应用python库

In [1]:
```
from skimage.feature import hog
from sklearn.svm import LinearSVC
from sklearn.preprocessing import StandardScaler
# for scikit-learn >= 0.18 use:
from sklearn.model_selection import train_test_split
# from sklearn.cross_validation import train_test_split
from scipy.ndimage.measurements import label
import matplotlib.image as mpimg
import matplotlib.pyplot as plt
from moviepy.editor import VideoFileClip
from IPython.display import HTML
import numpy as np
import pickle
import cv2
import glob
import time

%matplotlib inline

print('...')
```

```
...
```

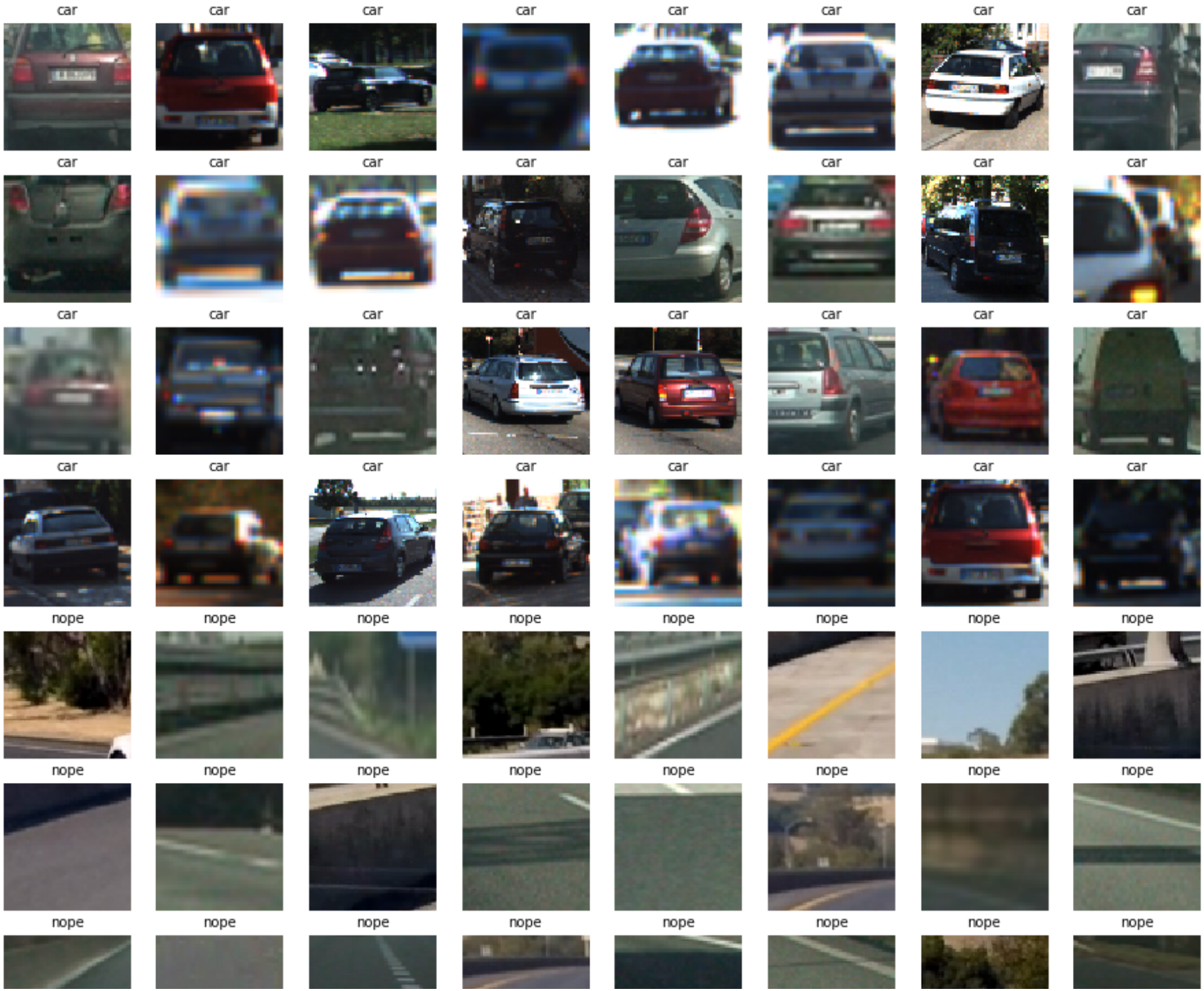
加载训练数据

In [2]:
```
car_images = glob.glob('E:\professional_work\Intelligent_detection_vehicle\OwnCollection/vehicles/**/*.png')
noncar_images = glob.glob('E:\professional_work\Intelligent_detection_vehicle\OwnCollection/non-vehicles/**/*.png')
print(len(car_images), len(noncar_images))
```

```
8792 8968
```

数据可视化

In [3]:
```
fig, axs = plt.subplots(8,8, figsize=(16, 16))
fig.subplots_adjust(hspace = .2, wspace=.001)
axs = axs.ravel()

# Step through the list and search for chessboard corners
for i in np.arange(32):
    img = cv2.imread(car_images[np.random.randint(0,len(car_images))])
    img = cv2.cvtColor(img,cv2.COLOR_BGR2RGB)
    axs[i].axis('off')
    axs[i].set_title('car', fontsize=10)
    axs[i].imshow(img)
for i in np.arange(32,64):
    img = cv2.imread(noncar_images[np.random.randint(0,len(noncar_images))])
    img = cv2.cvtColor(img,cv2.COLOR_BGR2RGB)
    axs[i].axis('off')
    axs[i].set_title('nope', fontsize=10)
    axs[i].imshow(img)
```


car car car car car car car car
car car car car car car car car
car car car car car car car car
car car car car car car car car
nope nope nope nope nope nope nope nope
nope nope nope nope nope nope nope nope
nope nope nope nope nope nope nope nope

定义将图像转换为定向梯度直方图(HOG)的方法

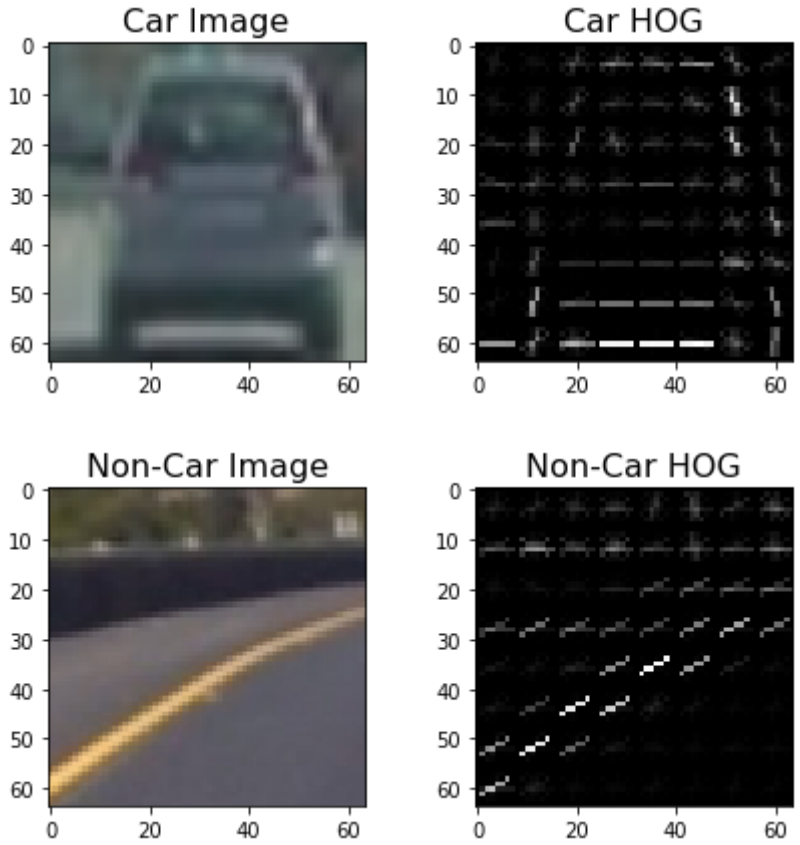
In [4]:
```
def get_hog_features(img, orient, pix_per_cell, cell_per_block,
                     vis=False, feature_vec=True):
    # Call with two outputs if vis==True
    if vis == True:
        features, hog_image = hog(img, orientations=orient,
                                  pixels_per_cell=(pix_per_cell, pix_per_cell),
                                  cells_per_block=(cell_per_block, cell_per_block),
                                  transform_sqrt=False,
                                  visualise=vis, feature_vector=feature_vec)
        return features, hog_image
    # Otherwise call with one output
    else:
        features = hog(img, orientations=orient,
                       pixels_per_cell=(pix_per_cell, pix_per_cell),
                       cells_per_block=(cell_per_block, cell_per_block),
                       transform_sqrt=False,
                       visualise=vis, feature_vector=feature_vec)
        return features

print('...')
```

```
...
```

