# New Approach Based on Morphological Residues For License Plate Localization

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*Abstract:* - In this paper we present a new approach to segment license plates from a static image. The method uses mathematical morphology techniques, combining a fast granulometry algorithm and a morphological residue approach. The sets of attributes, and processing sequence are both detailed in this paper. All the preprocessing methods, necessary for solving the problem, are given here. The results present high quality and processing time and performance are efficient.

*Key Words:* - Mathematical morphology, fast granulometry, morphological residue approach, segmentation, license plates.

## 1 Introduction

Due to the increasing need to automation in the problem solving in several areas, and the image processing and analysis increasing use for this end, we seek a solution for the traffic control and vehicle identification problems based on the development of a new technique using only mathematical morphology for the vehicles' license plates localization in static images.

In Brazil, the National Board of Traffic (Contran) established eight different types of license plates, which has the function of distinguishing the different uses of the vehicles. The resolution number 46 is the most general, foreseeing different license plates types for particular vehicles (private or commercial), rent, experience (carriers), learning (driving schools), manufacturers (assemblers), diplomatic missions, collection and official vehicles.

This type diversity, with different color and numeration standards introduces a great number of variables to the license plate localization and recognition processes. This diversity occurs in few countries and most of the time with a smaller number of standards.

These topics motivated the elaboration of a module to process automatically digital photos of vehicles in gray levels, with the goal of segmenting the license plates digits of particular vehicles, which are the majority of the vehicles in use. Using to this the mathematical morphology, reconstruction, granulometry and mapping from morphologic residues techniques. This process is accomplished through several steps, among them we can cite: acquisition or digitalization, pre-processing and segmentation.

In this work, we consider specifically the pre-processing and segmentation steps aiming at the capacity of locating the content of the vehicle license plate through the utilization of mathematical morphology and reconstruction.

This study is to introduce a new license plate number segmentation approach based on mathematical morphology and granulometry. In section 2 the license plate segmentation state of the art will be introduced, section 3 will describe the granulometry and morphological residues approaches, in section 4 the image data base used in this work will be described, in section 5 the proposed segmentation methodology will be described. In section 6 the efficiency of this new license plate segmentation approach will be illustrated and in section 7 the conclusions and future work suggestions will be presented.

## 2 State of the Art

Though a vast number of publications on segmentation and recognition is found in the literature, paradoxically only a few articles on License Plate extraction and Recognition are found.

Among the techniques surveyed for this study, the following may be mentioned: Siav system [6], based on tonal variation, CLPR system [1], based on a study of region extraction specifically applied to the

problem of license plate locating, and in [2] a license plate character extraction approach based on Markov random fields and genetic algorithms is presented.

### 2.1 SIAV System

The Siav system [6] is based on standardized tonal variation through the positive gradient analysis in the license plate area, for the license plate localization.

The license plate localization algorithm can be divided into two procedures:

1) In the first procedure we have the license plate localization through the algorithms below:

- Search for standardized tonal variation through the analysis of the positive gradient in the area of the license plate;
- Local adaptative binarization on the found region or, if necessary, on the whole image.

In this step, we have as result the coordinates of the probable license plate localization. 2) In the second procedure there is the confirmation of the local through the analysis of the number of digits found:

- Search for digits of pre-defined sizes;
- Analysis of the selected digits verifying the formation of some valid group.

As the final result we have the confirmation of the correct place.

Once found the license plate, it is necessary to segment the characters in order to separate them of the rest of the image and resize them to the correct neural network input size. A controlled growth technique, within each entity found in the license plate area, and a set of heuristics to discard undesirable noises and select correctly the characters was used.

### 2.2 CLPR System

The CLPR system described in [1] is a region extraction study applied to the specific problem of vehicle license plate localization. This article introduces a vehicle identification system in Dutch public pathways. In Holland, there is only one license plate type, with bright background and dark characters. The system consists in four main units: a segmentation unit, an isolation unit, a recognition unit and a syntactic analysis unit.

The segmentation unit determines the localization of the license plate based on structural characteristics and some size measures. The extracted license plate is presented to the character isolator that will segment each character of the license plate. The character recognition unit processes the isolated characters. The syntactic analyzer checks each possible character returned by the recognition unit using a set of syntactic rules present in the Dutch license plates. If these rules aren't satisfied, or one of the characters is unrecognizable, the image is rejected.

The system error rates are:

- 5% with mistakes in the application of the characteristics of license plates;
- 6% of rejection of all the images during the segmentation/isolation step.

