THE UNIVERSITY OF TENNESSEE KNOXVILLE

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Building a Autonomous Vehicle with Jetson Orin

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Acknowledgements

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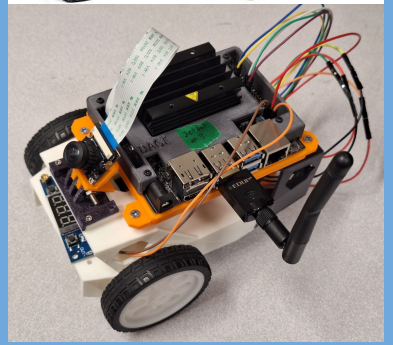
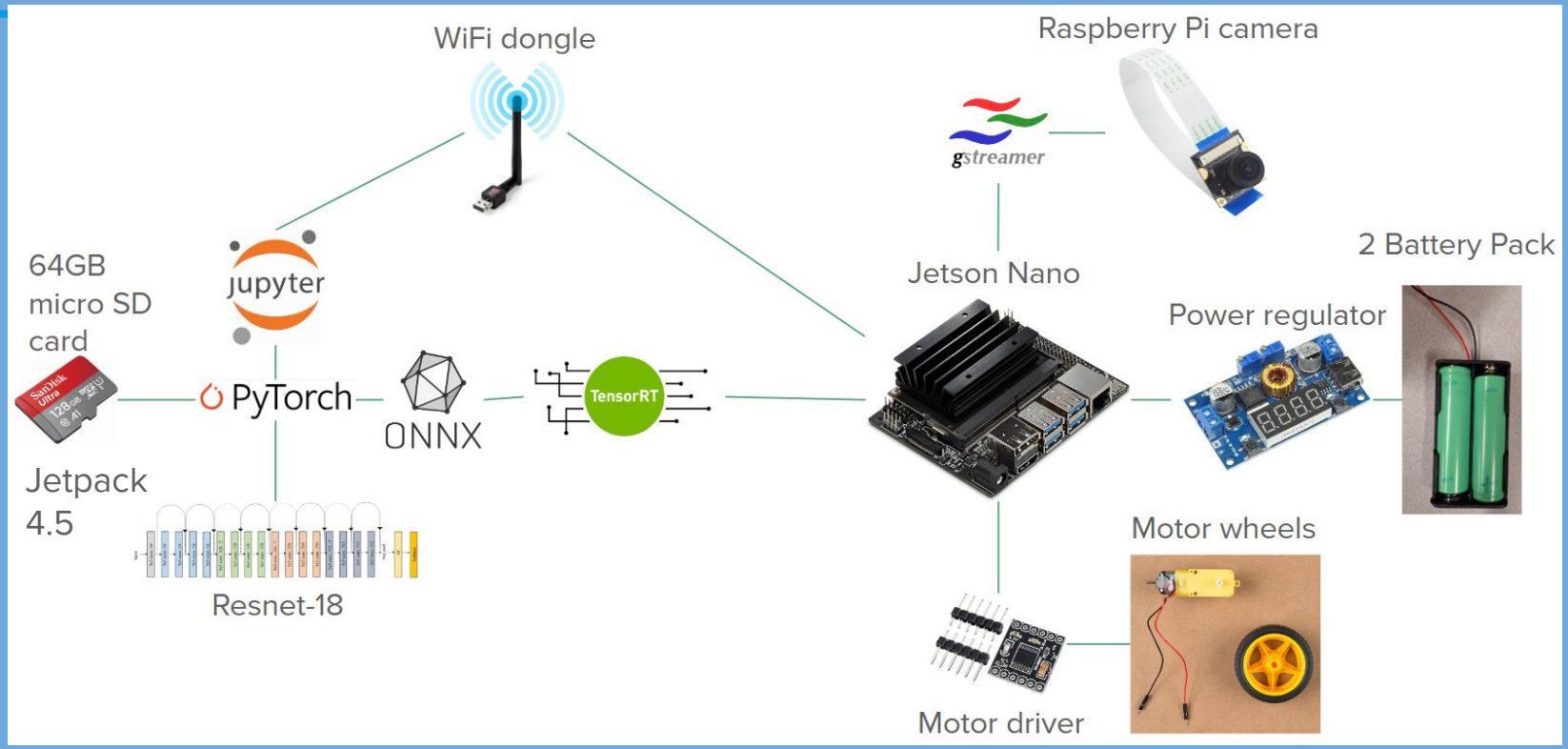
Grasping the Basics of Jetbot

- Starting with the Jetson Nano, we've recreated and tested preexisting Jetbots
- Version 1. Jetbot kit from NVIDIA guided us in understand the software and basic functions of the Jetbot
- Version 3. Jetbot kit made by Patrick Lau helped us comprehend how to assemble the hardware components to work together

