Vehicle Detection Project 2017/08/15

The goals / steps of this project are the following:

- Perform a Histogram of Oriented Gradients (HOG) feature extraction on a labeled training set of images and train a classifier Linear SVM classifier
- Optionally, you can also apply a color transform and append binned color features, as well as histograms of color, to your HOG feature vector.

  Note: for those first two steps don't forget to normalize your features and randomize a selection for training and testing.
- Implement a sliding-window technique and use your trained classifier to search for vehicles in images.
- Run your pipeline on a video stream (start with the test_video.mp4 and later implement on full project_video.mp4) and create a heat map of recurring detections frame by frame to reject outliers and follow detected vehicles.
- Estimate a bounding box for vehicles detected.

[Rubric](https://review.udacity.com/#!/rubrics/513/view) Points

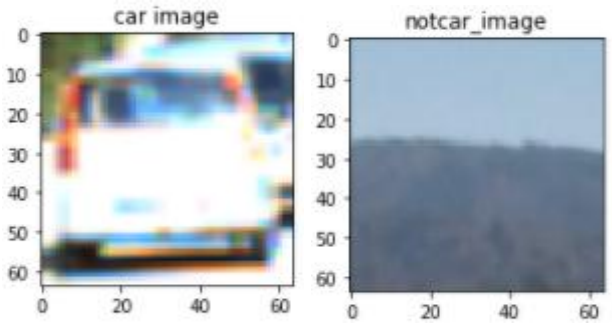
Here I will consider the rubric points individually and describe how I addressed each point in my implementation.

Histogram of Oriented Gradients (HOG)

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

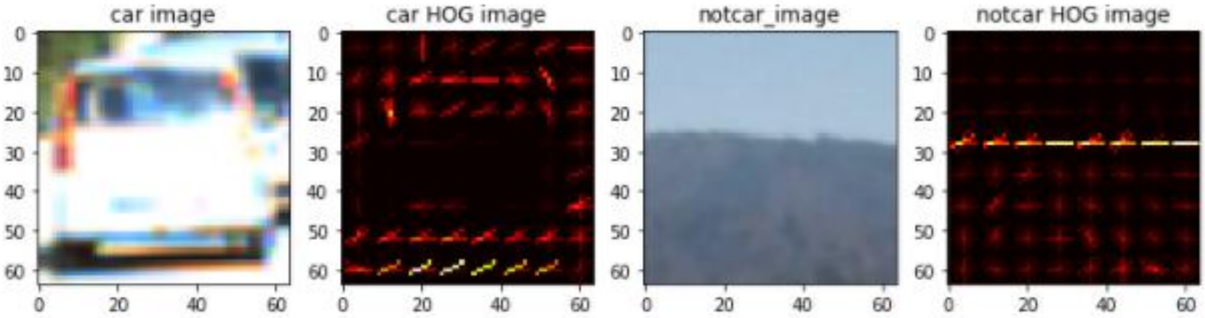
The code for this step is contained in the first code cell of the IPython notebook (Vehicle Detection Walkthrough.ipynb in third cell).

I started by reading in all the `vehicle` and `non-vehicle` images. Here is an example of one of each of the `vehicle` and `non-vehicle` classes:



I then explored different color spaces and different `skimage.hog()` parameters (`orientations`, `pixels_per_cell`, and `cells_per_block`). I grabbed random images from each of the two classes and displayed them to get a feel for what the `skimage.hog()` output looks like.

Here is an example using the `YCrCb` color space and HOG parameters of `orientations=8`, `pixels_per_cell=(8, 8)` and `cells_per_block=(2, 2)`:



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

I tried various combinations of parameters and my final choice of parameters are following.

Parameters	Numbers
Color Space	YCrCb
HOG orientations	9
HOG pixels per cell	8
HOG cells per block	2
HOG channels	ALL

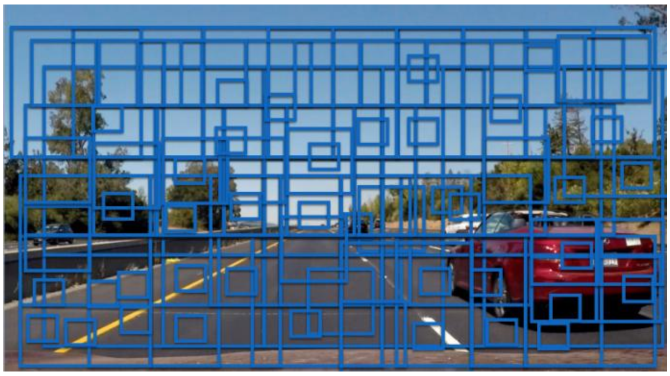
3. Describe how you trained a classifier using your selected HOG features.

