# Performance Evaluation of Number Plate Segmentation algorithm from Vehicle Image

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**Abstract** : Vehicle number plate detection is a complex research problem in digital image processing. Many related issues are addressed in the research carried out while detecting vehicle number plates. The features normally considered in number plates for detection are boundary features, global image features, texture features, color features, character features etc. Majority of the works reported have used one of the above features to detect vehicle number plate. In this work, an attempt is made to detect the number plate using two features, for better efficiency than the single feature based methods. The proposed approach uses watershed algorithm(boundary feature) along with visualization technique(color feature) to take care of environmental conditions such as indoor/outdoor, day/night, rainy/sunny and less sensitive for plate variations in size, location, color and inclination. The Performance evaluation of proposed algorithm is carried out by measuring the parameters such as Measure of overlapping(MOL), Measure of under segmentation(MUS), Measure of over segmentation(MOS), Dice similarity measure(DSM), Error-rate(ER). In order to corroborate the effectiveness of the proposed model we have carried out experimentation on a dataset of around 500 samples. Experimental results show that the proposed segmentation algorithm achieved best average accuracy in DSM, MOL,MOS and MUS.

**Keywords**: Number plate detection, boundary features, color features, performance evaluation

## 1. INTRODUCTION

An automatic number plate recognition system is an essential and crucial module in real-life application systems like automatic toll collection, traffic law enforcement, parking lot management, road traffic monitoring [1-4]. All the above systems require an efficient module that can recognize the number plate, such that further processing could be made comfortably. The number plate detection is the process of detecting the number plate from vehicle image and extraction of the contents from the plate [5]. Automatic recognition of number plates from a vehicle image is a complex problem because of challenges involved in the application domain. The challenges that are encountered in the detection process are the variations noticed in number plates and environmental conditions. The variations noticed in number plates are the size, location, color, font, inclination, occlusion and multi plates. The variations in environmental conditions are illumination, background, dust, rain etc. The efficiency of number plate detection drops in the algorithms because of lighting conditions, image perspective distortion and text on images. These variations hinder to come out with generic

solutions for the problem. Most of the proposed number plate detection algorithms available are restricted through various controlled conditions such as fixed backgrounds [6] and designated ranges of the distance between cameras and vehicles [7].

The number plates of vehicles are standardized in developed countries in terms of size, color, font style, font size and font color. Where as in developing countries like India, it is yet to be imposed, especially in terms of size, fonts and script. Hence number plate detection in Indian scenario is still a research problem to achieve perfection. Literature survey reveals that many researchers have presented methods for detection of number plate from an image. The researchers have made use of any single feature like color[8], shape[9], symmetry[10], texture of grayness[11], spatial frequency[12] and variance of intensity values[13] to locate the number plate in an image. Zhang and Jia used the global edge feature [14] to identify number plates through extracting characteristics like vertical and horizontal edge information. An approach by Lee and Chen used a Block-based method [15] through blocking high edge magnitude to identify number plate region. This approach is applicable to image with unclear number plate boundary with result of 92.5%. Broumandnia and Fathy [16] proposed a less complex method to locate the number plate with respective to several scenarios. It takes image by N distances with reducing threshold for counting edges. This method is computationally efficient and is independent of size as well as distance. Wang and Wang presented an approach based on HSI color model [17] using statistical threshold to find candidate region. This algorithm works better if vehicle body and number plate are similar in color. Yuwang and Jingyu proposed [18] a level set method for number plate detection. This work performs better than the other edge detection methods [19] and general gradient algorithms[20]. Waing and Nyein Aye [21] used geometric features to remove unwanted region from an image to extract number plate easily. This method is sensitive to the environmental conditions, angle of view and physical appearance.