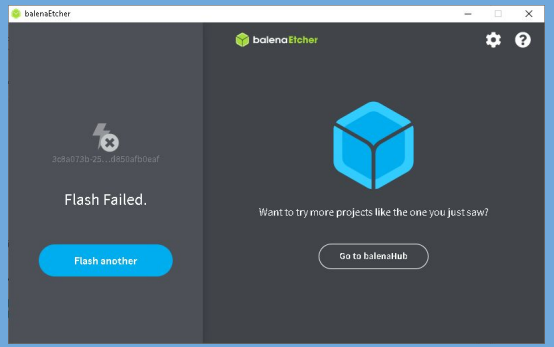


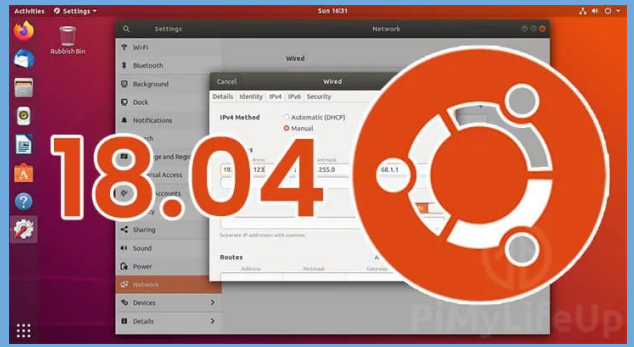
Jetson Nano Jetbot Schematic



Jetson Nano no longer supported

- Nvidia stopped supporting the Jetson Nano in 2023
- Recent software by Steven Qiu and Franklin Zhang showed us to how the Jetson Nano has incompatible and outdated updates and installations
- This led to relying on older versions of certain software and not being able to use certain upgrades





Upgrading the Jetbot via Jetson Orin

- Transitioning software for the Jetbot on the Jetson Nano to the newer Jetson Orin
- Creating a new chassis to support the Orin
- Trying new software for object detection and autonomous movement with new software.
- Creating a code such that multiple cameras can use object detection

Why?

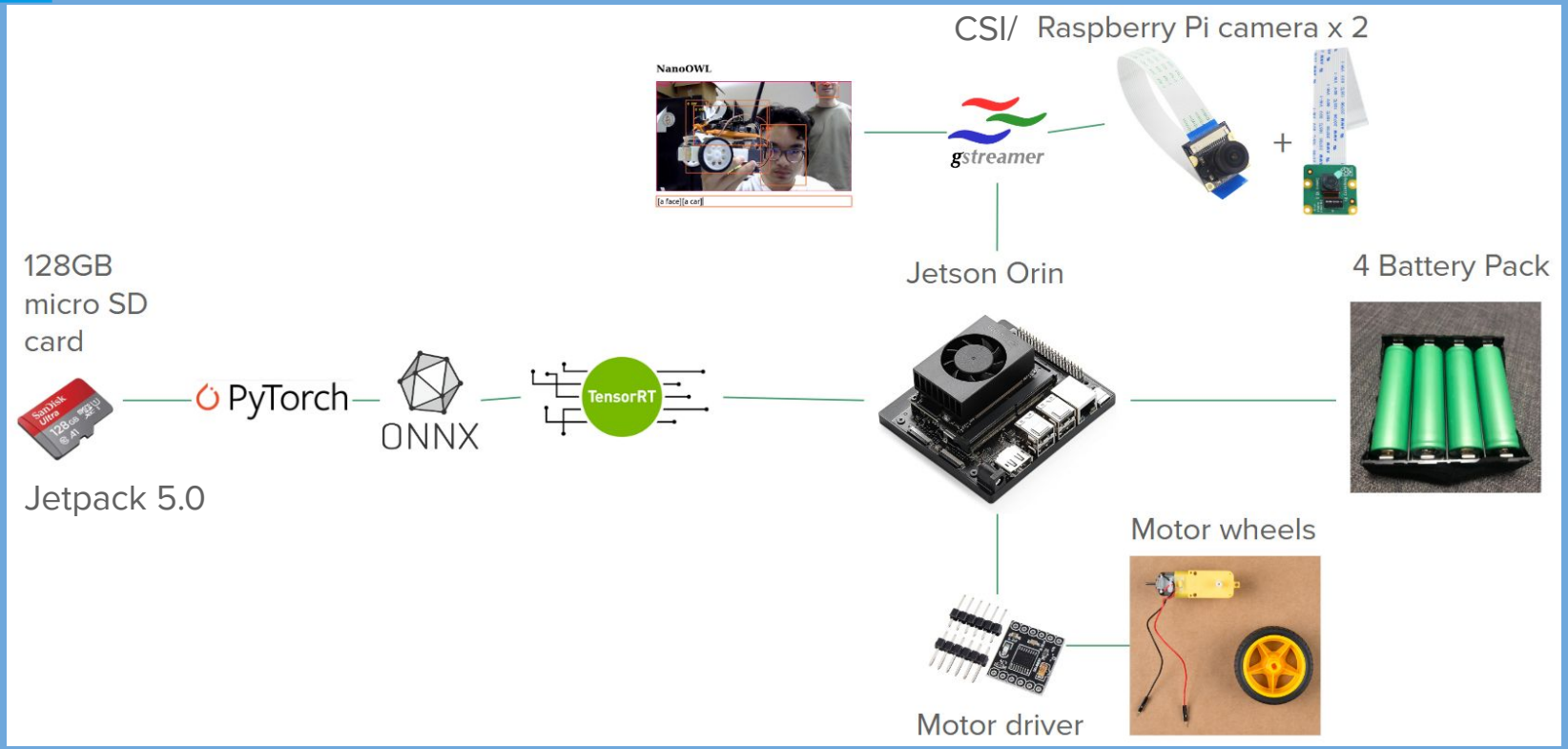
- Camera synchronization is better on the Jetson Orin
- 80x processing power than the Jetson Nano
- Software is being updated regularly

