Ornament Problem Suppression in Indonesian License Plate Recognition Systems

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Abstract. Based on the original work of fast performance algorithm in detecting Indonesian license plate, the proposed work will solve the error found in the license plate localization process caused by plate like pattern within the image, which was called the ornament problem. Although not in all cases, this problem could exist when a car has banner, regular pattern, car’s front grill, that could be misunderstood by the system as license plate letters. The proposed work will implement filtering systems instead of machine learning approach. The filtering methods will follow three steps: detection filter based on the number of elements in the vector, based on the letter proportion of a license plate number, and based on the distance between detected letters. This approach will maintain the fast properties of the original algorithm and will increase the accuracy of localizing the license plate within the given image. Keywords—license plate, localization, computer vision.

1. Introduction
In implementing ALPR (automatic license plate recognition) on a real traffic the algorithm implemented needs to be agile and fast. One of the processes of implementing ALPR system is the license plate localization process. The proposed work is based on the previous research that implements fast performance non-learning based algorithm [1]. However the algorithm still suffers from what was proposed in the related work as the ornament problem. The problem exist where contour pattern that has high similarity to a plate alphabet and number. This could negatively impact the license plate localization process. Figure 1 shows the result of wrongly localized license plate as a result of the front grill of the minibus mistakenly translated as the license plate letters. This is as a result of the vehicle’s grills contours (shows in figure 2) have high similarity as the basic contours of a series of license plate letters. The proposed work presents an algorithm to suppress this ornament problem in LPR (license plate recognition) system using interconnected image segmentation and relates them to the proportion of the contours’ bounding box.

Figure 1. Falsely localized license plate letters caused by ornament problem
Figure 2. Falsely localized license plate letters described at edge detection image
2. Related work
Recent work was also attempted to solve the problem using the contour detection technique [2] however it was tested against clean sample images that does not contain some of the ornament problems mentioned [1]. Another earlier work [3] used to verify the license plate is by using width and height of license plate candidate, and by implementing the so called horizontal crosscut to count how many objects within the horizontal line. However yet again this approach does not indicate any extreme case that could present in a form of other elements that consist of several objects, which could have high similarity as a license plate - if not higher cost function value. Other used a machine learning approach into what was named as geometric operation [4]. This is where object with certain characteristic were labeled using aspect ratio, total pixel, width, height, and presence of letters. Those aspects then will be fed into a hidden layer using an improved back propagation. The technique and some other previous works [5][6][7] require numbers of samples to improve the localization process. Rectangle detection in solving plate localization process was implemented using contour detection [8]. However the use of rectangle detection could be misleading to some cases where the background of license plate has similar color value to the vehicle’s color, and to the presence of other object in the sample (such as banners) that has rectangular boundary. Another approach as well used the license plate dimension as a method to localize license plate in a sample [9]. This works as well combine it with Euler method to detect the number of close loop of the license plate letters. However it did not tested against sample with more then one high Euler values present in the image – which indicating the presence of letters that are not license plate letters in the input sample.

Other recent work shows advance techniques in localizing and filtering various effect of lighting such as shadow, dark condition, exposure, and daylight [10]. However the technique uses local binary method to localize the license plate.

3. The proposed systems
The ornament problem in a LPR systems happen when the localization process fail to detect the location of a license plate within a given image due to distraction from other ornaments of the cars. Figure-3 shows wrong detection marked by the bounding boxes around phone numbers of the car’s windows banner. Figure-4 emphasizes the wrong detection by showing the only the bounding boxes of the detected contours image. It displays the bounding box of the location detected by the original algorithm in the 2D Euclidean plane of the given image sample.

Furthermore, this falsely located license plate was the result of a strong presence of other letters in the sample image that are not part of the license plate letters. The problem usually takes place in a case of vehicle’s banners, front grills, logos, and any other regularly placed contours in a real case traffic.
information systems. The propose systems implement filtering algorithm to suppress the so-called ornament problem [1] by dividing the system into three filtering functions. The three functions could be implemented separately, however through some of the experimental result we could see later on that combining the three will improve the localization process of license plate in Indonesian plate systems.

The proposed algorithm follows the following methods to suppress the ornament problems while still maintaining the fast and accurate properties of the original system:

1. Detection filter based on the number of elements in the vector
2. Detection filter based on the letter proportion of a license plate number
3. Detection filter based on the distance between detected letters.

The first method will filter detected set of contour based on certain threshold. Figure-5 is depicting eleven elements that were considered within the wrong localization process.

Secondly the algorithm equipped with filtering process based on the proportion of the boxes. A letter within a license plate system will have a certain ratio of width and height of the boxes (figure 6). Lastly, the algorithm proposed to have filtering system based on the distance measured from the center of every box to the center of its neighboring boxes (figure 7).

This filtering mechanism has been added to the original work [1] so it could raise the performance of license plate localization. This method was chosen above other methods that based on machine learning is to keep the fast properties of the original application.

