Autonomous Rover for Mobile Support (ARMS)

By Jackson, Omri, Luke, and Hans

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Introduction and Motivation

Motivation

- 79 million+ students carry backpacks
- Loaded backpack should never weigh more than 15% of carrier's body weight.
- ~55% of students carry a backpack that exceeds their maximum carrying capacity
- ~23,000 backpack-related injuries in 2007

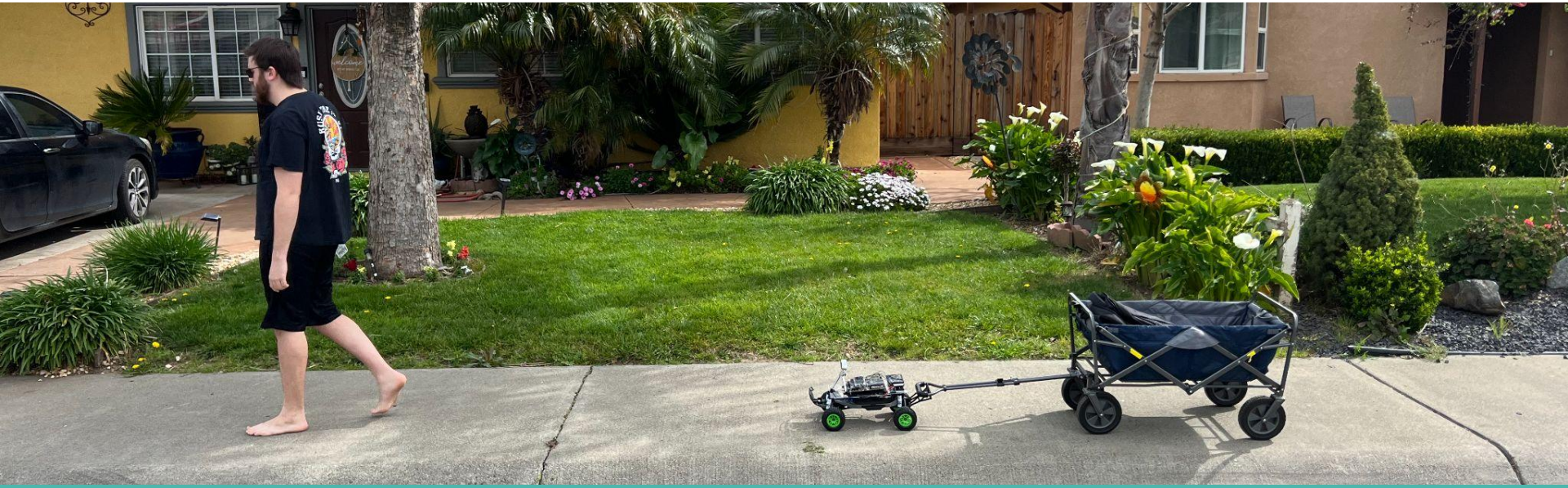
Current Solution

Autonomous rover that follows the user to carry their items.

- Piaggio's Gita implements first of its kind "cargo robot"
- The problem: The Gita gives no way for the user to interact with the robot