在示例图像上可视化HOG

In [5]:
```
car_img = mpimg.imread(car_images[5])
_, car_dst = get_hog_features(car_img[:,:,2], 9, 8, 8, vis=True, feature_vec=True)
noncar_img = mpimg.imread(noncar_images[5])
_, noncar_dst = get_hog_features(noncar_img[:,:,2], 9, 8, 8, vis=True, feature_vec=True)

# Visualize
f, ((ax1, ax2), (ax3, ax4)) = plt.subplots(2, 2, figsize=(7,7))
f.subplots_adjust(hspace = .4, wspace=.2)
ax1.imshow(car_img)
ax1.set_title('Car Image', fontsize=16)
ax2.imshow(car_dst, cmap='gray')
ax2.set_title('Car HOG', fontsize=16)
ax3.imshow(noncar_img)
ax3.set_title('Non-Car Image', fontsize=16)
ax4.imshow(noncar_dst, cmap='gray')
ax4.set_title('Non-Car HOG', fontsize=16)
print('...')
```

```
...
```


Car Image
Car HOG
Non-Car Image
Non-Car HOG

从一组汽车和非汽车图像中提取HOG特征的方法

In [6]:
```
# Define a function to extract features from a list of image locations
# This function could also be used to call bin_spatial() and color_hist() (as in the lessons) to extract
# flattened spatial color features and color histogram features and combine them all (making use of StandardScaler)
# to be used together for classification
def extract_features(imgs, cspace='RGB', orient=9,
                     pix_per_cell=8, cell_per_block=2, hog_channel=0):
    # Create a list to append feature vectors to
    features = []
    # Iterate through the list of images
    for file in imgs:
        # Read in each one by one
        image = mpimg.imread(file)
        # apply color conversion if other than 'RGB'
        if cspace != 'RGB':
            if cspace == 'HSV':
                feature_image = cv2.cvtColor(image, cv2.COLOR_RGB2HSV)
            elif cspace == 'LUV':
                feature_image = cv2.cvtColor(image, cv2.COLOR_RGB2LUV)
            elif cspace == 'HLS':
                feature_image = cv2.cvtColor(image, cv2.COLOR_RGB2HLS)
            elif cspace == 'YUV':
                feature_image = cv2.cvtColor(image, cv2.COLOR_RGB2YUV)
            elif cspace == 'YCrCb':
                feature_image = cv2.cvtColor(image, cv2.COLOR_RGB2YCrCb)
        else: feature_image = np.copy(image)

        # Call get_hog_features() with vis=False, feature_vec=True
        if hog_channel == 'ALL':
            hog_features = []
            for channel in range(feature_image.shape[2]):
                hog_features.append(get_hog_features(feature_image[:,:,channel],
                                    orient, pix_per_cell, cell_per_block,
                                    vis=False, feature_vec=True))
            hog_features = np.ravel(hog_features)
        else:
            hog_features = get_hog_features(feature_image[:,:,hog_channel], orient,
                        pix_per_cell, cell_per_block, vis=False, feature_vec=True)
        # Append the new feature vector to the features list
#         print(hog_features)
        features.append(hog_features)
    # Return list of feature vectors
```

```
    return features

print('...')
```

```
...
```

提取输入数据集的特征和组合，定义标签向量，分割训练集和测试集。

In [7]:
```
# Feature extraction parameters
colorspace = 'YUV' # Can be RGB, HSV, LUV, HLS, YUV, YCrCb
orient = 11
pix_per_cell = 16
cell_per_block = 2
hog_channel = 'ALL' # Can be 0, 1, 2, or "ALL"

t = time.time()
car_features = extract_features(car_images, cspace=colorspace, orient=orient,
                        pix_per_cell=pix_per_cell, cell_per_block=cell_per_block,
                        hog_channel=hog_channel)
notcar_features = extract_features(noncar_images, cspace=colorspace, orient=orient,
                        pix_per_cell=pix_per_cell, cell_per_block=cell_per_block,
                        hog_channel=hog_channel)
t2 = time.time()
print(round(t2-t, 2), 'Seconds to extract HOG features...')
# Create an array stack of feature vectors
X = np.vstack((car_features, notcar_features)).astype(np.float64)

# Fit a per-column scaler - this will be necessary if combining different types of features (HOG + color_hist/bin_spatial)
#X_scaler = StandardScaler().fit(X)
# Apply the scaler to X
#scaled_X = X_scaler.transform(X)

# Define the labels vector
y = np.hstack((np.ones(len(car_features)), np.zeros(len(notcar_features))))


# Split up data into randomized training and test sets
rand_state = np.random.randint(0, 100)
X_train, X_test, y_train, y_test = train_test_split(
    X, y, test_size=0.2, random_state=rand_state)

# print('Using:',orient,'orientations',pix_per_cell,
#     'pixels per cell and', cell_per_block,'cells per block')
# print('Feature vector length:', len(X_train[0]))
```

```
43.58 Seconds to extract HOG features...
```

Parameter exploration

Configuration Label	Colorspace	Orientations	Pixels Per Cell	Cells Per Block	HOG Channel	Extract Time
1	RGB	9	8	2	ALL	71.16
2	HSV	9	8	2	1	43.74
3	HSV	9	8	2	2	36.35
4	LUV	9	8	2	0	37.42
5	LUV	9	8	2	1	38.34
6	HLS	9	8	2	0	37.42
7	HLS	9	8	2	1	42.04
8	YUV	9	8	2	0	35.86
9	YCrCb	9	8	2	1	38.32
10	YCrCb	9	8	2	2	38.99
11	HSV	9	8	2	ALL	79.72
12	LUV	9	8	2	ALL	78.57
13	HLS	9	8	2	ALL	81.37
14	YUV	9	8	2	ALL	81.82
15	YCrCb	9	8	2	ALL	79.05
16	YUV	9	8	1	0	44.04
17	YUV	9	8	3	0	37.74
18	YUV	6	8	2	0	37.12
19	YUV	12	8	2	0	40.11
20	YUV	11	8	2	0	38.01
21	YUV	11	16	2	0	30.21
22	YUV	11	12	2	0	30.33
23	YUV	11	4	2	0	69.08
24	YUV	11	16	2	ALL	55.20

Configuration Label Colorspace Orientations Pixels Per Cell Cells Per Block HOG Channel Extract Time

训练分类器

In [8]:
```
# Use a linear SVC
svc = LinearSVC()
# Check the training time for the SVC
t = time.time()
svc.fit(X_train, y_train)
t2 = time.time()
print(round(t2-t, 2), 'Seconds to train SVC...')
# Check the score of the SVC
print('Test Accuracy of SVC = ', round(svc.score(X_test, y_test), 4))
# Check the prediction time for a single sample
t=time.time()
n_predict = 10
print('My SVC predicts: ', svc.predict(X_test[0:n_predict]))
print('For these',n_predict, 'labels: ', y_test[0:n_predict])
t2 = time.time()
print(round(t2-t, 5), 'Seconds to predict', n_predict,'labels with SVC')
```

```
1.03 Seconds to train SVC...
Test Accuracy of SVC =  0.9814
My SVC predicts:  [1. 0. 0. 1. 0. 0. 0. 0. 1. 1.]
For these 10 labels:  [1. 0. 0. 1. 0. 0. 0. 0. 1. 1.]
0.0 Seconds to predict 10 labels with SVC
```

Exploration

Configuration (above)	Classifier	Accuracy	Train Time
1	Linear SVC	97.52	19.21
2	Linear SVC	91.92	5.53
3	Linear SVC	96.09	4.29
4	Linear SVC	95.72	4.33
5	Linear SVC	94.51	4.51
6	Linear SVC	92.34	4.97

