Advancing Autonomous Vehicles through Robust Lane Detection and Real-Time Video Processing

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Introduction

Background:

- Advancements in computer vision and communication technologies have led to autonomous vehicles (AVs) becoming increasingly safer and efficient modes of transport
- Connected and automated vehicles (CAVs) are becoming increasingly important due to their potential to address many traffic challenges
- In the face of traffic congestion, accidents, and environmental concerns, CAVs present a viable solution to increase road efficiency

Figure 1. Vehicles broadcasting data

Goal:

- Demonstrate that autonomous vehicles can accurately detect road lanes and compute center deviation

Methods

This research involves developing a lane detection algorithm for autonomous vehicles using OpenCV with Python.

1) Apply grayscale and bilateral filter in order to flatten and smooth out colors within image
2) Apply canny edge detector and Hough transform to identify lane lines and acquire points within image describing lines bordering lane
3) Split list of lines from Hough transform between left and right lane
4) Calculate independent average of x-coordinates of left lines and right lines
5) Take average of left x-coordinate and right x-coordinate average
6) Compare final average of x-coordinates with center of image to acquire offset

To validate these algorithms, extensive testing was conducted with

- a variety of challenging situations such as lanes being obstructed, or offsets

The algorithm was assessed with

- static images and videos
- a series of simulated lanes using projections and tape.

1. Infrared Camera
2. NVIDIA jetson nano with Ubuntu 18.04 and ROS

Figure 2. Limo (robot)