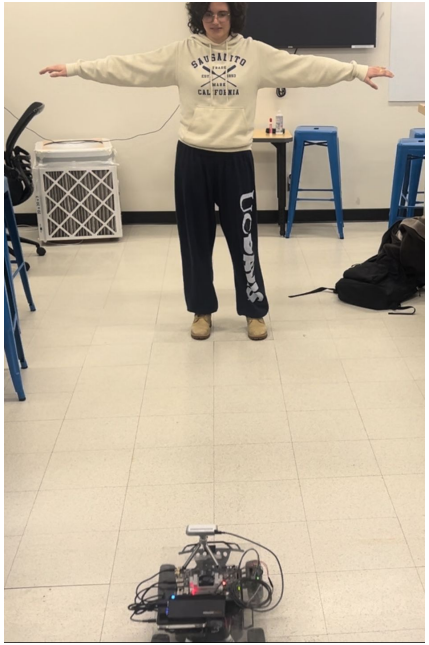
Our Solution

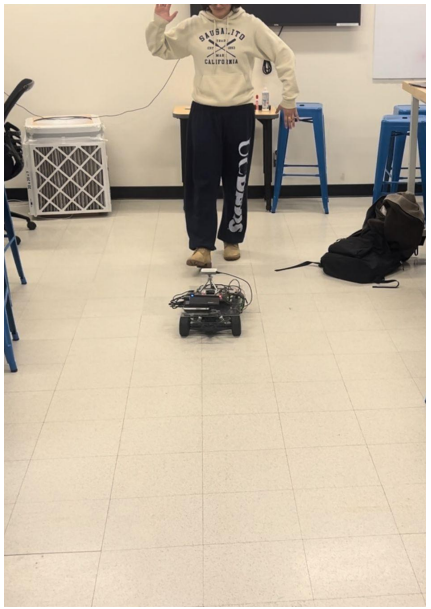
- Potential preventative measure against backpack-related injuries
- Compact rover retrofitted for cargo w/ body position and pose tracking
- Convenient use, accessible



Specifics

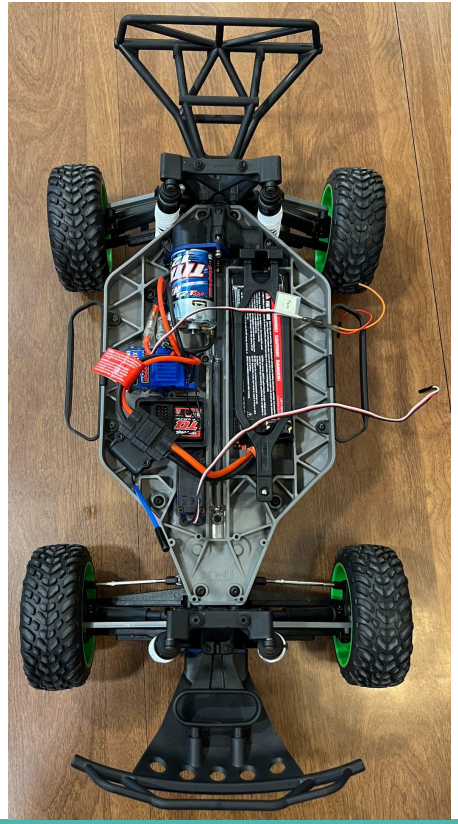
- Automated rover to carry backpacks and other cargo
  - Any chosen compatible carriage can be attached to the rover
- Controlled by posing and speed of user
  - Rover will auto brake if user leaves frame
  - Rover will auto brake if too close to user
- Turned on and off easily
  - Posing by user
- Rechargeable and swappable battery
  - Easy to use





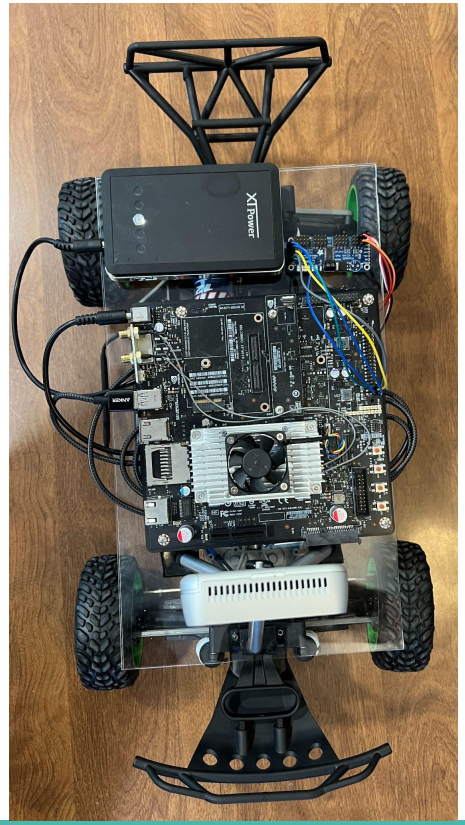
ARMS Design

Initial Hardware Setup



- Wired steering and throttle for manual use
  - Different setup than automated driving
- Calibrated the electronic speed control (ESC)
  - Specific to car type and model
- Calibrated controller to work with the ESC
- Tested functionality of the car
  - Throttle and variable speed
  - Steering
  - Braking
  - Battery life

Jetson Hardware Setup



- Wired steering and throttle for automated use
  - Controls go through I2C Servo Board
  - I2C Servo Board connected to power and commands from Jetson
- Modular back velcro for different uses
  - External battery (shown) for real world use
  - USB hub for stationary testing
- Access to Jetson
  - Through VNC for real world use
  - Through monitor, keyboard, and mouse for stationary testing

trt_pose

- Pose detection designed for Jetson
  - Easy to interface with
  - Optimized for our hardware
- Found specific points on wanted person
  - Elbow, shoulders, hands, head, and chest
- Explored functionality of trt_pose
  - Poses
  - Tracking
  - Sorting

