License/Number Plate Recognition System

Final Project Report

GROUP C

E/17/006	Alahakoon A. M. H. H.
E/17/100	Gunthilaka R.M.S.M.
E/17/246	Perera K.S.D.

Abstract

Image restoration plays the main role in image processing. One of the main applications of image restoration is identifying the number pattern of license plates. Because these images are not perfect and need to be restored and optimized. In this activity, several approaches are proposed to overcome the problem. The given data set has images that contain poor lighting and motion blur. Before identifying the patterns in the number plate the blur and the poor lighting should be removed from the image. Initially, filters are applied in the spatial domain to overcome the motion blur. Also, histogram processing is done to optimize the lightning. Since some images have huge deflection due to the motion blur it is hard to identify the matching filter for each image. Then the images are transformed to the frequency domain to identify whether there is noise in the images. Also, there are some advanced deblur techniques are applied such as unsupervised Wiener-Hunt Deconvolution and super-resolution and restorations methods. Since Wiener-Hunt Deconvolution requires the original image and point spread function it is not the best method to deblur since the point spread function can differ from image to image in the given dataset.

Recognizing number plates using image processing methods. Since we are dealing with a different kind of noisy, blurred, and poor lightning image we need to preprocess that image before using the recognition of the patterns. Therefore at this level, we need to use some basic filters to remove the noise also remove the blur and optimize the lighting and the angle. To detect and extract the characters we use OCR (Optical Characters Recognition tool) to identify the characters in the given images.

The remainder of this paper is organized as follows. Section I presents the problem domain and the approach to the solution . Section II presents the image degradation and restoration model. Section III presents Expermental results while Section IV concludes this paper

Introduction

In the world of IoT devices at present, CCTV camera systems play a huge role in security applications worldwide. Since CCTV cameras are installed everywhere in recent times a huge number of crimes have been recorded. In these recordings, a clear view of a suspicious vehicle's number plate will play a huge role in the identification of the criminals.

But in most cases, these images of number plates are distorted in many ways (Out of focus, Motion blur etc.) due to hardware incapabilities, environmental factors and many things. These images become unrecognizable due to the high speed of vehicles. Because these images are unrecognizable, blurred and undetectable they will not provide any substantial evidence in a case. This novel system of licence/number plate detection system will try to provide an answer to the above types of scenarios.

Although some methods of identifying these kinds of number plates are introduced in developed countries there is no such exact system implemented in Sri Lanka. Therefore having and implementing this kind of system may increase the potential of security forces in their duties in Sri Lanka.

The "License/Number Plate Recognition System" introduced here will have the capability of identifying the features of distorted images of Number plates, extracting those features and recognising the extracted characters. This system will have great use in a number of cases in different fields relating to security.

Background/Related Work:

As stated earlier, the detection of license plate numbers from CCTV footage has numerous advantages in relevant fields. However, this problem is harder to tackle. Therefore a lot of research is carried out on this topic. A fair amount of these research studies were carefully examined and the major takeaway points were collected in order to develop this License/Number plate detection system.

This particular problem was really difficult due to the lack of knowledge of the point spread function of the given test data. Similar kinds of problems were attempted and sorted out by a method called Blind Image Deconvolution. However, this approach also would need some kind of background knowledge about the distorted images. Therefore it was decided that analyzing test data with the main filters in frequency and spatial domain along with histogram equalization and interpolation would provide an accurate representation of the given data.

This method of image enhancement and character detection was mainly implemented under the influence of lots of research done worldwide in image restoration and deblurring techniques. Although this approach is a general approach to all domains of image restoration still this can be further extended to specific areas like motion blur, super-resolution etc.

Approach:

The objective of the license/number plate recogniser is to restore a given degraded image of the license plate and detect each of the characters. Image blurring can be mathematically formulated as

$$g(x, y) = f(x, y) \otimes h(x, y) + \eta(x, y)$$

where g - blurred image, h - degradation function, f - original sharp image, η - additive noise, $\otimes$ - convolution

Since the convolution between f and h in the spatial domain becomes multiplication in the frequency domain, image blurring can be formulated as,

$$G(u, v) = F(u, v)H(u, v) + N(u, v)$$

In order to do the deblurring process, many algorithms require prior knowledge regarding the degradation function to avoid going in the wrong direction. A majority of these algorithms estimate the degradation function while simultaneously applying a non-blind image deblurring (NBID) algorithm recursively to get the deblurred image.

When considering the license plate recognition, the license plate images can be affected by one or more combinations of degradations such as low light conditions, shadowing, reflection, blurring, motion defects, rotation etc. Since the degradation function is more complex, the deblurring process is not straightforward.

