Stop Sign Detection

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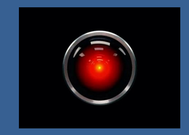


Abstract

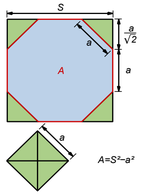
In this project I used basic MATLAB image processing techniques, as well as three different proposed algorithms, point feature matching, HAAR feature cascade training, and Convolutional Neural Networks combining with Color Transformation (not implemented) to attempt to detect stop signs from images taken in real life situations. I will compare the result for each algorithm and analyze their advantages and disadvantages.

MATLAB Image Processing

1. Color detection

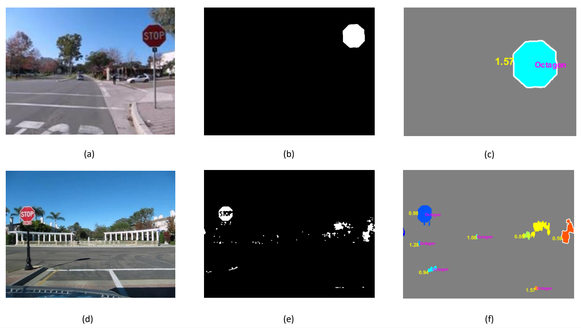
1(a) is the original image; 1(b) shows all pixels that have a value bigger than 40 in red channel; 1(c) shows all pixels that have a value less than 30 in green channel; 1(d) is the logical sum of 1(b) and 1(c) after noise elimination; and 1(e) is the original image with a bounding box drawn based on the result of 1(d).

2. Shape Detection



compute the octagoness metric (for stop signs):

area = 3*(a^2) (see Fig. 3), perimeter = 8*a,
hence metric = (64/3)*area/perimeter^2;



Proposed Algorithms

1. Point Feature Matching

In this implementation, I used MATLAB built in function detectSURFFeatures() to find the SURF of the stop sign and match the features with testing pictures.

2. HAAR Cascade Classifier Training

In the training process, I obtained 2101 negative samples. I used OpenCV create_sample function to generate positive samples by superimpose the one stop sign sample I have on all the negative images. I trained the model on a dimension of 30x30 considering the RAM and Disk on the server I have. Below are some samples of the generated positive training images.

Results

1. Point Feature Matching

This method was tested on 3 different images containing stop signs, and the one shown below is the only one that is successful. From the result, this method is not suitable for stop sign detection as stop signs containing relatively simple patterns and the images are sometimes blurry and this method is not successful in detecting images that has insufficient details, for example, low resolution or blurry images.

2. HAAR Cascade Classifier Training

I used the 1716 images containing stop signs from the dataset to test the HAAR cascade. From the 0-14 stages that I trained, I tested cascades contain 9, 10, 11, 12, 13, 14, 15 stages of training.

From the result shown in Table 1, this method is not successful. The best result out of the tested cascades is the cascade contains 9 stages. It detected 1416 positive out of 1716 images to have stop sign, in which only 26 are correctly detected. False positive rate is very high.

Table 1 Testing Result of HAAR cascade training

Number of Stages	Detected as positive	Correctly detected	percentage of correct/total	percentage of correct/positive
9	1416	26	1.52%	1.84%
10	931	10	0.58%	1.07%
11	603	5	0.29%	0.83%
12	315	4	0.23%	1.27%
13	217	1	0.06%	0.46%
14	133	1	0.06%	0.75%
15	97	1	0.06%	1.03%

Discussion

From the results above, possible reasons that the Point Feature Matching method did not work as expected could be that the SURF does not work well with uniformly-colored objects. Since the stop sign is mostly covered with red, this might limit the number of features the algorithm can find. Hence in the future, other types of features can be used for stop sign detection.

For the HAAR Cascade Classifier training method, the possible reasons that it did not achieve the expected accuracy could be that the positive samples I used do not contain enough real-life scenarios, such as different weather, lighting conditions, etc. Also a lot of testing images was blurry due to movement of the camera, and this method did not take that into consideration.

Conclusions

There will be plenty rooms for improvement even after the implementing all three Stages, such as continuing increasing the accuracy of detection or reducing the processing time to achieve real-time detection. Though, the main purpose of this project is for me to learn about how high-level machine learning algorithms work and to gain hands on experiences on how to operate them. In the process of completing this project I was exposed to a variety of diverse perspectives on the field of Computational Perception and Artificial Intelligence and found my interest to further explore the field. I would like to continue to finish this project on my own to get a better understanding of the algorithms that I am interested in learning but have not have the time to do so.

Contact

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