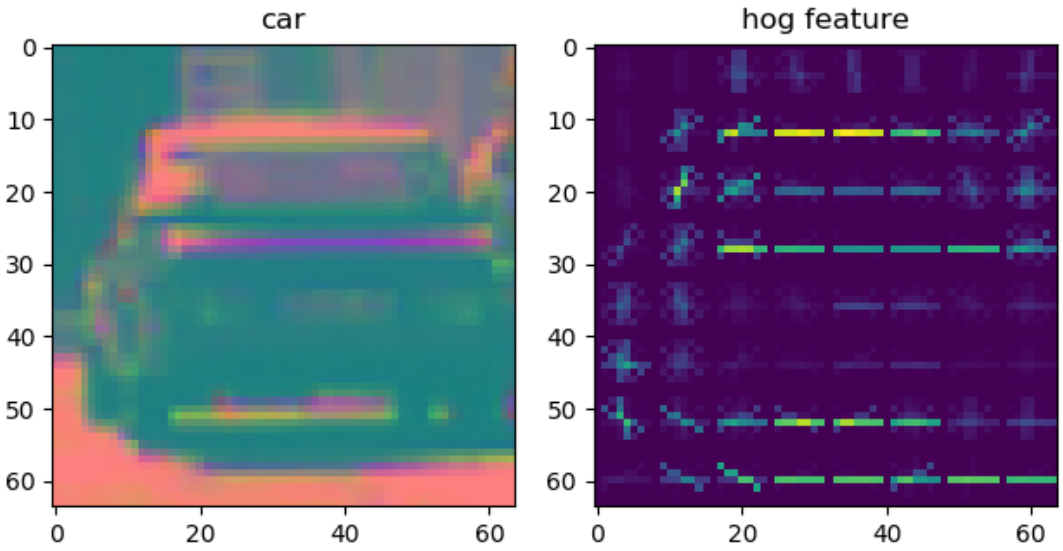
CarNd-P5 Write Up

Histogram of Oriented Graidents(HOG)

1. Explain how (and identify where in your code) you extracted HOG features from the training images.

The code for this step is contained in the function 'extract_features()' in the line 78 in 'train_svm.py'. First I read car and no-car images and transform them to 'YCrCb' color space. Then I flatten image to get spatial feature, and get it's color histogram with bins value 32, and get hog features using skimage's hog() function.

Here is an example using the `YCrCb` color space and HOG parameters of `orientations=9`, `pixels_per_cell=(8, 8)` and `cells_per_block=(3, 3)`:



2. Explain how you settled on your final choice of HOG parameters.

I tried various combinations of parameters and their accuracies are all high.

Finally I chose the best one:

orientations=9,

pixels_per_cell=(8, 8)

cells_per_block=(3, 3)

3. Describe how (and identify where in your code) you trained a classifier using your selected HOG features (and color features if you used them).

This step code is in line 111-136 in 'train_svm.py'.

First, I extract images' spatial feature, color feature and hog feature and combine them use 'numpy.concatenate()' function.

Second, I make features and labels to numpy form.

Third, I split data in to train, test parts.

Fourth, I normalize my training data.

Finally, I fit data.

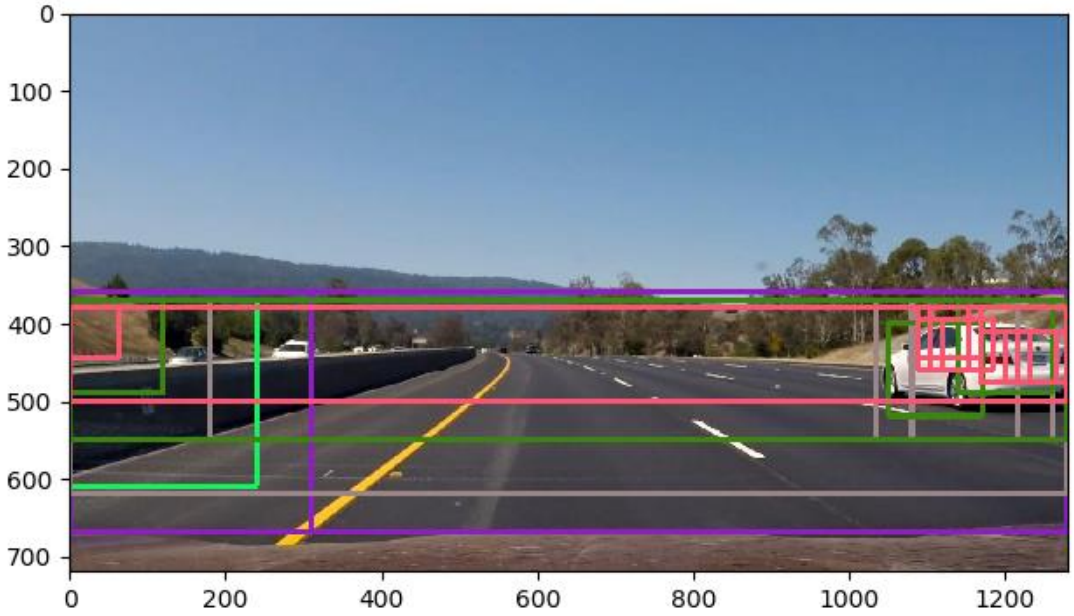
Sliding Window Search

1. Describe how (and identify where in your code) you implemented a sliding window search. How did you decide what scales to search and how much to overlap windows?

The code is in function find_car() in line 86 in file 'find_cars.py'. I count how many steps will be need sliding in x and y direction, and write a two-layer loop to loop through every single step.

