

# DESIGN AND DEVELOPMENT OF AUTOMATED TOLL COLLECTION THROUGH LICENSE PLATE RECOGNITION

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**Abstract** -This project reveals about the design and development of automated toll collection through license plate recognition. Toll gates are normally well thought-out a cause inconvenience to by travellers not only for the expenditure of the toll but also for the delay at toll counters, toll roads and bridges. If the vehicles belong to the authorized person, it automatically opens and closes the toll gate and a predetermined amount is automatically deducted from its account. Refuge systems can also be supplementary which further enlarge the system. License plate recognition algorithm is used to sense the locations of license plate LP symbols. An adaptive threshold method has been useful to conquer the dynamic changes of illumination circumstances when converting the images into binary. Connected component analysis technique is used to sense the candidate object inside the unidentified representation. The system has been implemented using MATLAB and an assortment of image samples.

**Keywords** – Image Recognition, License Plate Recognition, Vehicle Identification.

## I. INTRODUCTION

License Plate Recognition (LPR) is essential for the purpose of enforcement, border inspection, vehicle thefts, automatic toll collection and conceivably traffic control.

In any automatic plate recognition system, two main dissimilar stages can be distinguished; first, a meticulous region contained by the input image has to be identified as a car plate (localization), and then a character sequence inside the expanse has to be validated as an acceptable plate string subsequent some grammatical rules (character recognition). These stages are always functional on controlled environments, static backgrounds or inhibited light scenes. This is due to the growing require for the automatic means of transport discovery requisite for traffic control, border control, access-control, computation of parking time and payment, search for stolen cars or voluntary fees and the requirement for reliable identification at dissimilar lighting conditions, occurrence of random or structured noise in the plate and nationality specific features, regarding plate's size and type of characters. In license plate recognition, frequently three stepladders are necessary. One is the license plate localization, despite the consequences of the license-plate size and direction. The second step is the segmentation of the characters in the plate and the normalization of other factors like intensity, contrast, enlightenment, etc. Lastly is the recognition of the characters and consequently the license plate. Locating a license plate is not an inconsequential problem since of different plate sizes, orientations and complexity of the scene. The finding stage of the LP is the most critical step in an automatic vehicle

identification system. All the developed techniques can be branded according to the selected features upon which the detection algorithm was based and the type of the detection algorithm itself. The functional detection algorithms range from window-based statistical matching methods.

The rest of the paper is organized as follows; Section II briefly describes the proposed method Automatic License Plate Recognition. Section III describes the Morphological Process. Section IV modifications to prevail over the problem in Connected Component Analysis Technique. Section V concerns with simulation algorithm and results.

## II. AUTOMATIC LICENSE PLATE RECOGNITION

Automatic License Plate Recognition (ALPR) is a crowd observation method that uses visual character recognition on images to read vehicle registration plates. They can use existing closed-circuit television or road-rule enforcement cameras, or ones purposely intended for the task. They are used by various regulate forces and as a method of electronic toll collection on pay-per-use roads and categorization the schedule of traffic or individuals. ALPR can be used to store the images captured by the cameras as well as the passage from the license plate, with some configurable to store a take pictures of of the driver. Systems commonly use infrared illumination to allow the camera to take the picture at any time of the day. ALPR technology tends to be region-specific, owing to plate disparity from place to place. All the developed techniques can be characterized according to the selected features leading which the detection algorithm was based and the type of the detection algorithm itself.

It is the technical method of artificial vision that allows the recognition of number plates in images of vehicles. Historically, it has been applied on security systems to control accesses of vehicles and toll collections. ALPR equipment is able to recognize the number plate of vehicles that drive up to 200km/h. Generally, the ALPR technology can be bought in two modalities:

- The ALPR engine
- The ALPR equipment (Hardware + recognition engine)

### A. Parts of the generic system, Capture Unit (CU) + Process Unit (PU):

The great majority of systems are still using "CU+PU" architecture:

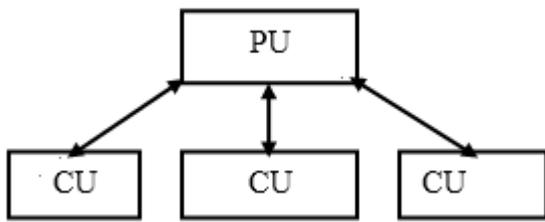


Fig 1: Architecture of Processing Unit and Control Unit.