Configuration (above)	Classifier	Accuracy	Train Time
7	Linear SVC	95.81	4.04
8	Linear SVC	96.28	5.04
9	Linear SVC	94.88	4.69
10	Linear SVC	93.78	4.59
11	Linear SVC	98.31	16.03
12	Linear SVC	97.52	14.77
13	Linear SVC	98.42	13.46
14	Linear SVC	98.40	15.68
15	Linear SVC	98.06	12.86
16	Linear SVC	94.76	5.11
17	Linear SVC	96.11	6.71
18	Linear SVC	95.81	3.79
19	Linear SVC	95.95	4.84
20	Linear SVC	96.59	5.46
21	Linear SVC	95.16	0.52
22	Linear SVC	94.85	1.27
23	Linear SVC	95.92	21.39
24	Linear SVC	98.17	1.14

使用分类器检测图像中的汽车

In [9]:
```
# Define a single function that can extract features using hog sub-sampling and make predictions
def find_cars(img, ystart, ystop, scale, cspace, hog_channel, svc, X_scaler, orient,
              pix_per_cell, cell_per_block, spatial_size, hist_bins, show_all_rectangles=False):

    # array of rectangles where cars were detected
    rectangles = []

    img = img.astype(np.float32)/255

    img_tosearch = img[ystart:ystop,:,:]

    # apply color conversion if other than 'RGB'
    if cspace != 'RGB':
        if cspace == 'HSV':
            ctrans_tosearch = cv2.cvtColor(img_tosearch, cv2.COLOR_RGB2HSV)
        elif cspace == 'LUV':
            ctrans_tosearch = cv2.cvtColor(img_tosearch, cv2.COLOR_RGB2LUV)
        elif cspace == 'HLS':
            ctrans_tosearch = cv2.cvtColor(img_tosearch, cv2.COLOR_RGB2HLS)
        elif cspace == 'YUV':
            ctrans_tosearch = cv2.cvtColor(img_tosearch, cv2.COLOR_RGB2YUV)
        elif cspace == 'YCrCb':
            ctrans_tosearch = cv2.cvtColor(img_tosearch, cv2.COLOR_RGB2YCrCb)
    else: ctrans_tosearch = np.copy(image)

    # rescale image if other than 1.0 scale
    if scale != 1:
        imshape = ctrans_tosearch.shape
        ctrans_tosearch = cv2.resize(ctrans_tosearch, (np.int(imshape[1]/scale), np.int(imshape[0]/scale)))

    # select colorspace channel for HOG
    if hog_channel == 'ALL':
        ch1 = ctrans_tosearch[:,:,0]
        ch2 = ctrans_tosearch[:,:,1]
        ch3 = ctrans_tosearch[:,:,2]
    else:
        ch1 = ctrans_tosearch[:,:,hog_channel]

    # Define blocks and steps as above
    nxblocks = (ch1.shape[1] // pix_per_cell)+1  #-1
    nyblocks = (ch1.shape[0] // pix_per_cell)+1  #-1
```

```
    nfeat_per_block = orient*cell_per_block**2
    # 64 was the orginal sampling rate, with 8 cells and 8 pix per cell
    window = 64
    nblocks_per_window = (window // pix_per_cell)-1
    cells_per_step = 2  # Instead of overlap, define how many cells to step
    nxsteps = (nxblocks - nblocks_per_window) // cells_per_step
    nysteps = (nyblocks - nblocks_per_window) // cells_per_step

    # Compute individual channel HOG features for the entire image
    hog1 = get_hog_features(ch1, orient, pix_per_cell, cell_per_block, feature_vec=False)
    if hog_channel == 'ALL':
        hog2 = get_hog_features(ch2, orient, pix_per_cell, cell_per_block, feature_vec=False)
        hog3 = get_hog_features(ch3, orient, pix_per_cell, cell_per_block, feature_vec=False)

    for xb in range(nxsteps):
        for yb in range(nysteps):
            ypos = yb*cells_per_step
            xpos = xb*cells_per_step
            # Extract HOG for this patch
            hog_feat1 = hog1[ypos:ypos+nblocks_per_window, xpos:xpos+nblocks_per_window].ravel()
            if hog_channel == 'ALL':
                hog_feat2 = hog2[ypos:ypos+nblocks_per_window, xpos:xpos+nblocks_per_window].ravel()
                hog_feat3 = hog3[ypos:ypos+nblocks_per_window, xpos:xpos+nblocks_per_window].ravel()
                hog_features = np.hstack((hog_feat1, hog_feat2, hog_feat3))
            else:
                hog_features = hog_feat1

            xleft = xpos*pix_per_cell
            ytop = ypos*pix_per_cell

            hog_features = hog_features.reshape(1,1188)
#            print(hog_features.shape)
            test_prediction = svc.predict(hog_features)

            if test_prediction == 1 or show_all_rectangles:
                xbox_left = np.int(xleft*scale)
                ytop_draw = np.int(ytop*scale)
                win_draw = np.int(window*scale)
                rectangles.append(((xbox_left, ytop_draw+ystart),(xbox_left+win_draw,ytop_draw+win_draw+ystart)))

    return rectangles
```

```
print('...')
```

```
...
```

在示例图像上测试Find_Cars

In [10]:
```
test_img = mpimg.imread('./test_images/test1.jpg')
# print(test_img)
ystart = 400
ystop = 656
scale = 1.5
colorspace = 'LUV' # Can be RGB, HSV, LUV, HLS, YUV, YCrCb
orient = 11
pix_per_cell = 16
cell_per_block = 2
hog_channel = 'ALL' # Can be 0, 1, 2, or "ALL"

rectangles = find_cars(test_img, ystart, ystop, scale, colorspace, hog_channel, svc, None, orient, pix_per_cell, cell_per_block, N
# print(rectangles)
print(len(rectangles), 'rectangles found in image')
```

```
9 rectangles found in image
```

在图像上绘制矩形的方法

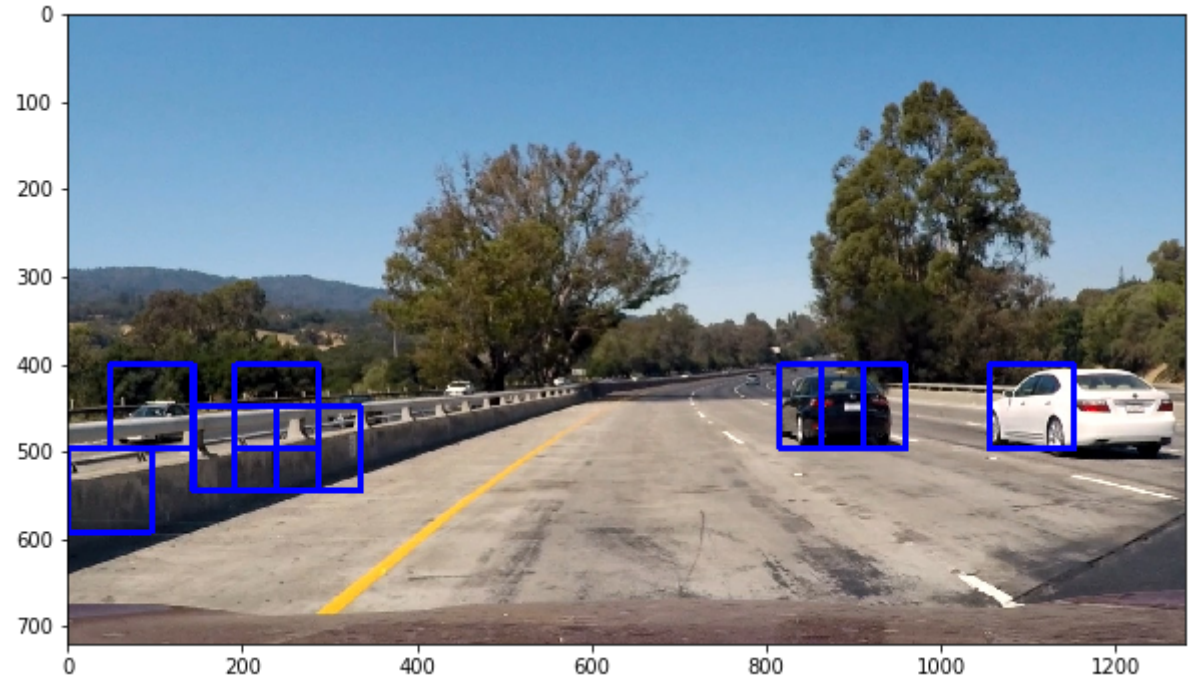
In [11]:
```
# Here is your draw_boxes function from the previous exercise
def draw_boxes(img, bboxes, color=(0, 0, 255), thick=6):
    # Make a copy of the image
    imcopy = np.copy(img)
    random_color = False
    # Iterate through the bounding boxes
    for bbox in bboxes:
        if color == 'random' or random_color:
            color = (np.random.randint(0,255), np.random.randint(0,255), np.random.randint(0,255))
            random_color = True
        # Draw a rectangle given bbox coordinates
        cv2.rectangle(imcopy, bbox[0], bbox[1], color, thick)
    # Return the image copy with boxes drawn
    return imcopy

print('...')
```

```
...
```