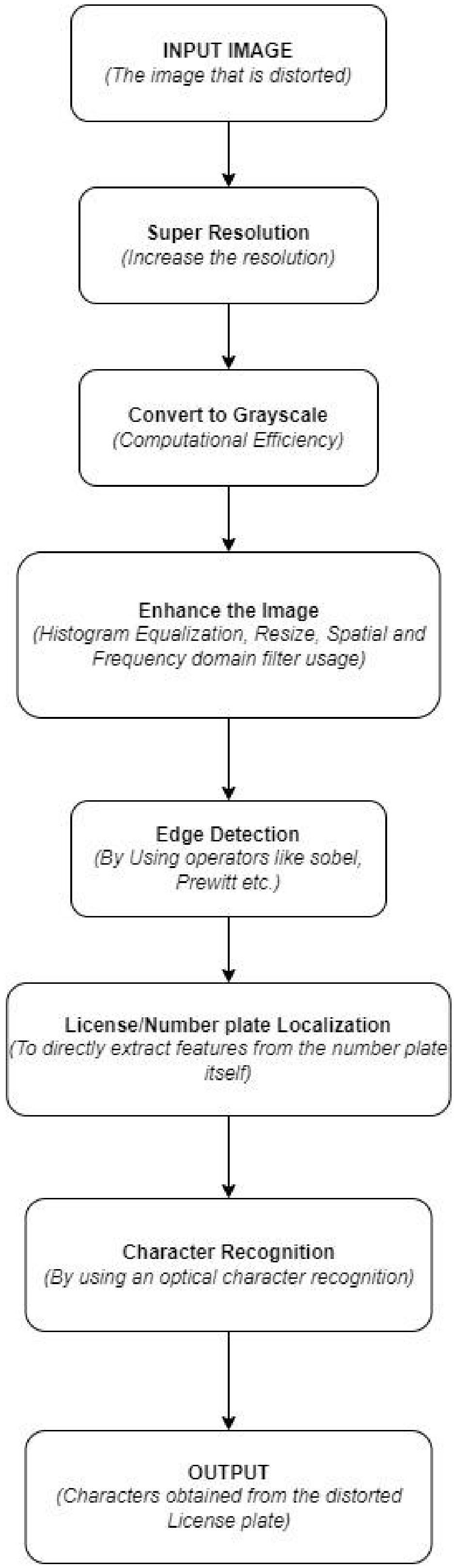

Figure1: Shows the workflow which is followed to recognize the characters of a degraded license/number plate image.

1) **Degraded Image**

The image that is inserted into the algorithm could be affected by one or more combinations of degradations such as low light conditions, shadowing, reflection, blurring, motion defects, rotation etc. The input image could be a full image of a vehicle with the license plate or a part of a vehicle with the license plate or just the frame containing the license plate. However, the characters of the license plate was not at all visible to the naked eye.

2) **Super Resolution and Restoration**

In this step, the resolution of the given input raw images was increased. The main reason for this was because the given images' resolution was so small. The characteristics of the raw image itself couldn't be identified by the naked eye by any means. After super resolution some detials started to pop out from the raw images.

3) **Convert Image to Grayscale**

The input image can be an RGB image or a grayscale image. Since the RGB image has 3 planes, the computational complexity is much higher. Therefore the RGB coloured image was converted to a Grayscale image as an input for the rest of the procedure. This also provides an additional advantage because it will be computationally efficient to do image processing in one channel rather than 3 channels.

4) **Enhancing the image**

In this step, the basic image enhancement technique of histogram equalization was used to balance the brightness of the test images. This gave some definition to the test images which were initially not visible to the naked eye. After that, to increase the resolution of some images a simple function of interpolation (BICUBIC in openCV) was used.

5) **Edge detection**

The image edge is prominent and clear, and it contains all the useful information. After enhancing the image for some level, gradient and gaussian operators can be used for edge detection. As the gradient operators Sobel operator, Prewitt operator, Robert operator can be used. As the Gaussian operators, the Canny edge detector and laplacian operators can be used. Other than that, image thresholding was used just to understand the features and characters of the enhanced image.

6) **License/Number plate localization**

Plate localization is used to detect plate rotation and skewness. The rotation angle can be determined by analyzing the spread distance of the feature pixels through a set of orthogonal projections. It is necessary to perform a refined localization that leaves out unnecessary regions and retains plate numbers only. Plate position refinement can be done according to the vertical and horizontal edges of the license plate. This step enables to get the needed information from the number plate itself rather than other unnecessary data.

7) **Character recognition**

Character recognition is done using optical character recognition. It is a technology that recognizes text within a digital image. OCR analyzes the patterns of light and dark that make up the letters and numbers to turn the image into text. Initially, OCR will convert the image into the black and white image. Then the character will be identified using pattern recognition or feature detection.

8) **Output**

The license plate numbers and characters will be displayed as the output.

Experiment

In this section, all the results obtained throughout the steps described above are represented accordingly. The output of the super-resolution and restoration layer is shown below. It is clearly visible that from this basic step some details of the unrecognizable number plates were discovered. However, these details were not enough to identify the characters exactly. Therefore some further processing was needed. This further processing was done by other layers down the order.

In the next figure, the conversion of the images to grayscale can be seen. This step was initially done to lower the computational cost but as seen below this added some more detail to the input image. These fine details will be very important in getting the characters out of the distorted image.

