CS4053: COMPUTER VISION
ASSIGNMENT 2: FIND AND RECOGNISE TRAFFIC LIGHTS

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For this lab we were asked to develop a program in C++ using OpenCV to locate and recognise traffic lights in the images and then extend the same to detect the colour of the lights as well. To do this I used the method called Haar-cascading. I was successfully able to detect most of the traffic lights and the colour of the traffic lights.

Object Detection using Haar feature-based classifiers is a very effective method which was proposed by Paul Viola and Michael Jones in 2001. It is a kind of machine learning based approach because a cascade function is trained from a lot of positive and negative images. It is then used to detect objects in other images.

Initially the algorithm needs a lot of positive images (images of just the traffic light/images of just the colour shown in the traffic light) and negative images (images without the traffic light) to train the classifier. Then we need to extract features from it. These features are just like our convolutional kernel. For doing the training for the dataset and creating the template file I used a software called Cascade-Trainer-GUI which I found on the internet and created cascades of the traffic lights and also the colour of each traffic light. To collect the data for the cascade I just went on a street and clicked about 500 images of traffic lights on the streets of Dublin. Then I edited those images to create two sets one was of positives and another was of negatives and then used the software to create the cascade. I could have used the OpenCV as well for creating the cascade but when I was trying to program for that I was having many difficulties so I ended up using the software mentioned above. Initially, I did this only for the traffic lights and once I was able to detect most of the traffic lights I extended this to detect the colours as well.

The coding part for this was easy. There are mainly 6 steps involved in this:

1. Read the image
2. Load the Traffic Light and colour cascades
3. Detect traffic lights and their colours (using the detectMultiScale function(detects objects of different sizes in the input image))

4. Draw rectangles around the traffic light and circle around the colours (each traffic light that gets detected is outlined by the turquoise colour and every red light is outlined by red, yellow light by yellow and green light by the colour green).
5. Show the results

The state of each detected light is shown by their respective colour they represent.

Difficulties and Improvements:

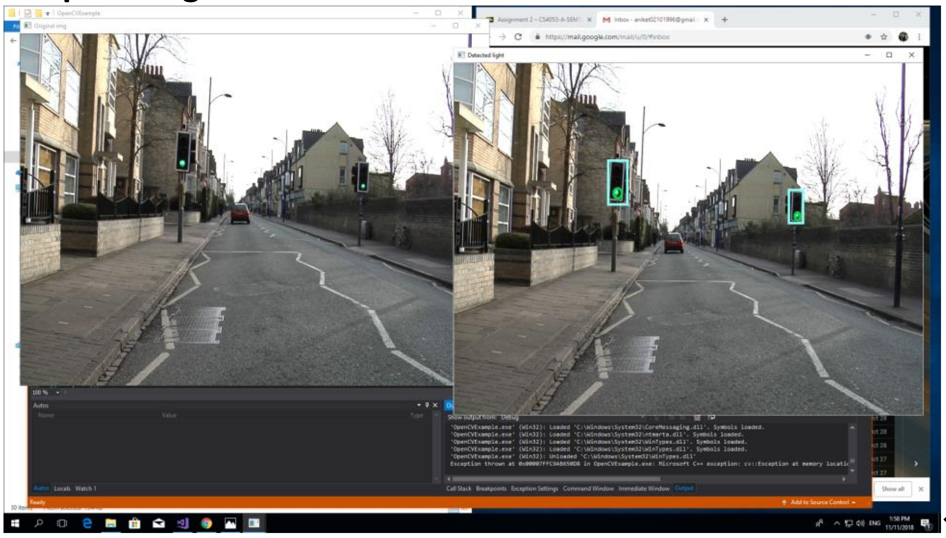
1. The main difficulty was the training part for the Haar-classifier. I spent a lot of time training the dataset. I clicked so many images at different angles from different positions so that I can get a good amount of data to train. I also spent a lot of time in training the dataset using OpenCV which is a challenge itself after finally I gave up and decided to use the software for training. If I was to improve on this I would use more data (let's say 500 more photos) and I would use OpenCV to train my data.
2. Image 8 where the colour in both the images is not getting detected was one of the few images I spent a lot of time trying to figure out and detect the colour in them but was unsuccessful in doing so.
3. In the Image 12 the two traffic lights at the back is not getting detected another thing I spent a lot of time and tried to use different datasets to solve but was unable to do so. To solve this I would try and find more datasets where I can find 4 traffic lights at the similar positions to include in my model.
4. Image 14 where the head of a woman is overlapping over the traffic light. But I was able to solve it at the end after I clicked some similar images and included in my dataset.

