob_blocked: {} 0.056671142578125
prob_blocked: {} 0.053466796875
```
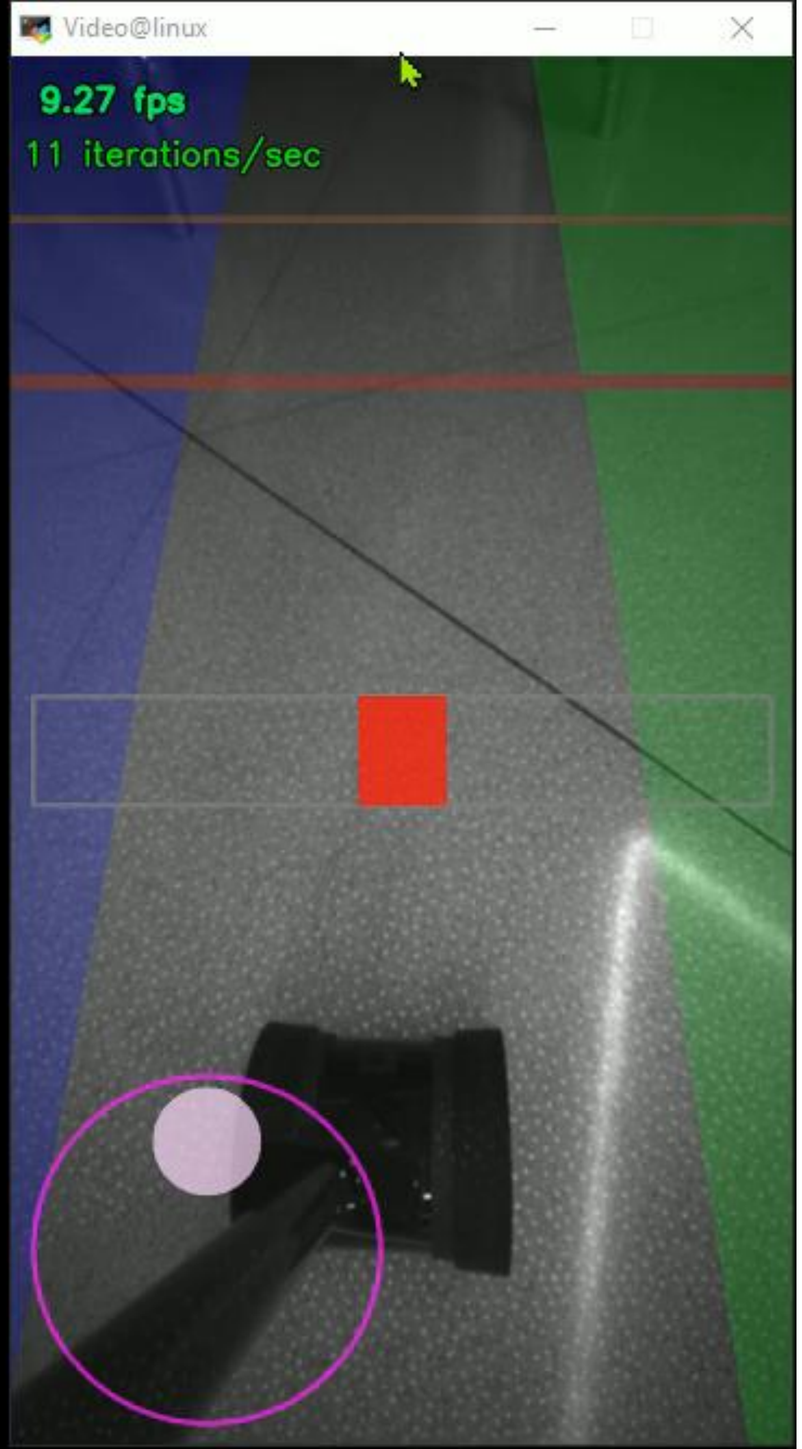



CREATE 3 BY IROBOT

Base for TurtleBot4

https://edu.irobot.com/what-we-offer/create3

Complete ROS2 robot

- ROS 2 on ARM Linux
- Connectivity
  - Wi-Fi
  - Ethernet over USB Host

Sensors

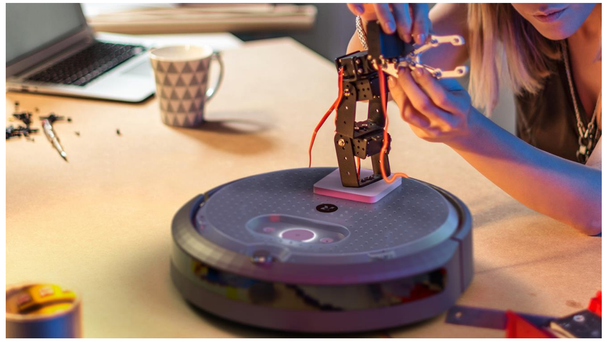
- 1x power button
- 2x user buttons
- 2x front bumper
- 2x wheel encoders
- 4x IR cliff sensors
- 6x IR obstacle sensors
- 1x downward optical flow sensor
- 1x IMU
- 1x battery level monitor

Actuators

- 2x drive motors
- 6x RGB LED ring
- 1x Speaker

Power

- Nominal 14.4V battery
- Power out
  - 1x USB-C for 3A/5V out (and data)
  - 1x 14.4V out (~2A)
- Docking port



https://iroboteducation.github.io/create3_docs/

RPi 4

Jetson Xavier NX Developer Kit

Jetson Nano 2G Developer Kit

https://iroboteducation.github.io/create3_docs/

Create® 3 Docs

Search

iRobotEducation/create3_d...
4 3

Create® 3 Docs
- Home
- Hardware
- Setup
- APIs
- Simulator
- Software Examples
- Software Releases

iRobot® Create® 3 Educational Robot

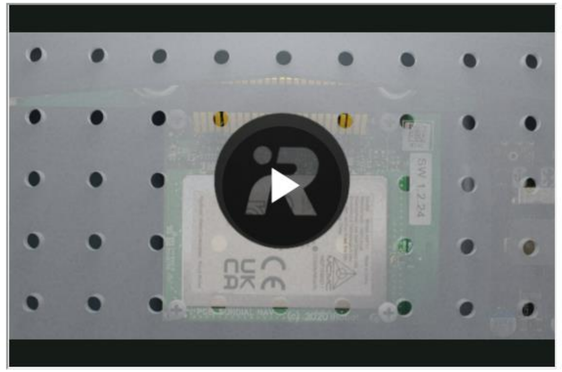


Table of contents

What is iRobot® Create® 3?