The limitations noticed in the above approaches motivated us to investigate a model through combining more than one features to locate number plate under different conditions for better efficiency. The rest of the paper is organized as follows. The proposed system model for detection of number plates is explained section 2. The evaluation of segmentation is discussed in section 3 and experimental results are discussed in section 4. The brief conclusion is made in section 5. The method assumes the images of front or rear view of vehicle is captured under different variation conditions which are converted to gray scale.

## 2. PROPOSED MODEL

Generally, vehicle number plates are found in rectangular shape and have rectangular area with increased occurrence of horizontal and vertical edges. The watershed segmentation algorithm [24] is applied to separate the distinct regions in the image which are bound by vertical and horizontal edges. The regions obtained are smoothened using morphological operations dilation and erosion. The over segmentation caused during the process is reduced through control markers. Mean while gradient magnitude [25] of the image is estimated initially and then the gradient magnitude is reestimated through visualization technique [26]. Further, overlapping the boundaries obtained by two techniques results a better segmentation of number plate.

The proposed method uses above extraction techniques as two stage segmentation process, initially number plate area is obtained using the boundary features through watershed algorithm in first stage and number plate area is obtained using color features through visualization technique in the second stage. Later the common area between the two are

considered as the best area to separate the number plate. The different stages involved in the proposed work is shown in Figure.1