The next figure respectively shows the resizing of the image to a manageable size. This step was undertaken in order to observe some characters with the naked eye. As is shown below, the characters are more visible, it can be slightly observed by the naked eye. But still, it needs further processing to have more details and identify the characteristics. In Figure5 LANCZOS4 interpolation method was used to resize the images.

In Figure6 the histogram equalization step was undertaken. Here it is clearly seen that some images had brightness issues and contrast issues. These distortions were corrected in this step. As it is shown in the figure the images' characteristics are more clearly visible at this point.

Next, in figure7 the magnitude spectrums of the images are represented. This step was undertaken to gather more hidden details about the images through Fourier domain analysis. However, there were not many details to collect from this stage. The noise in the images can be clearly seen by dots or impulses in a certain pattern in the magnitude spectrum.

Then, in figure8 Sobel filter was applied to the images. Sobel is an edge detection filter. By using this filter the edges of the characters were able to get identified. Furthermore, in figure 9 some thresholding was applied hoping to get a better view at the edges but it failed. In Figure 10, Canny edge detection was applied but no details were obtained. Sobel filter gave more details than the canny edge detection.

After the image processing part in figure 11, the results of the developed OCR are depicted. As it is shown in the figure the results were accurate for the given test images.

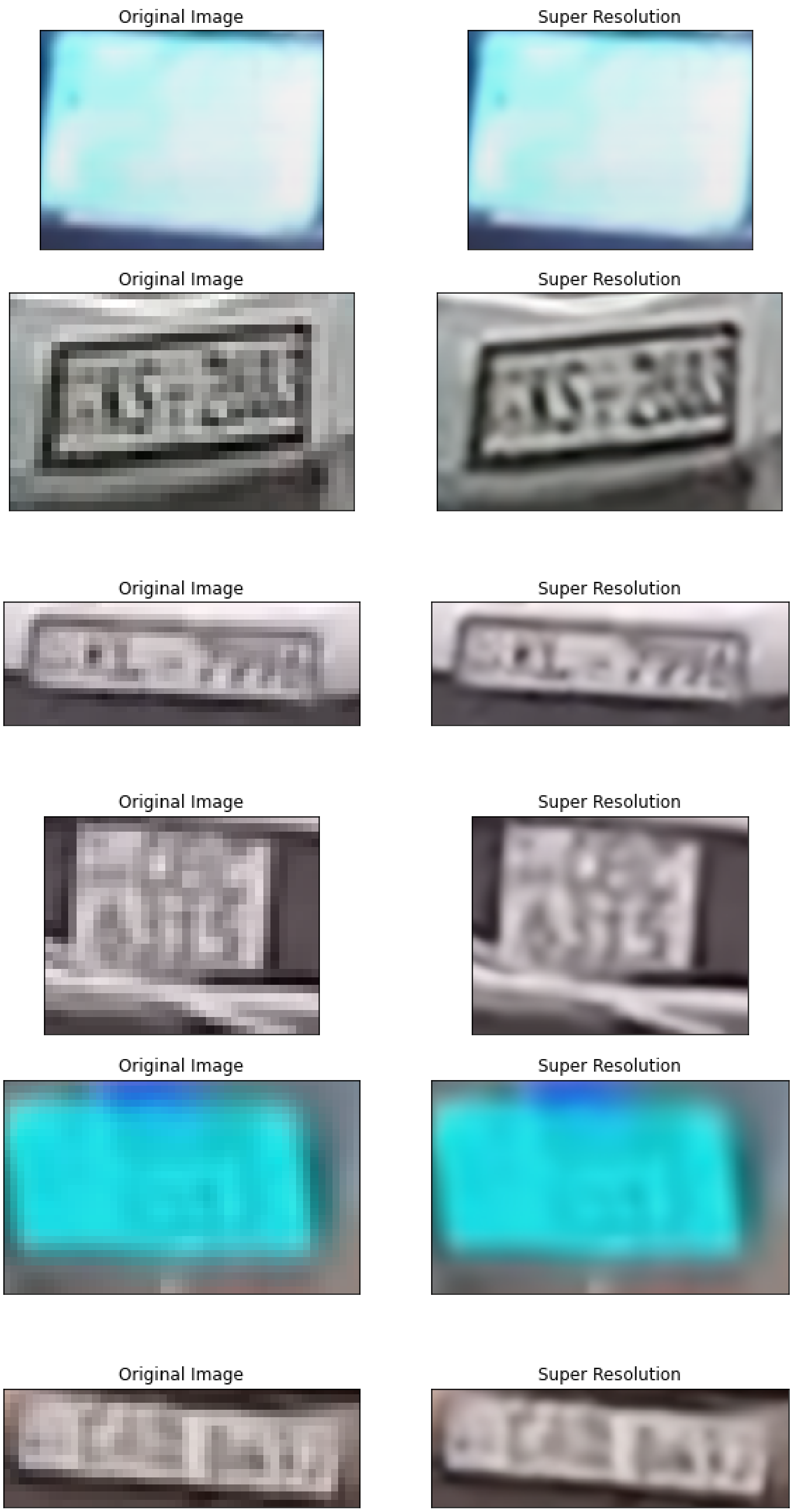

Figure2: The output of the Super-resolution and Restoration step.