Assembly Problems

Major Problems:

- No pre-existing software or developments
- Different versions of software cause conflicts with already pre-trained models and causes the Orin to run into errors.
- Our cameras didn’t work with the newest version of Jetpack released by Nvidia.
- Hardware has unidentifiable errors, which could be due to the quality of materials used.
- Batteries had a difficult time maintaining power on the Orin.

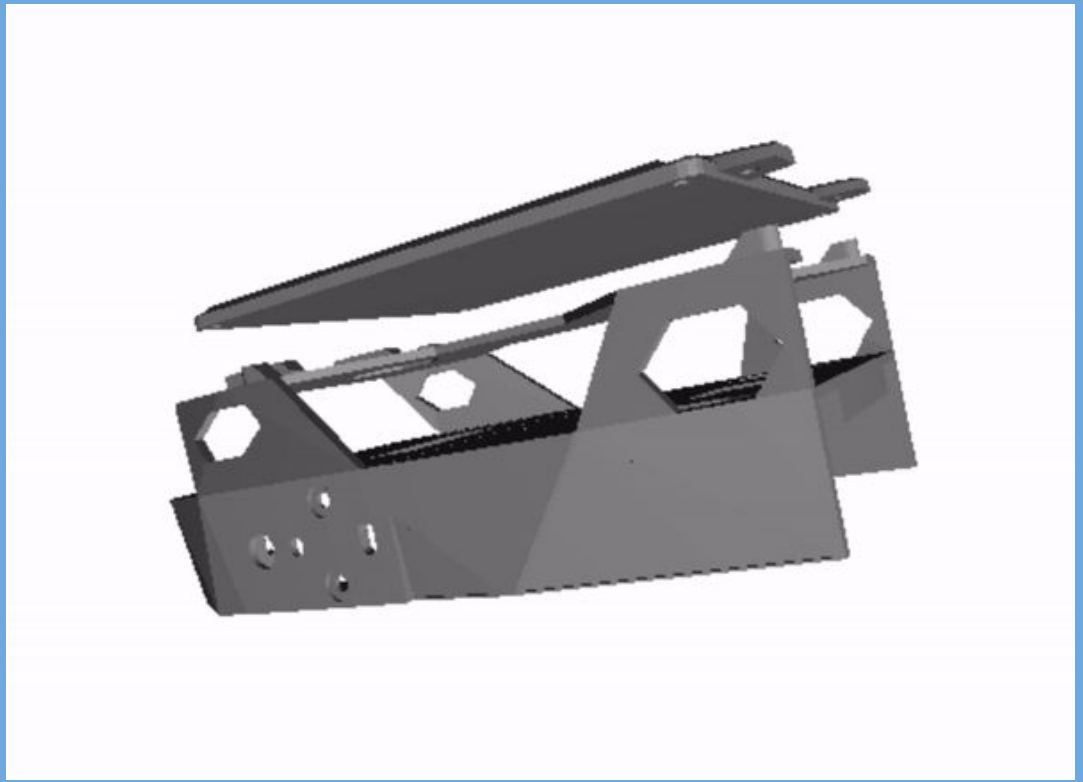
Jetson Orin Jetbot Schematic



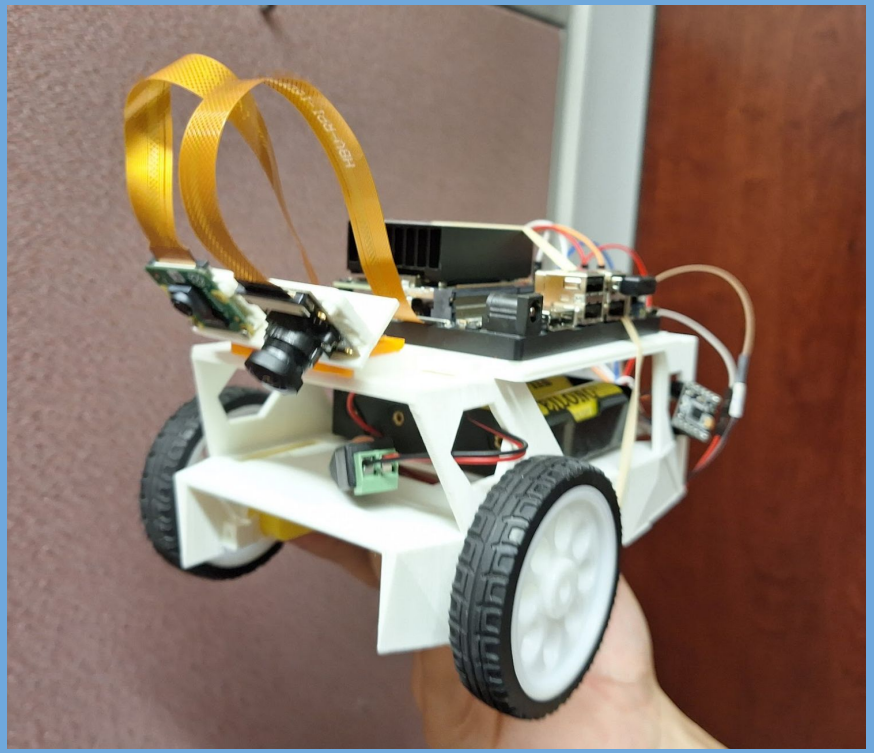
Modified 3D models

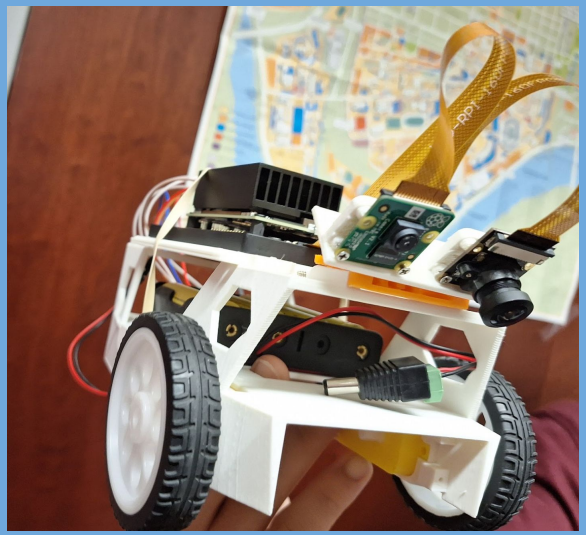
Here is a 3D render of the STL file.