Regions I believe my code will fail:

1. If the traffic lights are horizontal, like in some countries they are horizontally represented. My code will completely fail there.
2. Also traffic lights for pedestrians where there is only red and green it will fail completely.
3. It will fail totally in my country (India) where all the traffic lights are yellow coloured from outside as my dataset is only for the ones in colour black.

Performance Metrics after the output images

Output Images:-



```
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\CoreMessaging.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\ntmarta.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\WinTypes.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\WinTypes.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Unloaded 'C:\Windows\System32\WinTypes.dll'
Exception thrown at 0x00007FFC9A8650D8 in OpenCVExample.exe: Microsoft C++ exception: cv::Exception at memory locatio
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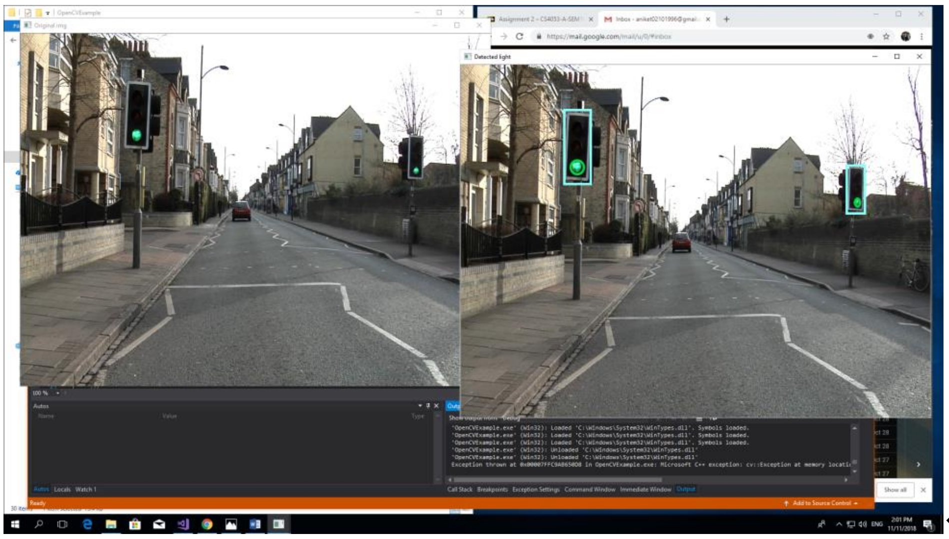
←1



```
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\WinTypes.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\WinTypes.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\WinTypes.dll'. Symbols loaded.
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Exception thrown at 0x00007FFC9A8650D8 in OpenCVExample.exe: Microsoft C++ exception: cv::Exception at memory locati
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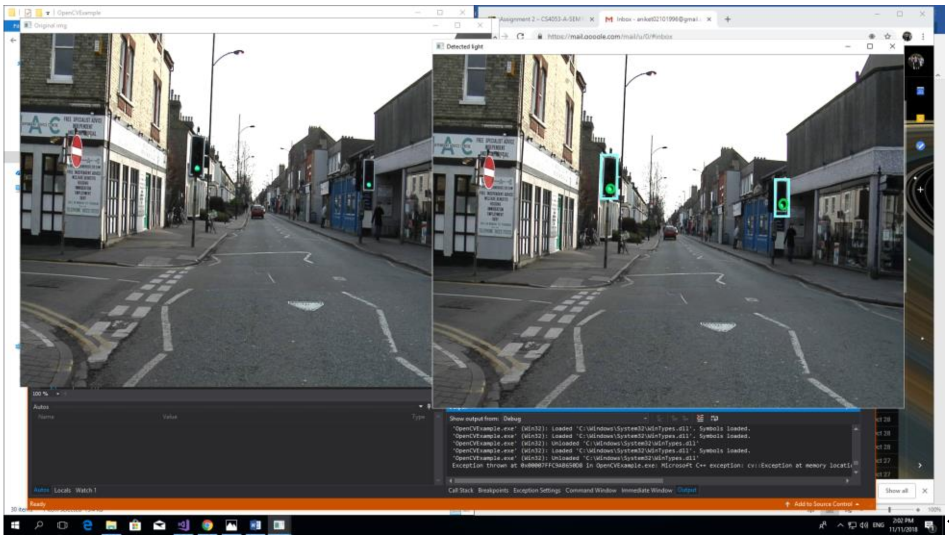
←2



