# An Accurate Method for License Plate Localization using Morphological Operations and Edge Processing

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***Abstract*—Various license plate localization techniques have been developed in the past with variable results. In this paper, we implement a localization method keeping in mind Indian vehicle license plate specifications. The proposed algorithm makes use of morphological operations like reconstruction, dilation, erosion and exploits license plate edge characteristics. We also make use of color segmentation in the YCbCr color space for special license plates. Skewed plates are corrected by applying Harris corner detection. After conducting tests on a wide range of images with variable illumination & arbitrary camera angles, the success rate of our algorithm was found to be 96.88%.**

***Keywords-image processing; ANPR; morphological operations; color segmentation; Harris corner detection; edge detection***

## I. BACKGROUND

Vehicle license plates in India, as specified by the Ministry of Road Transport & Highways [1], are required to be: (1) black color on yellow background in the case of transport vehicles (2) black color on white background in other cases. Both these types of license plates exhibit characteristic high contrast, which can be used as a distinguishing factor in isolating the license plate regions from the surroundings. However, this property cannot be used alone to localize license plates since there may exist other high contrast regions in the image such as grilles or reflections that mimic license plate regions. Therefore, additional properties of license plates like vertical edges need to be exploited for better results. In the past, license plate localization using morphological operations [2][3], histogram analysis [4] and neural networks [5] among other methods has been implemented. Our goal is to have a high success rate and minimize false detection.

## II. SYSTEM OVERVIEW

The proposed algorithm is implemented by cascading the operations in a sequential manner. The color segmentation and contrast stretching is done in the preprocessing stage. Using certain characteristics of license plate edges, we determine candidate license plate regions. From these candidate regions, the statistical properties of the corners and vertical edges are tested against a threshold. The corner detection is carried out using the Harris corner detection algorithm. Finally, the skew, if any, is corrected. All structuring elements used for morphological operations are scaled according to the size of the input image to ensure compatibility with images of different resolution. The block diagram is given below:

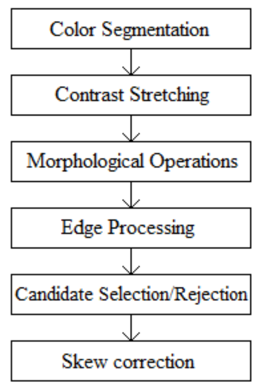



Figure 1. Block Diagram

## III. IMAGE PREPROCESSING

### A. Color Segmentation

In case of transport vehicles i.e. taxis and auto rickshaws, the license plate background is yellow with black lettering. Sometimes, due to bad illumination, this results in low contrast and consequently failure in detection of the plate. It is difficult to accurately define different shades of yellow in the RGB color space; hence we convert the image into luminance (Y) and chrominance (Cb and Cr) and replace the yellow regions with white using the following thresholds. A region is classified as yellow if:

$$\text{Yellow} \begin{cases} Y > 75 \\ Cr > 1.5*Cb \\ 100 < Cr < 180 \\ Cb < 100 \end{cases}$$

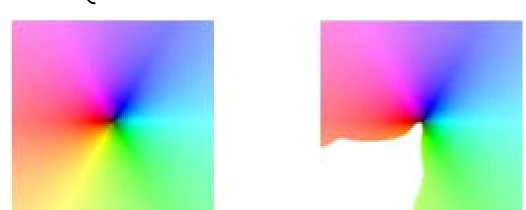


Figure 2. Replacing yellow regions by white

### B. *Contrast Stretching*

Taking into account illumination variations, the image needs to have a well defined and crisp contrast. To do this, we do contrast stretching with variable parameter values. This has its advantages over histogram equalization – the resultant image does not become grainy if the illumination is low. Depending on the need, fixed parameter values can be used if we have only images that are well lit. If we also have poorly illuminated images especially those taken at night, these parameter values are computed dynamically by taking the average of pixel intensities. The transformation relationship between f(x,y) and g(x,y) is:

$$g(x,y) = \begin{cases} t_1 & 0 \le f(x,y) < p_1 \\ \dfrac{t_2 - t_1}{p_2 - p_1}(f(x,y) - p_1) + t_1 & p_1 \le f(x,y) \le p_2 \\ t_2 & p_2 \le f(x,y) \le \max(f(x,y)) \end{cases} \quad (1)$$

where f(x,y) is the intensity of the $(x,y)^{th}$ pixel of the original image and g(x,y) is the intensity of the $(x,y)^{th}$ pixel of the resultant image.

