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DESIGN AND IMPLEMENTATION OF A SYSTEM FOR RECORDING AND REMOTE MONITORING OF A PARKING USING COMPUTER VISION AND IP SURVEILLANCE SYSTEMS

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ABSTRACT

This article presents the design and implementation of a system for detection of license plates for a public parking located at the municipality of Altamira at the state of Huila in Colombia. The system includes also, a module of surveillance cameras for remote monitoring. The detection system consists of three steps: the first step consists in locating and cutting the vehicle license plate from an image taken by an IP camera. The second step is an optical character recognition (OCR), responsible for identifying alphanumeric characters included in the license plate obtained in the first step. And the third step consists in the date and time register operation for the vehicles entry and exit. This data base stores also the license plate number, information about the contract between parking and vehicle owner and billing.

Keywords: image processing, vision, monitoring, surveillance, OCR.

1. INTRODUCTION

In recent years the automatic recognition plates numbers technology -ANPR- (Automatic Number Plate Recognition) has had a great development in congestion control systems in cities like London and Norway; as also in access control systems for parking in shopping centers, building, condominiums, vehicle verification systems installed on highway and patrols police, etc. (Soler, 2009). The ANPR systems are part of the field of computer vision; this field is also known as artificial vision and is itself a subfield of artificial intelligence. The purpose of computer vision is to program a computer to interpret a scene or features of an image. Several years ago people have attempted to give a concrete definition of this field. Some of the definitions given by renowned researchers in the field are:

- Science that develops theoretical fundamentals and algorithms to get information about the real world from one or more images (Haralick and Shapiro, 1992).
- Discipline that develops systems to interpret the content of natural scenes (Castleman, 1996).
- Science that has emerged as a discipline itself, based mainly in mathematics and computer science, which is to make a computer can see (Faugeras and Keriven, 2002).

Having an idea of what the ANPR systems are and knowing that field of science belong, it should be noted that the most important requirement for these systems is accuracy, and to ensure this, developers must create robust algorithms and use hardware of high performance, so the entities that need these systems must pay high costs.

The problem solved in this paper is a typical example where a solution of this type is required. It is required automatically record the entry and exit of vehicles in a parking and store them in digital way to gain control of the activity in the parking, minimizing errors that entail manual registration and storage of information in books accounting and papers.

This paper attempts to provide a reliable and economical solution, only through the use of free software (Open Source) to develop a complete system that meets all requirements. The work was carried out in 3 stages. The first and most important is the digital image processing, which consists of an algorithm that implements methods of segmentation, dilation and edge detection to carry out the identification, location and cropping a license plate within an image. This type of process in the field of digital image processing is known as the mid-level process (Garcia, 2008). In the second stage is the optical character recognition OCR (Optical Character Recognition), which consists of an algorithm based on neural, mathematical and logical methods, which is able to recognize patterns and identify the characters found within an image, in this case the license plates (Frydson and Gutierrez, 2011). It should be noted that this part of the system depends largely on the quality of images delivered by the first stage. As the third and final stage are the records in the databases. For the development of this system, completely worked in a OpenSource environment, using Ubuntu 12.10, Java platform and programming language, OpenCV as a library of image processing, Tesseract OCR as application of optical character recognition and MySQL as database server of data.

2. METHODOLOGY

The main objective of this work was to design a ANPR system (Automatic Number Plate Recognition) able to identify an incoming or outgoing vehicle on a parking, taking on a real-time image of the vehicle for processing and then to obtain the alphanumeric characters of the license plate to finally register them in a database along with the date and time of entry or exit. Another

objective was the installation of a surveillance system with access to the Internet. So then, the project was divided in stages which are presented below.

Design of the detection plates algorithm

To design the detection algorithm plates the first task was get a robust tool to facilitate the process. In this search a portable open source library written in C called OpenCV (OpenCV, 2013) was found. This library has more than 500 functions for image processing, in which there are many that were adjusted to the needs of the project.

Having defined the tool that it was going to work, we proceeded to detect and cut the license plate inside the image. Bearing in mind this objective algorithms and methods that make possible this process were investigated and found that the main methods for this are: segmentation, edge detection, geometric correction, and trim characters. To enable each of these stages, it was necessary to find parameters to optimize the results for which it was necessary to take samples and perform multiple tests.

Segmentation

Segmentation is the process in which a region of interest is labeled. In the labeling process all the pixels that make up a region of interest take the same value and the other image pixels take a different value (Rojas, 2008). This process can be carried out using the colors of the image; as it was done in this case where the region of interest in the image corresponded to pixels mainly yellow as shown in Figure-1.

To validate the segmentation results, it was performed a test with 187 images. The test consisted in

Figure-1. Input image color and segmented and binarized image.

visually identify the images resulting from segmentation and determining which were well segmented and which not, the results are shown in Table-1.

Table-1. Comparison between RGB and HSV segmentation.

Number of test images	**Number of images correctly segmented (**RGB**)**	**Number of images correctly segmented (**HSV**)**
187	61	187

Edge detection

The aim of this process is to detect closed loops within an image. These closed loops are formed by areas formed by pixels of the same color pixels enclosed by completely different colors. The boundaries of these areas form ties. When such bonds become close contours and these contours are found by edge detection methods. All pixels that form an area of interest are set to the same color that contrasts with the rest of the image, and this greatly facilitates the detection of contours as shown in Figure-2.

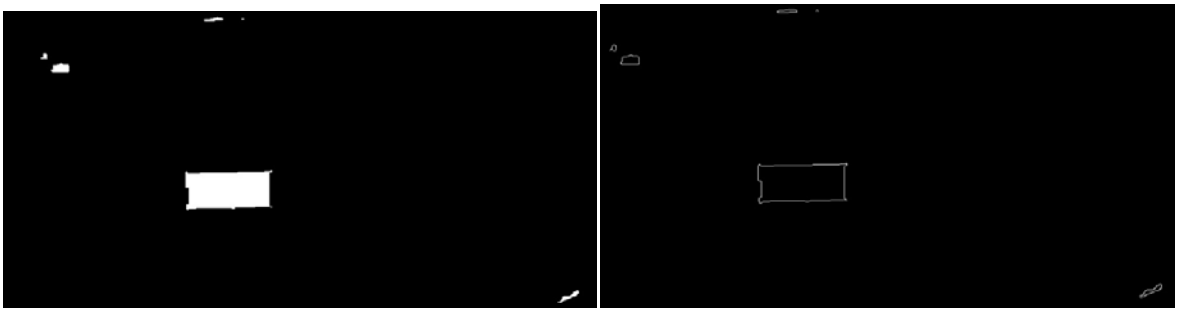


Figure-2. Input image color and segmented and binarized.

Table-1. Number of contours found without and with closing.

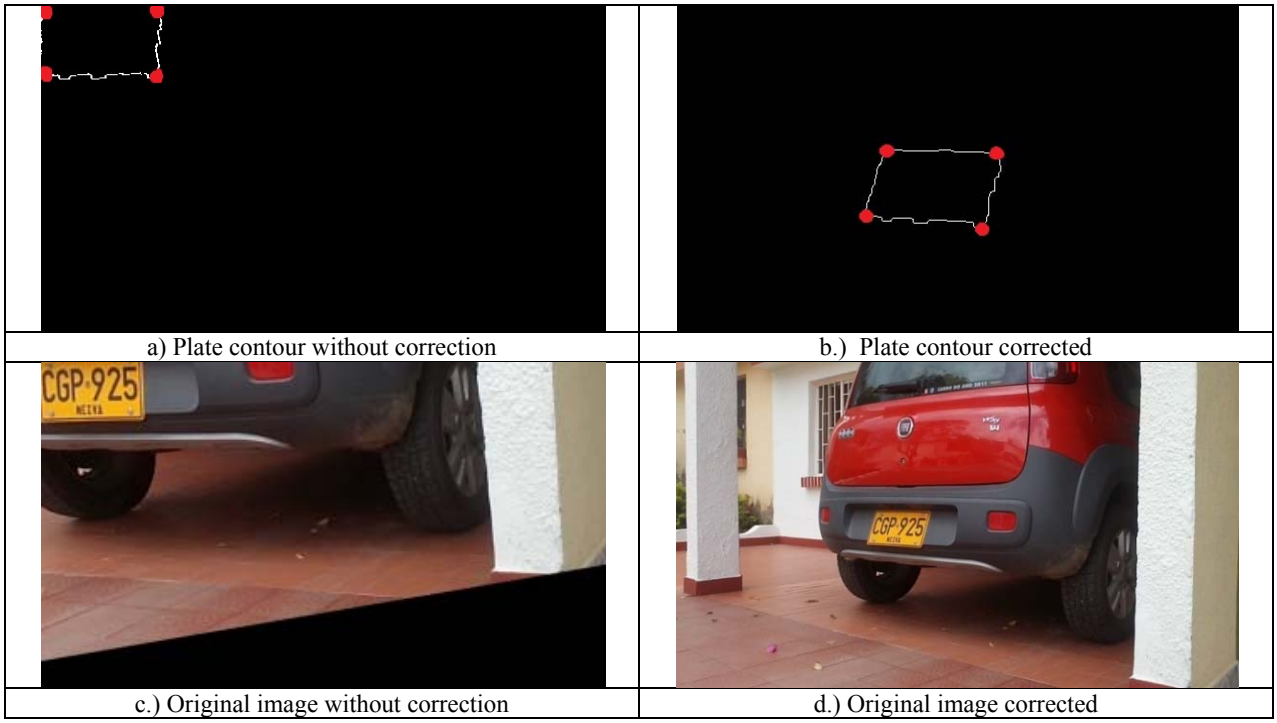
Number of test images	Number of images with contour plate without closing	Number of images with contour plate with closing
187	66	187

However, before doing edge detection, it is important to do a better conditioning of the image by applying morphological operations. In this case, it was made using a morphological operation called Closing, which consists in to dilate and then erode the image. Table-2 shows the results of a test, where the edge detection of images 187 it was evaluated with and without closing.

Once found the contours of an image contours corresponding to a plate. For this two conditions were established, the first is that the contour belongs to a plate should have 4 sides and the second is that the contour area belonging to a plate must be greater than 6000px and less than 45000px. To find these data, images taken at different distances between a vehicle and camera were used.

Geometric correction

The geometric correction is a projective transformation also defined as linear transformation; which consists in to give the position and desired perspective to an object within an image (Caballero, 2007). In this case the goal is to align the rectangle shaped plate with coordinate axes. In Figure 3 the geometric correction process is observed.



a) Plate contour without correction | b.) Plate contour corrected

c.) Original image without correction | d.) Original image corrected

Figure-3. Geometric correction process.

Because applying a geometric correction directly affects the results of optical character recognition (OCR), it was necessary to advance in this process to test and analyze the results when working with images corrected or uncorrected geometrically. Although to this point is not yet seen the stage of optical character recognition, in Table 3 are recorded the results obtained to illustrate how the homography brings good results to the application.

Table-3. Comparison between reconized plates with and without homography.

Number of test plates	Number of plates recognized without homography	Number of plates recognized with homography
187	164	184

Cutting characters

Once the plate is aligned, it proceeds to cut image. After that characters are cut. The next step is binarization of the plate, convert this image to grayscaleand apply the method of Otsu in order to highlight the characters. Then the characters are extracted from the image using the method Blobs, this method involves looking black colored regions within the binarized image.

From found regions features such as area, height and widthcan be extracted, which help to correctly identify characters of these regions. Once the characters have been found it is proceed to cut one by one to group them later in an image alphabetic characters and numeric characters in another. This process can be seen in Figure-4.

Figure-4. Original image, grayscale image, binarized image and regions found in binarized image.

Optical character recognition

The OCR Optical Character Recognition, is part of a broader field called pattern recognition which refers to the ability to distinguish specific characteristics of objects optically. In this case as its name implies OCR, recognition is a character, a word or phrase that is within a digital image (from a camera). These systems work based on neural networks, geometric methods, probabilistic, etc. (Frydson and Gutiérrez, 2011).

OCR is a vital piece in the ANPR systems, and thanks to these it is possible to recognize alphanumeric characters that make up the license plates.

There is much free software for optical character recognition, among them are: Cuneiform OCR, the OCRopus, Tesseract, Ocrad, GOCR. Others which must be paid for its use are: ExperVision, FineReader, Microsoft Office DocumentImaging, OmniPage, Readiris, ReadSoft, SimpleOCR, SmartScore.

One objective of this work was to work with free software and for this reason Tesseract, GOCR and Ocrad were analyzed (which are free software) to determine which of these is more accurate in identifying characters. The tests conducted to determine which is the best consisted mainly of test images, such as those in Figure-5 where there are alphanumeric characters to analyze the response of the software and obtain a success rate of each one.

Figure-5. Test images for optical image recognition.

Below in Table-4 and Table-5 are shown the comparison results obtained using GOCR, OCRAD and TESSERACT in the two test images shown in Figure-4.

Table-4. Comparison results for the first test image.

Application	Number of characters	Recognized characters	Unrecognized characters	Success rate
GOCR	36	30	6	83.33%
OCRAD	36	26	10	72.22%
DEFAULT TESSERACT	36	28	8	93.33%
PERSONALIZED TESSERACT	36	36	0	100%

Table-5. Comparison results for the second test image.

OCR	Total Characters	Characters Recognized	Characters No Recognized	Success Rate
GOCR	36	26	10	72.22%
OCRAD	36	24	12	66.66%
DEFAULT TESSERACT	36	24	12	66.66%
CUSTOMIZED TESSERACT	36	36	0	100%

Noting Table-4 and Table-5 can be seen that the highest success rate was 100% obtained by Tesseract, executed with the personalized language, this is thanks to the flexibility of Tesseract to allow modifications; on the contrary GOCR and OCRAD not have this flexibility and can only be run with its default settings, with a few optional configurations, seeing this reflected in their rates of success in this test were 83.33% for GOCR and 72.22% for OCRAD.

200 images of vehicles where the plates were clearly visible were downloaded from the Internet. These images were processed to cut the characters of each of the plates thus obtaining a total of 1200 images, 600 images of numeric characters and 600 images of alphabetic characters, the character size ranges from 15x25 pixels and 25x45 pixels. With all these images libraries were built training Tesseract taking into account all the recommendations and steps that provide developers on the official website of Tesseract.

3. RESULTS

An IP camera to capture images was used; it was installed at the entrance of the parking, in order to takeimages of the front plate of the vehicle. An example of the images taken by this camera can be seen in Figure-6.

Figure-6. Image taken by camera.

Given the need to take pictures only when the gate is open the parking lot, a sensor system that tells the program when it is open or closed that gate was designed. For the construction of this sensor system opening a magnetic sensor and a microcontroller 18F4550 it was used. The magnetic sensor is placed at the top of the gate, see Figure-7.

Figure-7. System sensor.

To use the program a very simple interface was designed, see Figure-8, where the operator can record vehicles entering or leaving the parking and were not detected by the system. Queries to the database system to check vehicles that have been registered it can be executed.

Figure-8. Application interface.

Figure shows the photograph of the vehicle was registered and the characters of the plate that are identified in this. It also shows that it is possible to input records by entering the vehicle license plate number. Similarly one can record the output of vehicles. Records can be done manually as well. Finally, the program allows queries to the database by the vehicle plate or a date range and specific time.

To test the entire system, 110 images were processed by the vision algorithm and identified with the character recognition algorithm. The results of this test are shown in Table-6.

Table-6. Success rate of the entire system.

Number of images	Number of plates identified	Number of plates identified correctly	Success rate (%)
110	100	95	86.36

4. CONCLUSIONS

The main objective of this work is to design a system for recording and remote monitoring using computer vision and IP surveillance systems for a parking in the municipality of Altamira Huila. This objective was fully implemented as the system processes the images from an IP camera to find the plate vehicles entering in the parking. After this finding the system makes plate character recognition to record the entry of the vehicle into a database. On the other hand, the system also provides a continuous flow of video, real-time surveillance with cameras which were installed in the parking.

As expected the greatest difficulty encountered in the project is that lighting plays an important role in image processing and working in open or uncontrolled environments, changes in this are very variants and this complicates accuracy system.

Another major difficulty encountered is the state of the license plates because when these are very deteriorated is very difficult to find patterns defined in the characters and this causes the system to fail and recognize wrong characters.

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