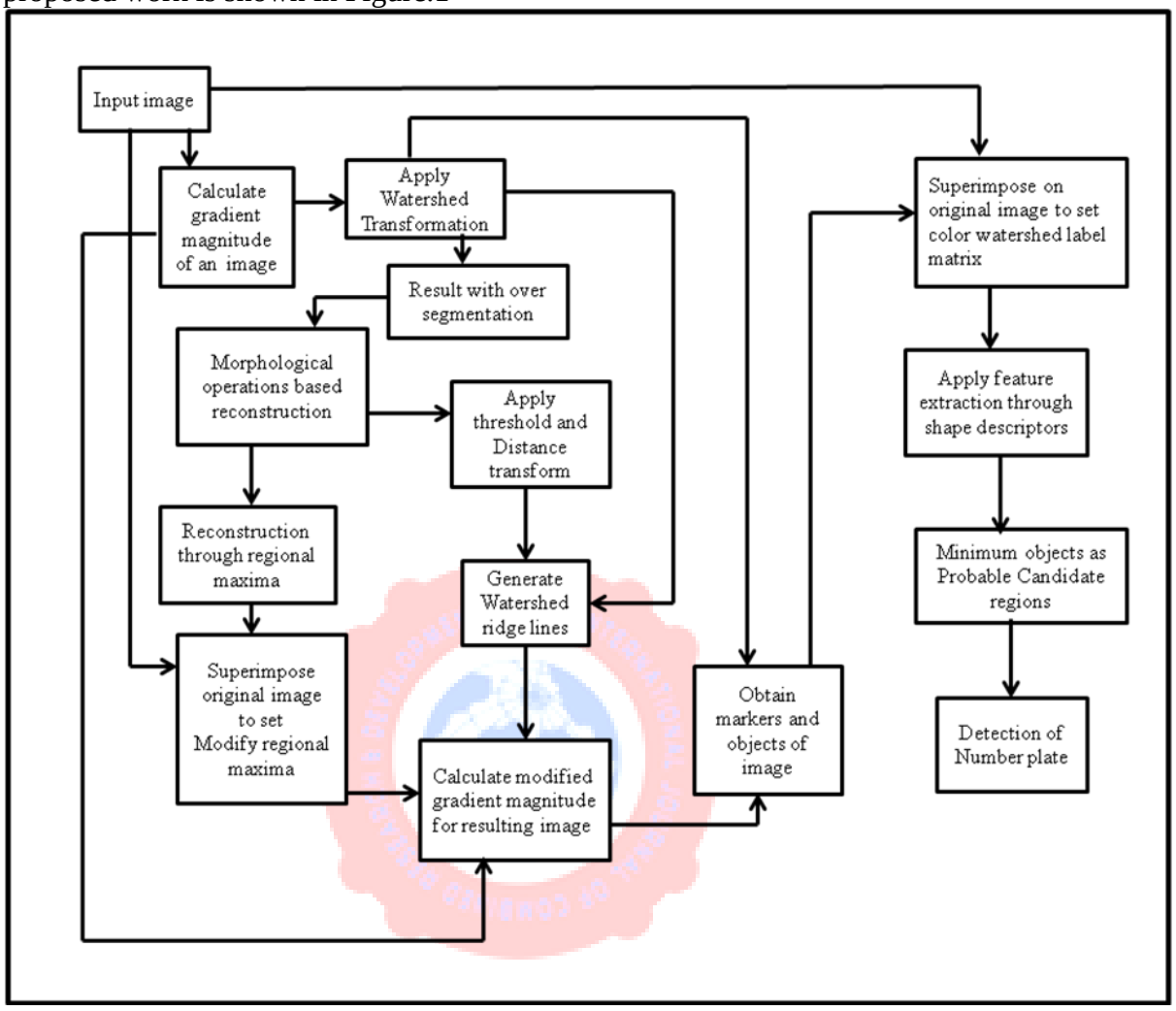



**Figure 1. Proposed System Model**

The input image Figure 2a assumed to be free from noise and image intensity is adjusted to preserve the information through median filter and converted to gray scale. Initially, the gradient magnitude [25] of the image is computed. Normally, the gradient is high at the borders of the object and relatively less inside the objects. When watershed algorithm [24] is applied on the gradient magnitude of the image, segmentation of objects in image gets structured and in majority of cases it results in over segmentation show in Figure 2b. Further, the distortions in resulted segmentation is reduced through effective morphological opening and closing operations[25], without affecting the overall shapes of the objects in the image. Regional maxima [27] are determined for each region to obtain foreground markers to improve the segmentation.


**Figure 2a: Input Image**

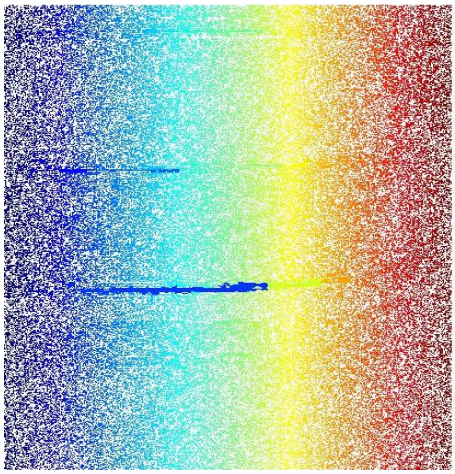


**Figure 2b: Watershed Transform gradient Magnitude**

The effective morphological operations on over segmented region have the background markers which are very close to the edges of the objects in the reconstructed image are eliminated through thresholding. Next, the distance transformation [28] is obtained from the resulting, image to split the regions with several sub regions connected through small line or bunch of pixels. This process fades out the edges and foregrounds by preserving the region centres. Combining the resulting image with the result of watershed algorithm generates the watershed ridge lines show Figure 2c. The reconstructed image from regional maxima is superimposed on original image to reestimate regional maxima for better segmentation.