Figure3: Converting the images to Grayscale.

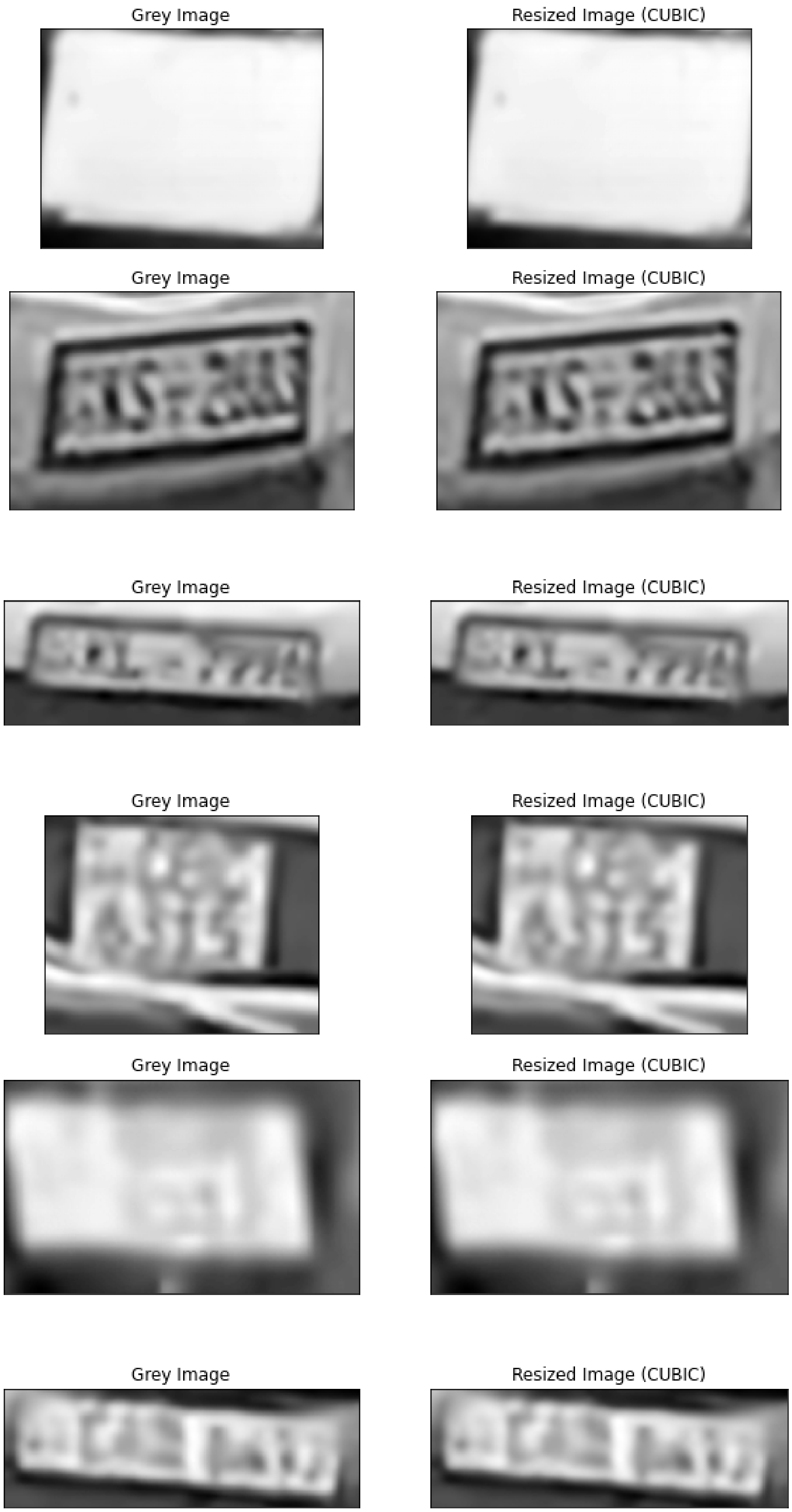

Figure4: Image Resizing with CUBIC interpolation in OpenCV