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'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\WinTypes.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\WinTypes.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Unloaded 'C:\Windows\System32\WinTypes.dll'
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\WinTypes.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Unloaded 'C:\Windows\System32\WinTypes.dll'
Exception thrown at 0x00007FFC9A8650D8 in OpenCVExample.exe: Microsoft C++ exception: cv::Exception at memory locati
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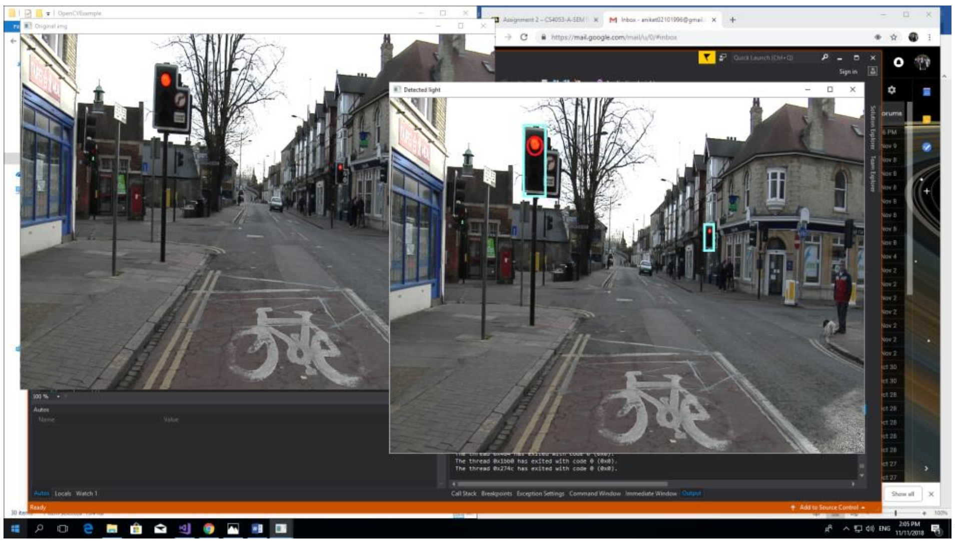
←3

(The first 3 images both the traffic light and the colour was detected successfully)



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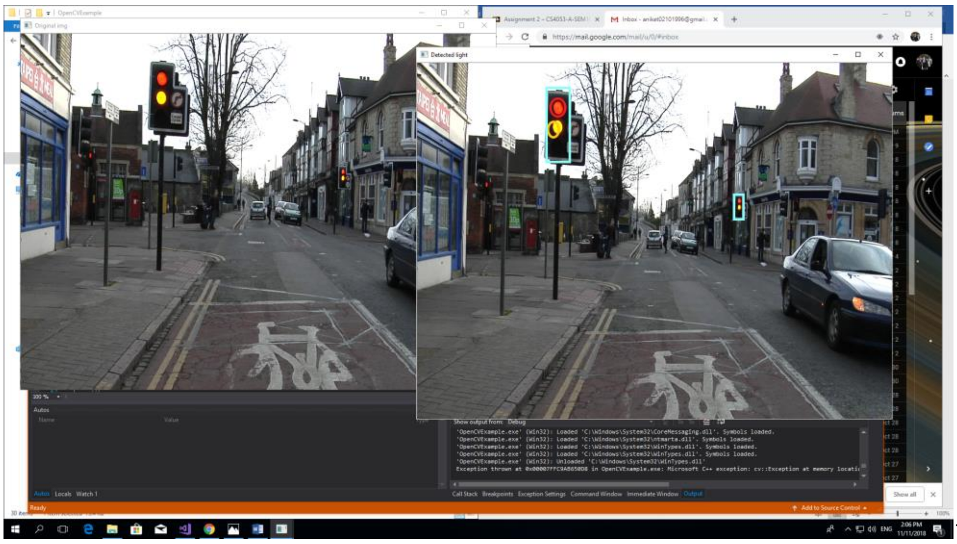
The thread 0x1bb0 has exited with code 0 (0x0).
The thread 0x274c has exited with code 0 (0x0).
```

←4



