Designing and Implementing a Self-Driving RC Car

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Objective

To learn about fully autonomous vehicles and their technology through research and implementation of an autonomous RC car using off the shelf hardware and open-source software.

Background

- An autonomous vehicle is a vehicle which is equipped with the necessary hardware and software to drive itself without the need for human intervention.
- The Society of Automotive Engineers have identified 6 levels of driving automation.
- In today's industry, Level 2 automation is the highest level that has been achieved in commercially available vehicles.
- I used designs by Waymo and Tesla to determine which components I would want to include into my own design.

Figure 1. Chrysler Pacifica modified by Waymo to be capable of Lv. 4 autonomy

Self-Driving Technology

Lidar: creates a 3D map of environment that can be used to judge distance, shape, and depth of objects

Cameras: capture live feed, provides information the software will use to drive and maneuver around obstacles

Radar: uses radio waves to determine distance and velocity of obstacles

Computers: Process all data from sensors to perform the same driving tasks as a human

Software: allows autonomous vehicles to function (ex: Perception, control, communication, decision-making, etc.)

Machine Learning: algorithms that allow vehicles to recognize and respond to various situations (ex: Convolution Neural Networks (CNN))

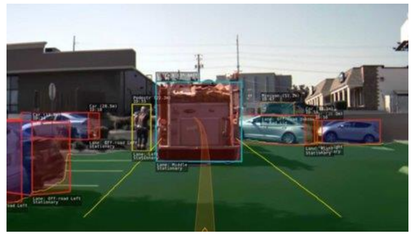
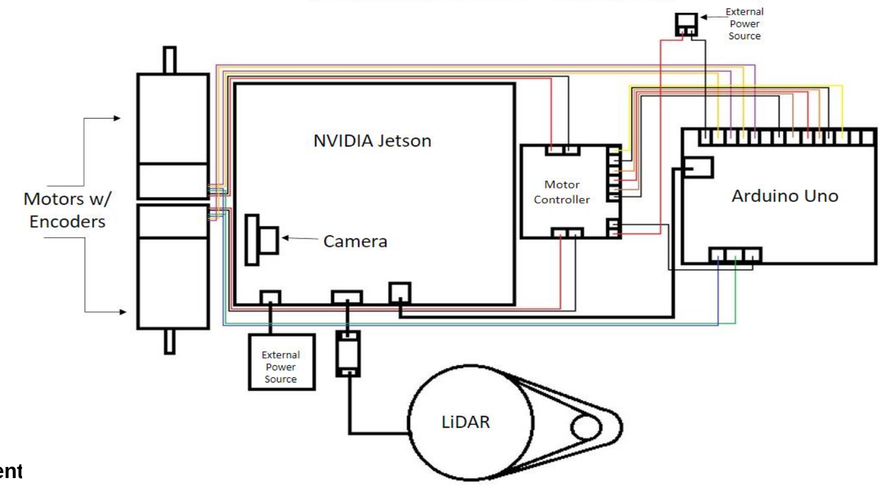


Figure 2. Camera feed with object detection and semantic segmentation algorithms

Implementation

Hardware



Component

- RPLidar A1 - used for capturing distances of objects in its field of view
- 8 MP IMX219 160° camera
- Arduino Uno R3 - controlled the motor controller and collected information from the encoders
- Arduino Motor Controller L298N - controlled motors from commands given by Arduino Uno
- Bemonoc motors with encoders
- NVIDIA Jetson Nano - small computer designed for AI applications like Object Detection models
- Power supplies: 4A, 5W (Jetson); 2A 12V (Motor controller)

Figure 3. Arduino Motor Controller (L298N)

Figure 4. Arduino Uno R3 Board

Figure 5. MIPI Camera and an NVIDIA Jetson Nano

Figure 6. Lidar from RPLidar (A1)

Implementation

Software Used:

- OpenCV library was used specifically for the object detection portion of the algorithm
- The Firmata library was used to allow for communication between the Arduino Uno and the NVIDIA Jetson Nano

Explanation of Code:

- Open the camera feed and start the motors to move forward at full speed
- While the code loops indefinitely
  - Grab a frame every half second
  - If an object from the CV model is detected,
    - ➢ Draw an identifying box around the object
    - ➢ Return what object was detected and at what confidence
    - ➢ Stop the motors and wait a half second
  - If no objects are detected
    - ➢ Start the motors again at full speed

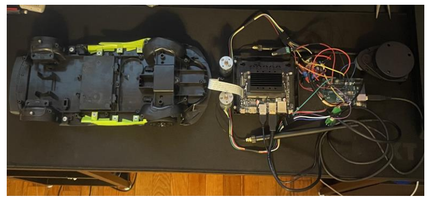


Figure 7. RC Car and hardware used in project

Acknowledgements

This work was supported by the New Jersey Space Grant Consortium and Brookdale Community College. I would like to thank my mentors, Professor Kevin Squires and Dr. Christopher Ochs, as well as my advisors, Professor Karina Ochs and Professor Ana Teodorescu.

Results and Limitations

Results

- Successfully integrated most of the hardware
- Software interacts with all components
- Currently continuing to work on the project
- Implemented a Python program that interacts with all hardware and software components
- Learned it is very difficult to create an autonomous vehicle
  - Couldn't fully integrate all hardware components
  - Object Detection algorithm did not work right away

Limitations

- Model used was limited in the number of objects it could detect
- The project required more time than anticipated
- A lack of experience in coding initially made it difficult to understand some of the open-source code I used
- Computer vision model was limited in the number of objects it could detect

Future Work

- Improve the drivability of the car by adding the Lidar that was having connection issues
- Continue to train the models used for object detection or create one from scratch
- Create a simulation that would allow for testing
- Evaluate how the car would drive without Lidar vs with Lidar

Conclusions

- An autonomous vehicle is a vehicle equipped with the necessary hardware and software to drive itself without the need for human intervention
- Integrated open-source software and off the shelf hardware to create a semiautonomous RC car
- Gained some understanding of Python language
- Further development required to achieve a fully autonomous RC car

References

Ackerman, Evan. "What Full Autonomy Means for the Waymo Driver." *IEEE Spectrum*, IEEE Spectrum, 24 June 2021, https://spectrum.ieee.org/full-autonomy-waymo-driver.

Cadence System Analysis. "The Use of Radar Technology in Autonomous Vehicles." *Cadence*, 13 Oct. 2022, https://resources.system-analysis.cadence.com/blog/msa2022-the-use-of-radar-technology-in-autonomous-vehicles.

California Public Utilities Commission. *Protest of Waymo LLC Tier 3 Advice Letter (0001)*. 23 Jan. 2023, https://www.sfmta.com/sites/default/files/reports-and-documents/2023/01/2023.01.23_protest_of_waymo_llc_tier_3_advice_letter_0001.pdf.

Dave, Paresh. "Dashcam Footage Shows Driverless Cars Clogging San Francisco." *Wired*, Conde Nast, 10 Apr. 2023, https://www.wired.com/story/dashcam-footage-shows-driverless-cars-cruise-waymo-clogging-san-francisco/.