I trained a linear SVM using HOG features, spatial binning and color histogram features. The feature vector length is 8460 and Test Accuracy of Support Vector Classifier is around 99 %.

Sliding Window Search

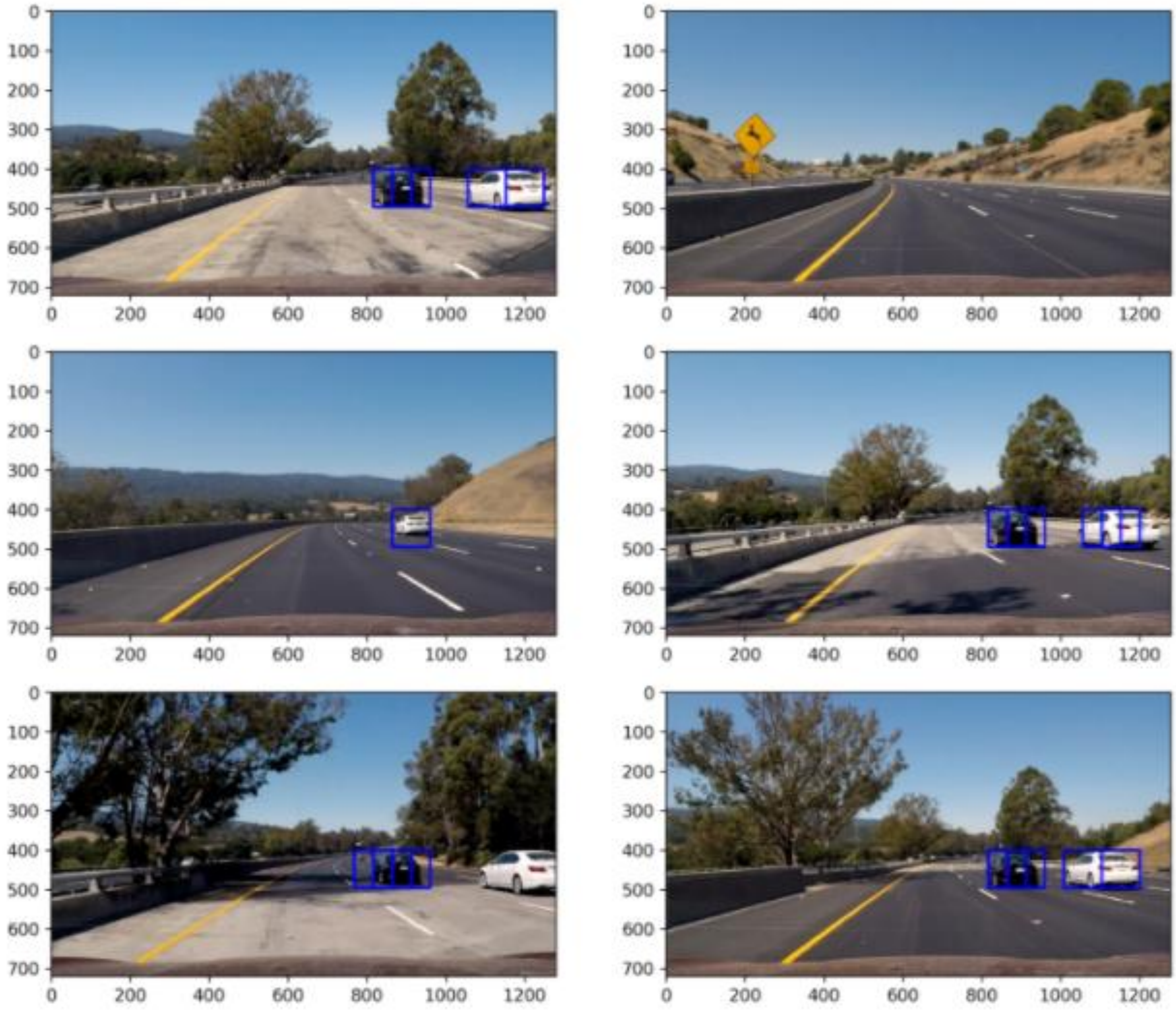
1. Describe how (and identify where in your code) you implemented a sliding window search. How did you decide what scales to search and how much to overlap windows?

