# License Plate Digit Recognition using 7x5 Binary Templates at an Outdoor Parking Lot entrance

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## Abstract

*Digit recognition for license plate recognition is a core process, simplicity on the algorithm to recognize digits on the LPR context is of importance, given that there is an ever increasing vehicle flow and need for recognizing license plates on different environments and applications such as*: *unattended parking lots, automatic toll collection, traffic supervision, access control of restricted office and housing areas*.

*This work uses digit templates as the means to recognize digits. These are 7x5 templates used to compare with binarized license plate digits and selecting one with the smallest difference. Uses image width of the segmented digit as a feature to a perfect recognition of digit '1'. A segmented digit is reduced to a multi-valued 7x5 matrix, then binarized and compared to select one.*

*841 segmented digits form the license plates are the test set. Test images were taken at the entrance of an outdoor parking lot. Results show a 97.3% correct recognition on a real outdoor environment*.

## 1. Introduction

License Plate Recognition (LPR) is an image processing application area; that, locates license plate, segments alphanumeric characters on the plate, and recognizes these characters. Automatic license plate recognition plays an important role on numerous applications, such as: unattended parking lots, automatic toll collection, access control of restricted office and housing areas [1] [2] [3].

This work uses images at an outdoor entrance of a parking lot. For images taken at the parking lot entrance, license plates have different sizes, orientations and positions. These variations are due to different car positions at the entrance and distance for the camera to the vehicle.

Previously used methods to recognize characters are: Neural Networks [4], Support Vector Machines, dynamic projection warping, fuzzy logic, pattern matching [5] [6] [7] [8].

This work uses template based pattern matching for license plate digit recognition.

The following sections describe algorithm, testing, and results from images taken on a real environment at an outdoor public parking entrance.

## 2. Algorithm

This work starts from a segmented and binarized numeric digit of a license plate, which was obtained at the entrance of a public parking lot on an outdoor environment, a sample image is presented on Figure 1, license plate extraction, its binary version and digit segmentation.


**Figure 1. Sample image set, from car to digit**

On [9] use 25 features on a 5x5 block divided image for each character pattern. Here a 7x5 digit template is used to compare with the segmented digit. Work [10] uses distance on digit features to recognize them. This algorithm starts from a binarized segmented digit of a license plate, first it is reduced to a 7x5 binary matrix; next this reduced matrix is compared to a set of templates, generating its differences by using 'xor' and counting the number of differing cells. This give a similarity index that is later used to select one with the smallest distance, all this is shown on Figure 2.


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Using image width of the segmented digit as a feature, it is possible to recognize digit '1' by its smallest width; thus the template set uses {0, 2, 3, 4, 5, 6, 7, 8, 9} as the remaining digits to compare with.

Reducing a segmented digit to a 7x5 four level gray scale, uses an r by c window of the segmented digit for each cell of the 7x5 reduced digit. Conversion of the r by c window to a one of four values, (background, quasi-background, quasi-foreground, foreground), uses percentage of black and white pixels. An example of this conversion is shown on Figure 3.

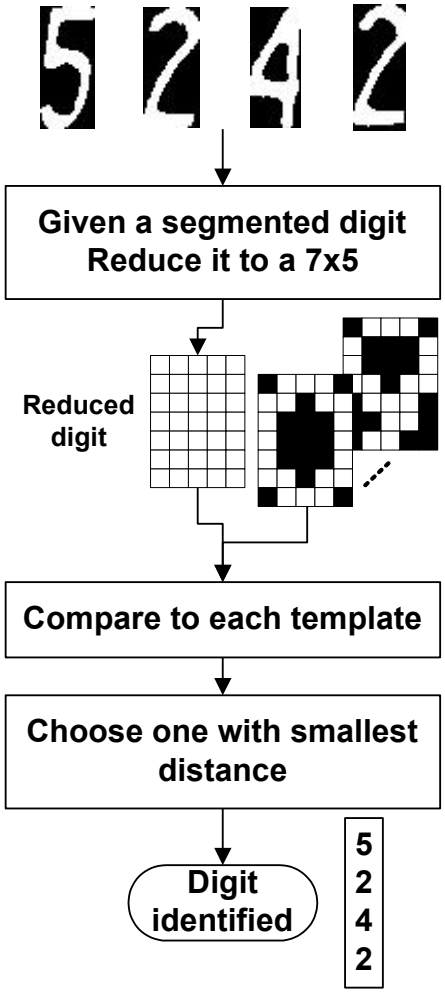


**Figure 2. Digit recognition algorithm**

Prior to choose a digit with smallest distance, the reduced digit is binarized considering that the digit should have a minimum of foreground elements, the conversion is:

if # foreground elements < minimum
    Make quasi-foreground as foreground

if # foreground elements < minimum
    Make quasi-background as foreground

In general the first option is equivalent to transform (background, quasi-background) as '0' and (quasi-foreground, foreground) as '1'. Once binarized the reduced digit, a distance is computed by using 'xor' and adding the number of cells that differ from a given template. The difference for templates {0,2,3,4,5,6,7,8,9}, by choosing one of the smallest distance, the digit is recognized.