Figure5: Image resizing with LANCZOS4 interpolation in OpenCV

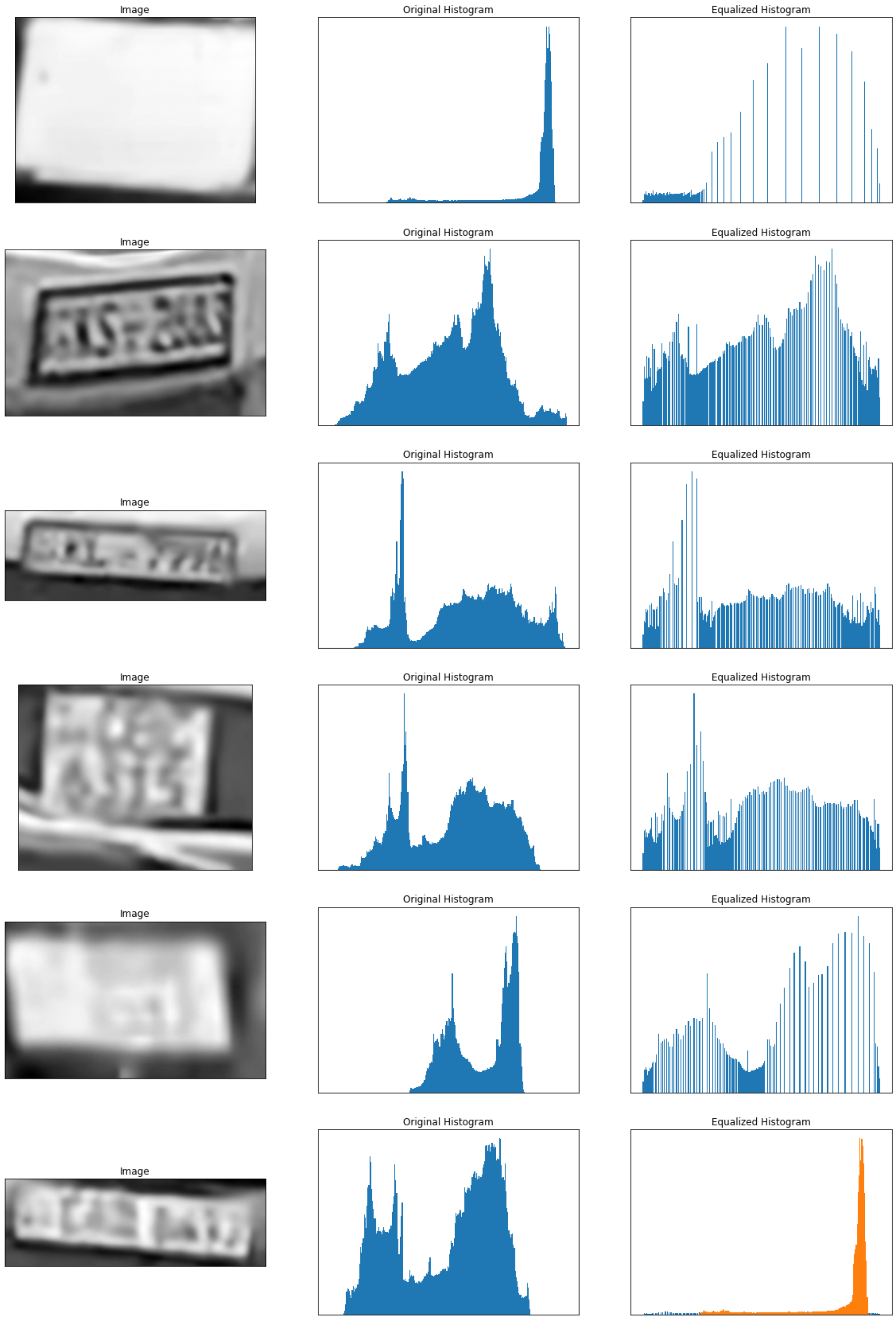

Figure6: Histogram Equalization of the images.

