Vehicle License Plate Detection in Images

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Abstract— **Frequently, there is a need to identify vehicle license plates (VLP) in images taken from a camera that is far away from the vehicle for security. The extracted information from vehicle license plates is used for enforcement, access-control, and flow management, e.g. to keep a time record for automatic payment calculations or to fight against crime. That's make license plates detection crucial and inevitable in the vehicle license plate recognition system. This paper aims to present a new robust method to detect and localize license plates in images. Especially we focus on the Moroccan's VLP. The proposed approach is based on edge features and characteristics of license plate's characters.**

Various images including Moroccan's VLP taken from different distances and under different angles were used to evaluate the proposed method. The experimental results show that our system can efficiently detect and localize the Moroccan's VLP in the images. Indeed, the recall/precision curve of the proposed method proves that 95% precision rate is obtained for recall rate value equals to 81%. In addition, the standard measure of quality is equal to 87.44 %.

Keywords-component; license plate; VLP detection; VLP locatization; image text detecion.

I. INTRODUCTION

The license plate detection is considered as an important research topic of vehicle license plates (VLP) recognition system; it is widely used in many applications such as detection of speeding cars, security control in restricted areas, unattended parking zone, traffic law enforcement and electronic toll collection. Last few years have seen a continued increase in the need for and use of VLP recognition. Thus, many vehicle plate recognition systems are developed by researchers [1-5]. Nonetheless, robust detection of different types of license plates in varying poses, changing lighting conditions and corrupting image noise without using an external illumination source, still present the challenges of the existing VLP recognition systems.

The numerous proposed VLP detection systems are based on different properties. Some techniques use simple rules based on deterministic methods while others employ elegant training based classifiers.

For example, a support vector machine (SVM) is used in [6] to analyze the color textural properties of VLPs. The color values of the raw pixels that make up the color textural pattern are fed directly to the SVM, which works well even in high-dimensional spaces. Next, LP regions are identified by applying a continuously adaptive mean shift algorithm (CAMShift) to the results of the color texture analysis. In [7] mean shift is used to filter and segment a color vehicle image in order to get candidate regions. These candidate regions are then analyzed and classified in order to decide whether a candidate region contains a license plate or none.

Another approach uses gray level morphology [8]. This approach focuses on local appearance properties of license plate regions such as brightness, symmetry, and orientation. Candidate regions are compared with a given license plate image based on the similarity of these properties. Alternatively, Wu et al [9] combine morphological operations and a projection searching algorithm for vehicles in Macao. The projection searching algorithm is used to detect region of the characters in the license plate through vertical and horizontal projections. The license plate styles found on vehicles in Macao are very much similar to the ones found in Malaysia and this can be a solid reference.

Kim et al proposed in [10], a method based on edge extraction for license plate localization in images taken in poor lighting conditions. Their method is composed of two steps: The first step involves the search of candidate regions from the input image using gradient information while the second step determines the plate area among candidates and adjusts the boundary of the area by introducing a plate template.

In this paper we present an effective algorithm for vehicle license plates detection and localization based on edge features and characteristics of license plate's characters. It starts by detecting all edges in the VLP image. The rational behind this is that we propose to preserve the most important structural features of that image by finding sharp contrasts and reducing the amount of data in the image. Because characters are represented by a closed contour we select all closed contours from detected edges. Once the candidate text regions are selected they may include non-text objects. Thus, each detected region must be verified in order to reduce false alarms and to

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generate valid text regions. In this aim, we propose to use some simple rules which are based the components geometry and vicinity. Although our proposed approach is a generic VLP recognition one, in this paper we propose to deal with vehicle licenses in Morocco.

The remain of this paper is organized as follows: Sections II gives the properties of the vehicle licenses in Morocco while section III details our new proposed approach. Then, experimental results are presented in section IV. Finally, conclusions are drawn in section V.

II. CHARACTERISTICS OF CHARACTERS

There are some basic regulations for vehicle licenses in Morocco.

- The license can be rectangle or square.
- Moroccan license plate is a device for identifying vehicles registered in Morocco. The plate is composed of five digits (1-99 999) designating the number of vehicle registration, a letter of the arabic alphabet in the middle incremented relative to the registration number and the identifier (ID) of the prefecture emission of the plate (from 1 to 72).
- The style of characters varies from license to other.
- The distance between characters is not standard; it depends on the constructor of the license plate.

III. THE PROPOSED ALGORITHM

The proposed algorithm is mainly based on the following properties of characters:

- The pixels presenting VLP's characters contour usually have a height contrast to their neighbor pixels.
- Contours of characters are always closed.
- There is a relationship between characters.

In addition, it is composed of four processes that are:

- Edge Detection;
- Selection of the candidate characters of a VLP;
- Character extraction;
- And vehicle license plate localization.