3.1. Expected result

The expected output of the proposed work will be a perfected fast performance algorithm of license plate recognition systems with suppression method for reducing the ornament problem [1] that is exist in a real live traffic monitoring system. Figure-8 shows the expected shift from the back window’s banner to the license plate letter below. The algorithm as well expected to translate the localized license plate using optical character recognition technique.

3.2. Filter algorithm by number of letters

The detection filter based on the number of elements within the vector would search for corresponding segmented images that relatively lay at the same horizontal line. Given the vector of segmented images $S$, then each image $S_i$ within $S$ will be compared to its neighbor $S_{j,n}$. If $S(x,y)$ position smaller
or equal to threshold $T$ of its neighboring segments $S_{j,n}$ than group $S_i$ and $S_{j,n}$ into filtered vector $FS_{i,n}$. For every sub vector $FS_i$ check whether the maximum number of letter is smaller than maximum Indonesian plate number digit $MT$. Return the largest element in $FS$. This will be heuristically the strongest candidate as a vector of valid license plate’s letters.

3.3. Filter algorithm by letter proportion
To filter using the proportion of width and height of the letter bounding box – this is different from earlier work [3] where the evaluated are was the entire license plate not on each letter, the following pseudo-code was implemented.

```java
private boolean validLetterRectangle(Rectangle rectangle) {
    Set w = 0.6; // width threshold
    Set h = 0.9; // height threshold
    R = w / h;
    ratio = (double) rectangle.Width / (double) rectangle.Height;
    if (ratio <= R)
        return true;
    else
        return false
}
```

Figure 9. Filter algorithm using the proportion of a valid letter (pseudo-code)

There are two threshold set for the algorithm based on valid Indonesian license plate letter proportion of width and height, whereas will be called $R$. This value of $R$ then will be compared to each of the bounding box ratio of width and height $r_{i,n}$ of the segmented images. For every $r_{i,n}$ that is smaller or equal to $R$, the image within the bounding box will be considered as a valid license plate letter.

3.4. Filter algorithm by distance between letter
This detection filter based on the distance of elements within the vector would search for corresponding segmented images that relatively lay at the same horizontal line and have distance $D_{i,n}$ that is smaller than valid threshold $DT$. Given the vector of segmented images $S$, then each image $S_i$ within $S$ will be compared to its neighbor $S_{j,n}$. If $S_{i}(x,y)$ position smaller or equal to threshold $T$ of its neighboring segments $S_{j,n}$ and $D_i$ is smaller than $DT$, than group $S_i$ and $S_{j,n}$ into filtered vector $FS_{i,n}$. Furthermore, similar process of examining every sub vector $FS_i$ check whether the maximum number of letter is smaller than maximum Indonesian plate number digit $MT$.

4. Experimental results
After implementing the filtering algorithms the accuracy of license plate localization process increase by 90%. The following are some of the image resulting from this particular process.

The experiment was tested against 20 various images that were previously have suffered from ornament problem [1]. The time elapsed had also varied depending on the size of the image. The smallest image fed to the systems was at 300x292 pixels with time to process at 65 millisecond. This is including the time to pre-process the image (smoothing), finding contours, filtering the image, and translating them into ASCII character. Proposed algorithm was also tested against smaller license plate image segment size. Figure 10 (a until f) shows the result of experimenting on some plate samples with ornament problems. The accuracy level of this experiment is close to 90% out of the 20 samples.
As the letter becomes smaller, the contours are not clearly separated each other, and on some cases a letter does not form a perfectly close loop contour. This could lead to missing information that can be seen from figure-11 and figure-12 where both letter “B” at the beginning and the end of the license plate are not detected (located).

The left outer most letter “B” suffer from the merging contour with the underline contour, whereas the most right letter “B” suffer from incomplete close loop contour, and the letter “K” was separated into two close loop contours. These are as result of missing information for small size plate segments’ size. To solve this missing information problem, a reasonable size of license plate letter image
segments size needed as the input to the ALPR system. Further research is needed to quantify the reasonable size of the input segments in term of pixel values.

5. Conclusion

In conclusion, implementing ALPR on a real live traffic system needs a robust algorithm to be able to handle input irregularity. One form of this arbitrary input is what was proposed to be called as the ornament problem. The algorithm proposed implements several filtering to solve the problem. One of which is to validate the ratio of every image segment bounding box width and height. The result is promising and could improve the accuracy of locating license plate letter within the given input as high as 90%. Moreover, as describe at the later part of the manuscript, an ideal size of the input image to the algorithm is yet to be identified. Future work would need to quantify what could be proposed as the reasonable input size, to minimize the missing information as a result of a “too” small image’s segment. Another input irregularity could come in a form of tilted image. Several approaches have been proposed and tested previously. However to the particular algorithm this approach are yet to be proven. Future work needs to identify and solve the tilted image segment problem and combine it with the current approach in order to increase the accuracy of license plate localization method.

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