```
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\CoreMessaging.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\ntmarta.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\WinTypes.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\WinTypes.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Unloaded 'C:\Windows\System32\WinTypes.dll'
Exception thrown at 0x00007FFC9A8650D8 in OpenCVExample.exe: Microsoft C++ exception: cv::Exception at memory locati
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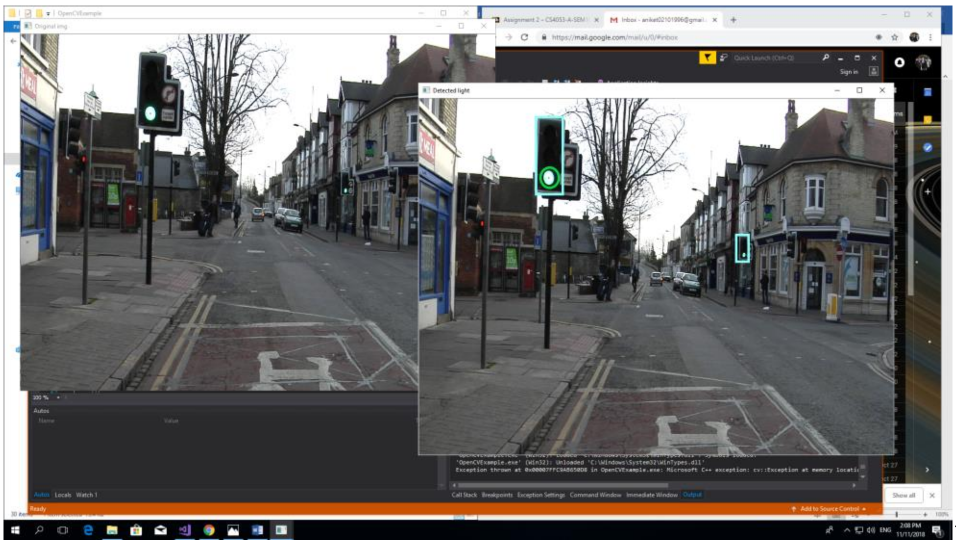
←5



```
'OpenCVExample.exe' (Win32): Unloaded 'C:\Windows\System32\WinTypes.dll'
Exception thrown at 0x00007FFC9A8650D8 in OpenCVExample.exe: Microsoft C++ exception: cv::Exception at memory locati
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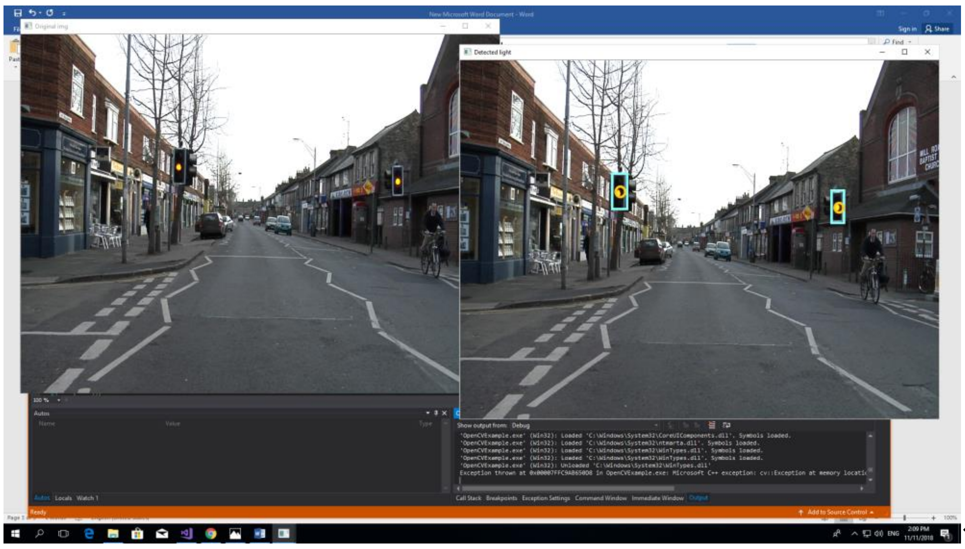
←6

(In the above three images all the traffic lights are getting detected but the colour in the second light is not getting detected in any of the images)