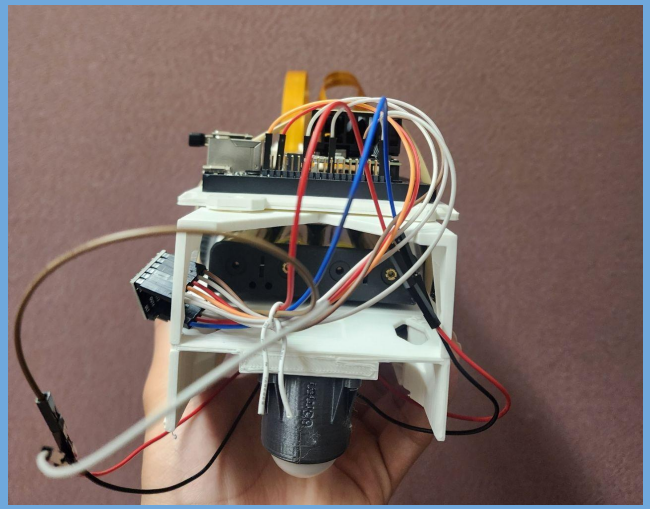
The chassis was modified to fit a four battery pack. The base has added screw hole attachments. This aligns with the open source Jetson Orin case we choose. A double camera mount was also made for 2 cameras.



3D Printed Jetson Orin Jetbot







Configuring Motors

Goals: Enabling the Jetson Orin to use motors.

What we did:

- Used the jetson-io interface to configure pins for PWM and GPIO function, so that the motors could move.
- Using python code to create a importable module, whereas on the Jetson Nano, the Nano was already configured to run motor functions.