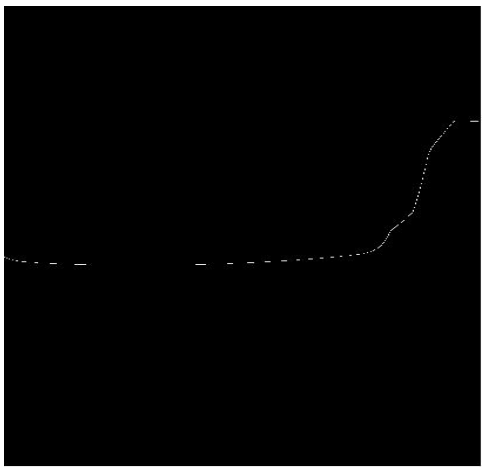


**Figure 2c: Watershed ridge lines**

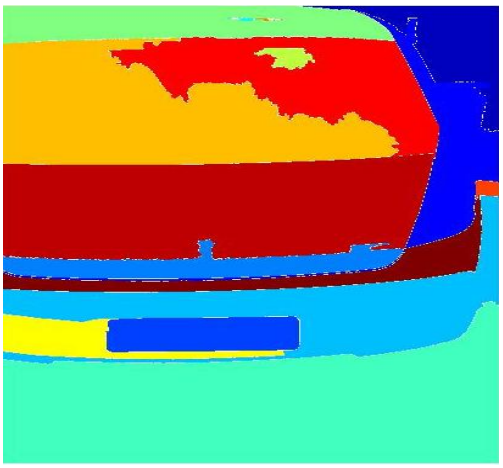


**Figure. 2d: Colored watershed label matrix superimposed on original image**

Next, the image with watershed ridge lines, modified regional maxima along with initial gradient magnitude are considered to calculate modified gradient magnitude. Further, the modified gradient magnitude is used in watershed transformation to get markers and objects of an image. The resulting image Figure 2d show superimposed on original image to get color watershed label matrix. This label matrix used in object extraction.

The resulted label matrix contains the objects which are in different shapes. All the identified regions in the resulted image are considered as candidate regions. The probability of plate available in these regions are high. In order to locate number plate in these regions shape

descriptors [29] are used to segment the regions. The regions are extracted based on object area and perimeter. The results of these parameters are used to find metric that indicates an object. When the metric value tends to be less than one, the object is assumed to be rectangular show in Figure 2e. The above decision leads to segment the number plate by cropping the object using maximum and minimum area of the object containing the number plate Figure 2f.

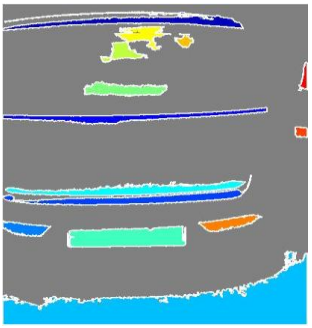


**Figure 2e: Available Candidate Regions**


**Figure 2f: Detection of Number Plate**

The tests have demonstrated the effectiveness of proposed model using boundary and colored features handling real traffic images including noisy, cluttered, snowy, rainy and scenes containing bad illumination conditions. Experimental results using real time data give the superiority of the proposed system model.

## 3. PERFORMANCE EVALUATION OF SEGMENTATION

The segmentation of vehicle number plate is evaluated using region based measures [31]. These measures are used when the size, location and area are the objectives of the segmentation. Considering **S** as the segmented region through proposed method and **G** as the ground truth region obtained manually show in Figure 3a through 3c. The following region based measures are used to evaluate the segmentation performance. All these measures yield results in the range 0 to 1. The values nearer to 0 are treated as low and values nearer to 1 are considered as high.


3a) Input Image


3b) Extracted Vehicle Number plate


3c) Ground truth image

**Measure of Overlap (Jaccard similarity measure)**

Measure of overlap is also known as the area overlap measure or the Jacquard similarity measure [31] and is defined as the ratio of the intersection of segmented number plate area S and ground truth number plate area G to the union of segmented number plate area S and ground truth area G. Measure of overlap(MOL) is given in equation 4. When the MOL is high, then the probability of segmentation performance is superior. Therefore MOL is expected to be high

(4)

Where, S=Segmented area G=Ground truth area
The Figure 4a and 4b shows the best measure of overlapping.



4a) Segmentation from proposed method 4b) Ground truth segmentation

**Measure of Under Segmentation**

Measure of under segmentation is defined as the ratio of the unsegmented number plate area U and the ground truth number plate area G [31]. Measure of under segmentation (MUS) is given in equation 5.When the MUS is low, then the probability of segmentation performance is superior. Therefore MUS is expected to be low.