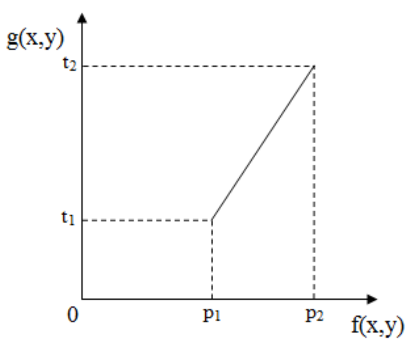



Figure 3. Transform characteristics

## IV. LICENSE PLATE DETECTION

### A. *Morphological Operations*

The characters in the vehicle license plate can be considered as ‘regional minima’ or holes which are not connected to the image border. An algorithm based on morphological reconstruction by erosion which can be used to fill these holes is explained in [6]:

$$G = R_f^{\varepsilon}(f_m) \quad (2)$$

where f is the original image, G is the resultant image and $f_m$ is the marker image. $R_f^{\varepsilon}$ denotes reconstruction by erosion. $f_m$ is set to the following values:

$$f_m(p) = \begin{cases} f(p), \text{ if p lies on the border of the image} \\ \text{maximum image value, otherwise.} \end{cases}$$

The original image (f) is then subtracted from the resultant image obtained after filling holes (G) to isolate the regional minima. It is assumed that the road should intersect with one of the edges of the image. In practical situations, this criterion is always met if the image is from a CCTV feed. Opening [7] by a structuring element having vertical shape is done to further eliminate stray horizontal noise in the image. The horizontal information in the license plate is also lost, but as our subsequent processing steps rely largely on the vertical information in the license plate, this does not affect the performance adversely. The formula for image opening is:

$$A \circ B = (A \ominus B) \oplus B \quad (3)$$

where A is the image and B is the structuring element.

The erosion and dilation operations respectively are defined as:

$$(f \ominus B)(x,y) = \min\{f(x+x', y+y') \mid (x',y') \in D_b\} \quad (4)$$

$$(f \oplus B)(x,y) = \max\{f(x-x', y-y') \mid (x',y') \in D_b\} \quad (5)$$

where $D_b$ is the domain of the structuring element B.


Figure 4. Result of subtracting original image from filled image

### B. *Edge processing*

An efficient approach to localize license plate regions can be achieved using simple convolution and mathematical operations. We first filter the image using the operator shown in Figure 5 with the aim of obtaining vertical edges:

| | | |
|---|---|---|
| 1 | 0 | -1 |

Figure 5. High Pass Mask

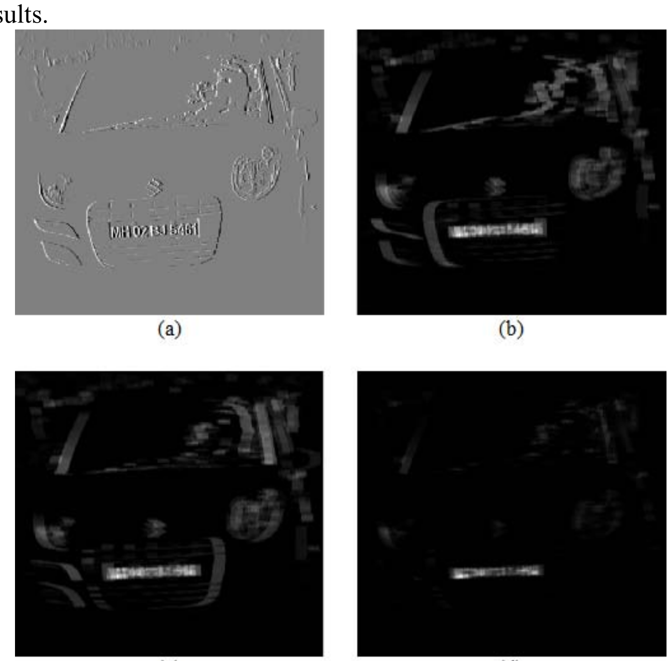
Vertical edges have been used in the past to localize license plates [8]. But instead of taking absolute of the filtered output, as is done in case of conventional edge detection, we separate its negative and positive parts to preserve information about whether an edge is a dark-to-bright(white) or a bright-to-dark(black) edge. A unique characteristic of license plate regions is the presence of a large density of black as well as white edges in close proximity as shown in Figure 6:


Figure 6. License plate region edge detail

We then filter the images with a low pass filter. The neighborhood to be used for proximity criterion is defined by the size of the low pass filter. The filtered edge images, shown in Figure 7(b) and 7(c), are then multiplied to obtain the result shown in Figure 7(d). Only the regions with both black and white edges will result in a non-zero multiplication; single edges will disappear. The merits of using the presence of both type of edges in a defined locality is evident from the result: the license plate region is prominent, owing to the presence of both black and white edges.