将矩形绘制到示例图像上

In [12]:
```
test_img_rects = draw_boxes(test_img, rectangles)
plt.figure(figsize=(10,10))
plt.imshow(test_img_rects)
print('...')
```

```
...
```

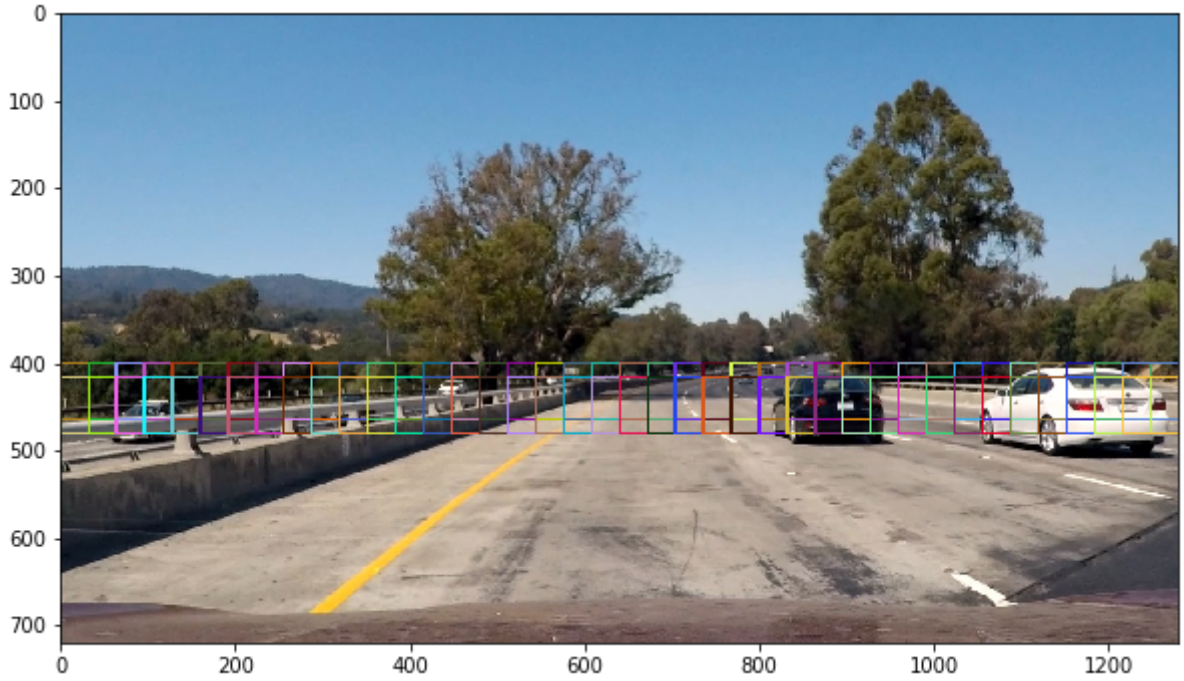


显示所有潜在的搜索区域

因为图像中汽车的大小和位置将根据它们与相机的距离而不同，所以 `find_cars` 将不得不使用不同的 `ystart` ， `ystop` 和 `scale` 值调用几次。接下来的几个代码块用于确定这些参数的最佳值。

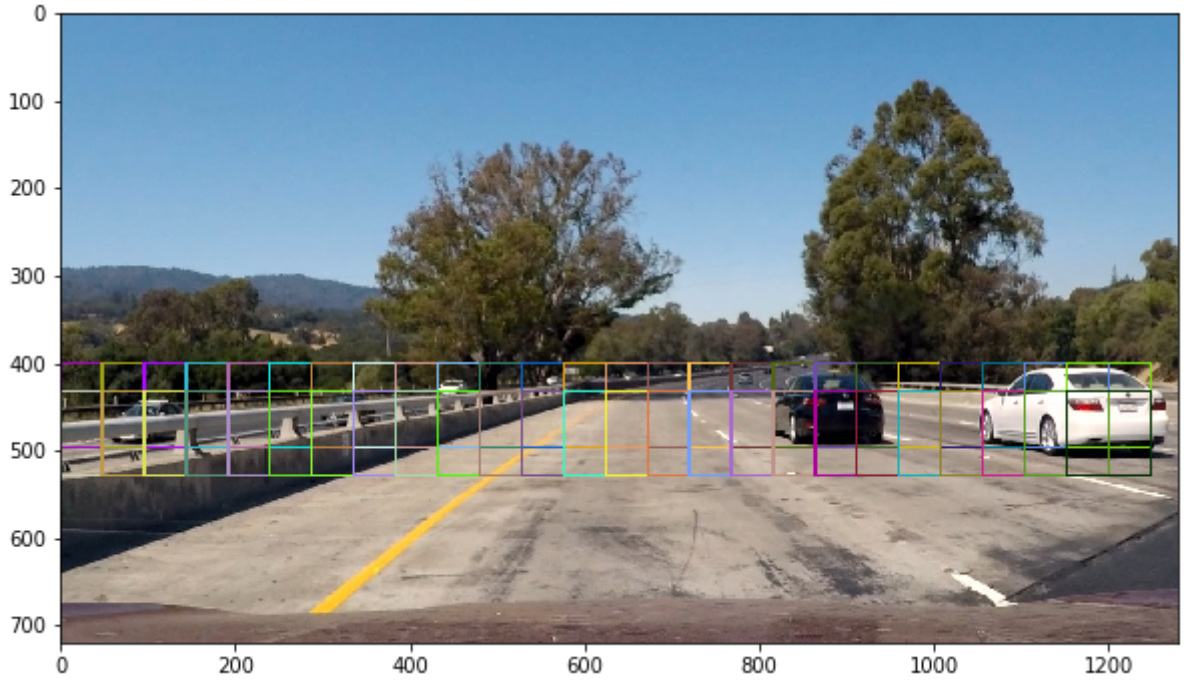
In [13]:
```
test_img = mpimg.imread('./test_images/test1.jpg')

rects = []

ystart = 400
ystop = 464
scale = 1.0
rects.append(find_cars(test_img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                       orient, pix_per_cell, cell_per_block, None, None, show_all_rectangles=True))
ystart = 416
ystop = 480
scale = 1.0
rects.append(find_cars(test_img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                       orient, pix_per_cell, cell_per_block, None, None, show_all_rectangles=True))

rectangles = [item for sublist in rects for item in sublist]
test_img_rects = draw_boxes(test_img, rectangles, color='random', thick=2)
plt.figure(figsize=(10,10))
plt.imshow(test_img_rects)
print('Number of boxes: ', len(rectangles))
```

```
Number of boxes:  78
```


