License Plate Localization at Night

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ABSTRACT
License plate localization is considered to be the significant process in Automatic Number Plate Recognition (ANPR) system, because the accuracy rate of license plate recognition relies on the performance of license plate localization. The majority of license plate localization papers are dedicated to daytime where many appearances can be used to locate license plate. The researches were also reported with high detection accuracy, more than 90%. However, a few studies are presented at night when license plate appearances are not easy to obtain. In this condition, license plate detection is very challenging due to the limitation of available appearances and other light sources may interfered. This paper presents a method to detect license plate position at night by combining color-based, edge-based and image processing techniques. The technique uses a variety of sizes of sub-image to improve local contrast in order to solve problems of low contrast and uneven-light images. The experiments were conducted on images at night in various lighting conditions and the method can detect license plate position with accuracy rate of about 85%.

General Terms
Image Processing, Computer Vision

Keywords
License plate localization, detection, night

1. INTRODUCTION
Automatic Number Plate Recognition (ANPR) is a valuable method, for which techniques have been presented for thirty years, widely used in many systems, for example, law enforcement systems, parking lot systems and toll systems. Generally, an ANPR system consists of three main processes: license plate localization or extraction, character segmentation and character recognition. License plate (LP) localization is an important process of ANPR systems because the performance of ANPR depends on the accuracy of LP localization.

Analysis of LP localization works shows that most of them were proposed for daytime or specific conditions where many features such as edge, color and LP shape can be easily extracted. The detection accuracies were reported as very high. A recent review of LP localization works and techniques can be seen in the work of Du et al. [1]. On the other hand, a few works were presented at night. Wanli and Shangbing [2] presented LP localization technique by applied color-based method. The technique begins with converting RGB image to HSV color space. Then, LP candidate regions are extracted by using HSV color thresholds. Last, the smallest region of integration in the H and S components is used to verify the final LP position. The detection accuracy was reported at 99.2%, experimenting on 1000 images. The problem of this method is sensitivity to light conditions. LP color could be changed due to a variety of interfering lights, such as lights of other cars and streetlamps. To solve the problem of low illumination, Chen et al. [3] proposed using an infrared (IR) camera to detect LP at night. The method, first, extracts edges of a given IR image in various image intensities. Then, the top third of highest stroke width is used to be the valid strokes. Next, an image is divided in to 20 × 20 sub-blocks (images). Candidate regions are extracted with number of edge strokes more than ¾ of the block-size. Finally, the number of character and LP aspect ratio, between 2 and 6, are used to decide the true LP location. The experiments showed LP detection accuracy of about 98%, tested on 64 images.

At night, there are some problems for a LP detection process. First, many LP appearances are faded due to the low light intensities. Next, reflections from other light sources, such as headlights, taillights, brake lights and streetlamps cause much noise on an image. Also, LP could be low contrast from two reasons: very low light and too much light on the LP area. In addition, LP color could be changed by the effect of other lights. Last, uneven light intensities can occur on captured images, which make the images having high varied illumination on the same image. This research aims to present an algorithm of LP detection at night by using an ordinary camera. Combining color and edge-based methods including image processing techniques is used to extract LP candidate regions. The technique uses a local contrast improvement strategy to solve the problem of image low contrast, in order to cope with the uneven light problem. Then majority vote of three measurements, number of characters, vertical edge pixel and candidate area, is used to verify the final LP position.

The remainder of this paper is organized as follows. In section 2, the proposed algorithm is shown with details. Section 3 illustrates experimental data such as generated images, tool and results and discussion of the proposed method. The conclusion of this study is given in section 4.

2. PROPOSED METHOD
LP detection in limited lighting conditions is very difficult because many appearance features are reduced. As discussed in the previous section, the problems of images captured at night are low contrast and possible interference by reflections. These problems could lead to faulty detection of LP. To solve these problems, the research proposes combining color and edge-based methods to extract LP candidate regions. Then, majority vote of three LP characteristic measurements is used to verify the true LP. Figure 1 shows the proposed algorithm to detect LP. The algorithm is based on state–of-the-art LP detection, including LP candidate extraction process and LP verification process.

2.1 LP candidate extraction

The aim of this process is to extract LP candidate regions which will probably contain the real LP. The most salient appearances of LP are characters within LP, color and rectangular shape. These appearances, the characters in LP and color, are the most utilized to find LP in an image in previous works [1]. In this study, color-based method is applied to detect LP color pixels by using LP color thresholds. To detect LP's characters, edge-based method is used to extract edges of an image. Then, mathematical morphological operations are applied to merge the edges expected to create LP regions. Last, the result images of the two processes are intersected in order to produce potential candidate regions.