MUS= (5)

Where U=Un segmented number plate area, G=Ground truth area

$U = |G - (S \cap G)|$

Where S=Segmented area
The Figure 5a and 5b shows the under segmentation results .


5a) Segmentation from proposed method 5b) Ground truth Segmentation

**Measure of Over Segmentation**

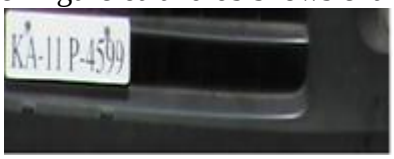
Measure of over segmentation is defined as the ration of the segmented non number plate area V and the ground truth area G [31]. Measure of over segmentation(MOS) is given in equation 6. When the MOS is low, then the probability of segmentation performance is superior. Therefore MOS is expected to be low.

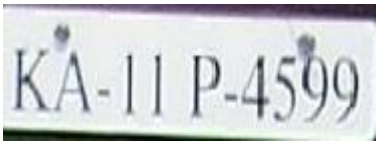
(6)

Where V=Segmented non number plate area, S=Segmented number plate area

$V = |S - (S \cap G)|$

Where G=Ground truth number plate area
The Figure 6a and 6b shows example of measure of over segmentation



6a) Segmentation from proposed method 6b) Ground truth Segmentation

**Dice Similarity measure (DSM)**

Dice similarity measure (DSM) is derived from a reliability measure known as the kappa statistic [32] and computes the ratio of the intersection area divided by the mean sum of each individual area. Let S denote the segmented area and G denote the ground truth area. Then the Dice similarity measure (DSM) is defined as

(7)

When the DSM is high, then the segmentation is said to be superior. Therefore DSM expected to be high.

**Error Rate (ER)**

The error rate ER is defined as the normalized agreement of segmentation results and the ground truth [32]. Let S denote the segmented area and G denote the ground truth area. The error rate ER is given in equation 8

(8)

When the ER is low then the segmentation is said to be superior. Therefore ER is expected to be low.

## 4. EXPERIMENTAL RESULTS

Images of vehicle number plate in colour are acquired using Sony digital color camera. We have created own dataset containing 500 images. We have collected vehicle images from various places parking place, highway, signal place etc. The experiment is conducted on these dataset. The segmentation performance is calculated based on the comparison between the manually segmented ground truth G for number plate area and segmented result S generated by the proposed segmentation approach. In order to find the effectiveness of the proposed segmentation algorithm, six performance measures such as Measure of overlapping(MOL), Measure of Under segmentation(MUS), Measure of over-segmentation(MOS), Dice similarity measure(DSM), Error Rate(ER) are calculated for 500 segmented area of vehicle number plate. The results shows the segmentation measures in Table.1 with respective proposed algorithm and ground truth. The proposed algorithm results are better when performance parameters MOL, DSM are high, MUS, MOS and ER are low.

**Table .1: Values of region based measure for segmentation from different class of Vehicle Number plates**

| Environment | Time | MOL | MUS | MOS | DSM | ER |
|---|---|---|---|---|---|---|
| Parking Area | Day/Night | 1 | 0.0182 | 0.1821 | 0.0057 | 0.3636 |
| Road Side traffic Scene | Day/Night | 1 | 0.0026 | 0.0026 | 0.0134 | 0.0053 |

The failure cases observed in the proposed system due to the non object extraction and large orientation in the number plates in the vehicle image

## 5. CONCLUSION

The proposed model for segmenting number plate in a vehicle is preformed efficiently using image enhancement, dilation, erosion operations and colour features through watershed and visualization technique. The result of segmentation are relatively better and performance measures MOL,MUS,MOS,DSM and ER shows acceptable results and is close to ground truth segmentation. The proposed method can be implemented using parallel computation for faster segmentation to meet requirements of real time application which is under investigation.

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