0
100
200
300
400
500
600
700
0
200
400
600
800
1000
1200

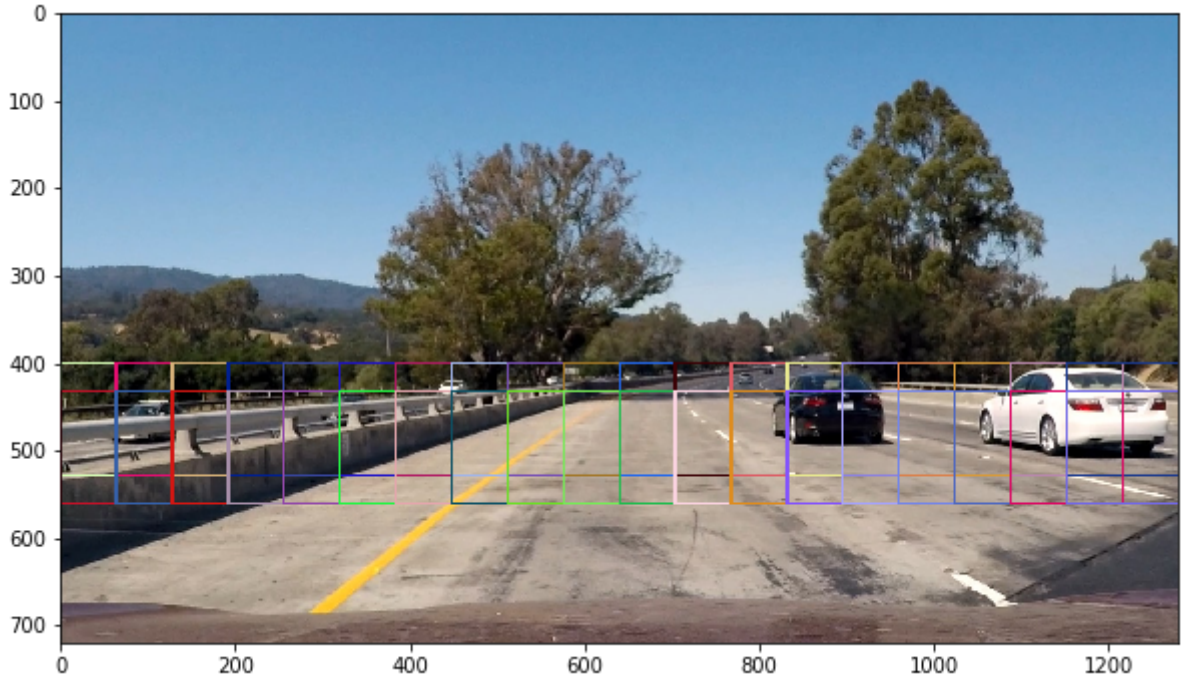
In [14]:
```
test_img = mpimg.imread('./test_images/test1.jpg')

rects = []

ystart = 400
ystop = 496
scale = 1.5
rects.append(find_cars(test_img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                       orient, pix_per_cell, cell_per_block, None, None, show_all_rectangles=True))
ystart = 432
ystop = 528
scale = 1.5
rects.append(find_cars(test_img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                       orient, pix_per_cell, cell_per_block, None, None, show_all_rectangles=True))

rectangles = [item for sublist in rects for item in sublist]
test_img_rects = draw_boxes(test_img, rectangles, color='random', thick=2)
plt.figure(figsize=(10,10))
plt.imshow(test_img_rects)
print('Number of boxes: ', len(rectangles))
```

```
Number of boxes:  50
```


0
100
200
300
400
500
600
700
0
200
400
600
800
1000
1200

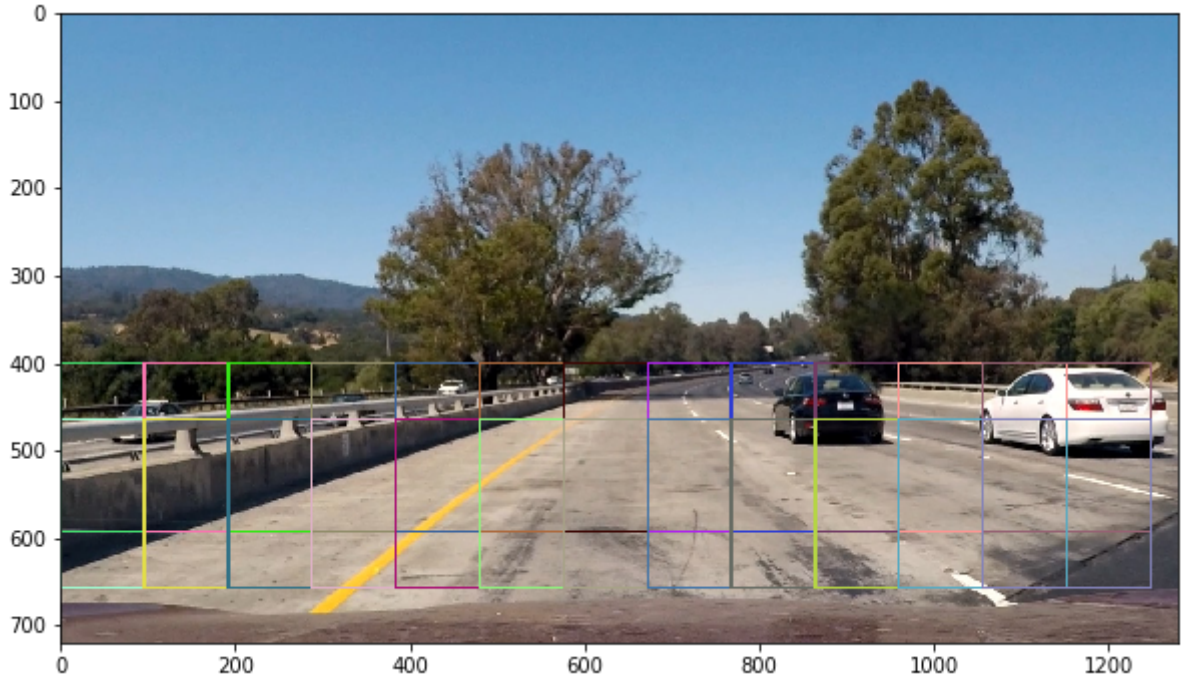
In [15]:
```
test_img = mpimg.imread('./test_images/test1.jpg')

rects = []

ystart = 400
ystop = 528
scale = 2.0
rects.append(find_cars(test_img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                       orient, pix_per_cell, cell_per_block, None, None, show_all_rectangles=True))
ystart = 432
ystop = 560
scale = 2.0
rects.append(find_cars(test_img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                       orient, pix_per_cell, cell_per_block, None, None, show_all_rectangles=True))

rectangles = [item for sublist in rects for item in sublist]
test_img_rects = draw_boxes(test_img, rectangles, color='random', thick=2)
plt.figure(figsize=(10,10))
plt.imshow(test_img_rects)
print('Number of boxes: ', len(rectangles))
```

```
Number of boxes:  38
```


0
100
200
300
400
500
600
700
0
200
400
600
800
1000
1200

In [16]:
```
test_img = mpimg.imread('./test_images/test1.jpg')

rects = []

ystart = 400
ystop = 596
scale = 3.0
rects.append(find_cars(test_img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                       orient, pix_per_cell, cell_per_block, None, None, show_all_rectangles=True))
ystart = 464
ystop = 660
scale = 3.0
rects.append(find_cars(test_img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                       orient, pix_per_cell, cell_per_block, None, None, show_all_rectangles=True))

rectangles = [item for sublist in rects for item in sublist]
test_img_rects = draw_boxes(test_img, rectangles, color='random', thick=2)
plt.figure(figsize=(10,10))
plt.imshow(test_img_rects)
print('Number of boxes: ', len(rectangles))
```

```
Number of boxes:  24
```