In the next, we detail the different steps of our proposed algorithm.

A. Edge Detection

'Weak edges' is a characteristic of character regions; this property can be used to find possible character regions. Supposing that text is present in complex background where the grey-level edge may be quite weak, we have to use an edge detection technique to detect it. Many edge detectors exist in the literature but the choice of the best relevant one is an important task. In this work, we choose to use the canny edge detector [11] that is considered to be the ideal edge detection algorithm for images.

Fig. 1 illustrates some results obtained by using the edge detection algorithm. The first column presents the inputs of the algorithm that are color images, while the second column gives its outputs. Thanks to the canny detector, we notice that the different edges are well determined on the output images that are binary edge ones. Especially, the characters contained on the images are included in the selected edges.

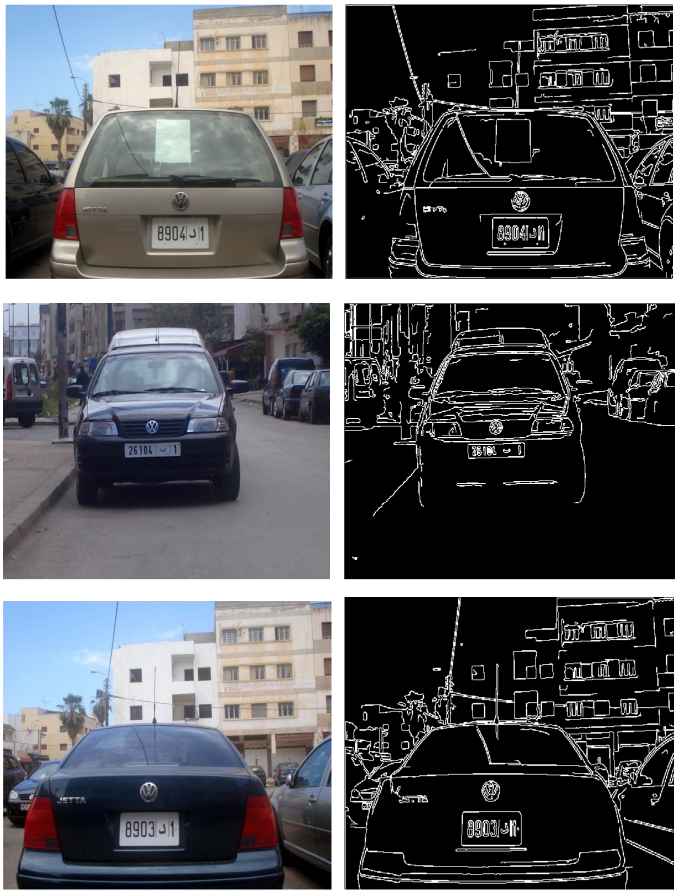

Figure1. Some inputs (color images) and outputs of the edge detection algorithm.

The next step is to select the VLP's character regions from the different edges contained in a result image of the edge detection process.

B. Selection of the Candidate Characters of a VLP

We capitalize on the fact that a text area is always a closed contour. Because all characters are represented by a closed contour, we have to select all closed contours present in the binary edge image.

To select closed contour we analyze each connected component in the edge image. We define a closed contour as a contour in which the starting point is the ending one.

Fig. 2 illustrates some results obtained by selecting closed contours from some edge images.

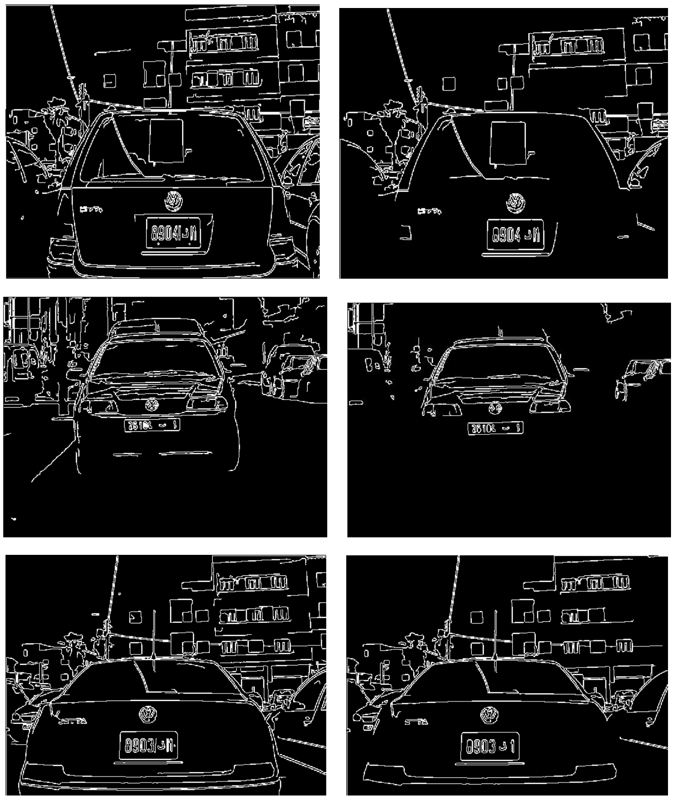

Figure2. Some results of the selection of closed contours.
The left column represents some inputs while the right one gives the outputs.