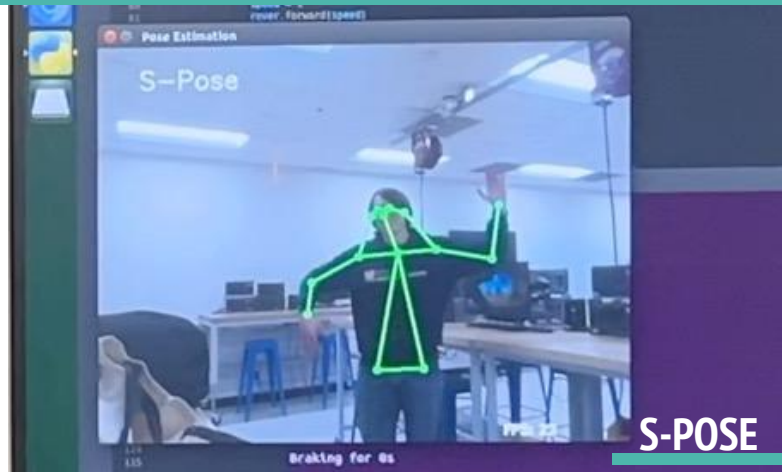
Model	Jetson Nano FPS	Jetson Xavier FPS
resnet18	22	251
densenet18	12	101

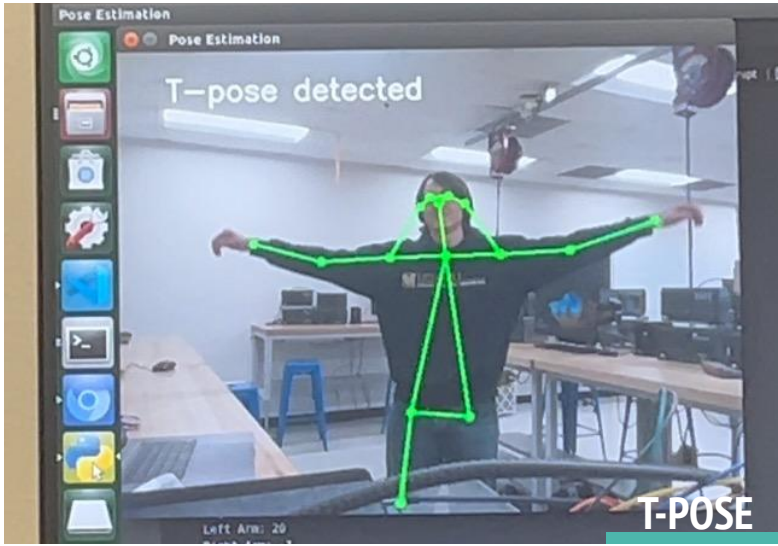
Chest-Based Tracking

- Follow chest point on the user
  - Calculate horizontal distance from center of camera feed to the chest point
  - Adjust wheel angle based on the difference
    - Scaled to the max and min turn radius
- Braking based on chest point
  - Rover will stop if:
    - Chest point leaves frame
    - Chest point is too close to camera
  - Rover will only go if:
    - Chest point is in frame
    - Chest point is further than specified depth