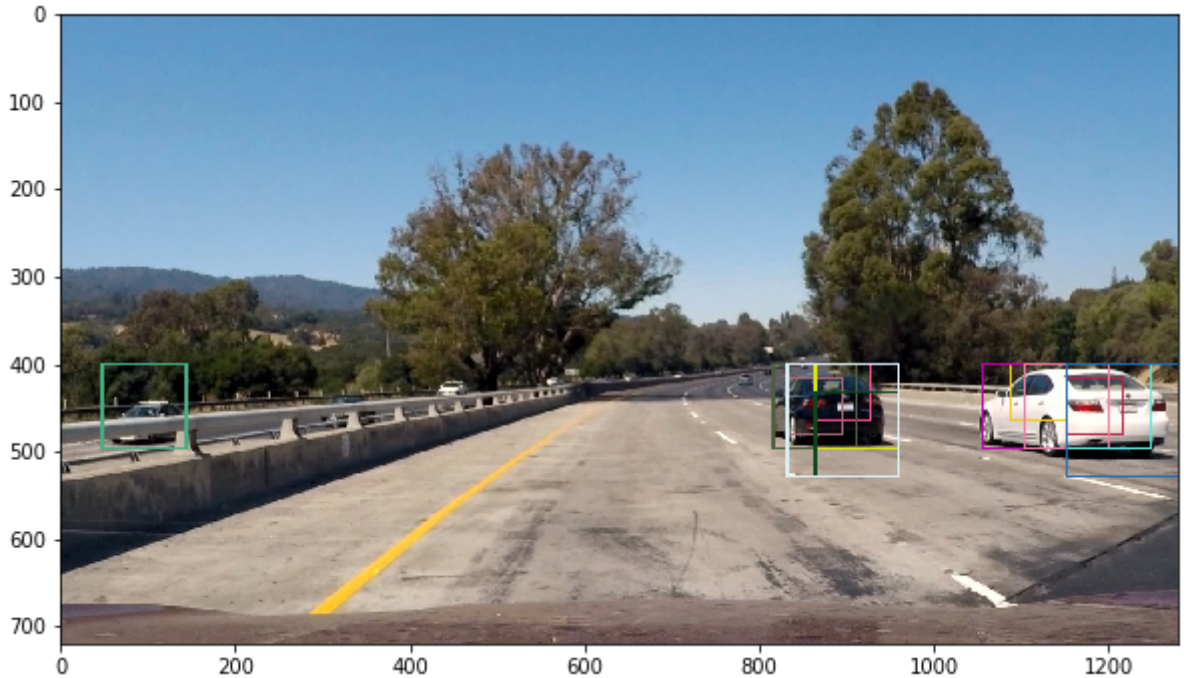

0
100
200
300
400
500
600
700
0
200
400
600
800
1000
1200

组合各种滑动窗口搜索

In [17]:
```
test_img = mpimg.imread('./test_images/test1.jpg')

rectangles = []

colorspace = 'YUV' # Can be RGB, HSV, LUV, HLS, YUV, YCrCb
orient = 11
pix_per_cell = 16
cell_per_block = 2
hog_channel = 'ALL' # Can be 0, 1, 2, or "ALL"


ystart = 400
ystop = 464
scale = 1.0
rectangles.append(find_cars(test_img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                        orient, pix_per_cell, cell_per_block, None, None))
ystart = 416
ystop = 480
scale = 1.0
rectangles.append(find_cars(test_img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                        orient, pix_per_cell, cell_per_block, None, None))
ystart = 400
ystop = 496
scale = 1.5
rectangles.append(find_cars(test_img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                        orient, pix_per_cell, cell_per_block, None, None))
ystart = 432
ystop = 528
scale = 1.5
rectangles.append(find_cars(test_img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                        orient, pix_per_cell, cell_per_block, None, None))
ystart = 400
ystop = 528
scale = 2.0
rectangles.append(find_cars(test_img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                        orient, pix_per_cell, cell_per_block, None, None))
ystart = 432
ystop = 560
scale = 2.0
rectangles.append(find_cars(test_img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                        orient, pix_per_cell, cell_per_block, None, None))
```

```
ystart = 400
ystop = 596
scale = 3.5
rectangles.append(find_cars(test_img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                    orient, pix_per_cell, cell_per_block, None, None))
ystart = 464
ystop = 660
scale = 3.5
rectangles.append(find_cars(test_img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                    orient, pix_per_cell, cell_per_block, None, None))

# apparently this is the best way to flatten a list of lists
rectangles = [item for sublist in rectangles for item in sublist]
test_img_rects = draw_boxes(test_img, rectangles, color='random', thick=2)
plt.figure(figsize=(10,10))
plt.imshow(test_img_rects)
print('...')
```

```
...
```



*探索发现:

- 低于1.0的量表似乎会产生很多误报。
- 在接下来的工作中开始和停止的位置和比例可能需要一些调整，这取决于视频性能。

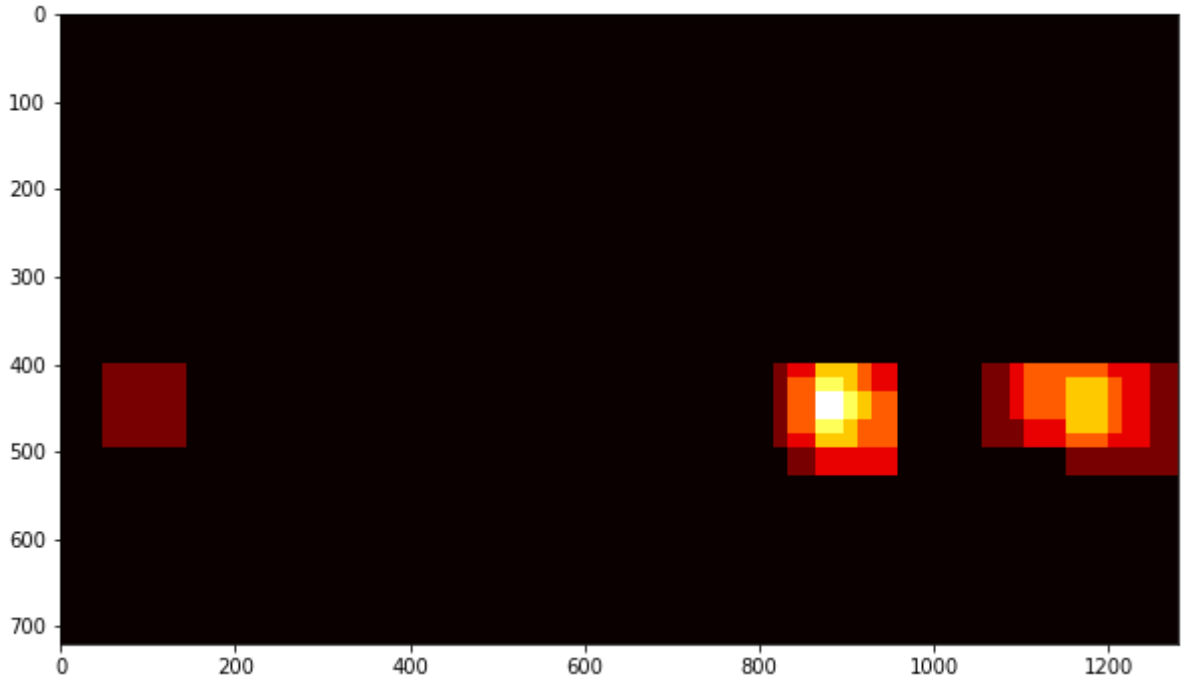
热图

In [18]:
```
def add_heat(heatmap, bbox_list):
    # Iterate through list of bboxes
    for box in bbox_list:
        # Add += 1 for all pixels inside each bbox
        # Assuming each "box" takes the form ((x1, y1), (x2, y2))
        heatmap[box[0][1]:box[1][1], box[0][0]:box[1][0]] += 1

    # Return updated heatmap
    return heatmap

print('...')
```

```
...
```

In [19]:
```
# Test out the heatmap
heatmap_img = np.zeros_like(test_img[:,:,0])
heatmap_img = add_heat(heatmap_img, rectangles)
plt.figure(figsize=(10,10))
plt.imshow(heatmap_img, cmap='hot')

print('...')
```

```
...
```