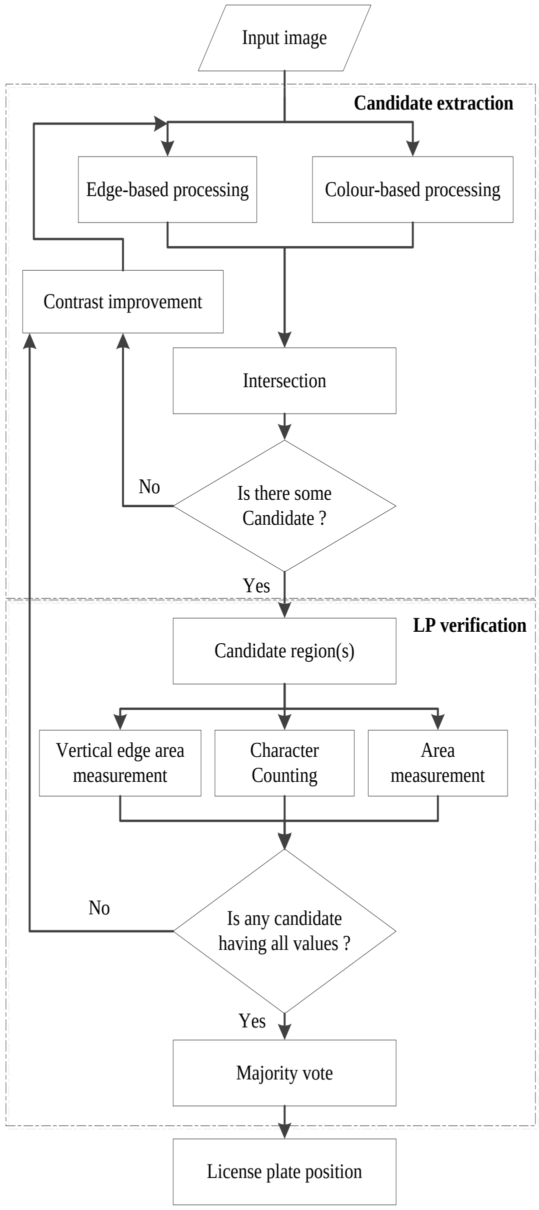


Fig 1: Algorithm for LP localization

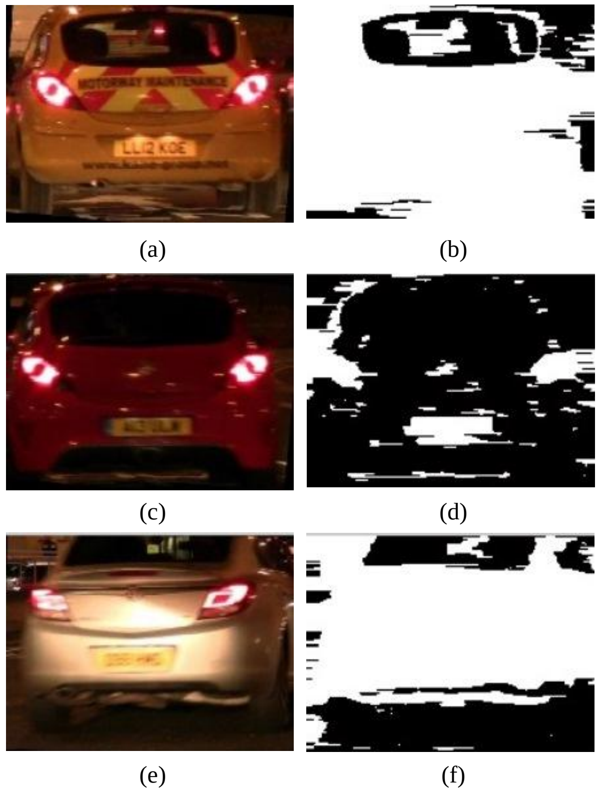


Fig 2: Images of color-based processing. a) LP color is same as car color. c) Low intensity LP. e) High intensity LP. b), d) and f) Binary images of a), c) and e), respectively

2.1.1 Color-based processing

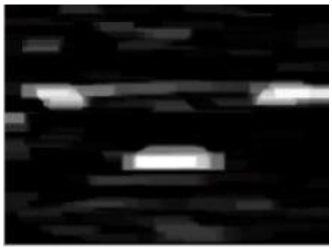
Color is one of the most dominant appearances of LP. Some countries have specific colors and there are common LP colors, e.g. yellow, white, black, and blue. Therefore, the proposed work is designed to extract the candidate region by color feature.