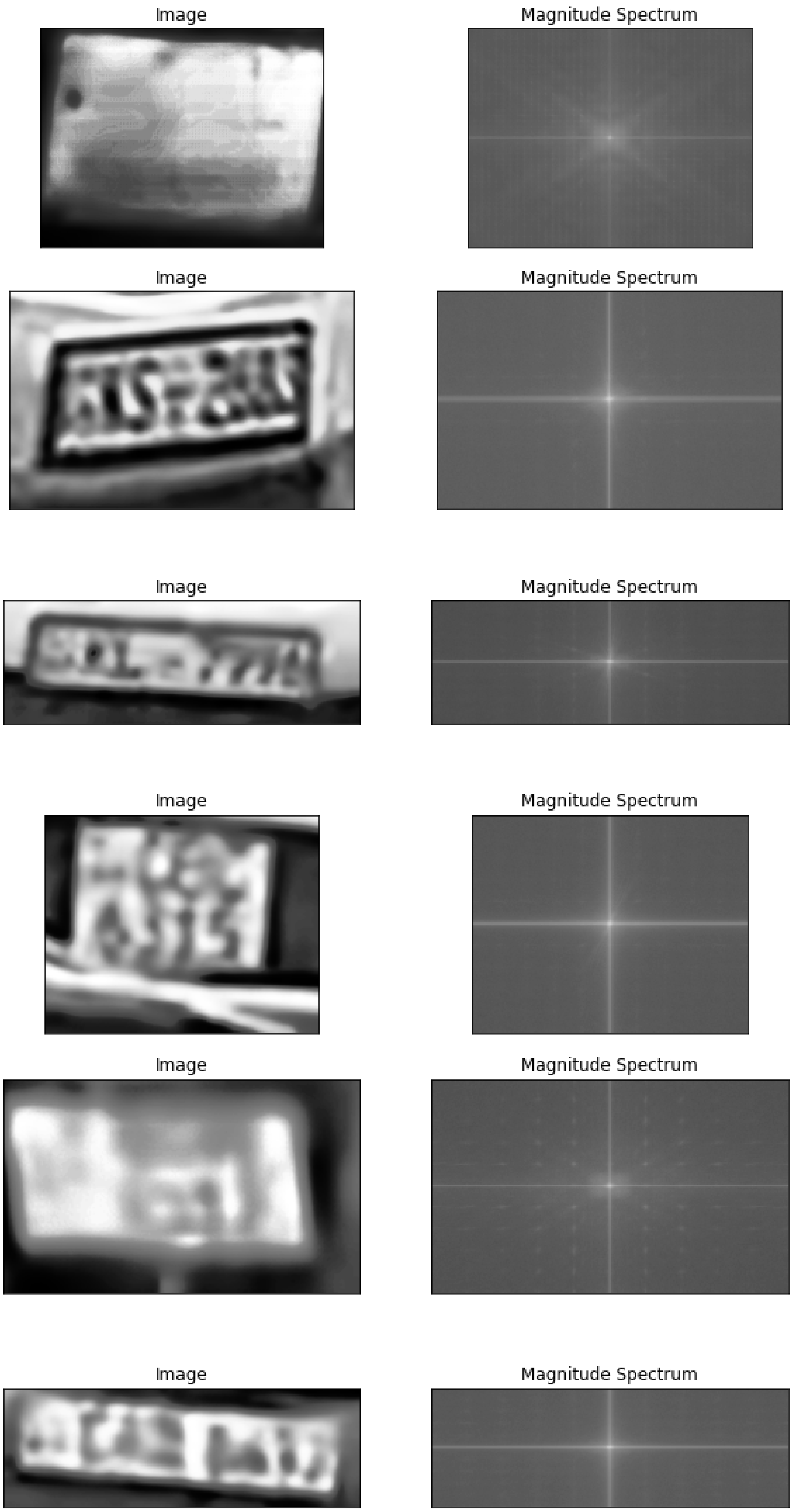

Figure7: Magnitude spectrum of the test images

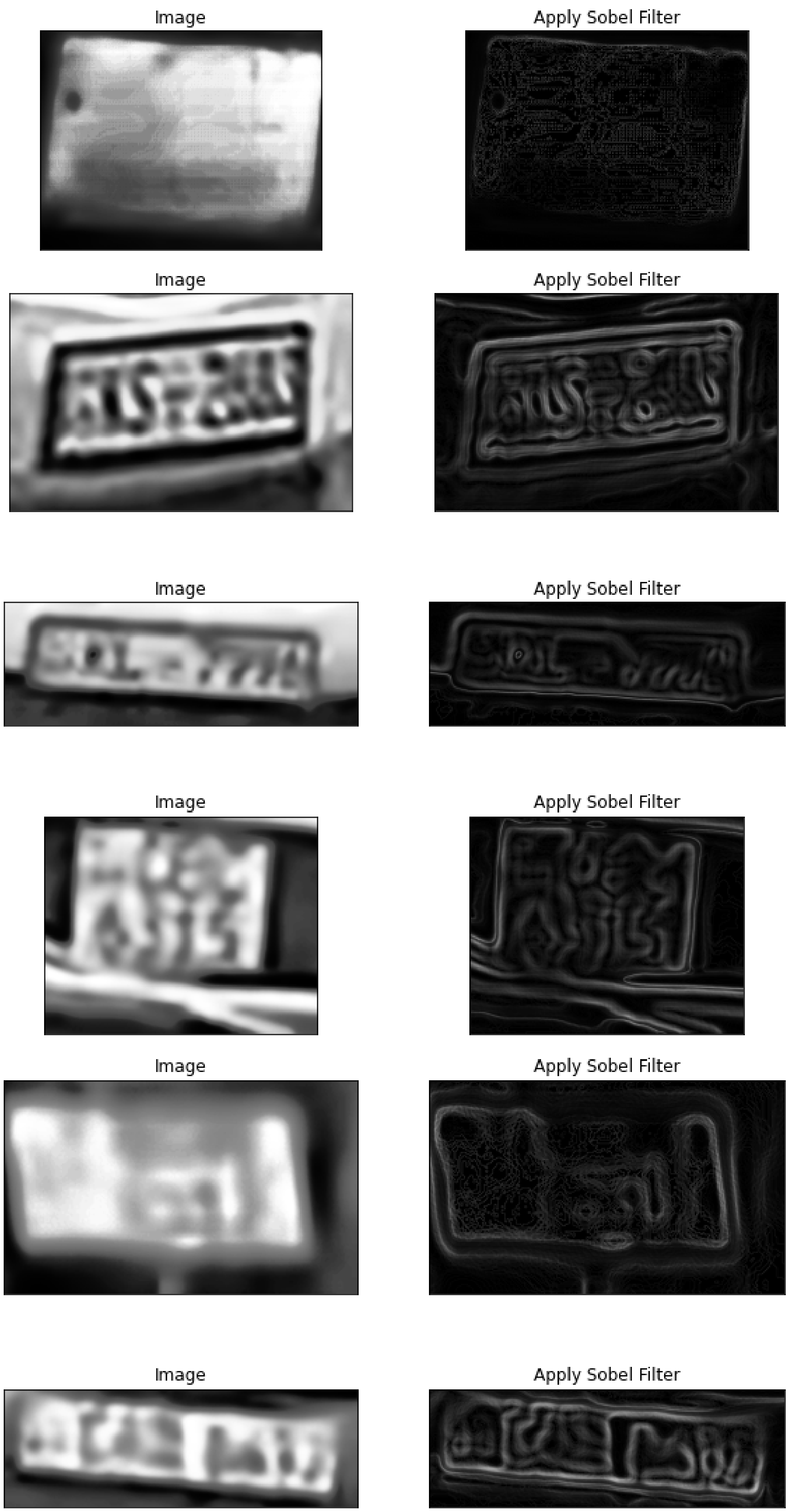