### 2.3 System using Markov's Random Fields and Genetic Algorithms

In [2] a study of region extraction applied to the specific problem of vehicle license plate localization is presented. In this article is presented an approach to extract, follow, and threshold the characters in moving vehicles license plates. The base hypothesis is that a vehicle license plate consists in dark characters in a bright background. The text region of a license plate is located using the texture information. A warping process is employed to correct the perspective of the license plate at the moment of the acquisition. The license plate localization problem is treated as text localization in images. The presented solution used a method of space variation to identify the text region. For each pixel in the region marked as text, the partial derivatives are computed using windows sized 5x5 pixels. For the license plate's characters binarization the temporal and regional information are used simultaneously structured as Markov's Random Fields (MRF). The process is optimized using Genetic Algorithms.

## 3 Morphological techniques used in this work

### 3.1 Dual reconstruction

Lets consider two gray level images, S and Z, defined at the same domain, taking the discrete values k ∈ [0, n], and respecting the order relation Z ≥ S. The dual reconstruction in gray levels (or reconstruction by geodetic erosion) can be defined as [3]:

$$\rho_s(Z) = \min_{n\geq 1}[\varepsilon_S^{nB_s}(Z)] = \min_{n\geq 1}\underbrace{\varepsilon_S^{B}(\ldots\varepsilon_S^{B}}_{n}(Z)) \qquad (1)$$

### 3.2 Gray level Linear Granulometry

Vincent has elaborated [7] a fast gray level granulometry method, which consists in analyzing the image lines counting the sizes of line, segments according to the gray levels as the following description. The algorithm result is a spectrum pattern that describes the line segments quantity of each size for all the gray levels of the image.

Considering the case of horizontal linear granulometry, with line segments $L_n$ and $n \geq 0$, where $L_n$ is a line of the image with n+1 pixels (the lines can be processed independently) where the granulometric information are contained in the of maximums of each line. Being $M = \{p_0, p_1, ...., p_{n-1}\}$ a maximum of the line L, with altitude L(M) = h:

- any opening accomplished in L for $L_k$ with k<n lets M unaffected;
- accomplishing the opening of L for $L_n$ results in all the pixels of M to value as the neighborhood of M with the highest value, as Figure 1;
- the contribution of this maximum to the nth element of the pattern spectrum is $n \times (h - h')$.

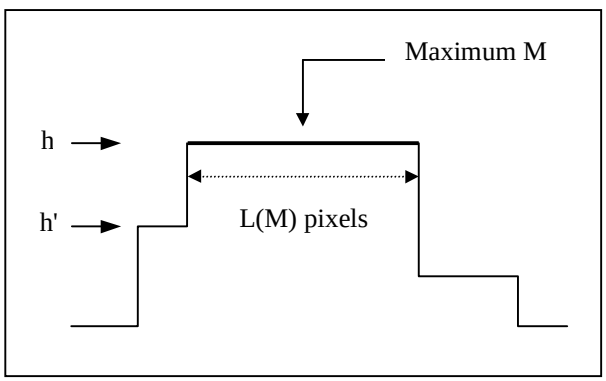


Fig. 1 – Maximum region association

### 3.3 Morphological residues

The morphological residue characterizes the information extracted of an image starting from a series of granulometric transformations. This residue is given by the difference of two consecutive granulometric levels.

Lets consider $T^{(\lambda)}(f)$ a granulometric transformation, the morphological residue $R_\lambda$, of residual level λ associated with size parameters λ, is defined as the difference among results of two consecutive granulometric levels. In other words:

$$\forall \lambda \geq 1, f \in R^N, R_\lambda(f) = T^{(\lambda-1)}(f) - T^{(\lambda)}(f) \qquad (2)$$

which defines the morphological residue for gray levels images, and it represents the preserved components in level (λ-1) which were eliminated in the granulometric level λ [4].

### 3.4 Morphological residues mapping

Lets consider $(\phi R_\lambda)_{\lambda \geq 1}$ a family of binarized morphological residues. For all p ∈ S, being S an image and p a pixel in this image, we define a mapping constituted of information concerning the size argument $\lambda \in N$, associated to each residual level λ.

$$M_\lambda(p) = \begin{cases} 1 & se \quad \phi_{R_\lambda}(p) = 1 \\ 0 & se \quad \phi_{R_\lambda}(p) = 0 \end{cases} \qquad (3)$$

From this information, we can consider the size information associated to the different levels in which the pixels of the image are erased (change from 1 to 0) [4].