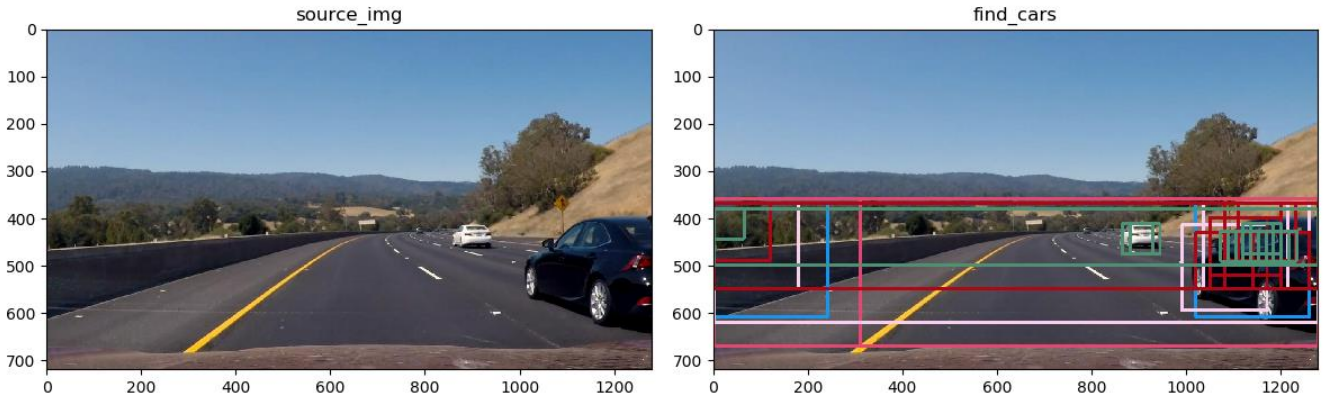
I draw the range and window on test image to make sure scales and the numbers of overlap just like this

Finally, I use five overlaps.



2. Show some examples of test images to demonstrate how your pipeline is working. What did you do to optimize the performance of your classifier?

Examples:



I used a linear svc at first, but it's not good enough for sometimes it can not detect car and will have false positive results. So I use svc's default parameters and get a good result.

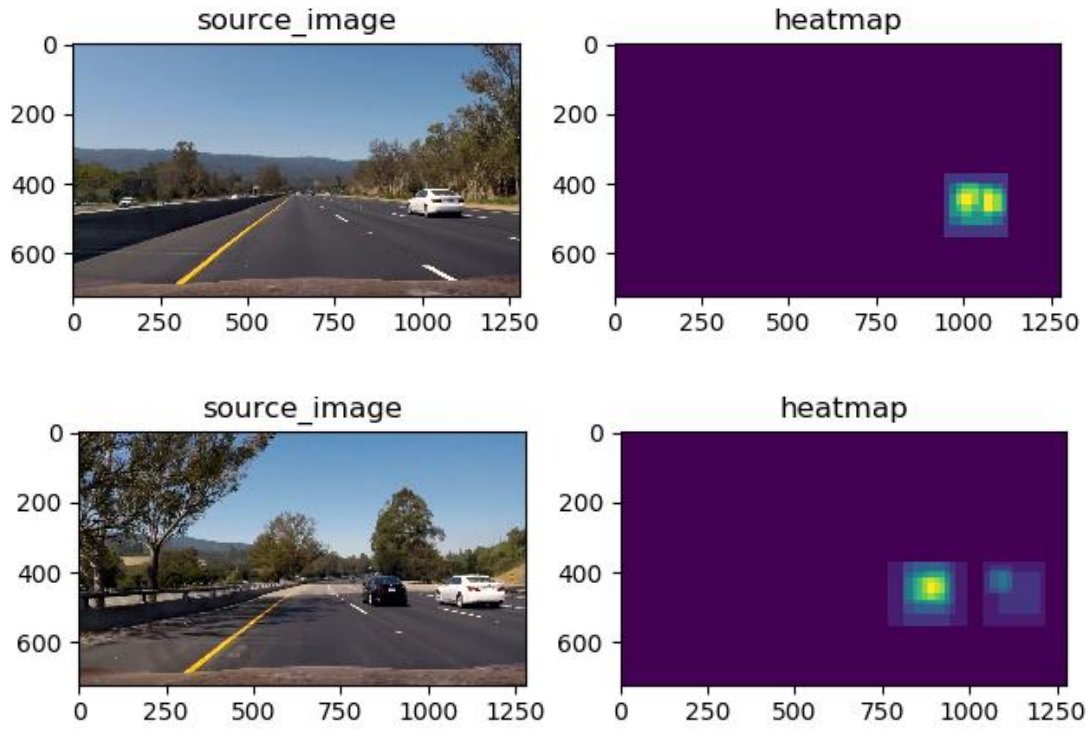
Video Implementation

1. ‘find_cars.mp4’ is my final video output.

2. Describe how (and identify where in your code) you implemented some kind of filter for false positives and some method for combining overlapping bounding boxes.

I use heatmap to combine bounding boxes. My code is at line 154 in function ‘get_realcar_boxes()’ in file ‘find_cars.py’

Heatmap like this:



I use `scipy.ndimage.measurements.label()` to make sure cars bounding box.

Filter: this step’s code is in function ‘draw_cars()’ at line 178 in file ‘find_cars.py’.

I create a deque(length=3) to storage boxes detected. Also, I use a heat map to draw boxes in deque. If a box got detected in continuous 3 frames, it’s center value will be three. This way, I delete false positive value.

Discussion

1. The speed of my code to deal video is very low. The reason might be my svm

model is too complex. I could optimize my algorithm to speed up it.

2. Although my code always detected cars, the bounding box is not stable. It's related to the sliding window's size. If I speed up my algorithm, I can use more overlap which will get a more stable result.