Results

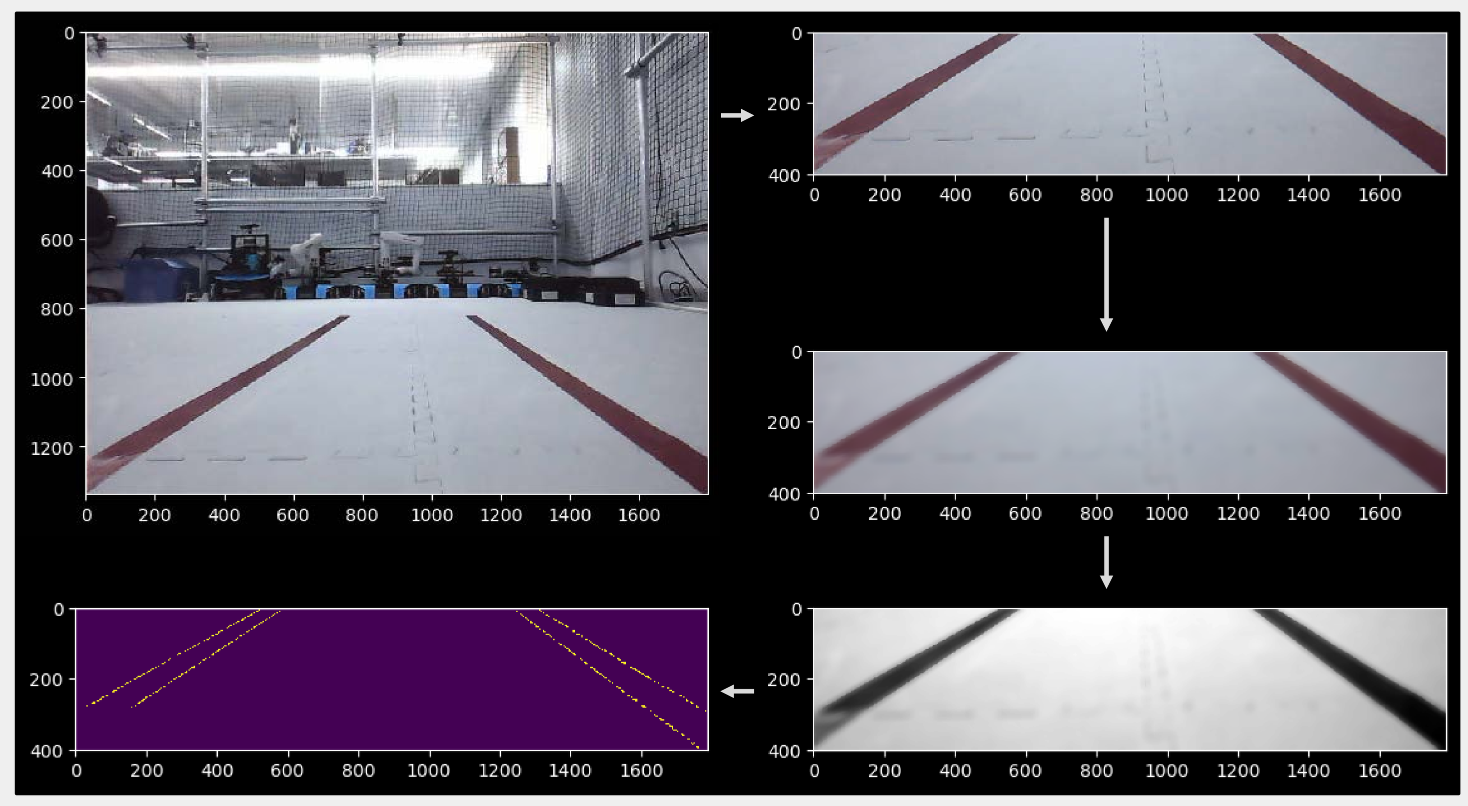
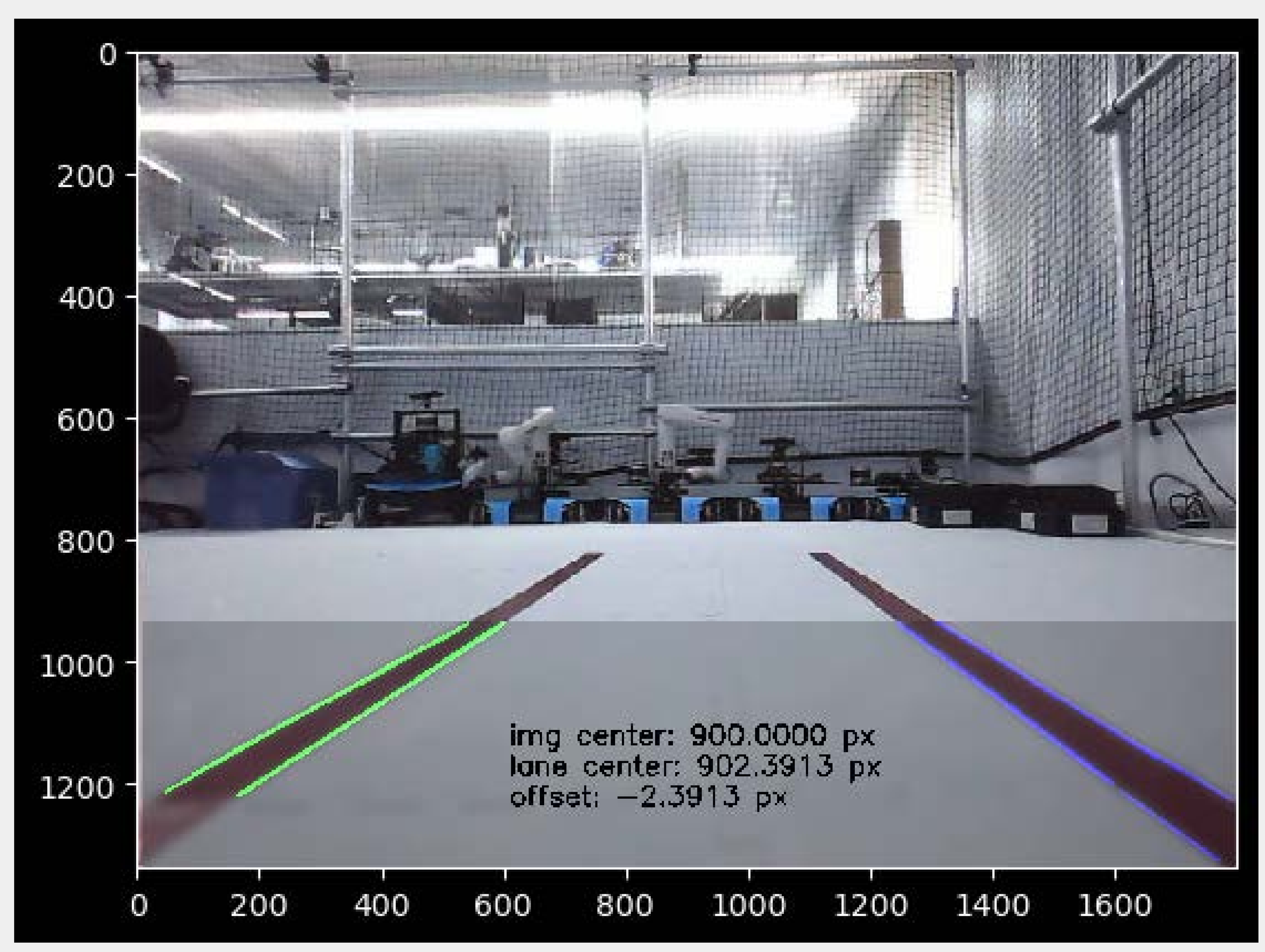