The advantages of this method are the ability to detect inclined and deformed LP [4]. This research designs to detect yellow LP and then RGB color space is used which seems to be the most suitable color space to represent yellow color. First, LP color thresholds are defined to handle varying light intensity. The value of red is more than 50 and the values of green and blue are more than 10. Figure 2(a) illustrates an example image of LP and car having the same color. Figures 2(c) and 2(e) show low and high light intensity on LP images, respectively. Figures 2(b), 2(d), and 2(f) display binary images of color filtering of figures 2(a), 2(c), and 2(e), respectively.

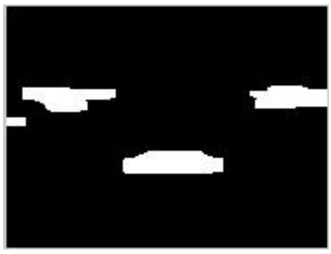
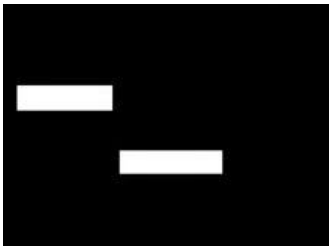
2.1.2 Edge-based processing

Another dominant LP's appearance is the characters within LP with having similar size and shape. To extract the characters, many previous works presented edge-based method that was reported with high detection rate [5, 6, 7, 8]. The edge-based technique contains many steps and this work is designed based on the work of Mendes et al. [7]. The technique begins with converting RGB image to grey level image, given in Figure 3(a). Then, Sobel's edge detection method is applied to extract vertical edges of an image. Figure 3(b) shows vertical edge detection.





(a) (b) (c)


(e) (f) (g)

Fig 3: Images of edge-based processing and candidate extraction

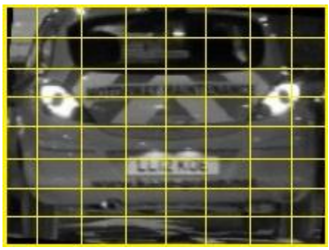
Next, morphological operations, opening and closing, are employed to manipulate the edges in order to create LP candidate regions [7], shown in Figure 3(c). After that, the image is converted to binary image by applying Otsu's method [10] for selecting automatic threshold, given in Figure 3(e). Potential candidates are preserved by applying LP geometric constraints (thresholds). The constraints are: 1) the standard LP width is larger than its height, 2) LP aspect ratio is a value between 2 and 8, 3) LP width, more than 72, and height, more than 12, is used to ensure the candidate has the correct size, 4) LP position does not lie on the image's border. Last, two result images, Figure 2(b) and Figure 3(e), from previous processes are intersected to produce final candidate regions. Figure 3(f) shows the result of image intersection and potential candidate regions are preserved. Figure 3(g) illustrates candidate regions on the original image.

2.1.3 Contrast improvement

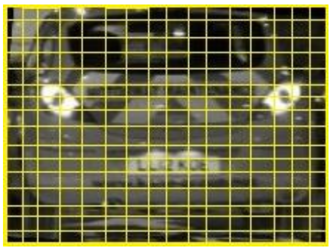
Images captured at night might have low contrast in the LP region affected by low or high illumination that causes the proposed method unable to detect the LP position. Image contrast enhancement might be employed in order to improve image contrast. In this research, local contrast improvement strategy [9] is used in order to improve local contrast rather than global contrast. In addition, the local enhancement can experimentally deal with uneven lighting. In the contrast improvement technique, an image is separated to sub-images, 8×8, 16×16 and 32×32, shown in Figure 4. The more sub-images there are, the more separation of the local area. Then, each sub-image has histogram equalization separately applied. In the proposed technique, the original image is first processed and then if no candidate is detected, contrast enhancement is employed on the image with the three predefined sub-images. In total, the technique is performed on a subject image at most four times.

