A Multi-style License Plate Recognition System based on Tree of Shapes for Character Segmentation

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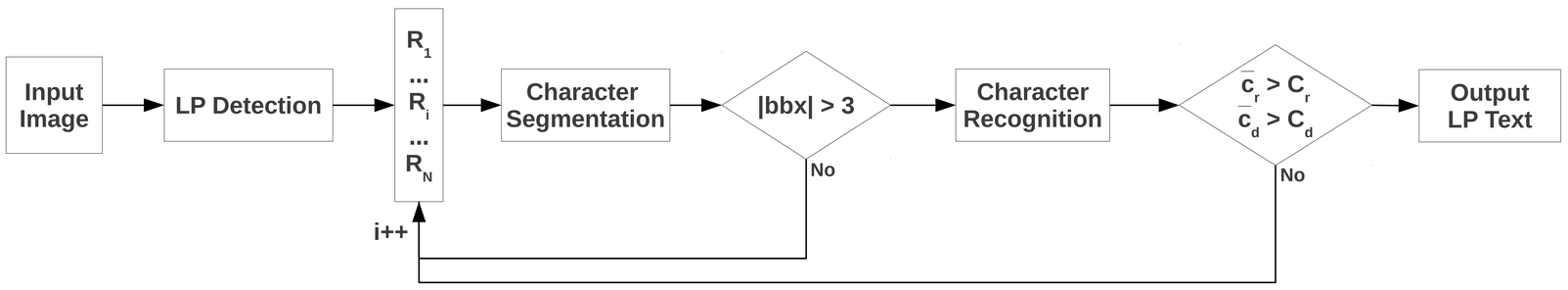
Introduction

In this work we develop a novel license plate recognition (LPR) system for multi-style license plates on still images, adaptable to different countries. The system was tested on two datasets obtaining high performance rates.

Contribution

A new character extraction method is proposed based on the tree of shapes of an image. This method is well adapted to work under different license plate styles, does not require rotation or skew correction and is parameterless. Also, it has invariance under changes in scale, contrast, or affine changes in illumination.

License Plate Recognition System Diagram



We implement the LPR system in three steps:

1. **License Plate Detection:** *i)* RoI generation using morph. filters *ii)* Sorting by LP candidate.
2. **Character Segmentation:** processing the Tree of Shapes searching for groups of characters.
3. **Character Recognition:** using a Support Vector Machine and a validation step.

If the analysis fails in the character segmentation or recognition steps, the second most probable region will be evaluated, and so on, until the R_N region is reached.

1. License Plate Detection

The initial task of any LPR system is to find the location of the license plate (LP) in the image. Thus, our LP detection process starts generating several regions of interest (RoI) using morphological filters. To validate the RoIs $R_i, i = 1, \ldots, N$ and choose the most probable LP region, more exhaustive analyses are applied to give a score to each region using template matching and feature extraction. Finally, the RoIs are sorted by its score.

