

Goal

Based on the current study of the self-driving system, we want to improve the interaction among self-driving cars and pedestrians,[1] so that the collision among cars will be reduced, which will decrease the legal dispute of the car accident. Route detection, keeping safety distance, barrier recognition and traffic sign recognition will be all the desired functions we want to add to our self-driving car system. With these functions, we can build an interactive self-driving system.

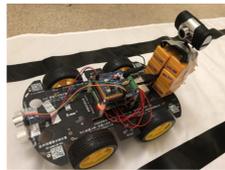
Motivations and Objectives

Motivations

- The legal dispute also exists in self-driving, and the only way to reduce the legal dispute is to make a perfect interaction system among the self-driving cars.[1]
- Use the self-driving system to test our knowledge of computer vision

Objectives

- Route and traffic sign Recognition
- Safety Distance
- Safety of Swerving at Intersection



Research Challenges

Deep learning network for route detection

We choose to build a CNN network. After finishing the network, the Raspberry Pi board's low performance of image processing has been a challenge for us. As a solution, we try to use the Socket to send the images to the personal computer to process the images. And then the personal computer sends back the results.

Environment influence on route detection

During testing our route detection program, we found that the environment around the car's camera will affect the precision of our deep learning model. As a solution, we use the white cloth to cover the surroundings, so that the environment influence will be reduced to the minimum.

Stop sign detection

At the beginning, we try to use the pre-trained network for the stop sign detection. However, we cannot find a pre-trained network having the appropriate class for our detection. And it will be a heavy work for us to modify the pre-trained network. As a solution, we choose our own built CNN network to detect the stop sign.

Acknowledgement

We would like to thank our advisor, Professor Kristin Dana and teaching us in her Robotics and Computer Vision class. Additional thanks to the director of ECE department, Hana Godrich.

Methodology

Network

Use CNN network, Keras(open source natural network library) to train own route detection model. we set up a sequential model with 18 layers including 2D convolution layers with ReLU activation function, Max pooling, Dropout, and Softmax.

Socket communication

Because of the limit of Raspberry Pi Hardware, we choose own laptop to do the main classification. So, the Raspberry Pi uses the socket to communicate with the laptop.

Safety Distance

We put ultrasound sensor in front of the car and use the algorithm $distance = \frac{(t2 - t1) * soundspeed}{2}$

Stop Sign recognition

Firstly, we want to extract the sign part from the whole picture, which can decrease many distractions for the recognition. By using HSV representation, we extract the red part of pictures, then do the recognition. [2]

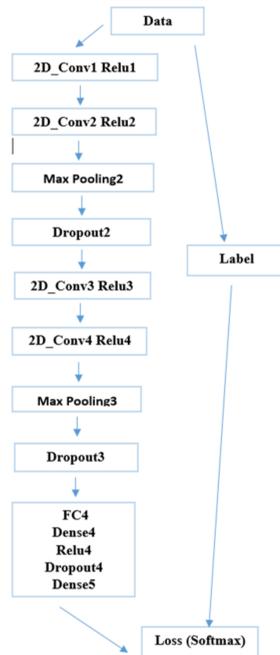


Figure 1: Neural Network Architecture

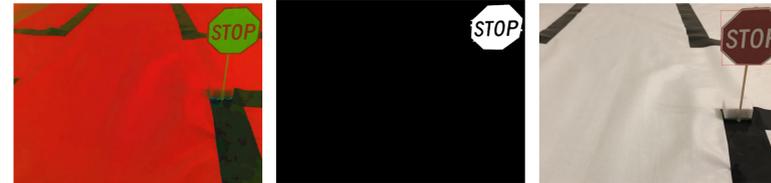


Figure 2: Extracting the stop sign

Results

Our own CNN network has the precision 99%

	precision	recall	f1-score	support
class 0(left)	1.00	1.00	1.00	40
class 1(right)	0.96	0.88	0.92	26
class 2(forward)	0.92	0.97	0.94	34
avg / total	0.96	0.96	0.96	100

Figure 3: Classification Report

Based on our network, the Raspberry Pi car can follow the route to move forward, to turn left, and to turn right

Our ultrasound detection for safety distance can keep the uncertainty between the detection distance and the real distance in the range of 0.6 centimeters

Our Raspberry car can make an appropriate stop in front of a STOP sign

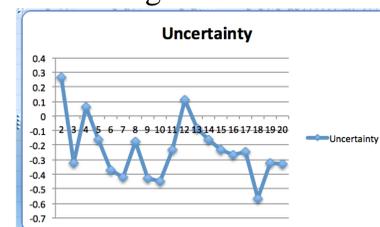


Figure 4: Uncertainty Plot

	Left	Right	Forward
Left	40	0	0
Right	0	23	3
Forward	0	1	33

Figure 5: the Confusion Matrix of Route Detection Model

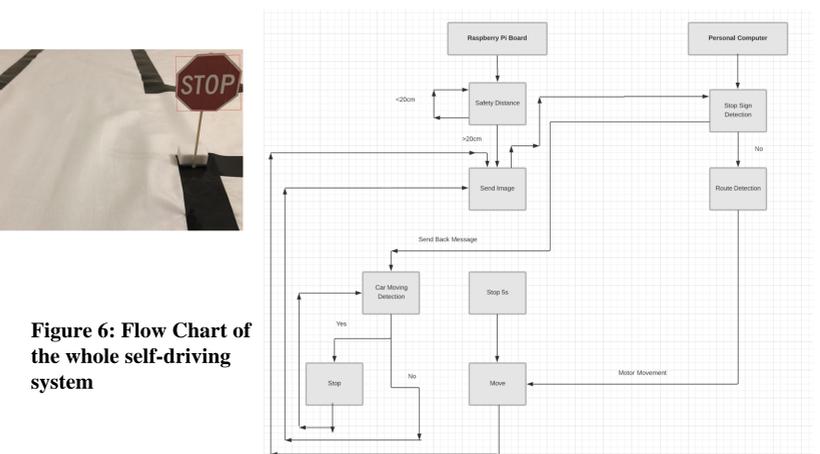


Figure 6: Flow Chart of the whole self-driving system

Discussion

During the whole process, we have been more familiar with the Computer Vision, especially the deep-learning network. Based on computer vision, we archived the route recognition function, traffic sign recognition function and swerving at intersection function. For the safety distance part, we use the ultrasound device to detect the distance between two cars. With these functions, our AI cars can have good interactions during driving.

Lane-change is a function we really want to add to our self-driving system. Lane-change is a very important interaction among cars during driving. Due to the time limitation, we cannot finish this function, but we will continue exploring this part in the future.

References

- [1] Litman, Todd. *Autonomous vehicle implementation predictions*. Victoria Transport Policy Institute, 2017.APA
 [2] S. Vitabile, G. Pollaccia, G. Pilato and F. Sorbello, "Road signs recognition using a dynamic pixel aggregation technique in the HSV color space," *Proceedings 11th International Conference on Image Analysis and Processing*, Palermo, 2001, pp. 572-577.