```
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\CoreUIComponents.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\ntmarta.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\WinTypes.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\WinTypes.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Unloaded 'C:\Windows\System32\WinTypes.dll'
Exception thrown at 0x00007FFC9AB650D8 in OpenCVExample.exe: Microsoft C++ exception: cv::Exception at memory locati
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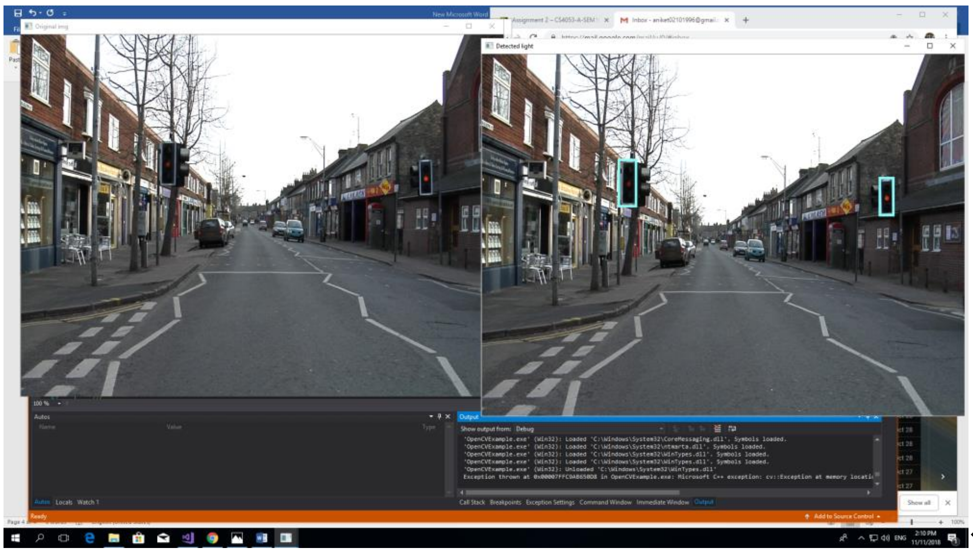
←7



```
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\CoreMessaging.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\ntmarta.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\WinTypes.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\WinTypes.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Unloaded 'C:\Windows\System32\WinTypes.dll'
Exception thrown at 0x00007FFC9AB650D8 in OpenCVExample.exe: Microsoft C++ exception: cv::Exception at memory locati
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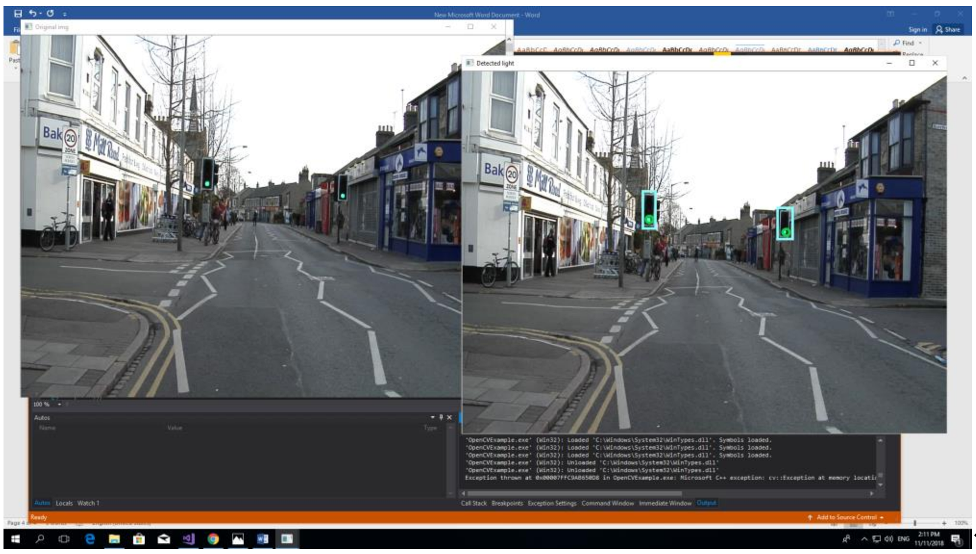
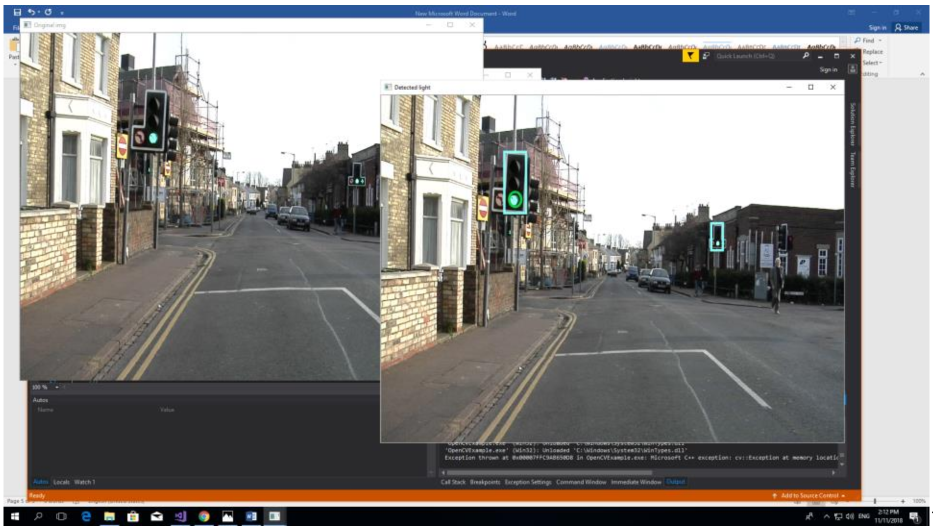
←8