Results: Motors function and can move forward, right, and left. One motor is able to move backwards.

```python
class Robot():

    def set_motors(self, left_velocity, right_velocity):
        self.set_left_motor(left_velocity)
        self.set_right_motor(right_velocity)

    def stop(self):
        self.p_left.ChangeDutyCycle(0)
        self.p_right.ChangeDutyCycle(0)
        GPIO.output(self.IN1, GPIO.LOW)
        GPIO.output(self.IN3, GPIO.LOW)


    def forward(self, speed=1.0):
        self.set_motors(speed, speed)


    def backward(self, speed=1.0):
        self.set_motors(-1 * speed, -1 * speed)


    def left(self, speed=1.0):
        self.set_motors(-1 * speed, speed)


    def right(self, speed=1.0):
        self.set_motors(speed, -1 * speed)
```

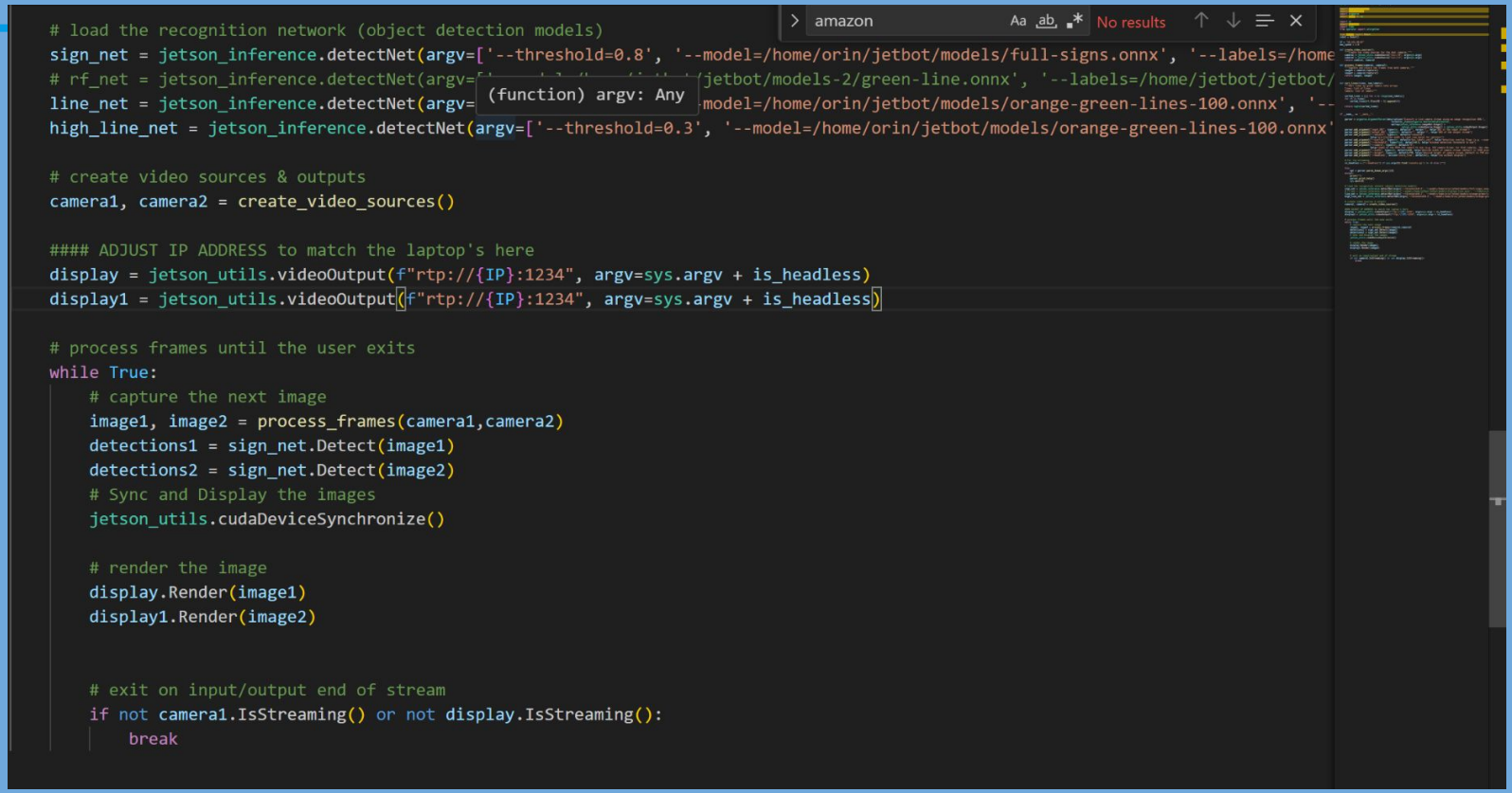
Using Cameras

On the Jetson Nano, using multiple cameras would cause the Nano to crash, so we have created a code such that multiple cameras can be used at the same time on the Orin.