2.2 LP verification

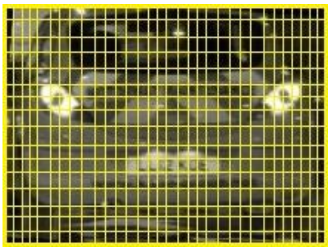
This step aims to verify the true LP among all candidates. As stated in the previous subsection, the dominant appearances of LP are its color, similar size of characters and rectangular shape. Then, these properties are used to decide the real LP.



(a)



(b)



(c)

Fig 4: Local contrast improvement. a) 8×8 sub-images. b) 16×16 sub-images. c) 32×32 sub-images

The LP should have the largest character count, vertical edges, and area. Majority vote of the measurement is finally used to decide the real LP. First, character counting is a process to indicate the number of characters within LP. The technique starts by converting grey level image at the candidate coordinates to binary image by applying Otsu's method [10]. Then, vertical projection is applied on the binary image to find lines to separate groups of characters. Projections less than 0.3 of candidate area height are removed. Last, the groups of pixel projections are counted as a character. Potential candidates are preserved with the constraint that the number of characters is more than two.

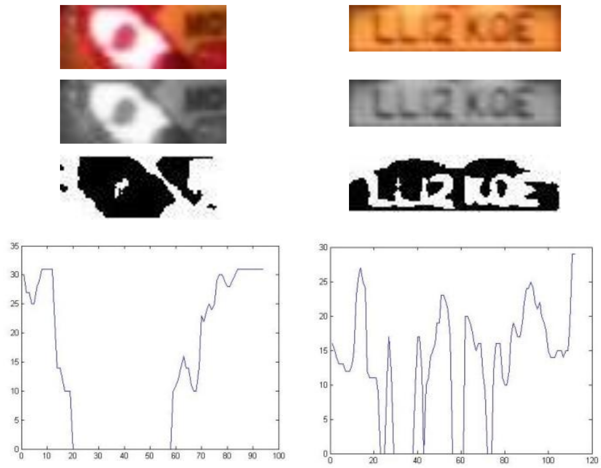


Fig 5: Character counting steps on candidate images

If there is no candidate with characters more than the constraint, the contrast improvement method is implemented on the original grey level image and the process repeats at the start of the edge processing step. Figure 5 show the steps of character counting of candidates in Figure 3(g). The index of the candidate with maximum number of character is considered as shown in (1) where *c* is the number of candidates.

$$\text{idx1} = \max(\textstyle\sum_{i=1\ldots c} Character) > 2 \qquad (1)$$

Second, vertical edge area is measured by counting vertical edge pixels of the candidate. The technique firstly detects vertical edges of the candidate region by applying Sobel's vertical edge detection technique on the grey image. Then, the obtained edge pixels are counted. Equation (2) indicates the candidate's index with highest edge pixel counting.

$$\text{idx2} = \max(\textstyle\sum_{i=1\ldots c} Edge\ pixel) \qquad (2)$$

Last, to obtain the candidates' area, connected component analysis method is applied and then we can have area of candidate and other information such as position, width, and height. The candidate's index with largest area is considered by (3).

$$\text{idx3} = \max(Area_{i=1\ldots c}) \qquad (3)$$

Majority vote is used to finally decide the real LP with the highest index of each measurement.

$$\text{Final\_idx} = \text{mode}\ (\text{idx1, idx2, idx3}) \qquad (4)$$

3. EXPERIMENTAL RESULTS AND DISCUSSION

3.1 Experimental results

Video data were collected of passing cars in rear view. The videos were taken in a city area at night and contained 220 images. Videos were taken on the left side of a road. Then images were rotated clockwise by 5° with the fixed angle of camera. Next, the images were resized to 300 x 400 associated with the pre-defined thresholds to reduce computational time.

Image processing software, AVS video convertor, was used to extract image frames from the video stream file. In addition, the programming language MATLAB (version R2013a) was used to implement the proposed method. Image processing toolbox including image manipulating functions, histogram equalization, image transformation, morphological operations, edge detection and connected component analysis function was employed.

The experimental results show that the proposed algorithm can detect LP with 85.9% accuracy, which is shown in the last row of Table 1, and Figure 6 illustrates the results of LP detection images.

3.2 Discussion

A comparison of detection rate, image data set, computation time and technique used with others studies, is shown in Table 1. Wanli et al. [2] presented color-based method to locate LP at night. The experimental results were reported the localization accuracy at 99.2 %, tested on 1000 images. The average of computation time was 2.365 seconds (including LP localization, segmentation and recognition). However, in the study showed only good light conditions on LP region images and has not provided reference data set. Although, the technique showed high detection rate, but there are some problems with this method: general sensitivity to light conditions and similarity of LP color to car color. To solve the problem of varying illumination at night, Chen et al. [3] used an infrared camera to capture images and implemented edge-based technique to detect LP. The detection accuracy was reported at about 98%, implemented on 64 images. The study could work well in the case of using images captured by an infrared unit but not efficiently on images captured by an ordinary camera. The proposed method, combining color and edge techniques on ordinary images, indicates the lowest detection rate, about 85%. The research uses local contrast improvement with various sub-image sizes to enhance image contrast aiming to handle uneven lighting intensities. In addition, the computation time was reported 0.496 seconds which was acceptable for LP localization time. In addition, the system was implemented using MATLAB. If the algorithm employed other technologies, the computation times may be decreased.

A problem of the this method is when the image is low contrast in the LP region caused by too much or low light and there is other text in the image with same color of LP. The proposed method fails in the cases of low light and contrast on LP, Figure 7(a), when containing other text in an image, in Figure 7(b), and too much light and low contrast on LP, in Figure 7(c). There is a promising that the system with infrared camera implementation showed the good LP detection performance [3]. Infrared camera is claimed that can recognize license plate and robust throughout 24 hours.

Table 1. TL detection accuracy

Works	Accuracy (%)	# Images	Time (sec)	Technique	Camera
Wanli et al. [2]	99.2	1000	2.365	Color-based	Ordinary
Chen et al. [3]	98.7	64	NA	Edge-based	Infrared
Proposed work	85.9	220	0.496	Edge- and color-based	Ordinary

(a) (b) (c)

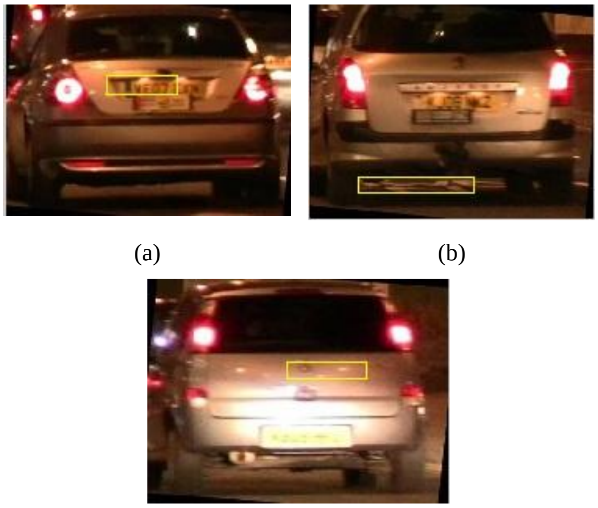
Fig 6: Example of LP detection results

In addition, images captured form the infrared cameras provide clear and shape images with no different in day and night-time [11]. Although, infrared cameras are expensive, there might be reduced in the future and can be used in existing systems.

4. CONCLUSION

This research aims to develop a method to locate LP position at night where images have limited illumination. The localization technique combines color and edge-based methods to extract LP candidate regions. In case of low contrast images, varying local contrast enhancement block-sizes are employed to improve image contrast. The majority vote of highest character counting, vertical edge area and candidate area is utilized to decide the final LP position. The experimental results show that the proposed algorithm illustrated localization accuracy of about 85%.

The challenge with this method is when implemented on an extreme low contrast image, e.g. too dark or bright LP images, that renders the method unable to extract edge or color appearances. Future work will find methods or techniques to improve the contrast of an image. In addition, uneven lighting is another problem that makes the whole image having varied light intensity. Local contrast operation is experimentally work satisfied in the research. Also, this strategy might be considered and presented in future research. Moreover, image data set used in the experiments were captured in city areas making the images are not too dark. In this circumstance, some LP data can be extracted from the image that can be used to detect LP. In extreme dark images, such as images captured in rural areas, this works might not work well in this condition. Future work will attempt to localize LP in the extreme dark images. Last, this research presents a combining of traditional LP detection techniques (color and edge-based methods). More complex features or techniques will improve detection performance in future study.



(a) (b)

(c)

Fig. 7: Example of error LP detection. (a) Low contrast image of low light, (b) Other text in the image, (c) Low contrast image with too much light

5. REFERENCES

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