```
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\WinTypes.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\WinTypes.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\WinTypes.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Unloaded 'C:\Windows\System32\WinTypes.dll'
'OpenCVExample.exe' (Win32): Unloaded 'C:\Windows\System32\WinTypes.dll'
Exception thrown at 0x00007FFC9AB650D8 in OpenCVExample.exe: Microsoft C++ exception: cv::Exception at memory locati
```

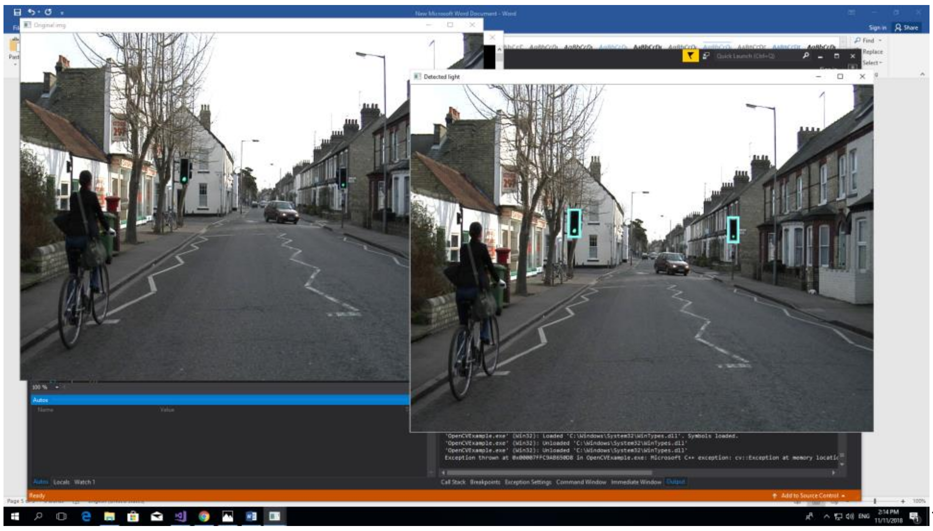
←9

(In the above three images both the traffic light and the colour is getting detected except for the image 8 where the colour is not getting detected in both the traffic lights)



```
'OpenCVExample.exe' (Win32): Unloaded 'C:\Windows\System32\WinTypes.dll'
Exception thrown at 0x00007FFC9A8658DB in OpenCVExample.exe: Microsoft C++ exception: cv::Exception at memory locatic
```

←10