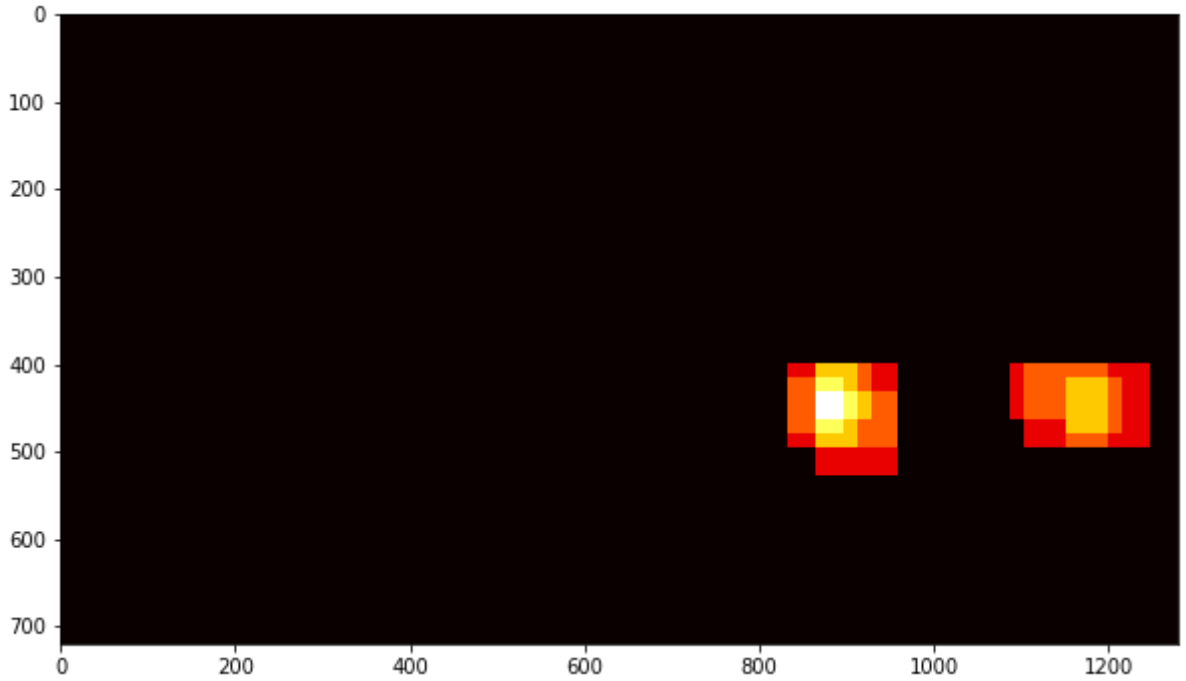
为热图应用阈值

In [20]:
```
def apply_threshold(heatmap, threshold):
    # Zero out pixels below the threshold
    heatmap[heatmap <= threshold] = 0
    # Return thresholded map
    return heatmap

print('...')
```

```
...
```

In [21]:
```
heatmap_img = apply_threshold(heatmap_img, 1)
plt.figure(figsize=(10,10))
plt.imshow(heatmap_img, cmap='hot')

print('...')
```

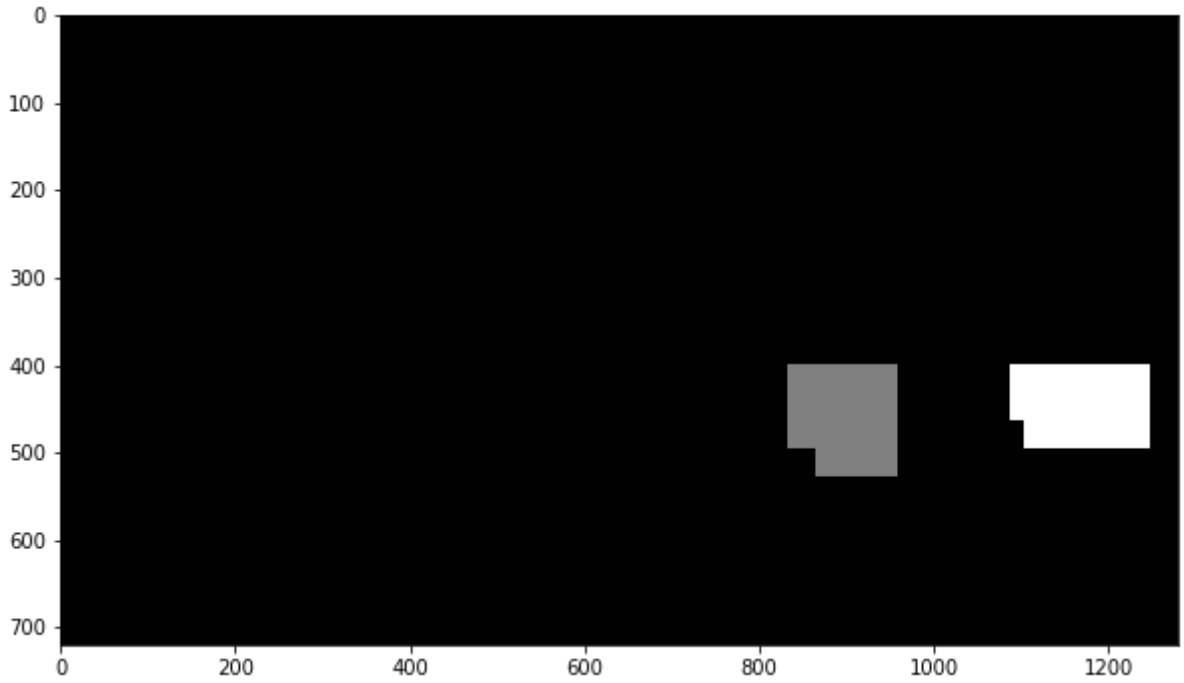
```
...
```



将SciPy应用于热图

In [22]:
```
labels = label(heatmap_img)
plt.figure(figsize=(10,10))
plt.imshow(labels[0], cmap='gray')
print(labels[1], 'cars found')
```

```
2 cars found
```



为标签绘制边界框

In [23]:
```
def draw_labeled_bboxes(img, labels):
    # Iterate through all detected cars
    rects = []
    for car_number in range(1, labels[1]+1):
        # Find pixels with each car_number label value
        nonzero = (labels[0] == car_number).nonzero()
        # Identify x and y values of those pixels
        nonzeroy = np.array(nonzero[0])
        nonzerox = np.array(nonzero[1])
        # Define a bounding box based on min/max x and y
        bbox = ((np.min(nonzerox), np.min(nonzeroy)), (np.max(nonzerox), np.max(nonzeroy)))
        rects.append(bbox)
        # Draw the box on the image
        cv2.rectangle(img, bbox[0], bbox[1], (0,0,255), 6)
    # Return the image and final rectangles
    return img, rects

# Draw bounding boxes on a copy of the image
draw_img, rect = draw_labeled_bboxes(np.copy(test_img), labels)
# Display the image
plt.figure(figsize=(10,10))
plt.imshow(draw_img)
print('...')
```

```
...
```


0
100
200
300
400
500
600
700
0
200
400
600
800
1000
1200

把它们放在一起

In [24]:
```
def process_frame(img):

    rectangles = []

    colorspace = 'YUV' # Can be RGB, HSV, LUV, HLS, YUV, YCrCb
    orient = 11
    pix_per_cell = 16
    cell_per_block = 2
    hog_channel = 'ALL' # Can be 0, 1, 2, or "ALL"

    ystart = 400
    ystop = 464
    scale = 1.0
    rectangles.append(find_cars(img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                        orient, pix_per_cell, cell_per_block, None, None))
    ystart = 416
    ystop = 480
    scale = 1.0
    rectangles.append(find_cars(img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                        orient, pix_per_cell, cell_per_block, None, None))
    ystart = 400
    ystop = 496
    scale = 1.5
    rectangles.append(find_cars(img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                        orient, pix_per_cell, cell_per_block, None, None))
    ystart = 432
    ystop = 528
    scale = 1.5
    rectangles.append(find_cars(img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                        orient, pix_per_cell, cell_per_block, None, None))
    ystart = 400
    ystop = 528
    scale = 2.0
    rectangles.append(find_cars(img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                        orient, pix_per_cell, cell_per_block, None, None))
    ystart = 432
    ystop = 560
    scale = 2.0
    rectangles.append(find_cars(img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                        orient, pix_per_cell, cell_per_block, None, None))
    ystart = 400
```

```
    ystop = 596
    scale = 3.5
    rectangles.append(find_cars(img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                        orient, pix_per_cell, cell_per_block, None, None))
    ystart = 464
    ystop = 660
    scale = 3.5
    rectangles.append(find_cars(img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                        orient, pix_per_cell, cell_per_block, None, None))

    rectangles = [item for sublist in rectangles for item in sublist]

    heatmap_img = np.zeros_like(img[:,:,0])
    heatmap_img = add_heat(heatmap_img, rectangles)
    heatmap_img = apply_threshold(heatmap_img, 1)
    labels = label(heatmap_img)
    draw_img, rects = draw_labeled_bboxes(np.copy(img), labels)
    return draw_img

print('...')
```

```
...
```

在所有测试映像上运行综合解决方案。

In [25]:
```
test_images = glob.glob('E:\\professional_work\\Intelligent_detection_vehicle\\test_images\\test*.jpg')

fig, axs = plt.subplots(3, 2, figsize=(16,14))
fig.subplots_adjust(hspace = .004, wspace=.002)
axs = axs.ravel()

for i, im in enumerate(test_images):
    axs[i].imshow(process_frame(mpimg.imread(im)))
    axs[i].axis('off')
```

通过综合解决方案运行视频(原始版本)