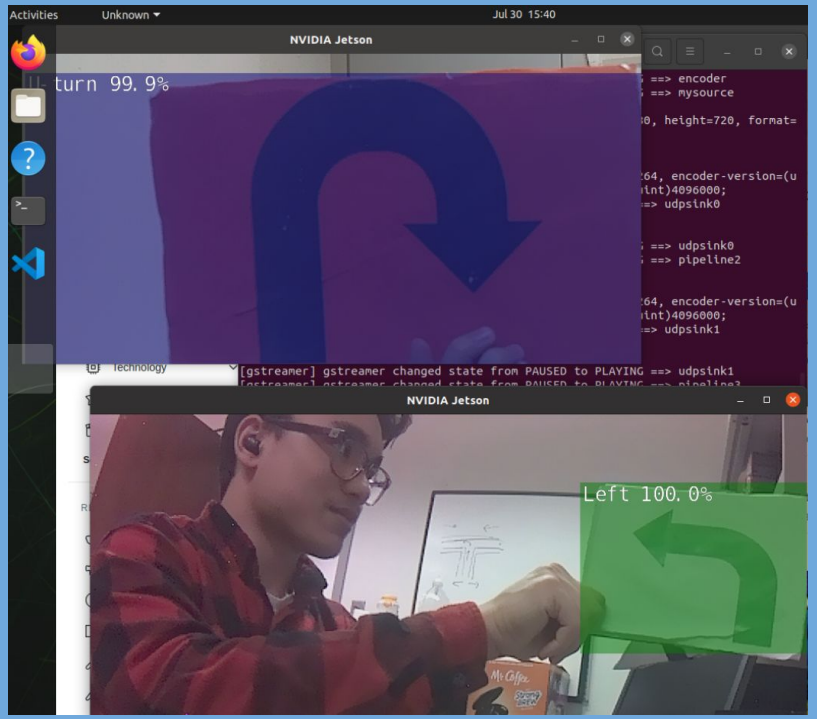
The cameras can do object detection on multiple models.

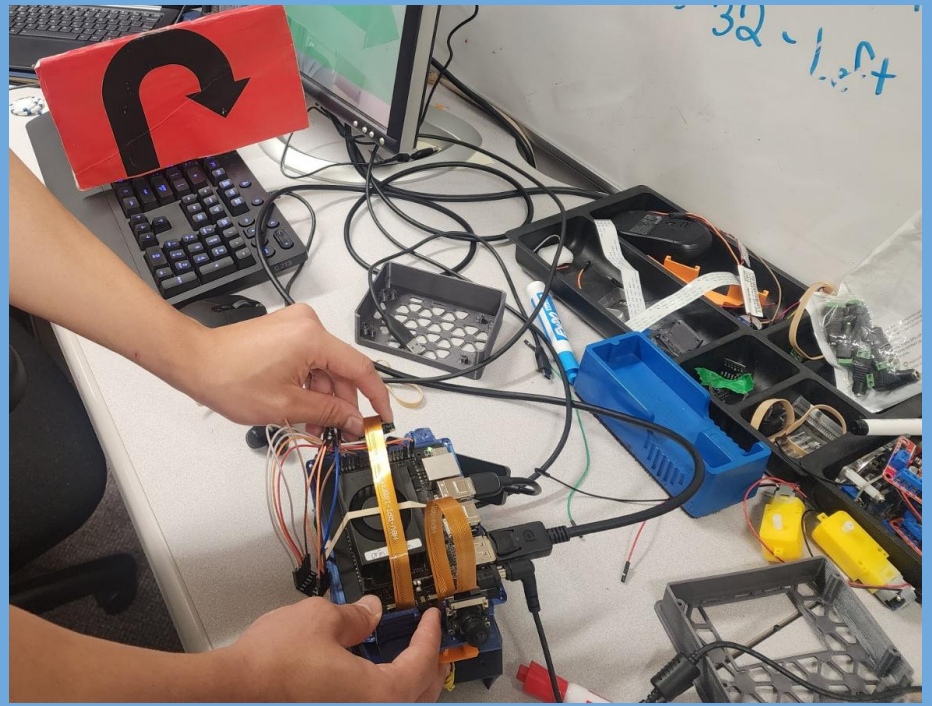
Note: While a camera can do detection on multiple models, it can only detect one at a time.