Key internal docs links
Useful external links

What is iRobot® Create® 3?

iRobot® Create® 3 is an affordable, mobile robotics platform for educators, students, and developers.

The robot has a full suite of on-board sensors and actuators which will allow you to develop and test your robotics algorithms.

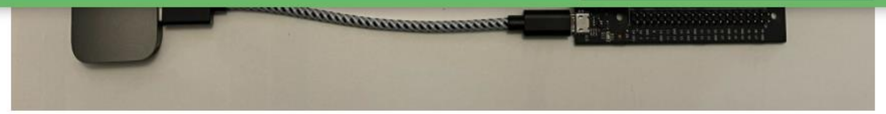
The software is entirely based on ROS 2: all sensors data are produced through ROS 2 publications while ROS 2 servers and subscriptions are used to control actuators and respond to users requests. The robot also provides some autonomous behaviors out of the box, such as docking, wall-follow and reactions to obstacles. All these can be triggered and/or configured through ROS 2 actions and parameters.

Designed for beginner to advanced ROS 2 users, Create® 3 allows for a variety of programming methods. With Wi-fi and Bluetooth capability, Ethernet over USB connections, plus a removable faceplate for attaching payloads, you can start building with your Create® 3 right away.

More detailed documentation can be accessed using the left navigation bar, or if it is collapsed, the ☰ menu in the top left corner of this page.