On the following section a MATLAB implementation of the algorithm is presented. Later a test and results section will deal with the experimental setup and results obtained.

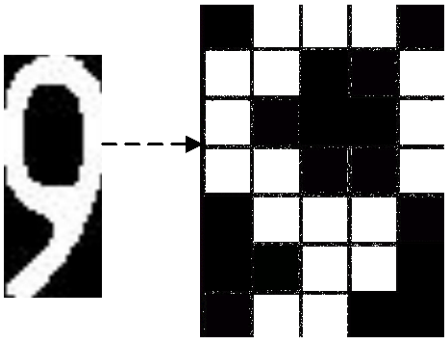

**Figure 3. Reduced digit**

## 3. MATLAB implementation

Software based tools are good for quick development and test cycles. Here we used MATLAB for implementation and imaging facilities. Input images are on JPG format on a distinct folder to ease multi-file runs. An appropriate folder and file structure is used to generate results on an MS-EXCEL file to resume results.

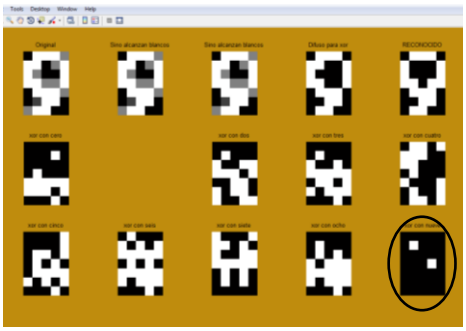

**Figure 4. Digit and its template differences**


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Coding on 'M' language is straight forward, using matrix and image handling facilities. To save results of the processing test set, a digit by digit information of the source and processing images are stored on an excel file, including the recognized digit; as well as the manual capture of the correct value.

With the purpose to evaluate intermediate results, which was helpful while developing the algorithm, on Figure 4 we can see a sample of the 'xor' resulting images for each template of a sample reduced digit. The operation with minimum difference to a template is shown with an oval mark.

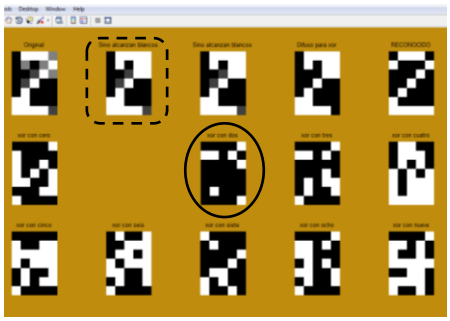

**Figure 5. Minimum of whites on segmented digit**

Figure 5 shows with a dashed rectangle a case when the reduced digit (top left) does not have the minimum of foreground elements and its quasi-foreground elements are taken as foreground, resulting on the binarized digit shown with the dashed rectangle. An oval marks the template with minimum difference to the binarized digit, and on the top right the template of the recognized digit is displayed.

On the following section describes tests runs that were performed and their results.

## 4. Tests and Results

Two sets of photos were taken at the entrance of the public parking lot of the National Institute of Astrophysics, Optics and Electronics. For some vehicles more than one photo was taken so that we could have images at different distances. No special care was taken on the position of the cars while getting into the entrance. From the set of license plate images, 841 segmented digits from 212 license plates are the test set. Twenty three digits were incorrectly identified, of these, thirteen with multiple options for selection. With a 97.3% of correct recognition of digits on a real outdoor environment, together with its simplicity are very promising to continue developing of a complete system.


**Figure 6. License plate images' resolution range**

Resolution range of license plate images go from 56 x 109 up to 272 x574 pixels and are shown on Figure 6. This image lets you see the proportion on the license plate images that were taken and recognized.

## 5. Conclusions

A new 7x5 pattern template based algorithm to recognize license plate digits was presented. Its simplicity and efficiency of 97.3% correct recognition on a real outdoor environment. These results are promising for a further, and more extensive implementation and test. The use of geometric (width) features for the recognition of digit '1' was perfect on this test set.

Transforming a binarized digit into a 7x5 reduced digit showed tolerance to some license plate tilting.

An analysis on the failure cases shows that some post-processing on cases with more than one smallest distance on the template comparison will be needed.

## 6. References


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