Example Code



Camera Synchronization





NanoOWL

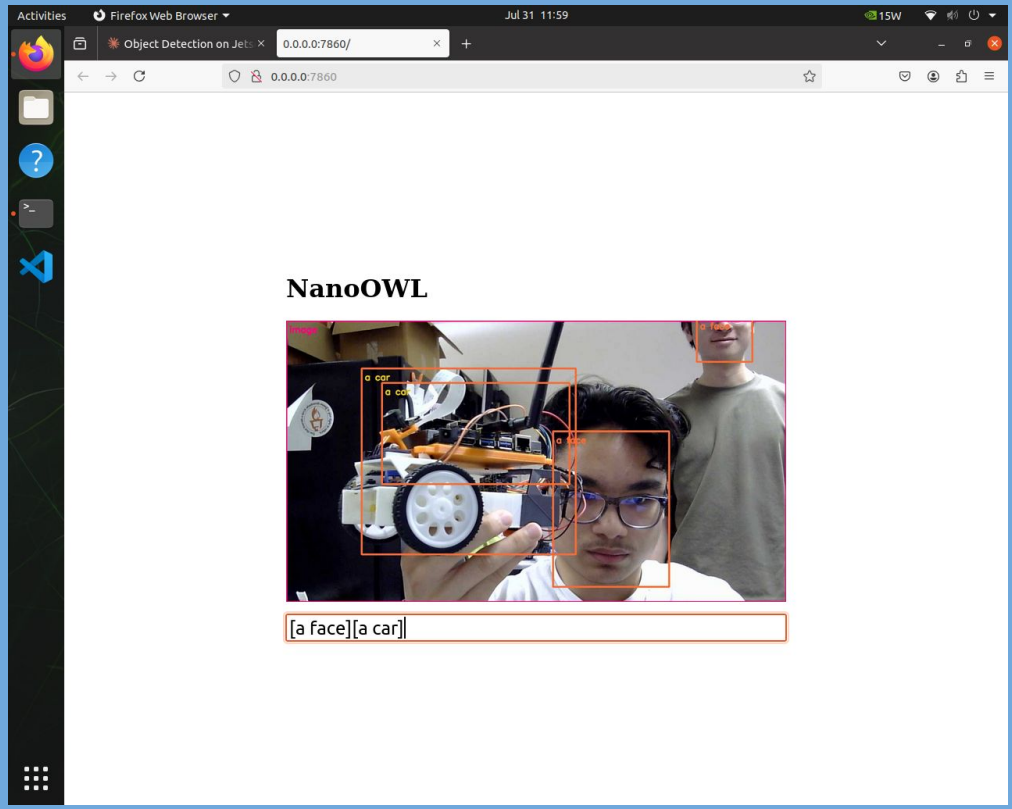
NanoOWL is a real-time object detection/image classification software, which saves time training new models.

Goal: To have NanoOWL detecting according to various prompts, such as “stop sign”, “person”, “ambulance”

Problems:

- Configuring which camera to use.
- Requires more time to create code for.

The following is a pilot code.



NanoOWL Developments

```
# If you wish to change the model, you can, but this is the default upon creating a instance of class OwlPredictor
model = "google/owlvit-base-patch32"
image_encoder_engine = "/home/orin/nanoowl/data/owl_image_encoder_patch32.engine"
predictor = OwlPredictor(model, image_encoder_engine=image_encoder_engine)

# Gets prompt and then searches for detections
texts = "[a tree, a face, a car ]"
threshold = 0.1
texts = texts.strip("][()")
text = texts.split(',')
print(text)
images = Image.fromarray(np.uint8(image.value))
text_encodings = predictor.encode_text(text)
detections = predictor.predict(image=images, text=text, text_encodings=text_encodings, threshold=threshold, pad_square=False)
print("detections: ", detections)
```

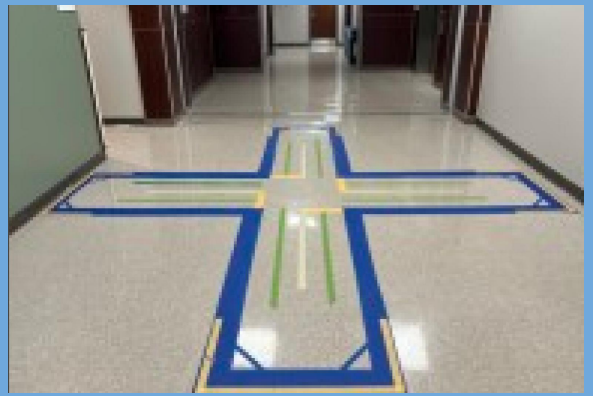
Road Following

With one camera

- Python code has already been established
- Can run on track with object detection when motors are fully working
- Only one model is being run at one time.