Once the closed contours are determined they may include non-text objects that have closed contours. Thus we have to discriminate character and non-character regions.

In the next stage we describe another characteristic of the VLP's character regions in order to eliminate non-character regions.

C. Character Extraction

In this step of the proposed algorithm, we propose to use some rules to discriminate VLP's character regions from non-character ones. The proposed rules are based on geometry and vicinity components.

A given component i is considered as a VLP's character if it meets the following rules:

$$0.1 \leq \frac{W_i}{H_i} \leq 2 \quad (1)$$

$$50 \leq W_i \times H_i . \quad (2)$$

Where Wi and Hi are respectively the width and the height of the possible character region labeled i.

In addition, he/she can consider the geometric spatial relationship of components. Thus, given two neighboring regions $(xi; yi; Wi; Hi)$ and $(xj; yj; Wj; Hj)$, the vicinity based rules can be written as:

$$\text{dist(xi, xj)} \leq 0.2\text{max(Hi, Hj)} \quad (3)$$

$$\text{dist(yi, yj)} \leq 50 \quad (4)$$

$$0.5 \leq \frac{Hi}{Hj} \leq 2 \quad (5)$$

Where $dist(xi, xj)$ is the distance between the coordinates of the object gravity center of the region labeled i (resp. j).

The rule given in (3) affirms that components are neighbors in horizontal direction while the rule given in (4) ensures that the considered components belong to the same text line [12], and the rule presented by (5) specifies that they have similar heights.

Moroccan's VLP is composed by numbers and one Arabic character; these characters are characterized by a special characteristic. Indeed, numbers and Arabic characters contour of a Moroccan's VLP contain one hole. Fig. 3 illustrates some examples.

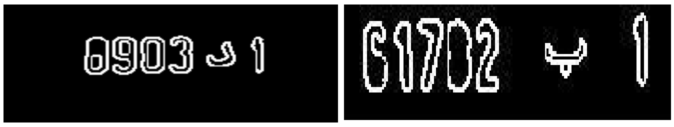

Figure3. Numbers and Arabic characters contour of a Moroccan's VLP.

Fig.4 gives some inputs and outputs of the character extraction process. The input images are the results of the algorithm second process that is the selection of the candidate characters of a VLP. About the output images, they are binary ones that represent the characters of VLPs.

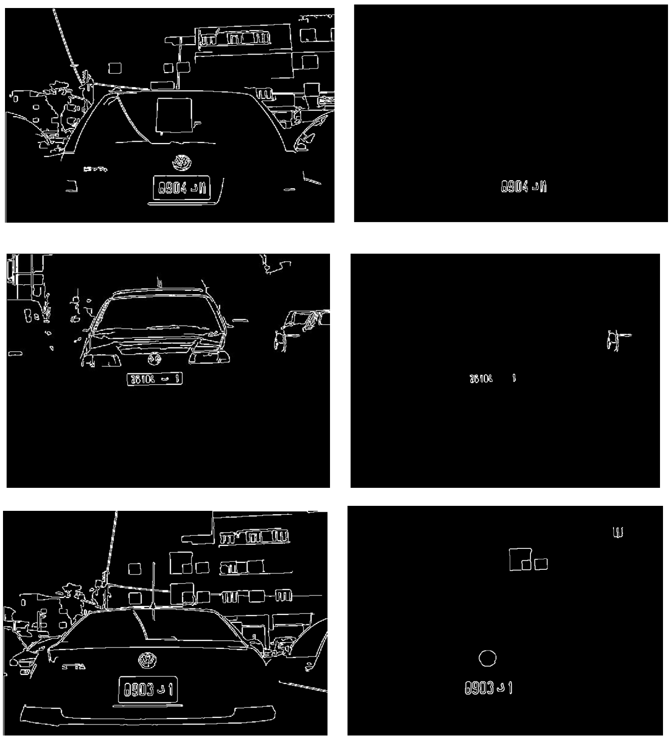

Figure4. Some input images (left column) and output ones (right column) of the character extraction process.

D. Vehicle License Plate Localisation

We assume that VLP characters consist of horizontally aligned line. In order to find subsets of regions which are aligned horizontally a grouping step is applied.

In our approach character's line is assumed to consist of more than three regions having small horizontal distances and large vertical overlap to each other.

Figure5. Some examples the VLP localization process.