Figure8: Applying Sobel filter to the images.

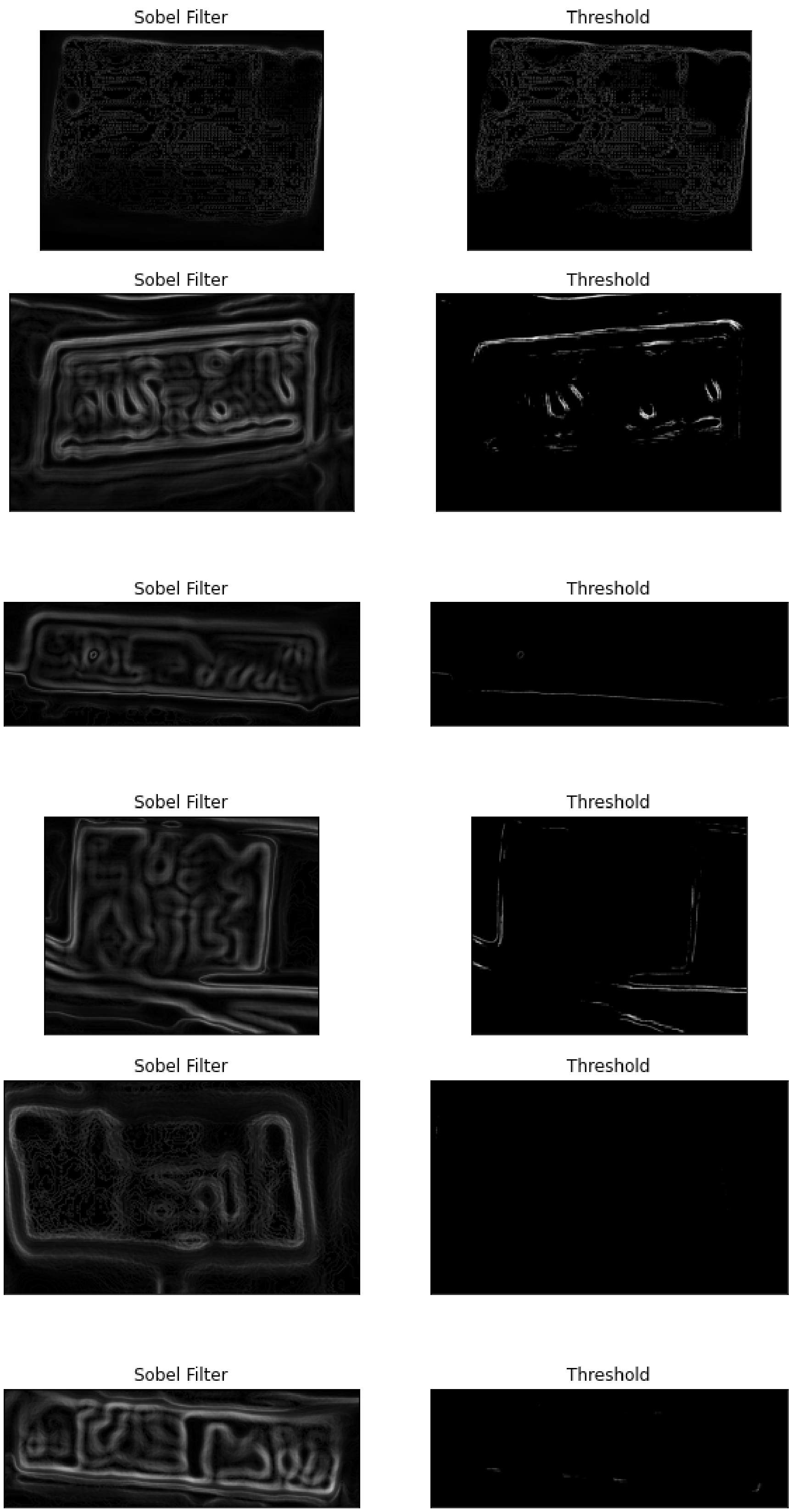

Figure9: Applying a threshold to the Sobel filtered images.