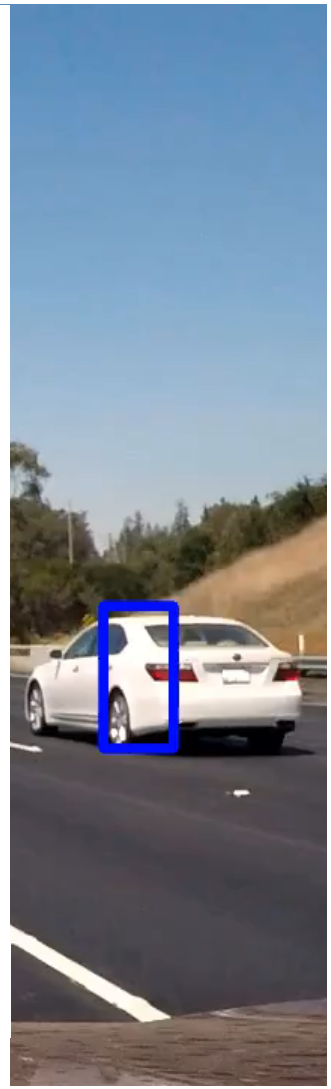
这一次只处理一帧，而不考虑来自前一帧的信息

In [26]:
```
test_out_file = 'test_video_out.mp4'
clip_test = VideoFileClip('test_video.mp4')
clip_test_out = clip_test.fl_image(process_frame)
%time clip_test_out.write_videofile(test_out_file, audio=False)
```

```
Moviepy - Building video test_video_out.mp4.
Moviepy - Writing video test_video_out.mp4



Moviepy - Done !
Moviepy - video ready test_video_out.mp4
Wall time: 9.19 s
```

In [27]:
```
HTML("""
<video width="960" height="540" controls>
  <source src="{0}">
</video>
""".format(test_out_file))
```

Out[27]:



定义一个类来存储来自车辆检测的数据

In [28]:
```
# Define a class to store data from video
class Vehicle_Detect():
    def __init__(self):
        # history of rectangles previous n frames
        self.prev_rects = []

    def add_rects(self, rects):
        self.prev_rects.append(rects)
        if len(self.prev_rects) > 15:
            # throw out oldest rectangle set(s)
            self.prev_rects = self.prev_rects[len(self.prev_rects)-15:]

print('...')
```

```
...
```

处理视频帧的综合解决方案

In [29]:
```
def process_frame_for_video(img):

    rectangles = []

    colorspace = 'YUV' # Can be RGB, HSV, LUV, HLS, YUV, YCrCb
    orient = 11
    pix_per_cell = 16
    cell_per_block = 2
    hog_channel = 'ALL' # Can be 0, 1, 2, or "ALL"

    ystart = 400
    ystop = 464
    scale = 1.0
    rectangles.append(find_cars(img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                        orient, pix_per_cell, cell_per_block, None, None))
    ystart = 416
    ystop = 480
    scale = 1.0
    rectangles.append(find_cars(img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                        orient, pix_per_cell, cell_per_block, None, None))
    ystart = 400
    ystop = 496
    scale = 1.5
    rectangles.append(find_cars(img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                        orient, pix_per_cell, cell_per_block, None, None))
    ystart = 432
    ystop = 528
    scale = 1.5
    rectangles.append(find_cars(img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                        orient, pix_per_cell, cell_per_block, None, None))
    ystart = 400
    ystop = 528
    scale = 2.0
    rectangles.append(find_cars(img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                        orient, pix_per_cell, cell_per_block, None, None))
    ystart = 432
    ystop = 560
    scale = 2.0
    rectangles.append(find_cars(img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                        orient, pix_per_cell, cell_per_block, None, None))
    ystart = 400
```

```
    ystop = 596
    scale = 3.5
    rectangles.append(find_cars(img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                            orient, pix_per_cell, cell_per_block, None, None))
    ystart = 464
    ystop = 660
    scale = 3.5
    rectangles.append(find_cars(img, ystart, ystop, scale, colorspace, hog_channel, svc, None,
                            orient, pix_per_cell, cell_per_block, None, None))

    rectangles = [item for sublist in rectangles for item in sublist]

    # add detections to the history
    if len(rectangles) > 0:
        det.add_rects(rectangles)

    heatmap_img = np.zeros_like(img[:,:,0])
    for rect_set in det.prev_rects:
        heatmap_img = add_heat(heatmap_img, rect_set)
    heatmap_img = apply_threshold(heatmap_img, 1 + len(det.prev_rects)//2)

    labels = label(heatmap_img)
    draw_img, rect = draw_labeled_bboxes(np.copy(img), labels)
    return draw_img

print('...')
```

```
...
```

通过综合解决方案运行视频(高级版本)

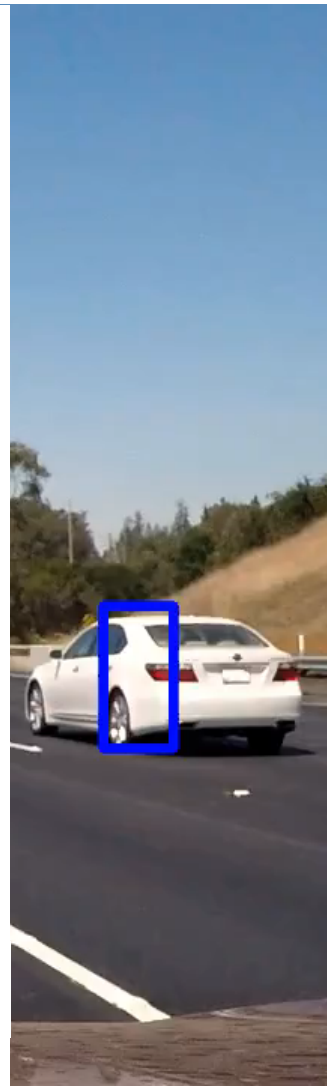
这在处理每一帧的同时考虑到来自前一帧的信息

In [30]:
```
det = Vehicle_Detect()

test_out_file2 = 'test_video_out_2.mp4'
clip_test2 = VideoFileClip('test_video.mp4')
clip_test_out2 = clip_test2.fl_image(process_frame_for_video)
%time clip_test_out2.write_videofile(test_out_file2, audio=False)
```

```
Moviepy - Building video test_video_out_2.mp4.
Moviepy - Writing video test_video_out_2.mp4



Moviepy - Done !
Moviepy - video ready test_video_out_2.mp4
Wall time: 9.28 s
```

In [31]:
```
HTML("""
<video width="960" height="540" controls>
  <source src="{0}">
</video>
""".format(test_out_file2))
```

Out[31]:

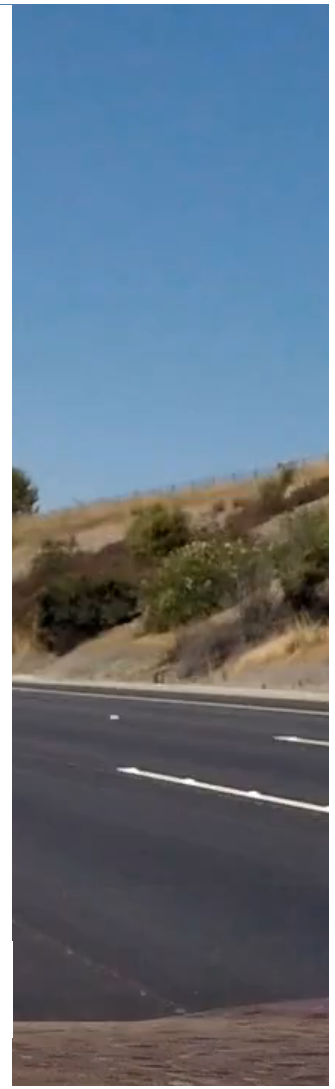


In [32]:
```
det = Vehicle_Detect()

proj_out_file = 'project_video_out.mp4'
clip_proj = VideoFileClip('project_video.mp4') #.subclip(23,26)  # subclip = only specified span of video
#clip_proj.save_frame('./test_images/project1.jpg', t=1.0) # saves the frame at time = t seconds
clip_proj_out = clip_proj.fl_image(process_frame_for_video)
%time clip_proj_out.write_videofile(proj_out_file, audio=False)
```

```
Moviepy - Building video project_video_out.mp4.
Moviepy - Writing video project_video_out.mp4




Moviepy - Done !
Moviepy - video ready project_video_out.mp4
Wall time: 4min 43s
```

In [33]:
```
HTML("""
<video width="960" height="540" controls>
  <source src="{0}">
</video>
""".format(proj_out_file))
```

Out[33]:



In [ ]: