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Automatic Car Number Plate Extraction Using Connected Components and Geometrical Features Approach

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Abstract

As today information era of advanced and secure digital technology field, monitoring system and security mechanisms are played as the most important role. By using specialized security camera in public sectors and pedestrian crossings, it can monitor and record a real time events and information of the sectors as video clips to track criminals. According to get the important data clearly and correctly from the video clips, the detection and extraction methods are essential. The proposed system focuses on the detection and extraction of car number plate that are taken from over speed driving cars. So, these number plates are deburred to overcome some of the security threat and enhance the motion deburring technique. Our proposed method is the combination of connected component based approach with the regional geometrical features. In this method, key frames are generated from an input video clips using Discrete Wavelet Transform (DWT) based approach. From the key frame images, rectangle shape areas which has high luminance value is detected and extracted as foreground regions and others are discarded as background by using regional geometric features. Finally, the rectangle shapes are checked whether any text is included or not. If a rectangle shape area contains text, this system accepts that it is a number plate and other region is omitted. Then the accuracy of the research method is evaluated with various experiments to compare with previous researches.

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This system can be widely used in E-mail address: phyothetkhin1986@gmail.com, laelae83@gmail.com, htwe.aye@gmail.com. Many applications such as detection of speeding cars, security control in restricted areas, unattended parking zone, traffic law enforcement and electronic toll collection.

Keywords: connected component; license palate region extraction; regional geometric features; text detection; video clip.

1. Introduction

Now a day, vehicles have been widely used in every area of production and life of people. The license plate number is a simple and an effective way for identifying vehicles; it is unique information for every car. With the total number of vehicles increases quickly, traffic violations will appear more frequently in the public traffic, such as running the red light, over speed, etc. The license plate extraction is considered as an important part of car license plate recognition system.

Roughly, a license plate recognition system can be conceptually considered as containing four stages: (i) license plate detection; (ii) license plate extraction; (iii) character segmentation; and (iv) character recognition. Among them, the license plate extraction is the second phase and the most important phase of the license plate recognition system. For the overall system to be accurate, the license plate detection has to detect the license plate correctly in different conditions, so the license plate area can be correctly extracted. Variability of the environment and conditions in which the image is captured as well as variations in license plate texture are the main challenges for license plate extraction systems. The image can be captured in various illumination conditions and may contain one or more license plates in various locations and sizes. Texture of the license plate can vary due to shadows, dirt and plate types. Also a background may include trees, road, platform, cars bumpers and headlights, etc., containing patterns similar to license plate. The numerous proposed license plate extraction systems are based on different properties.

In this paper, connected component analysis and geometric feature approach is researched for number plate extraction system. There are two main stages. The first stage is rectangle shape detection which can be detected the rectangle shape area that contains text. The second stage is text (number plate) area extraction in which characters from a single line are segmented using connected component analysis based method and estimated the gradient pairs in horizontal and vertical direction to verify and enhance the result image. If any touching characters occur in the detected text line, then that line is further processed for morphological operations. The rest of this paper is organized as follows. Section 2 reviews the related work. Section 3 describes the key frame generation and rectangle shape detection. It also discusses the text area detection and extraction and then the enhancement of number plate region. The experimental results are shown in Section 4. Finally, concluding remarks are presented in section 5.

2. Related Works

Most of existing video text detection process has been proposed on the basis of region, color, edge, and texture-based feature.

Region-based methods can still be divided into two approaches [1,2,3]: connected component (CC)-based [2], [3] methods and edge-based [1] methods. CC-based methods work in a bottom-up fashion by identifying and combining sub-structures such as CCs and classify them into text or non-text regions. In fact, for the latter approach, it is common to use morphological filters to identify text region candidates [1,2,3] and then applying heuristics [1,3] or classifiers [2,4] to label them as text or non-text regions. Component-based methods, text regions are detected by analyzing the geometrical arrangement of edges or homogeneous color/gray scale components that belong to characters. For example, Smith and Kanade [5] located text as horizontal structures of clustered sharp edges. Similarly, Lienhard [6] identified text as connected components which are of same color and have corresponding matching components in successive video frames. Jain and Yu [7] decomposed the video frames into sub images of different colors and then examined if each sub image contains text components which satisfy some specified heuristics. Connected component analysis is performed on the edge pixels of remaining regions.

Edge-based methods work in a top-down fashion by emphasizing high contrast between texts and their background in order to identify regions and classify them into text or non-text regions. Edge-based approaches are also considered useful for video text detection since text regions contain rich edge information. The commonly adopted method is to apply an edge detector to the video frame and then identify regions with high edge density and strength. This method performs well if there is no complex background and it becomes less reliable as the scene contains more edges in the background. Lyu and his colleagues [8] use a modified edge map with strength for text region detection.

A modified color texture-based method for detecting license plate in images was presented in [1]. Bertini and his colleagues [9] detect corner points from the video scene and then detect the text region using similarity of corner points between frames. Zhong and his colleagues [10] detect text in JPEG/MPEG compressed domain using texture features from DCT coefficients. The potential caption text regions are verified by the vertical spectrum energy. However, it can only handle captions and cannot deal with complex text layouts. Some methods combine these two paradigms. For example, Wernicke and Lienhart [11] performed multiple passes of horizontal and vertical projections within initial bounding boxes to cope with complex text layouts.

After the text detection step, the text extraction step should be employed. The text extraction methods can be classified into colour-based [11] and stroke based methods [12], since the text pixels are of different color from the background pixels, so that they can be segmented by thresholding. The former holds the assumption that besides the validity of the assumption, another difficulty in this approach is the color polarity of text, i.e., light or dark, must be determined. Antani and his colleagues [13] proposed a color-based method that first generates two segmented results in both polarities for each text string and then selects the one with a higher score on text-like characteristics as the final result.

The stroke-based methods, on the other hand, employ some filters to output only those pixels likely on the strokes to the final results, such as the asymmetric filter, the four-direction character extraction filter [14], and the topographical feature mask.

These filters are intended to enhance the stripe (i.e., stroke-like) shapes and to suppress others; however, the intersection of strokes may also be suppressed due to the lack of stripe shape.[14], proposed the wavelet transform technique and gradient features for text extraction respectively. Recently, it has been proposed a region based method to label regions, extracted from scene images by morphological filters (opening and closing top-hats), into text or non-text region. Finally the plate region is obtained based on Connected Component Labeling and geometrical relationship of numbers on plate [16].

3. Proposed Method

In this system, all rectangle shape without connected components are not car number plates that it is assumed, all regions which contain connected components are impossible car number plates. A car number plate has both rectangle shaped area and connected components (number and text). The text is connected components and also has high luminance value on low intensity background. Based on these assumptions, if an extracted region is rectangle shape which has connected components, the region can be exactly defined as car number plate. By this way, the car number plate can be exactly detected and extracted from a video clip. Hence, the proposed car number plate extraction method can be divided into three main stages.

The first stage is the key frame generation. And the second stage is rectangle shape detection. The last one is text area detection and extraction. After the car number plate has extracted, it may be blurred or degraded in visual quality. As a result, we imagine the visual qualities of the result car number plate are improved. The car number plate extraction process can be presented in the following flow chart and explanations.

3.1. Key frame generation

In a video clip, there are many scenes which are composed of many frame images. Even in a video scene, more than 30 frame images are included. These frame images are nearly the same and can present only information related to the scene. Hence, only one scene of a video clip, only one frame image which can present the information of the scene is needed to process instead of processing all frames.

The frame which can present entirely information of a scene can be called key frame of the scene. Hence, as the first section of the proposed method, key frame is extracted from different scenes of a video clip. Here, each key frame is special image which can represent each related scene and also entirely contains all important information of the scene. So, we do not need all frame of a particular video clip.

Hence, key frame generation method is suitable for most of video processing. In the proposed method, the key frame generation is implemented based on DWT approach. Whenever visual contents are changed in original image, the frequency components of transformed image are also changed.

As soon as the changes occur in the scene, the visual contents of current and later frames are not the same. Hence, the frequency components of the frames are exactly different. By using the difference of frequency components of the two consecutive frame images, we can detect the key frame of next scene.

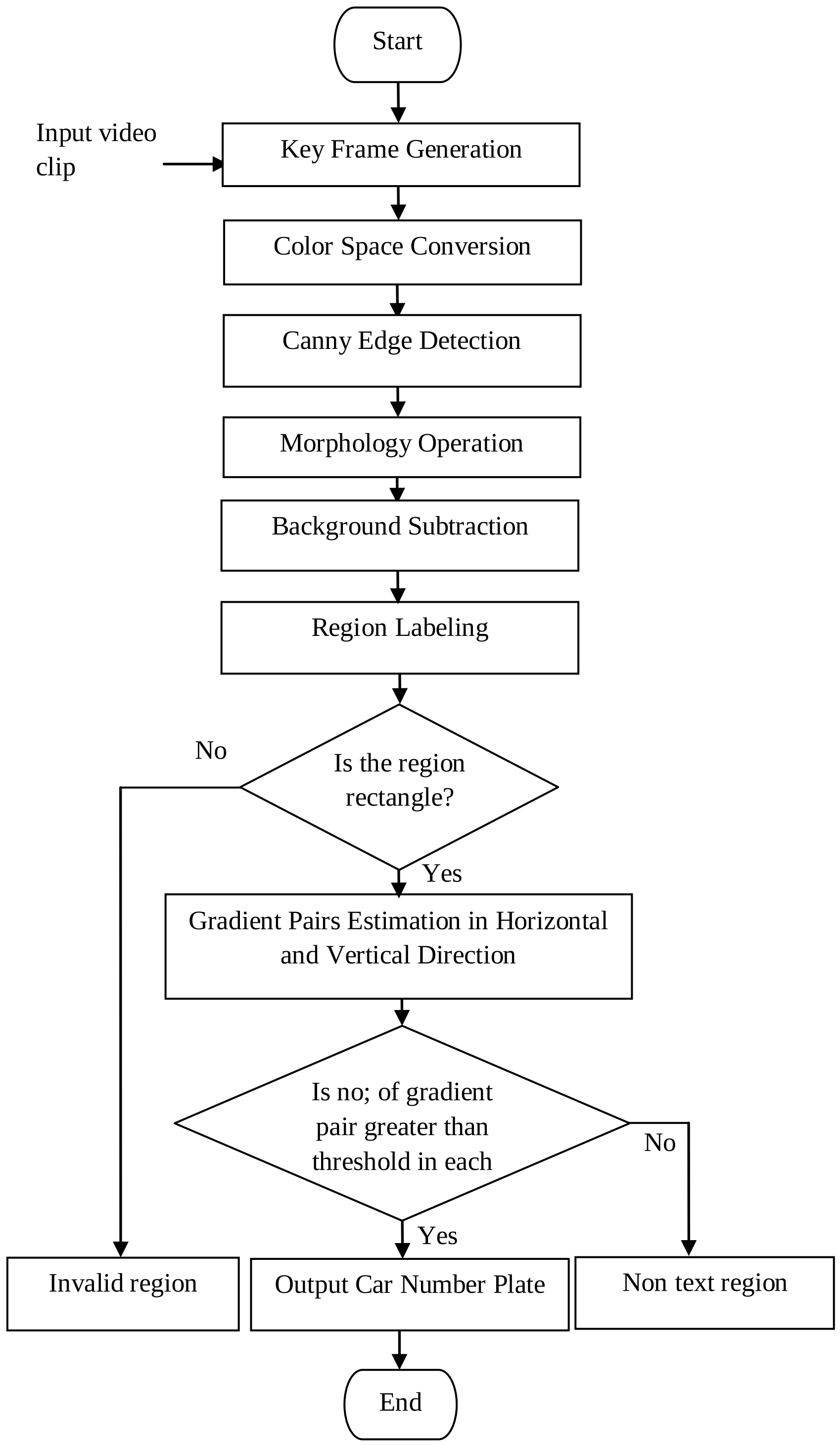


Figure 1: Flow chart of the proposed system

The key frame generating process can be presented by the following steps.

- In the first step, two successive frames are read and transformed with DWT to achieve four sub-bands, LL, HL, LH and HH. Among the four sub-bands, only two sub-bands, LL and LH are used to detect key frame and other two bands are omitted in order to improve processing speed.

- For each sub-band, different value is estimated by subtracting related frequency component values of current and next frame.
- Mean and Standard Deviation are computed from the difference values of each sub-band.
- Threshold value for each sub-band is calculated by adding the Mean and Standard Deviation.

(T = M + α*STD, here α is a constant to adjust the number of key frames and processing speed).

- In final step, the threshold and difference value of each band are compared. If two difference values of any two sub-bands are over the related threshold, the last frame can be considered as a key frame.
- The output key frames are saved as images for the later processes.

After the Key Frame Generation process, rectangle shape detection and text area detection and extraction steps are expressed in next sub section. In both section, the input key frame is firstly converted into YUV colour space to detect the rectangle shape and extract the license plate area. Among three channel of the image, only Y channel is used which can represent the brightness and intensity of an image. And then, Canny Edge detector is used to detect the edges of the region. These edges are modified and enhanced with morphology to connect and fill boundaries and region. Long and narrow region, unwanted lines and noises are removed by using median filter with larger kernel size such as 7x7 or 9x9. Hence, these steps can be considered as background subtraction. After finishing these steps, the remaining process of Rectangle Shape Detection and Tex Area Detection and Extraction are presented in the next sub section.

3.2. *Rectangle shape detection*

This section is the accuracy enhancement of previous [16] and the main point of the research method because it is the detection of geometrical features of car number plate. As we already known that all car number plates are rectangle shapes. Furthermore, text components (usually white colour) which have higher luminance value are printed on lower luminance background (black or red).The text background colour of number plate is very distinct with the color of body frame on which number plate is put on. Hence, in a visual scene, the car number plate can be seen from a rather distance. As distinct as in visual, the car number plates can be remained as rectangle shaped regions in image segmentation process. Hence, we can exactly detect and extract the car number plates by holding the features of the rectangle shape.

The main geometrical feature of a rectangle shape is the distance between its major axis length and minor axis length. In a square, major axis and minor axis are the same length and their difference is zero. In the rectangle, there is a different value between major axis length and minor axis length because major axis length is always longer than minor axis length. Hence, the difference between the two axes is a key factor to detect the rectangle. Moreover, when we took the testing video clips, we made a fixed target area and view point in capturing them. Hence, the areas of all car number plates are laid in limited boundary because of taking with fixed target area. For this reason, the area of segmented region is a considerable factor to detect the car number plate. Similarly, as the fixed target area, the tracks of the motion of cars must be laid within the area.

And, the centroid of the car number plates also must be laid on the track. Hence, the centroid is also a geometrical feature to detect the car number plates. In proposed method, we used the three key features, the centroid, the area and the difference between major axis and minor axis, are used to detect required rectangle shape regions (car number plate regions) among segmented regions.

Just as usual, detection process is implemented by candy edge detector and morphological processes. After these processing steps, the three geometrical features are used to detect rectangle shaped regions among segmented regions.

The first three steps of rectangle shape detection are expressed in previous section. So, the remaining processes are summarized as follow.

- After the above processing steps, these regions are label and inquired regional geometric features such as area, major axis length, minor axis length, and centroid.
- According to the geometric features, if the area of a particular region is lied within predefined limitation and the difference of major axis and minor axis is less than predefined threshold, the region can be remarked as rectangle shaped region. The detection procedure can be described as follow.

```
If (area of region is within predefined limitation)&& (the difference between Major Axis Length and Minor Axis Length is within predefined interval) && (Centroid position of the region is lie with predefined interval))
        The region can be remarked as rectangle shaped.
        It is selected and covered by Bounding Box.
```

After the rectangle shape detection process, these rectangle shapes are also detect which contain text or non-text. Because all rectangle shapes are not car number plate. So, Text Area Detection and Extraction process are presented in the next sub section.

3.3 Text area detection and extraction

According to the assumption of the research method, the car number plate must be rectangle shape and also has connected components. Thus, after we have achieved the rectangle shaped regions, we have to detect whether texts and numbers are include or not in the rectangle shaped regions by finding connected components. If there is no connected component, the regions will be skipped. If connected components are found, the region can be considered as number plate region and it is cropped and saved. The first three steps of text area detection and extraction are the same as rectangle shape detection process.

In remaining process, the connected components or texts are detected and extracted by the following steps.

- Edges of the number region can be subtracted from background and ready for counting gradient pairs.

- Gradient values between two consecutive pixels are firstly calculated in vertical direction and horizontal direction. In calculating the gradient value, negative gradient is found at the entering edge of number region and positive gradient is found at the outgoing edge. The negative edge gradient and positive edge gradient are defined as a gradient pair.
- In both directions, if the numbers of gradient pair is larger than predefined threshold, the image contains text.
- If text is detected on a particular region, the region is not only rectangle shaped but also contains text, this region is cropped.
- This cropped region is displayed as output car number plate images.