I decided to search random window positions at random scales all over the image and came up with this (ok just kidding I didn't actually ;):



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?

Ultimately I searched on two scales using YCrCb 3-channel HOG features plus spatially binned color and histograms of color in the feature vector, which provided a nice result. Here are some example images:



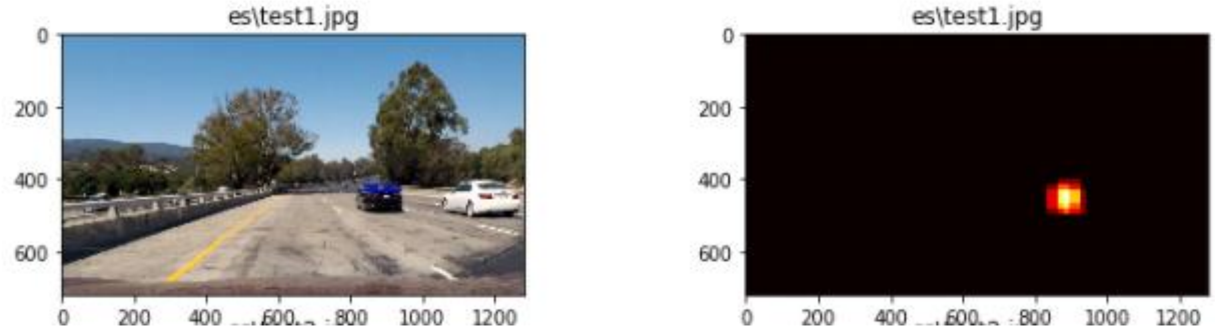
Video Implementation

1. Here's the video output test.mp4 in my project file.

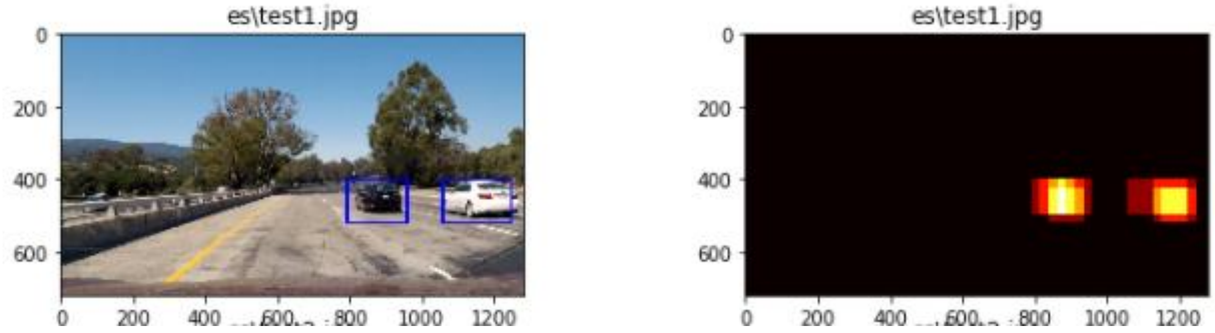
2. Describe how (and identify where in your code) you implemented some kind of filter for false positives and some method for combining overlapping bounding boxes.

I recorded the positions of positive detections in each frame of the video. From the positive detections I created a heatmap and then thresholded that map to identify vehicle positions. I then used `scipy.ndimage.measurements.label()` to identify individual blobs in the heatmap. I then assumed each blob corresponded to a vehicle. I constructed bounding boxes to cover the area of each blob detected. Here's an example result showing the heatmap from a series of frames of video, the result of `scipy.ndimage.measurements.label()` and the bounding boxes then overlaid on the last frame of video:

Here are six frames and their corresponding heatmaps:



Here the resulting bounding boxes are drawn onto the last frame in the series:



Discussion

1. Here I'll talk about the approach I took, what techniques I used, what worked and why, where the pipeline might fail and how I might improve it if I were going to pursue this project further.

Firstly, I made a classifier with using HOG, spatial binning and color histogram. I used linear support vector machine since it is fast and good classifier.

Second I implemented sliding windows to search to cars in an image. At first, I was searching the entire image, but changed the search range to the range where the car runs. As a result, I succeeded in reducing the number of windows to search. By using heatmap it is now possible to detect a car, but I also recognized the shadow of a tree as a car. By using this pipeline, it is considered that false detection occurs in bad weather condition.