```
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\WinTypes.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Unloaded 'C:\Windows\System32\WinTypes.dll'
'OpenCVExample.exe' (Win32): Unloaded 'C:\Windows\System32\WinTypes.dll'
Exception thrown at 0x00007FFC9A8658DB in OpenCVExample.exe: Microsoft C++ exception: cv::Exception at memory locatic
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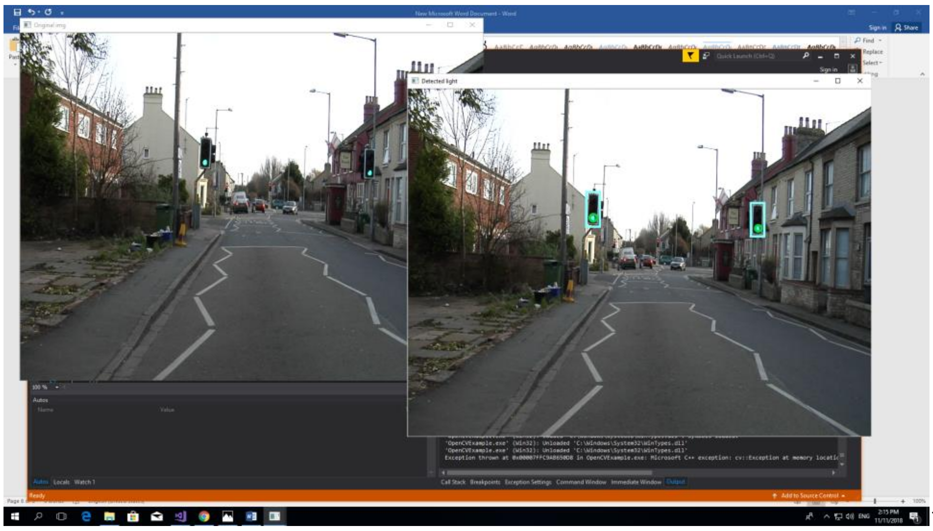
←11



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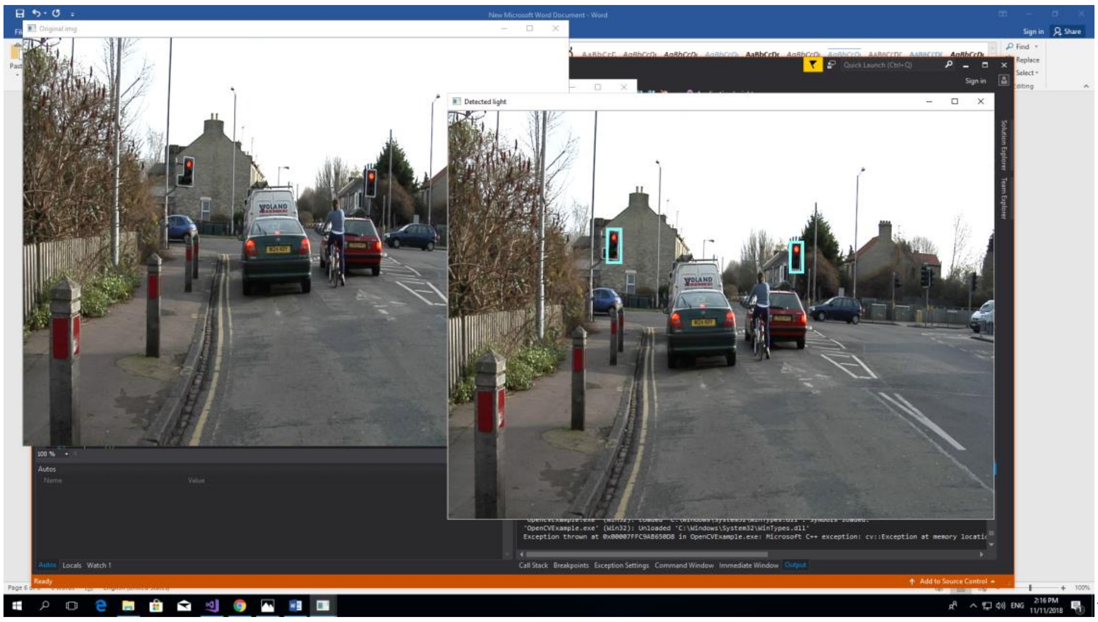
'OpenCVExample.exe' (Win32): Unloaded 'C:\Windows\System32\WinTypes.dll'
'OpenCVExample.exe' (Win32): Unloaded 'C:\Windows\System32\WinTypes.dll'
Exception thrown at 0x00007FFC9A8658DB in OpenCVExample.exe: Microsoft C++ exception: cv::Exception at memory locatic
```

←12

(In the 10th image the colour of the second light is not getting detected and in the 11th image the colour is not getting detected in either of the lights and in the 12th image there are 4 lights and only 2 of them are getting detected with their colours. The two at the far-back with red-lights are not getting detected.)