We then remove areas smaller than a threshold and dilate the image to remove any breaks that might occur due to large character spacing. This image then acts as a mask to extract candidate regions from the original image.

In the past, wavelet transform [9] using an expanded Haar wavelet to identify candidate regions has been used [10]. This method takes the wavelet transform of the original gray image. They use the HL subimage which also contains positive and negative components. Instead of thresholding or scaling the HL subimage, similar processing as carried in our method can be carried out to obtain better results. Alternatively, variance can be calculated using a sliding window to obtain similar results.



(a) (b) (c) (d)

Figure 7. (a) Vertical Edges (b) White edge (c) Black edge (d) Resultant image obtained by multiplication of (b) and (c)

### C. Candidate selection/rejection

We use statistical properties of the edge image obtained in the previous stage to select or reject a candidate region. We first threshold the edge image and then use mean, variance and the centre of gravity of this image. Using these properties alone gives a high accuracy rate. But cascading one more stage for candidate selection/rejection greatly reduced the rate of false positives generated by the algorithm.

### D. Harris Corner Detection

Locating license plates using corner features and thresholds [11] by implementing Moravec's corner detection algorithm and Harris' corner detection has been done in the past. We implement a Harris corner detector, as introduced in [12]. The corner features are then used as an additional validity test for the candidate regions. If the candidate passes the second test, the skew, if any, is corrected. For this, the region is divided into ten windows along its width. The corners having minimum and maximum row values in these windows are used to find approximations to the upper and lower edge of the plate by finding the regression line for these points. The tilt angle is taken as the average of the angles of these lines. Depending on the tilt, the plate is projected by the appropriate angle and a correctly oriented license plate image is obtained.

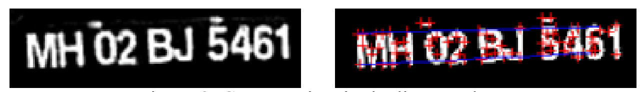



Figure 8. Corner points in the license plate


Figure 9. Result of skew correction

## V. EXPERIMENTAL RESULTS

After testing the proposed algorithm on a range of images, the success rate of correct localization was found to be 96.88%. The test cases consisted of well lit, dark (Figure 10. (b)) and blurry images along with skewed license plate images. Out of 312 images containing 353 license plates, 342 license plates were successfully localized. False positives (Figure 11) were obtained in 3 images.

Table I. EXPERIMENTAL RESULTS OF PROPOSED ALGORITHM

| Total License Plates | Success | Failure | Success Rate |
|---|---|---|---|
| 353 | 342 | 11 | 96.88% |


(a)


(b)


(c)


(d)


(e)

Figure 10. Some extracted license plates


Figure 11. False positive

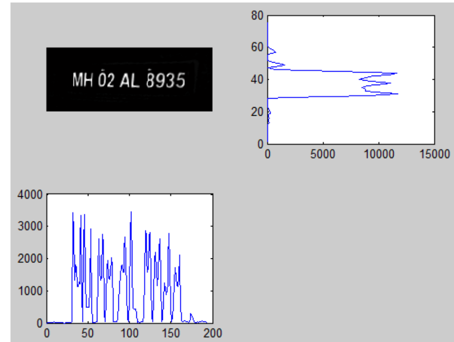



Figure 12. Skew correction of result obtained in Figure 10. (d)

## VI. CONCLUSION

In this paper, we have presented an accurate algorithm which uses sequential operations to localize license plates. The proposed algorithm is robust. Keeping in mind Indian license plates, the algorithm is quite reliable and it can adjust to different lighting conditions. The only limitation of the algorithm is the failure to reject certain types of vehicle grilles since they share all the characteristics of license plates. Further research needs to be done to solve this problem.

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