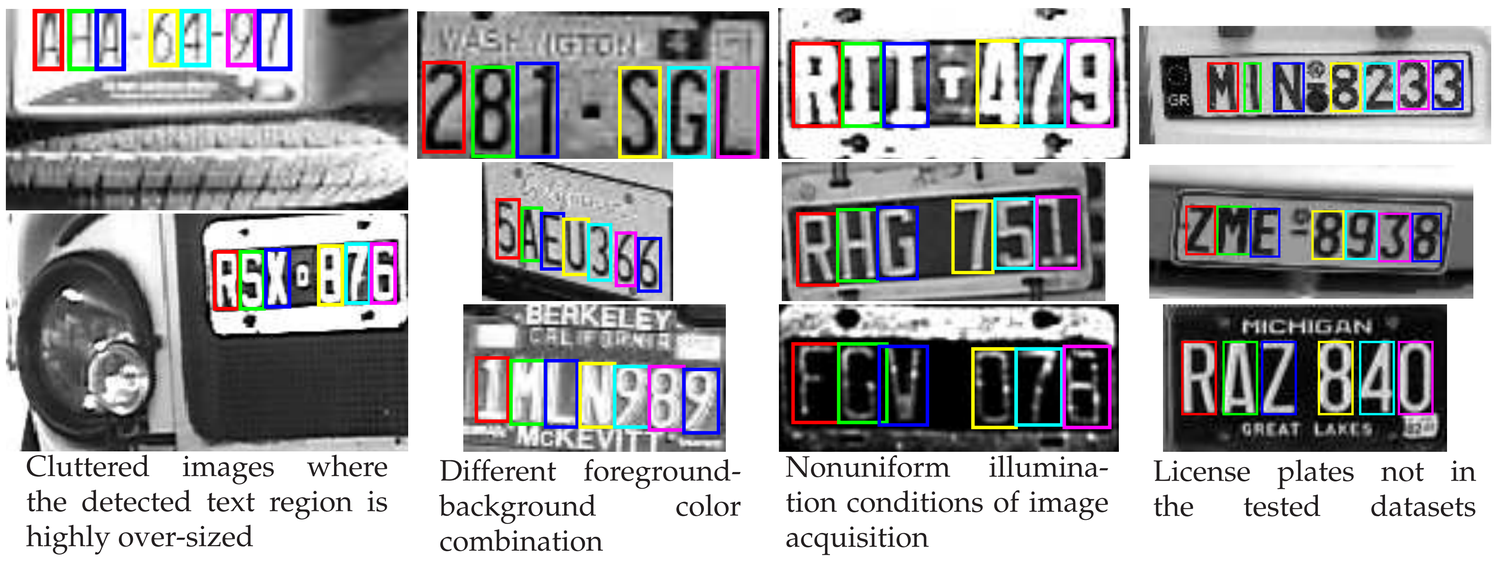
3. Character Recognition

Recognition: A Support Vector Machine (SVM) based classifier is trained using the Histogram of Gradient (HoG) as features. The strategy for the classification is the *One Against All* approach.

Validation: Two confidence values are estimated from the SVM classifiers outputs: c_r and c_d, that indicate classifier performance and discriminability, resp. Then, each mean value of these results, $\bar{c_r}$ and $\bar{c_d}$, is tested against C_d or C_r resp. of the training dataset.

2. Character Segmentation

To extract the characters in the LP we propose a new method called *char grouping algorithm* (CGA), which processes the tree of shapes of an image [2] to search for groups of characters.
The nodes in the tree of shapes are consistent with what we expect to be "objects" in the image. For instance, a **character** in an image will be represented by a **shape** (or a set of shapes) in the tree. The goal of this procedure is to state properties shared by every LP with no restrictions on the style of the plate. Segmentation examples below:



Cluttered images where the detected text region is highly over-sized

Different foreground-background color combination

Nonuniform illumination conditions of image acquisition

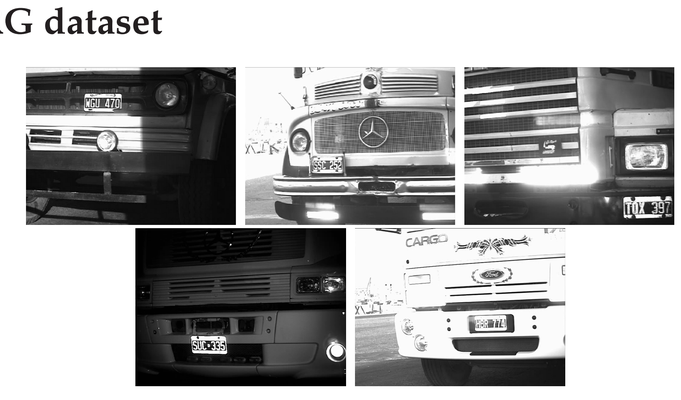
License plates not in the tested datasets

The character segmentation step validates its result if it has encountered more than three bounding boxes. The returned bounding boxes are used as an input to the character recognition step.

Results

We tested our LPR system performance on two datasets: *i)* The USA dataset is composed of 158 images tagged as non-deteriorated from the UCSD/Calit2 database *ii)* The ARG datase is composed of 439 truck images from Argentina.
Additionally, we assess our system using Maximally Stable Extremal Regions (MSER) [1] in the segmentation step. MSER+ detects bright regions with darker boundary, and MSER- detects dark regions with brighter boundary.

ARG dataset



	Det	Seg	Rec
CGA	97.27	98.17	95.08
MSER+	97.04	95.54	92.18

USA dataset

	Det	Seg	Rec
CGA	90.51	93.76	92.45
MSER-	89.12	90.47	89.27

Conclusions

As we can see, the *char-grouping algorithm* has no need of rotation or skew correction, it is style independent and furthermore it is parameterless. Also, it works under changes in the scale of the license plate and under changes in contrast or illumination conditions. These properties are achieved without constraints on the style of license plate or a priori information and are derived by the properties of the tree of shapes [2]. The quantitative and qualitative results shown support the mentioned properties. Further work has to be done to study the adaptation of the detection thresholds without any a priori information. Also, we think that adding features to the nodes of the tree of shapes, like pixel distribution inside a bounding box, will enhance the comparison. Moreover, the need to extend the system to handle two-row LP is an important task to tackle in further studies.

References

[1] J. Matas, O. Chum, U. Martin, and T. Pajdla. Robust wide baseline stereo from maximally stable extremal regions. In *BMVC*, volume 1, pages 384–393, 2002.

[2] Pascal Monasse. *Morphological representation of digital images and application to registration*. PhD thesis, Université Paris IX-Dauphine, June 2000.