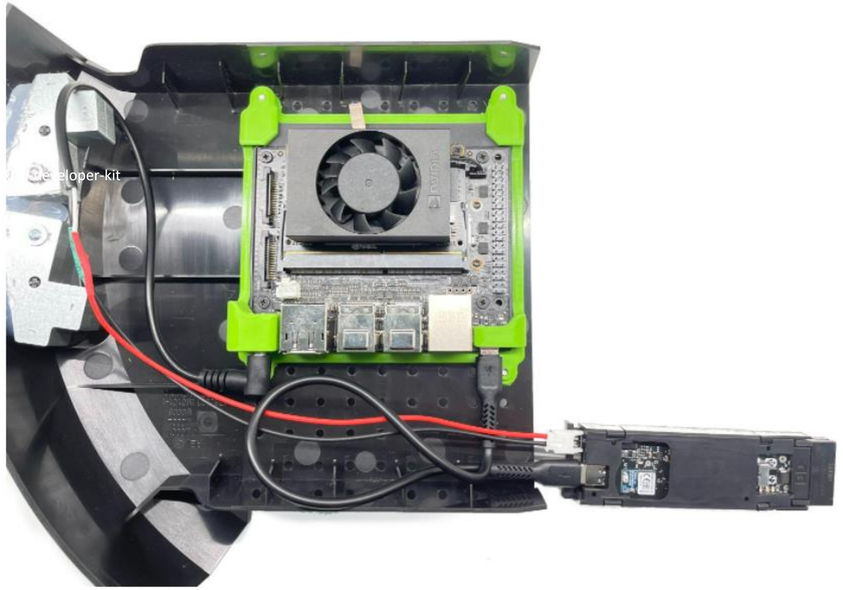
https://iroboteducation.github.io/create3_docs/hw/hookup/

Create® 3 Docs
Home
Hardware
Overview
Mechanical
Electrical
Hookup Examples
Setup
APIs
Simulator
Software Examples
Software Releases



NVIDIA® Jetson Xavier NX™ Developer Kit

The Jetson Xavier NX™ Developer Kit has a 5.5mm x 2.5mm barrel connector jack (J16) for power (9 V to 20 V) and a USB Micro-B port (J5) for downstream data.
This can be powered from the unregulated battery port of the Create® 3 adapter board by using a JST-XH female connector to DC barrel plug cable. The data connection is established by using a USB Micro B to USB-C® cable.



Mounting NVIDIA® Jetson Xavier NX™ Developer Kit

You can 3d print the mount adapter to place the Jetson Xavier NX Developer Kit in the cargo bay or on the faceplate.

Note

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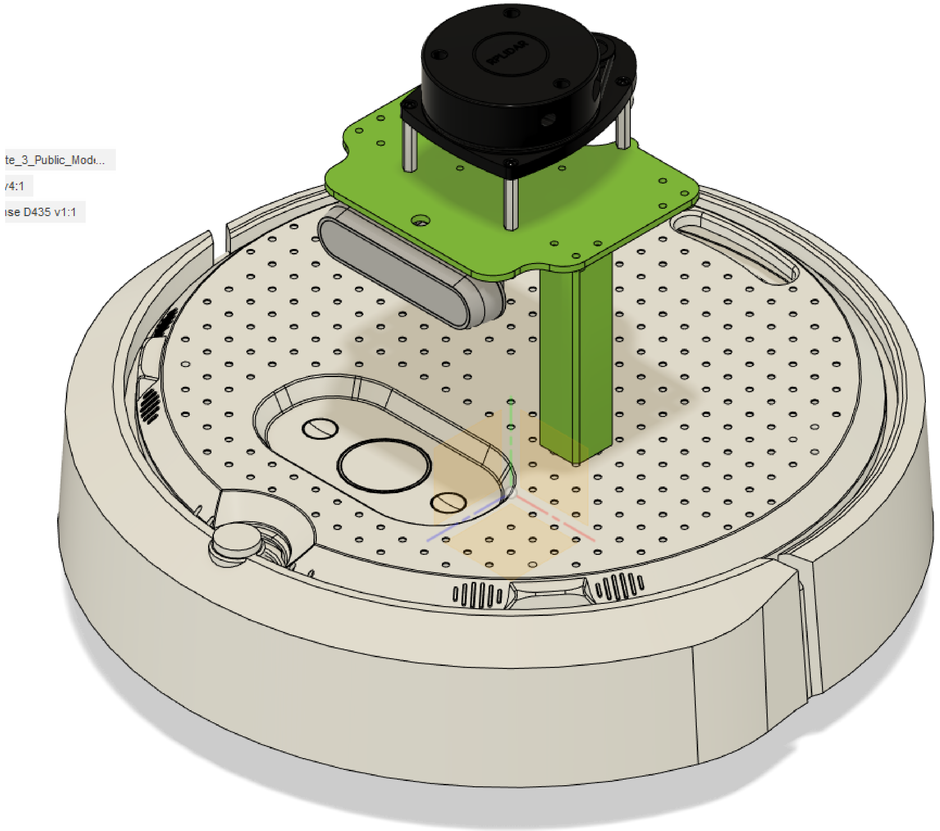
Raspberry Pi®
Raspberry Pi® 4
Raspberry Pi® 1-3 Model B
Raspberry Pi® Zero
NVIDIA® Jetson Nano™ 2GB
NVIDIA® Jetson Xavier NX™ Developer Kit
Mounting NVIDIA® Jetson Xavier NX™ Developer Kit

CREATE 3 ROS2 TOPICS

```
$ ros2 topic list -t
/battery_state [sensor_msgs/msg/BatteryState]
/cmd_audio [irobot_create_msgs/msg/AudioNoteVector]