According to this processes, we can be easily extracted the car number plates from a recorded video clips. The processing time is depending on the length and frame rate of given video clips. However, because of the fast motion of cars, the car number plates are possible blurred or degraded in visual quality. Hence, they are needed to enhance to improve their visual quality. Therefore, the following additional enhancement process is needed to perform.

3.4. Number plate enhancement

The process is to enhance the cropped number plates in visual quality. In this process, motion deblurring and contract enhancement are performed. In the deblurring process, instead of Laplacian distribution, Maximum a Posteriori (MAP) technique is used to estimate the optimum point spread function (PSF) for colour image deblurring. There are less gradients in natural images (smooth image) but large gradients in blurred images as the results of spares. In other word, the most favored image under prior (natural) is a flat image with no gradient. Hence, natural image is recovered by selecting minimum values of MAP estimations. To calculate the MAP estimations, centered region area of blurred image is used as sub image in relative size. From this sub image, true kernel of PSF (x', k') is estimated by using the following formula [15].

$$(x',k') = arg\,min_{x,k}\left(-exp\left(\frac{\gamma}{2}\|x * k - y\|^2\right) + \left(\sum_i\left([D_x x]_i^2 + [D_y x]_i^2\right)^{\frac{1}{2}} + \sum_i k_i + C\right)\right) \quad (1)$$

Where, x is a visually plausible sharp image and k is a non- negative blur kernel. D_x and D_y are partial derivative operators in order to horizontal and vertical direction, k_i is zero for no gradient and no change or positive for spares. From this calculation, we can received sub natural image and true kernel of PSF (x', k'). After that, no blurred image is restored by convoluting with the kernel (k') to the whole blurred image.

After the deblurring process, the deblurred image is also enhanced in contrast using contrast stretching depending on the output image histogram. The contrast stretching operation is implemented by the formula.

$$I_{output}(i,j) = \left(I_{input}(i,j) - c\right)\left(\frac{a-b}{c-d}\right) + a \quad (2)$$

Where, I_{output} and I_{input} are output pixel and input pixel at the image location of (i,j).

And *a* and *b* are the maximum (255) and minimum (0) pixel values of a given image, and then *c* and *d* are the 5th and 95th percentile points of the cumulative histogram distribution. By the two processes, deblurring and contrast stretching, we can enhance the output cropped car number plate to be clearer in visual perception.

After finishing the above four main processes, we can received readable car number plate to identify. The accuracy of the number plate extraction can be seen in next section.

4. Experimental Results & Discussions

In this section, we are going to represent the accuracy measurement of the research method with many different video clips.

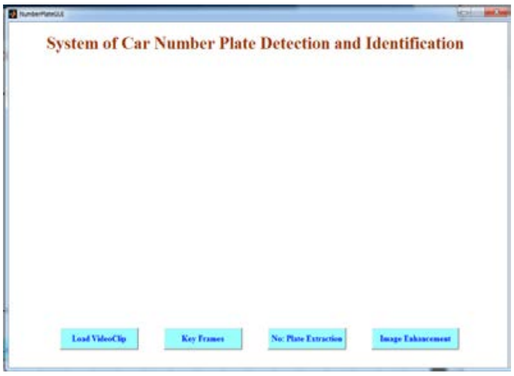
The objective of research method is to detect and extract car number plate from any video clip in more precisely. To measure and proof of the accuracy of the proposed method, experimental settings and some experimental results can be shown as follow.

4.1. Implementation of the proposed system

The proposed method is tested with many video clips with different frame length and different types of car. Among our experiments, the results of three video clips which represent different types of car and different locations are discussed. In the proposed method, Matlab 2014Ra is used to simulate the proposed processing procedures.

Under the implementation process, we have first to load video clip to generate the key frame in second stage. After the second stage has finished, the number plate extraction process is applied. Finally, we have to smooth over the visual qualities of the result by enhancing extracted number plate image. In the loading process, desired video clip which is situated on current processed machine or anywhere can be load and opened from opened dialog box. After loading the video clip, it is copied and saved in the processed folder. To reduce the processing frame image and eliminate the processing time, key frame generation is performed by using DWT transformed based method as discussed in the above section.

After generating the key frames, they are saved in the destination folder for later processes. Car number plate extraction is performed on all key frames which are already saved. The extraction action is displayed on the implemented GUI. In the extraction processes, there are many extracted regions from the key frame images but they are all rectangle shaped. Among these rectangle shaped regions, the certain regions which contain number and text are selected by Boundary Box and cropped, and then the cropped regions are saved in output folder. In the final process, the cropped images in output folder are enhanced in edges and colours contract and then they are displayed on the system GUI as destined outputs. The implementation process is demonstrated with the series of GUIs as described in the following figures.