```
'OpenCVExample.exe' (Win32): Unloaded 'C:\Windows\System32\WinTypes.dll'
Exception thrown at 0x00007FFC9AB650D8 in OpenCVExample.exe: Microsoft C++ exception: cv::Exception at memory locati
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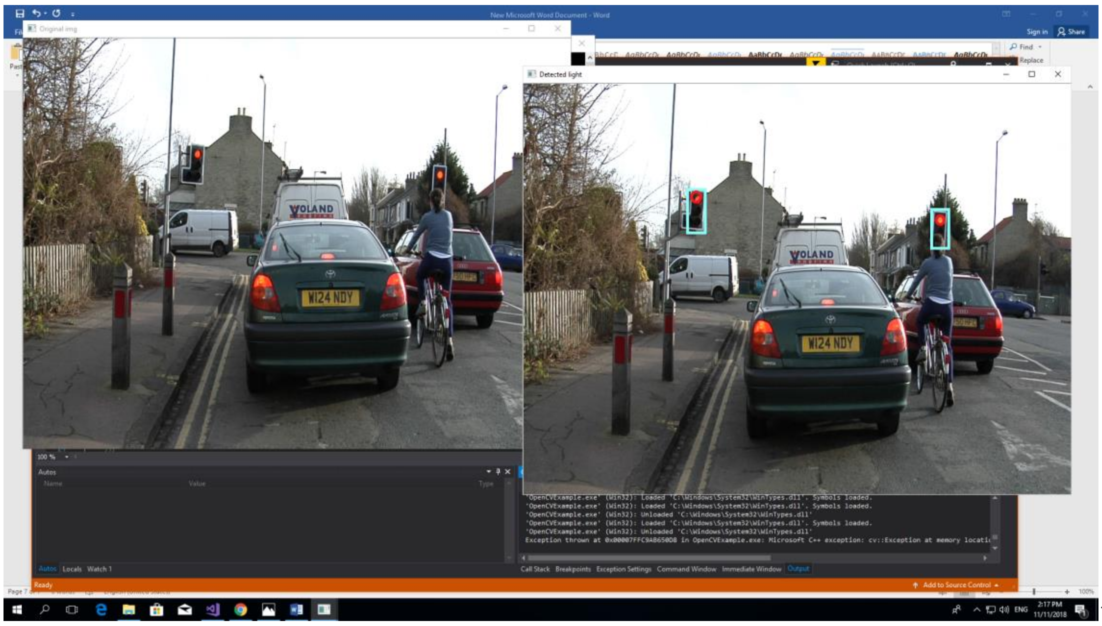
←13



```
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\WinTypes.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\WinTypes.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Unloaded 'C:\Windows\System32\WinTypes.dll'
'OpenCVExample.exe' (Win32): Loaded 'C:\Windows\System32\WinTypes.dll'. Symbols loaded.
'OpenCVExample.exe' (Win32): Unloaded 'C:\Windows\System32\WinTypes.dll'
Exception thrown at 0x00007FFC9AB650D8 in OpenCVExample.exe: Microsoft C++ exception: cv::Exception at memory locati
```

←14

(In the 13th image none of the images is detecting the colour)

Performance Metrics/Results:
For calculating the performance metrics I define a true positive when it successfully determines both the traffic light and its colour and false negatives when it does not determine the colour when it has already detected the traffic light and when it doesn’t detect the traffic light and its colour.

Total Samples = 14 Images * 2(two traffic lights in each) + 2 (two extra ones from image 12) = 30

True Positives = 18
True Negatives = 0
False Positives = 0
False Negatives = 12

Precision = 18 / (18+0) = 1

Recall = 18 / (18+12) = 0.6

Accuracy = (18+ 0) / 30 = 0.6

F1 score (Dice Co-Efficient) = 2 (0.6) (1) / (1+0.6) = 0.75

Observations:
The performance of my program is relatively low. I think this can be improved if I use a larger dataset and include more images in my model, although I am not sure if it still be able to detect all of them.