Issue with Road Following

```
if state == "rf":
    # Look for road line.
    road_lines = high_line_net.Detect(image1, overlay=opt.overlay)
    road_lines.sort(key=attrgetter("Right"), reverse=True)
    appropriate_line = False
    for rl in road_lines:
        if not appropriate_line and rl_follow_dir(rl):
            appropriate_line = True
    if not appropriate_line:
        strikes += 1
        if strikes % 4 == 0:
            robot.set_motors(0.3 * max_speed, 0.3 * max_speed)
            time.sleep(0.2)
        elif strikes % 4 == 1:
            robot.set_motors(0.3 * max_speed, 0.3 * max_speed)
            time.sleep(0.2)
        robot.stop()
        time.sleep(0.2)
    if strikes == 10:
        # After the robot fails to detect any road lines many frames in a row,
        # stop and look for signs.
        state = "signs"
        strikes = 0
```



Hard-coded to search for green line and continue until orange line, where it then searches for signs

```
elif state == "signs":
    # Look for signs.
    signs = sign_net.Detect(image1, overlay=opt.overlay)
    valid_sign = False
    for sign in signs:
        # The robot may see other signs, but it only cares about sufficiently large signs
        # on the right side of the image - that's where the sign is placed.
        if sign.Right > image1.width / 2 and sign.Area > img_area / 50:
            # Turn depending on what sign is detected,
            # then stop and look for the road.
            valid_sign = True
            strikes = 0
            if sign.ClassID == 1:
                # Turn left a little bit, then start looking for the
                # correct green line (new state).
                state = "left-turn"
                print("LEFT")
                robot.set_motors(0.47 * max_speed, 0.7 * max_speed)
                time.sleep(0.6 / max_speed)
                robot.stop()
```

Multi-Camera Autonomous Driving

Proposed Plan:

- Having a single camera detect for lines
- Having another camera detect for cars or other objects.
- For more cameras, more models can be run, which would require multiprocessing.

Problem: While this can be implemented with multiple cameras, dealing with states of multiple cameras is complicated. Requires much more time than available and testing.

Proposed Plan

```python
if confidence > 0.4:
    # overlay the result on the image
    font.OverlayText(image1, image1.width, image1.height, "{:05.2f}% {:s}".format(confidence * 100, class_desc), 5, 5, fon

    # check if it is a return journey, reverse left and right
    if forward == False:
        if class_id == 0:
            class_id = 1
        elif class_id == 1:
            class_id = 0

    # When the Jetbot is facing straight, go straight
    if class_id == 2:
        print("Straight")
        robot.set_motors(0.60 * max_speed, 0.60 * max_speed)
        time.sleep(0.5)

    # When the Jetbot is facing left, turn right
    elif class_id == 0:
        print ("Facing Left")
        robot.set_motors(0.80 * max_speed, 0.40 * max_speed)
        time.sleep(0.5)

    # When the Jetbot is facing right, turn left
    elif class_id == 1:
        print ("Facing right")
        robot.set_motors(0.40 * max_speed, 0.80 * max_speed)
        time.sleep(0.5)
```

```python
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model = "google/owlvit-base-patch32"
image_encoder_engine = "/home/orin/nanoowl/data/owl_image_encoder_patch32.engine"
predictor = OwlPredictor(model, image_encoder_engine=image_encoder_engine)

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        if sign.Right > image1.width / 2 and sign.Area > img_area / 50:
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            strikes = 0
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                # correct green line (new state).
                state = "left-turn"
                print("LEFT")
                robot.set_motors(0.47 * max_speed, 0.7 * max_speed)
                time.sleep(0.6 / max_speed)
                robot.stop()
```

Replicating the Jetbot

By replicating this project with the Jetson Orin, we are now able to leverage these new capabilities. Also, in the future, better models can be trained using ResNet50 and kept up to date with the newest versions of TensorRT. Due to a lack of time to further test we have done the following

- Created a documentation for those using the Jetson Orin that will allow for replication as well as provide debugging help.
- Updated Jetson Nano documentation as they can still be used to help train Orin Jetbots while also cheaper
- Uploaded all code to a Github with clear and detailed instructions, which with documentation can be replicated

Future Work

To continue progress with the Jetson Orin Nano

- Python code should continue to be developed so that NanoOWL can identify many prompts and avoid them as best as possible.
- Use CVAT or another type of annotation tool for semantic segmentation, which could be used on multiple cameras.
- Create multiprocessing python scripts
- Add a ultrasonic sensor

If a budget allows, we suggest searching for motor driver and motor upgrades, so the Jetson Orin moves more efficiently

Thank you!

Questions?

References

Tutorial - Nanoowl. NanoOWL - NVIDIA Jetson AI Lab. (n.d.) https://www.jetson-ai-lab.com/vit/tutorial_nanoowl.html

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Nvidia-Ai-Iot. (n.d.). Nvidia-ai-IOT/nanoowl: A project that optimizes owl-VIT for real-time inference with Nvidia TENSORRT. GitHub. https://github.com/NVIDIA-AI-IOT/nanoowl