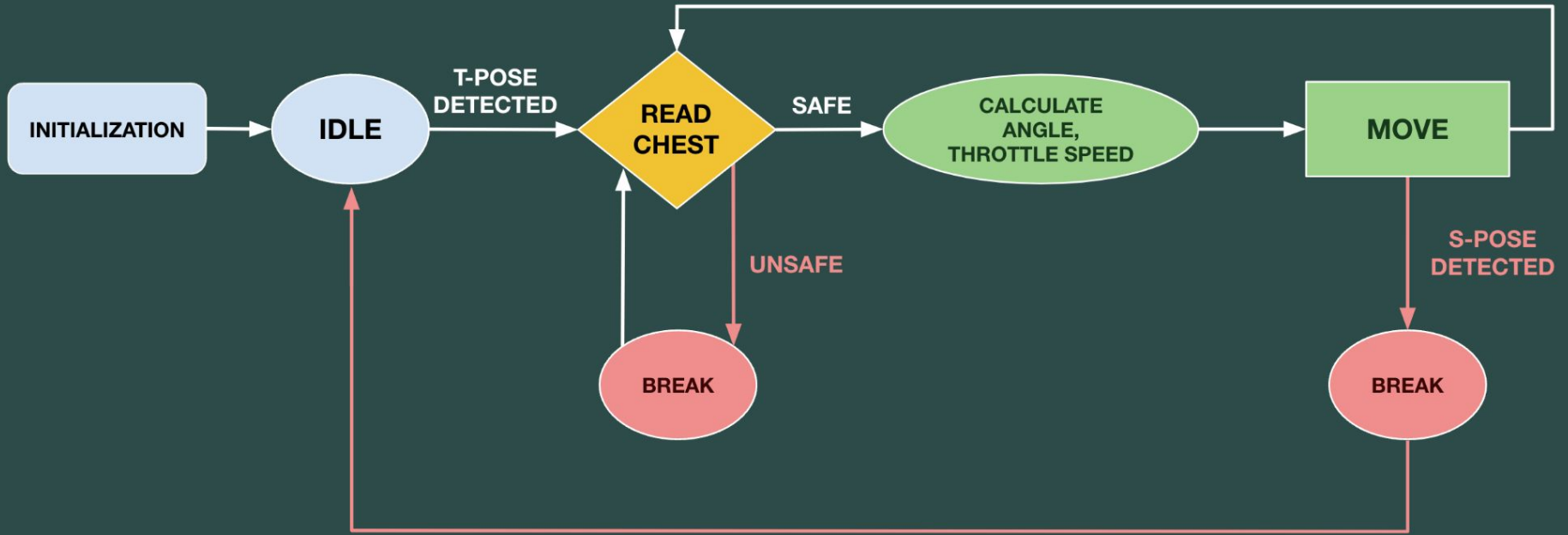
Pose-Based Control

- Calculate poses with body points
  - Comparison to each other
  - User chest must be in frame
  - User chest must be at valid distance
- T-Pose starts the car
  - Hands, elbows, and shoulders in a row
- S-Pose stops the car
  - Body points in a sideways S form
- Old poses not used
  - W-Pose to speed up
    - Dangerous!!!
  - M-Pose to slow down
  - Distance measuring used instead