/cmd_lightring [irobot_create_msgs/msg/LightringLeds]
/cmd_vel [geometry_msgs/msg/Twist]
/dock [irobot_create_msgs/msg/Dock]
/hazard_detection [irobot_create_msgs/msg/HazardDetectionVector]
/imu [sensor_msgs/msg/Imu]
/interface_buttons [irobot_create_msgs/msg/InterfaceButtons]
/ir_intensity [irobot_create_msgs/msg/IrIntensityVector]
/ir_opcode [irobot_create_msgs/msg/IrOpcode]
/kidnap_status [irobot_create_msgs/msg/KidnapStatus]
/mouse [irobot_create_msgs/msg/Mouse]
/odom [nav_msgs/msg/Odometry]
/parameter_events [rcl_interfaces/msg/ParameterEvent]
/rosout [rcl_interfaces/msg/Log]
/slip_status [irobot_create_msgs/msg/SlipStatus]
/stop_status [irobot_create_msgs/msg/StopStatus]
/tf_static [tf2_msgs/msg/TFMessage]
/wheel_status [irobot_create_msgs/msg/WheelStatus]
/wheel_ticks [irobot_create_msgs/msg/WheelTicks]
/wheel_vels [irobot_create_msgs/msg/WheelVels]
```


te_3_Public_Mod...
/4:1
ise D435 v1:1

TurtleBot
CLEARPATH

CYBERDOG BY XIAOMI

Jetson Xavier NX on a quadruped

Hardware

- 12DoF, 14kg

Sensors

- Jetson
  - 13MP AI camera (OV13B10)
  - Stereo camera (OV7251 x2)
  - Intel Realsense D450
- Ultrasonic
- Others.

Software

- Controllable through ROS2 and gRPC

Power

- USB-C to recharge