**Pixel disappearance definition:** The mapping of a pixel is represented by consecutive changes of the state 1 to the state 0 in the mapping M, representing the instant in which pixels does not belong to the morphological residue.

Associated to this disappearance information, we can do two possible considerations: one about the occurrence order, η, of these disappearances, and another, about the number of occurrence, ρ, of these disappearances. The first is related to the different instants in which a pixel disappears in the different residual levels, and the second with the number of transitions. Usually the number of disappearances can be associate to the irregularity (complexity) of the structures present in the image.

## 4 Database

The image database used in this work relies on 180 colored images. The images in this database were classified as follows: 33% are images of the vehicle's front and 67% are images of the vehicle's rear, 2% are pictures taken with an angle superior to 30 degrees considering the vehicle's center.

These images have the following characteristics:

- colored (RGB);
- 640x480 pixels;
- front and rear pictures of the vehicles (in some cases with two or more samples with different angles of the same vehicle);
- homogeneous and heterogeneous light distribution on the license plate surface;

- distance variation from the camera to the vehicle: 2,0m – 3,5m.

## 5 New license plate localization and segmentation method

The segmentation method proposed in this work is constituted of four steps, arranged into three groups, as follows.

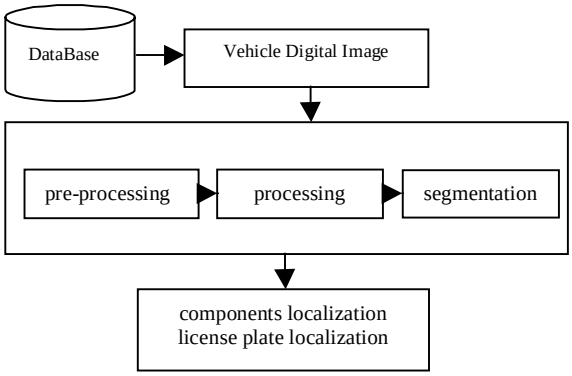


Fig. 2 – License plate localization stages

The pre-processing step is constituted by the colored images conversion to gray levels, tophat and the image's complexity reduction; gray level granulometry and the dual reconstruction form the process; and segmentation embodies the components localization and components filtration.

**Step 1**

After the image conversion to gray levels, the image is processed using tophat to enhance the image's valleys, facilitating thus the vehicle's license plate letters demarcation with granulometry, which will be applied in the next step. Tophat was applied with 3 iterations using the square-structuring element. The complexity reduction of the image was necessary to reduce the granulometry processing time. Therefore, the image's regions were homogenized, decreasing the number of small elements and accelerating granulometry process. The complexity reduction process was accomplished dividing the gray level of each pixel of the image by a complexity reduction factor (64).

**Step 2**

In the processing phase, the gray level granulometry was used to obtain the markers for the license plate characters. The granulometry process is a composition of the algorithms introduced by Vincent [7] and Guimarães [4]. The results of Vincent's algorithm are used as markers in Guimarães' algorithm.

The granulometry algorithm introduced by Vincent is used to obtain a profile of the horizontal sizes of the image's objects. This profile is used in place of the morphological residues in the mapping algorithm described by Guimarães and thus obtaining the image with the markers of the vehicle's license plate characters.

Using this image, and as the mask, the image resulting from the complexity elimination process, the dual reconstruction process is applied [3]. Thus, the result of this reconstruction should contain the characters that constitute the license plate of the vehicle.

**Step 3**

For the image's components localization, which are the result of the reconstruction process, that will indicate the position of the vehicle's license plate in the image, the process described below was adopted:

- Gray level distribution histogram calculation;
- determination of the image's background gray level, region with the biggest number of pixels;
- search for pixels groups whose gray level intensity is larger then that of the background region;
- Position information for each pixel group is annotated.

The result obtained in the components localization usually introduces an elevated number of undesirable elements. These components are present because they have size and color characteristics similar to those of the license plate's characters. Therefore some rules were determined to reduce the number of components in the image. These rules are listed below:

1. components that are located in the border of the image are eliminated;
2. components which one of its dimensions, height or width, are greater than to other are eliminated (85% of difference);
3. components whose dimensions are above 85% of the size average of all the image's elements are eliminated;
4. components whose dimensions are below 35% of the size average of all the image's elements are eliminated;
5. components that meet itself aligned with less than three elements in the horizontal direction are eliminated, because it is considered that at least 3 characters of the license plate will be found;
6. components whose region number of pixels not belonging to image background are above 85% or below 35% are eliminated.