Figure 3 (above). Clockwise from top left: original image, cropped image, bilateral filter applied, grayscale applied, canny edge detector applied

Figure 4 (below). Hough Line Transform applied and cropped back onto original image



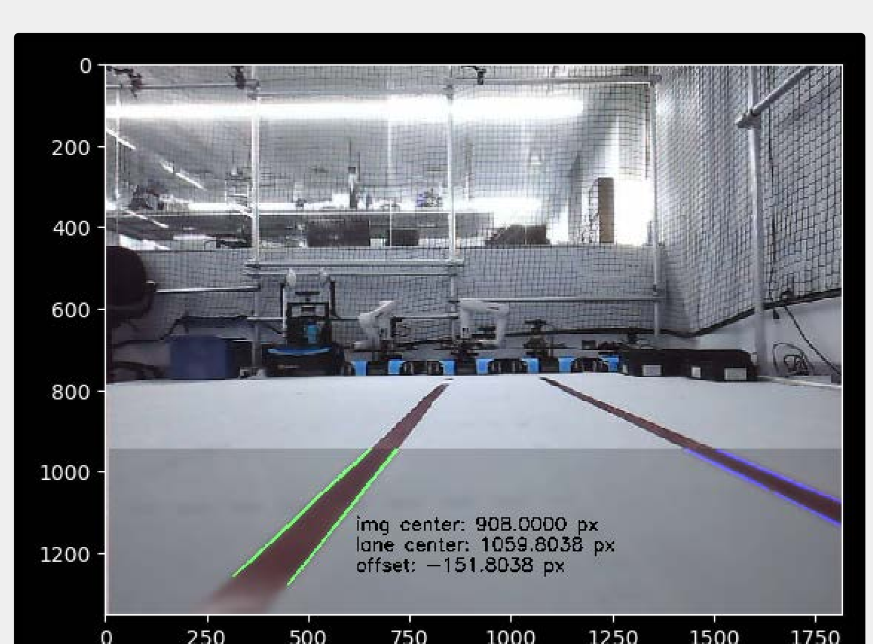
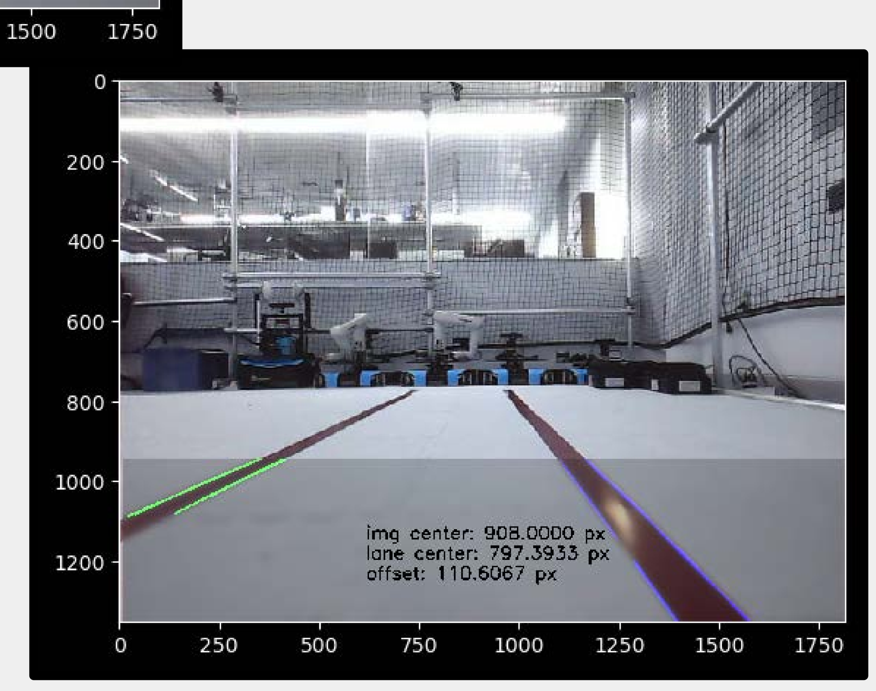