Automated Pipeline

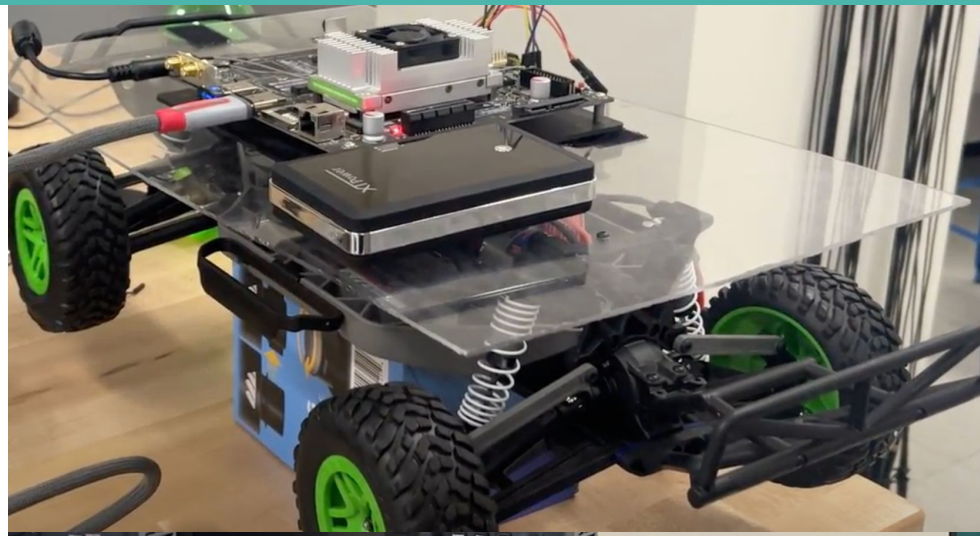


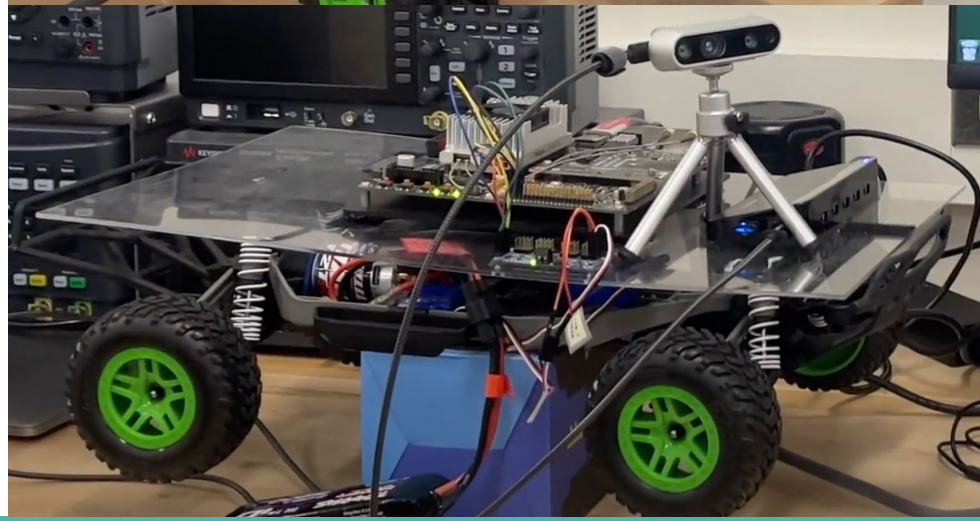
Remote Access

- Connect to Jetson virtually to run rover from laptop or phone
  - Easier than having to carry around screen, mouse, and keyboard
  - We used the X11 VNC
    - Linux-friendly
- Eduroam complications
  - Eduroam security did not allow rover to connect
  - Phone hotspot was used for laptop and rover
  - Easy to attach to rover and have amazing service

The Old Acrylic

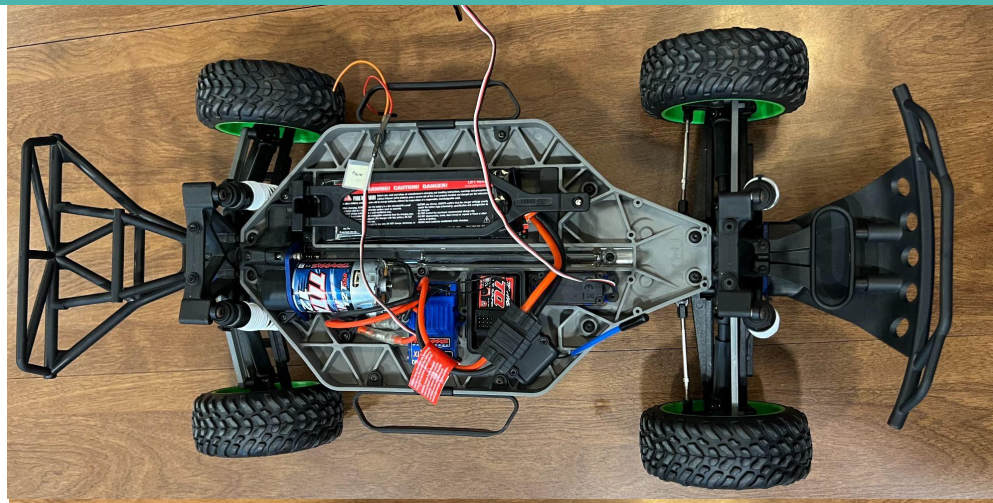
- Acrylic was larger than the rover
  - Built-in collision absorption nullified
- More acrylic surface area than needed
  - Wasted space
  - Uneven distribution of weight
- Too much useless weight on car
  - Shocks needed to be upgraded
    - Tripled shock strength
- Improperly secured
  - Moved around during use
    - Effected camera functionality