- Detachable battery

https://github.com/MiRoboticsLab/cyberdog_ros2/blob/main/README_EN.md

OVERVIEW

Cyberdog Hardware

To Access Nvidia Xavier NX:

1. Power On
2. Plug in monitor + keyboard. User: “mi” password: “123”
3. Or ssh mi@192.168.1.55 over USB

Figure: Cyberdog

Figure: USB and HDM ports on top of the robot

After login:

- Modified JetPack 4.5
- sudo access
- no strings attached

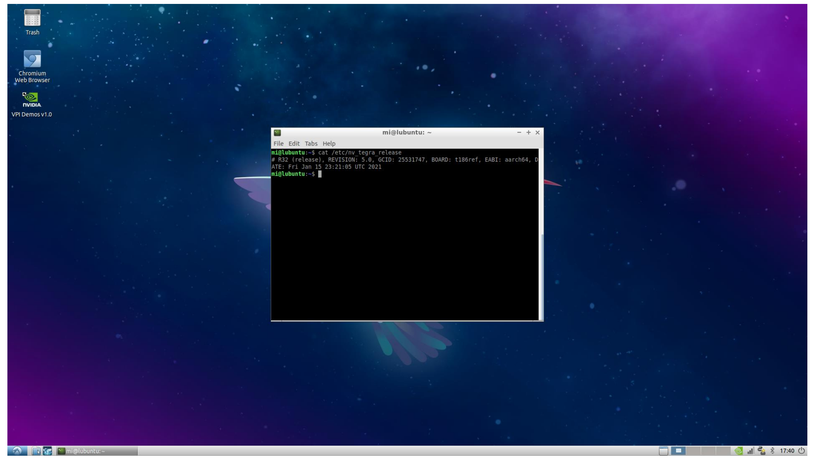


Figure: Cyberdog’s Desktop Environment

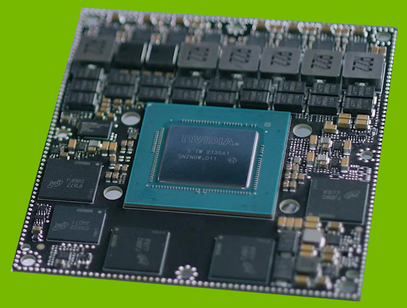
SOFTWARE

Resources

- Cyberdog source code:
  https://github.com/MiRoboticsLab/cyberdog_ros2
- Cyberdog Linux kernel (JetPack 4.5 + drivers):
  https://github.com/MiRoboticsLab/cyberdog_tegra_kernel
- Motor SDK:
  https://github.com/MiRoboticsLab/cyberdog_motor_sdk

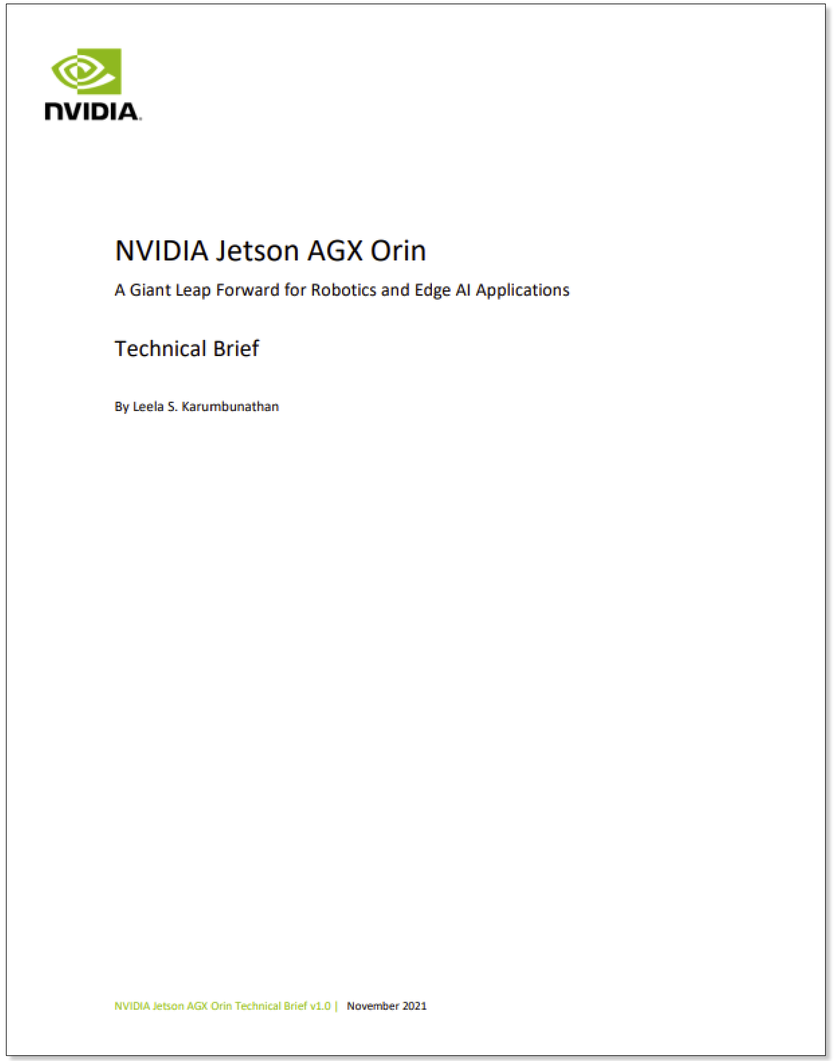
Keep in touch!

dustinf@nvidia.com | cyato@nvidia.com



Jetson Portal	developer.nvidia.com/jetson
Jetson Zoo	eLinux.org/jetson_zoo
Dev Forums	forums.developer.nvidia.com
Get Certified	nvidia.com/jetson-ai-certification

Q&A: What can we help you build?



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Technical Brief

By Leela S. Karumbunathan

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