Figure 5 (left). Extreme negative (left) offset

Figure 6 (below). Extreme positive (right) offset



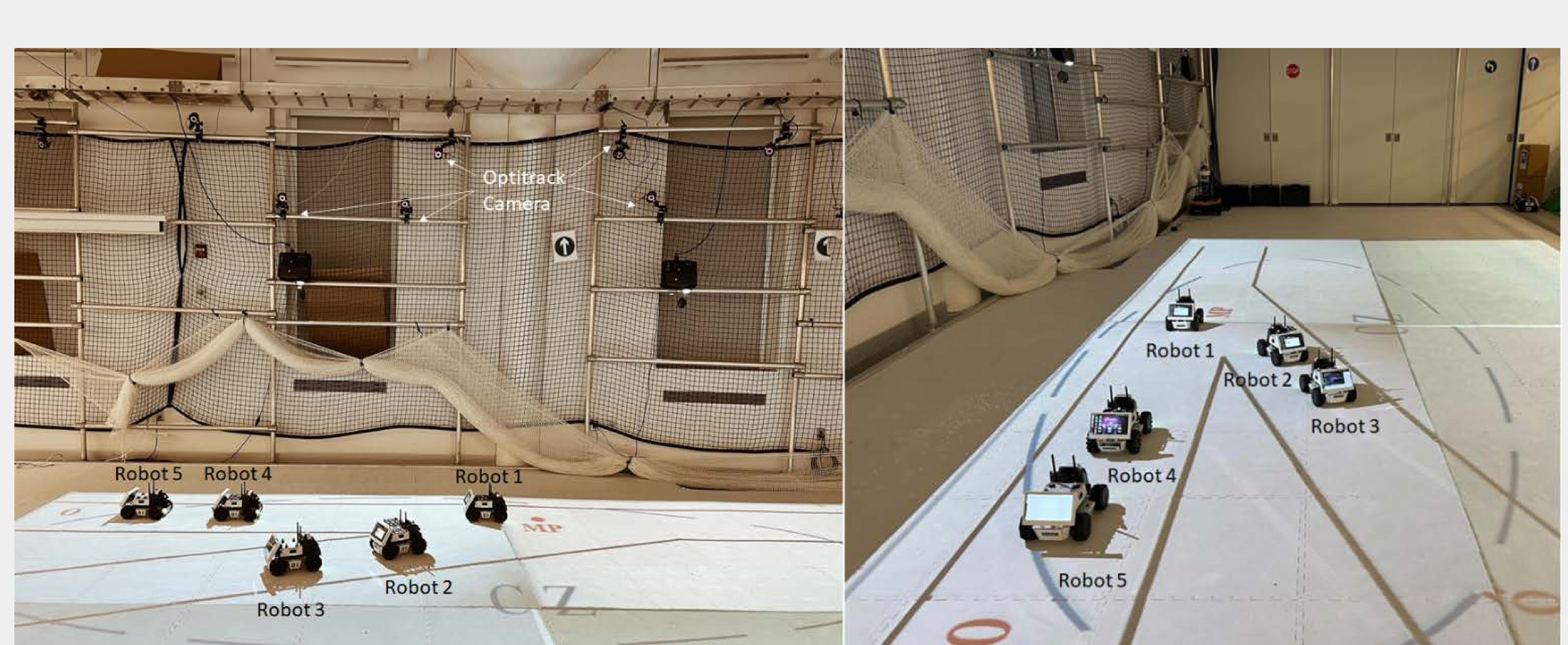


Figure 7. Multiple LIMOs (robots) merging utilizing communication and lane detection

Conclusions

Discussion:

- The algorithm was shown to be accurate and reliable in detecting lanes towards the center of the lane as well as at the extremes of the lanes
- The successful integration of the algorithm with ROS - a framework that helps robots communicate and coordinate with it's parts and environment - (path shown below) showed that it can output data at a frequency that it useable with any control loop, such as a PID or MPC controller

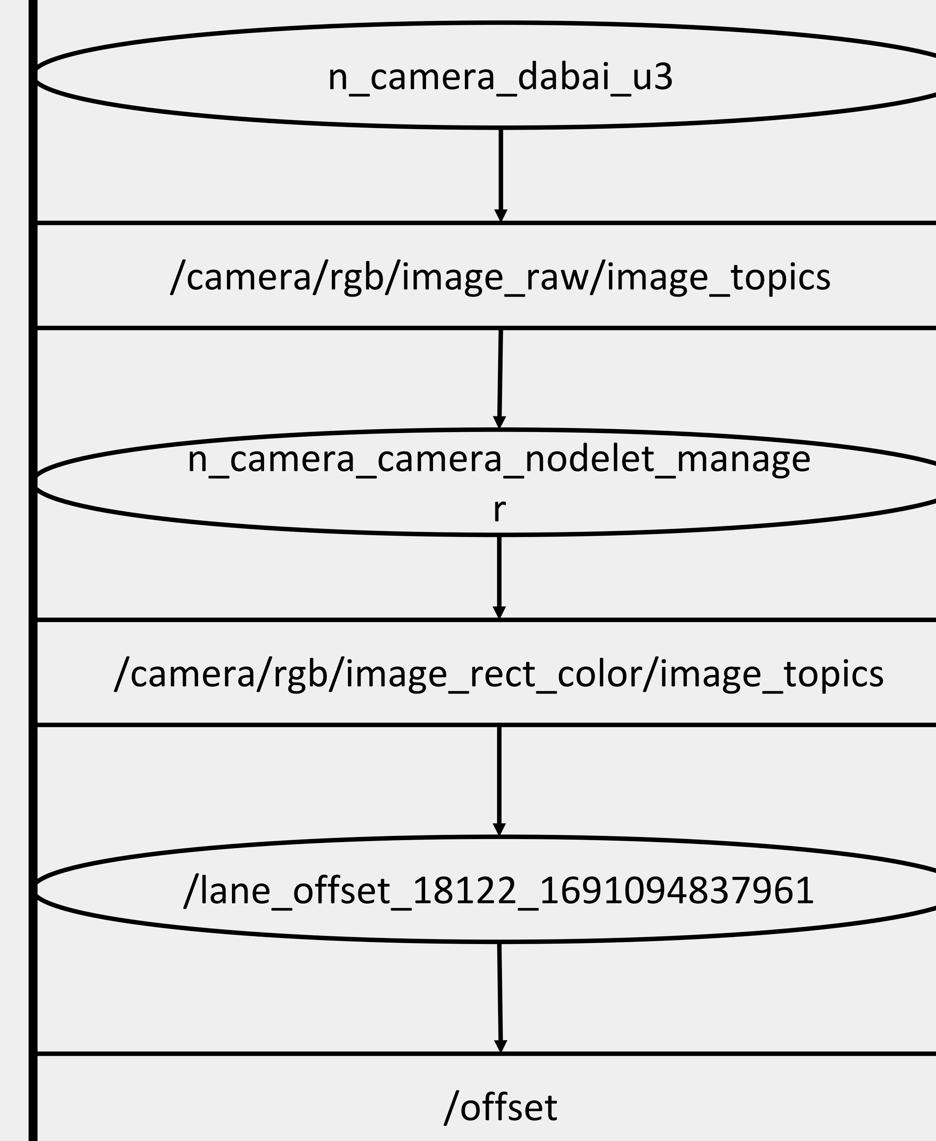


Figure 8. ROS pathway for current system (camera in to lane offset out)

Future Directions:

- Pairing robust onboard vision processing of a single CAV with the data it receives from other nearby CAVs would allow it to efficiently navigate roads while also reacting to any obstacles in real time
- The broadcasted data from nearby CAVs could be utilized to automatically control the velocity vectors of a CAV's motion
- The onboard lane and obstacle detection could be used to verify the data it receives, increasing the robustness of every CAV

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