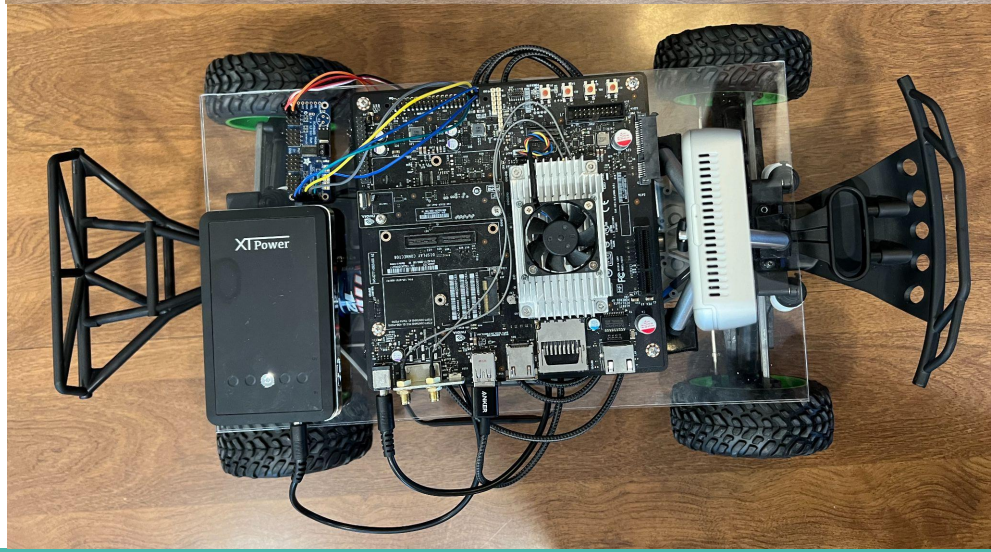




An Improved Acrylic

- Smaller acrylic to utilize built-in shock absorption
- Better use of area on acrylic
- More modular velcro
  - Battery in back for ground use
  - USB hub in back for desk use
- Lower amount of weight on car
  - Weight was also more centered





Results & Demo

Final Product

- Follows user well
- Pose detection functions
  - Fast on Jetson
  - Begins and ends properly
- Automatic braking
  - Too close to an object
  - No person is in frame
- Average frame rate of ~20fps

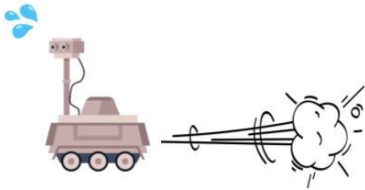
Future Work

Tuning Current Implementation

- Rover had very sensitive movement
  - Better communication between processes
  - Tuning
  - More solid construction
- User needed to be vigilant of sharp turns
  - Camera view change
    - Higher
    - Wider
  - Code optimization
  - Closer following
- Rover confused person-like objects as people
  - Tuning
  - MOTS

Variable Following Distance

- Currently following distance is hard-coded into the program
  - Make a pose to increase or decrease following distance
- Rover can then automatically change speed depending on distance
  - Higher speed if too far
  - Lower speed if too close
- PID controller functionality for proper distance
  - Continuously variable speed



Multi-Object Tracking & Segmentation (MOTS)

- Currently works with only one person in frame
  - Only single person functionality
  - TRTPose may have built in tracking
- Rover would be more functional in areas with many people
- Would work well with the variable distance
- Camera position would ideally be moved up for both features

Acknowledgements and Resources

Acknowledgements

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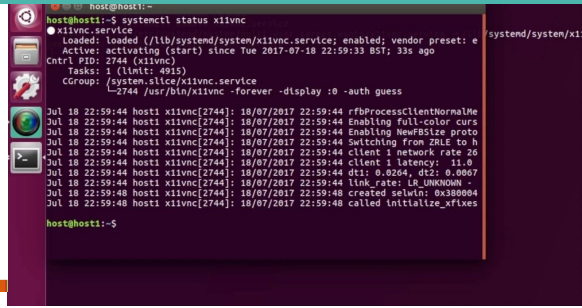
Resources

- Hardware
  - Traxxas Ford Fiesta
  - NVIDIA Jetson TX2
  - Intel RealSense
- Software
  - trt_pose
  - X11VNC
  - CV2

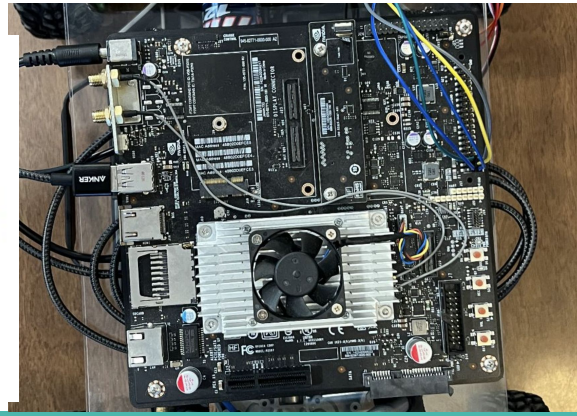
NVIDIA-AI-IOT/
trt_pose

Real-time pose estimation accelerated with NVIDIA TensorRT

2 Contributors · 129 Issues · 932 Stars · 290 Forks



OpenCV



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