(a) GUI user interface

(b) Moving Car

(c) Key frame image

(d) Key frame generation

(e) Selected car number plate by Boundary Box

(f) Extracted car number plate

Figure 2: Illustration of system implementation and its processing simulations

4.2. Experimental results

In this section, the experimental results are discussed based on extraction results. The accuracy and processing time of the proposed method (Connected Component Based Method with geometrical feature approach) is evaluated and compared with previous method (Connected Component Based Method). The value of accuracy and processing speed of the previous method are taken from [16].

(a) Cropped number plate from video1.avi

(a) Cropped number plate from

(c) Cropped number plate from video3.avi

Figure 3: illustration of extracted number plate of proposed method

The experimental results of the proposed method are carried out many video clips with different frame length and different types of car by using Intel (R) Core(TM) i7-3517U CPU@ 1.90GHz.

The purpose of the proposed system is how much precisely extracted the car number plate image from a particular recorded video clip. The accuracy can be described as the following formula.

$$Accuracy\ (\%) = \frac{N_{plate}}{N_{cropped}} \times 100 \qquad (3)$$

Where,

N_{plate} = numbers of cropped car number plate images that especially contain car number plate area

$N_{cropped}$ = numbers of all cropped images that contain the image of car number plate area and other part of the whole car image

To calculate the accuracy, we need the value of numbers of cropped car number plate images (N_{plate}) and total numbers of all cropped images ($N_{cropped}$). For example, in Video 1, the value of $N_{cropped}$ is 12 and the value of N_{plate} is 11. So the accuracy value of Video 1 implemented by the proposed system is 91.6667. And, in Video 2, the value of $N_{cropped}$ is 5 and the value of N_{plate} is 5. So the accuracy value of Video 2 implemented by the proposed system is 100. Similarly, in Video 3, the value of $N_{cropped}$ is 5 and the value of N_{plate} is 5. So the accuracy value of Video 3 implemented by the proposed system is 100. Moreover, the accuracy value of proposed method is compared with the accuracy value of previous method. These results are shown in Table 1. The proposed system is not only evaluated the accuracy value but also the processing speed. To complete the system, it takes the time to generate the key frame from the video clip and extract the car number plate area. The processing time is evaluated from the key frame generation process until the output results. The processing speed of proposed method is also compared with the previous method. Although the geometric features are added to the proposed system, the processing speed doesn't take more time. It can give acceptable time compared with the previous method

Table 1: Accuracy and processing time of proposed method and connected previous method.

No	Video clip	Processing speed (seconds)		Accuracy (%)	
		Connected Component Based Method	Connected Component Based Method with Geometrical Features Approach	Connected Component Based Method	Connected Component Based Method with Geometrical Features Approach
1	Video1.avi	11.5873	12.177330	84.6153	91.6667
2	Video2.avi	78.2465	70.85126	83.3333	100
3	Video3.avi	10. 82765	10. 2365	71.4285	100

According to the above table and experimental results, the proposed method can detected and extracted the car number plate exactly. In the above table, the proposed method achieves 100% accuracy which means that all cropped images of the proposed method are exactly car number plates. In the previous method, cropped images contain other item likes texts. It is because it neglected geometrical shape feature of number plates. As the proposed method achieved faster processing speed and the most precise accuracy, the proposed method outperform in detection and extraction.

5. Conclusion

In this paper, we discussed the key frame generation and presented the car number plate extraction method by combining connected components and regional geometrical features approach. According to the experimental results, the proposed system can reduce the key frame calculation time by using the difference features of adjacent video frame instead of calculating the length of all frames in video clip. Connected components for each candidate region are generated and we filter out clutter regions from this candidates region by using geometrical features of the plate region. The boundaries of the detected text regions are localized accurately using the projection of text pixels. Final extraction of the plate region is performed by using the correlation and geometrical feature approach between candidate regions and a plate. According to experimental results, the research method achieved faster speed and outperformed accuracy in extraction. In the future researches, we will go on the monitoring and security based image processing area in trying to achieve more precise and better results and then we will continue the deblurring research with other optimized methods such as genetic algorithm, iterative annealing and so on.

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