The Fig. 5 shows some results obtained by tour proposed VLP detection and localization approach. The detected regions of interest are represented by their bounding boxes.

IV. EXPERIMENTAL RESULTS

A database of VLP images is performed to evaluate the VLP detection and localization algorithm presented in the previous sections.

In this section we first discus the criterions for evaluating the performance of the proposed algorithm. We then report experimental results of our proposed approach.

A. Evaluation criterions

The performance of the vehicle license plate detection and localization approach is measured in terms of region level. To this end, for quantitative comparison, two metrics: Recall and Precision are adopted to evaluate the performance of the proposed algorithm. The region recall rate *(RRR)* is defined as follows:

$$RRR = \frac{RR}{RT} \qquad (6)$$

Where *RR* denotes the total number of VLP regions that are estimated correctly by the algorithm and *RT* is defined as a total number of character regions in the ground truth.

The region precision rate *(RPR)* is defined by:

$$RPR = \frac{RR}{RE} \qquad (7)$$

Where *RE* is the total number of VLP regions that are claimed.

The highest value of recall (RRR) denotes the superior ability in detecting the relevant vehicle license plate region, while the highest value of precision (RPR) indicates the highest detection rate with correct plate regions.

In addition, precision and recall can be combined into a single standard measure of quality (f) given by (8). The relative weights of recall and precision are controlled by δ which we set to 0.5 in order to give equal weight to the two considered metrics RRR and RPR.

$$f = \frac{1}{\delta / RPR + (1-\delta) / RRR} \qquad (8)$$

B. Results of the algorithm

Experiments were carried out on database consisting of 100 images. This data set contains pictures took at the various lighting conditions i.e. in the sunshine or in the night. In these pictures there are many kinds of vehicles like trucks, off-road vehicles, sports cars and buses. Moreover, the database includes license plates in varying poses (pictures were taken from different distances and under different angles) and contained in complex background.

Fig.6 shows some examples of detected vehicle license plate on some images of our database. In fact, this figure presents the outputs of our global system dealing with the VLP detection and localization problem.

Figure 6. Some results of our VLP detection and localization process

From the images given fig.6, we can see that although the background is complex, the localization of the license plate is accurate and effective.

Fig.7 shows some examples of the false detection and localization of our algorithm. The false detections are caused by other existing captions in the image (in the left figure) and the mechanical plate damage (in the right figure).

Figure 7. Examples of Text detection errors

In the used database, our algorithm offers *81%* of recall rate *(RRR)* and *95 %* of precision rate (RPR).

Fig.8 shows the Recall/Precision curve of our method. This figure highlights that the new approach offers best precisions for all recall values.

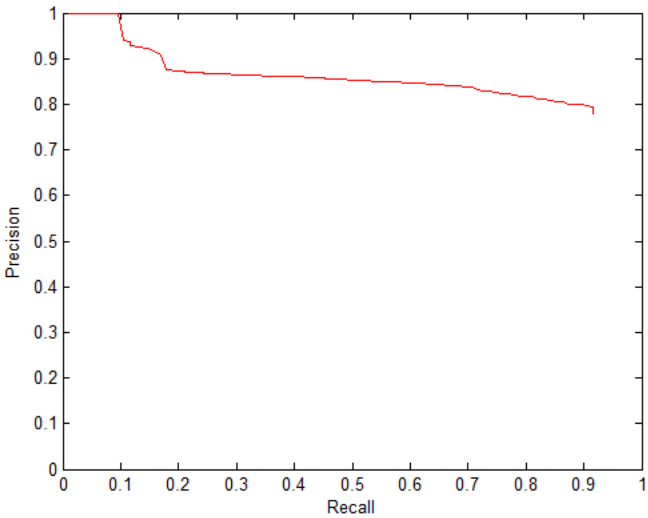

Figure 8. The Recall/Precision curve of our method

For the proposed approach, the value of f is equal to *87.44%.*

Thus in terms of qualitative and quantitative evaluations, we conclude that our approach is efficient and robust results.

V. CONCLUSION

In this paper, we presented a scheme for detecting and localizing vehicle license plate in images. The proposed approach is basically based on edge features and connected components analysis. In particular, we focused in the detection and the localization of the Moroccan's VLP. From results we can conclude that factors which may have a negative influence on the results of license plate identification method from photos can be divided into a few groups:

- weather conditions;
- lighting conditions;
- license plate placement in the picture;
- vehicle movement;
- mechanical plate damages;
- and other captions in the picture.

As an overview of the results of the previous sections, we can conclude that our system detects efficiently vehicle license plates in images. In particular, the precision and the recall rates are equal to *95%* and *81%* respectively. In addition, the standard measure of quality f is equal to *87.44%.* Consequently, the proposed method gives robust and effective performances.

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