The application of these rules in the component set results in maintaining of the components that are located in the region of the vehicle's license plate.

**Step 4**

After the components filtration was accomplished the following process was applied to determinate the license plate localization:

1. determination of the threshold of each one of the image components using Otsu's algorithm [5];
2. determination of the gray level of larger incidence in the image background for each one of the components
3. the search of this gray level is accomplished in the pixels whose gray levels are of smaller intensity than that of the resultant threshold obtained from Otsu's algorithm;
4. calculation of the average of the values of the gray levels of larger incidence in each one of the components found in the step 2;
5. determination of the region defined by gray levels larger or equal to the average found in step 3.

The region obtained with this process contains the vehicle license plate, as shown in Fig. 3.


Fig. 3 - Localization of a license plate

## 6 Experiments and results analysis

The obtained results aloud to demonstrate some interesting features of the proposed method.

The granulometry and morphological residues method was efficient on the following cases:

- incorrect positioning of the license plates - In the cases which the license plate isn't correctly fastened or positioned, the localization result didn't suffer interference;
- brightness factor - In situations that the license plate is in the shade projected by the vehicle, in sunny days, so the license plate isn't highlighted regarding the vehicle;
- skewed images - The method works with a great variability of the camera positioning regarding the vehicle (figure 4).
- images with more than one vehicle - When the vehicles are in an appropriated distance, the license plates of these are both correctly located independently (figure 5);
- vehicles with stickers - When there are stickers on the vehicle's painting, the process isn't influenced if the pattern of these stickers don't correspond to the pattern of the license plate characters;

Fig. 4 – Skewed image

Fig. 5 - Image with two vehicles

The results obtained with the application of the proposed method in this work were considered as satisfactory considering the different situations of the

analyzed images, the complexity of these images and the non utilization of classical algorithms for this complexity level problem

The results obtained in the experiments were:

- 75% of hit in the license plates;
- 81% of hit in the characters segmentation.

The processing time was 28 seconds in a Pentium processor II, 350 MHz, microcomputer with 128 MB of RAM.

## 7. Conclusions and future work

A new approach of License Plate Extraction based on the use of Morphological Granulometry and Residues was proposed and tested from a real database. We remember the fact that this method initiate the segmentation process searching for the license plate characters, in the whole image, and not in a pre selected region as other similar systems.

The proposed approach proved to be efficient in terms of different illumination conditions, positioning and distortion and the processing time for the method, that is independent of the image complexity.

The versatility of the method regarding the illumination several terms, positioning and distance from camera is its best. However, the method still gives a reasonable result, considering the feature of initiating the segmentation process seeking the characters of the license plate in the complete scene image, and not in a selected region as in other similar systems. Beyond this characteristic, also should be pointed out the good performance regarding the processing time of this method, 28 seconds per image.

The main results of work embody a vehicle license plate segmentation methodology in images in shades of gray using granulometry. This segmentation process is tolerant to angle variations in the vehicle positioning, and also is tolerant to the illumination conditions. The proposed process introduces a good performance regarding processing time, independent form the image complexity.

In the future, this morphological approach is intended to be tested with faster algorithms and fewer heuristic parameters in the several processes combined in this work.

*References:*


[1] Brugge, M. H. T., Nijhuis J. A. G., Spaanenburg L., Sdevens J. H., License Plate Recognition, Kowledge-Based Intelligent Techniques in Character Recognition, Edited by Lakhmi C. Jain and Beatrice Lazzerini, pp 263-295, 1999

[2] Cui, Y., Huang, Q.; Automatic License Extration from Moving Vehicles. Siemens Corporate Research, Inc, ICIP´97

[3] Facon, Jacques; Morfologia Matemática: Teoria e Exemplos. Curitiba, Brasil, 1996

[4] Guimarães, Silvio J. F.; Filtragem de imagens a partir da sua decomposição em resíduos morfológicos. Dissertação de Mestrado, Universidade Estadual de Campinas, 1999

[5] Otsu N., A Threshold Selection Method from Gray-Level Histograms, IEEE Trans. Sys. Man and Cybernnetics, v. SMC9, nº1, pp. 62-66, 1979

[6] Souza, F. P. C.; Susin, A. A.; Sistema de identificação automática de veículos. www.iee.ufrgs.br/iee/siav.htm