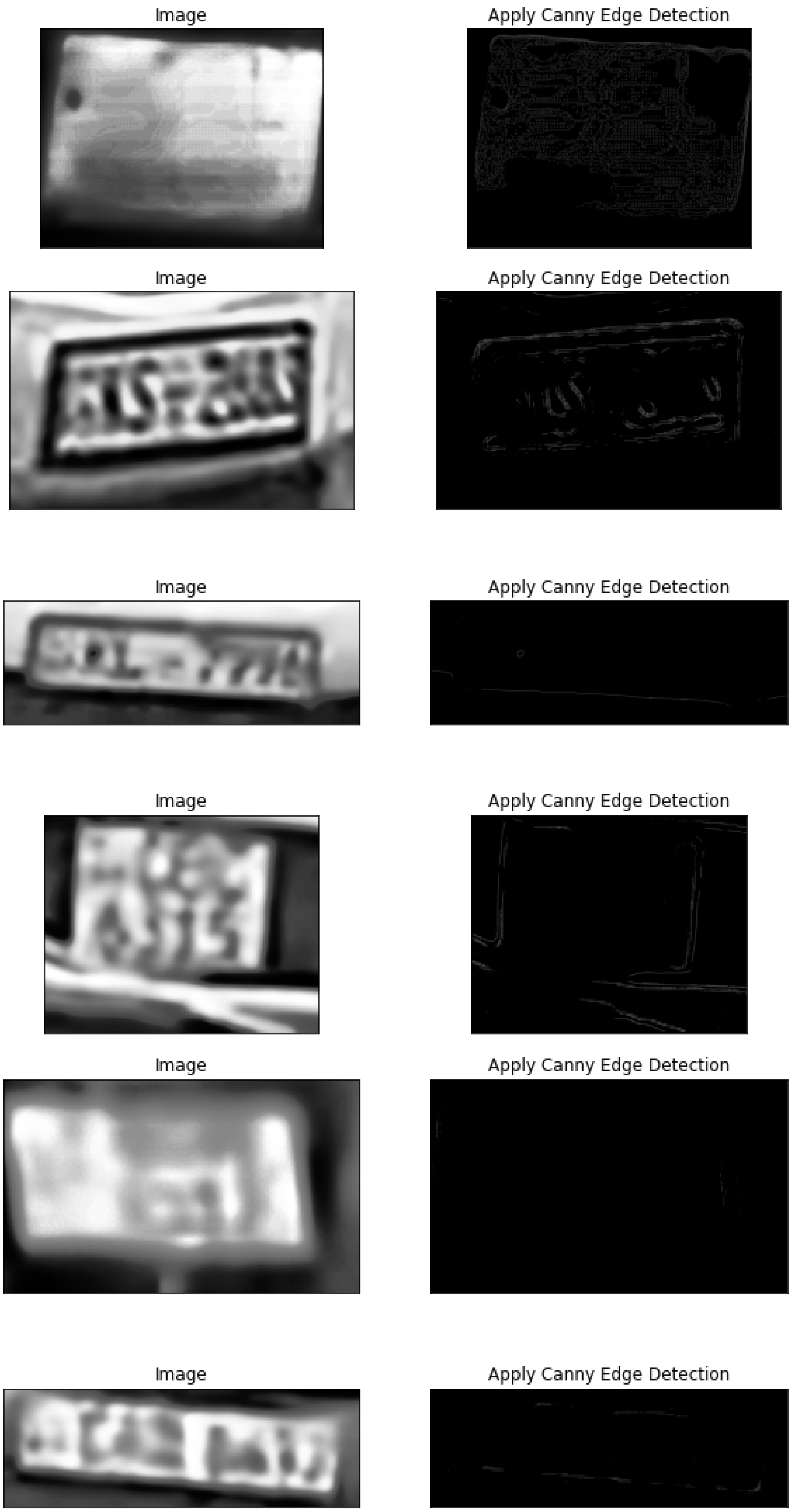

Figure 10: Applying Canny Edge Detection

Figure 11: Applying the OCR to some test images.

Conclusion

The procedure used to detect the characters of distorted Lisence/Number plates here looks promising to some extent. Although it was not 100% accurate, after a series of filtering in different domains and basic techniques like histogram equalization some characters were quite visible and were detected by the OCR. These characters were not entirely visible to the naked eye. Therefore this method of detecting license/number plate detection would be useful when the photographs are mildly distorted. However, when the images are heavily distorted due to various factors like motion blur, out of focus blur etc. this method will have the minimum impact on identifying the necessary characteristics.

This method could be further optimized if there were some similar images that match the distorted images. With this additional data, the model would be more accurate and be able to identify finer details in the test images.

References

- https://ieeexplore.ieee.org/document/6408136
- https://ieeexplore.ieee.org/document/489268
- https://iopscience.iop.org/article/10.1088/1361-6420/aaa4a7
- https://www.techtarget.com/searchcontentmanagement/definition/OCR-optical-character-recognition
- https://ieeexplore.ieee.org/document/9643412
- https://ieeexplore.ieee.org/document/9001232
- https://ieeexplore.ieee.org/document/8246510