#### B. Capture Unit (CU):

Camera Housing, Camera, Infrared focus

#### C. Processing Unit (PU):

Embedded Computer, Framegrabber, and Recognition engine.

#### D. Operation of the system

The "CU+PU" system consists of two parts. The Capture Unit that takes the image of the vehicle, and the Process Unit that receive the image from the Capture Unit and makes the recognition of the number plate. The Process Units can control one or more Capture Units simultaneously. The quality of the solution depends on each manufacturer, although generally the "CU+PU" architecture has disadvantages respect the ALPR All-in-One, they are the following ones:

#### E. No robust architecture

1. The Capture Units controlled from the one only Process Unit will fall if the Process Unit does not work.
2. Complex installation and start-up.
3. It is necessary to install video and control wire for each one of the cameras.
4. Furthermore, it is necessary to provide power supply cable to the cameras, focus and Process Units.
5. If the distance between the lanes is too long, the signal of the cameras will not arrive with clearness to the Process Unit.
6. By contrast to the generic ALPR, the ALPR equipment integrates directly in the housing the camera, the processor, the communications and the power supply unit.
7. If the Process Units are installed directly on the lane it will be necessary to protect it with a weatherproof rack.
8. Working of ALPR:

The ALPR process is divided into three steps. The detection of the vehicle, the capture of the images and the process of recognition.

*Detection of the vehicle:* The first step is to take an image of the vehicle at the right time. Thus, the number plate of the vehicle will be visible in the image. Nowadays, three kind of trigger control exist.

*Hardware trigger:* The ALPR equipment controls physically a sensor directly installed in the lane. Whenever a vehicle has been detected by the sensor, the ALPR equipment will know its presence, and then the process of the capture begins.

*Software trigger:* The ALPR equipment communicates with the client application, which physically controls a sensor directly installed in the lane. Whenever a vehicle has been detected by the sensor, the client application knows the presence of the vehicle and communicates it to the ALPR equipment. At this moment the process of the capture begins.

*Free flow:* The ALPR equipment does not need to receive signal from any external sensor. The ALPR equipment takes images continuously and it is able to detect the vehicles automatically.

*Capture of the images:* Once the vehicle is detected, the following step is the capture of the vehicle. In order to take a right image, the following points will have to be considered.

*Number plate recognition process:* Each ALPR manufacturer has developed its own recognition algorithms, although, these are the main ones and the common ones.

1. To locate and to isolate the number plate in the image.
2. To correct the brightness and the contrast of the number plate.
3. To separate each character of the number plate.
4. To recognize each character of the number plate.

#### 1. Access control

The ALPR equipment has been used for the access control of vehicles, it was thought as one more tool that allows increasing the security. The client application could control users through personal cards, and the ALPR allows vehicles control. Nowadays, the ALPR equipment are used for automatizing the accesses of vehicles.

These are the main advantages to incorporate ALPR equipment in access control.

*Security increased:* Integrating the ALPR technology in access control applications together with the traditional control devices, allows vehicle and people control. Thanks to this combination the security is increased.

*Dynamic access of vehicles:* Automatizing vehicle access is possible through ALPR equipment. If the data base knows the vehicle, the client application will open the barrier automatically. By contrast, if the data base does not know the vehicle, it will not open the barrier.

*Vehicle images:* It is possible to store the image used for the ALPR equipment during the recognition process. It allows having more information about the vehicle in the client application.

#### Traffic Control

*Detecting vehicles in a black list:* It is possible to control vehicles that are in search and capture, thought the installation of the ALPR equipment in the main accesses to cities, such as highways and roads.

*Average speed control:* The majority of speed control devices, such as radars or speed traps, control the vehicle instantaneous speed. With the ALPR equipment it is possible to control the average speed during an itinerary. By means of the installation of two ALPR equipment in different points in the same lane, it is possible to make two consecutive recognitions of the number plate and to calculate the average speed of the vehicle.

*Traffic optimization:* It is important to improve the vehicles mobility during rush hours and traffic jam. The installation of ALPR equipment allows knowing how much time a

vehicle spends to cross an itinerary. This way, the average time can be informed.

*Urban toll payment:* This application solution has been successfully experienced. This proves that the mobility in the central zones of the city improves considerably. Another possibility of urban tolls is to maintain a register of foreign vehicles using the public ways, without contributing in the road tax.

### III. MORPHOLOGICAL PROCESS

#### A. Mathematical morphology:

A shape (in blue) and its morphological dilation (in green) and erosion (in yellow) by a diamond-shape structuring element. Mathematical morphology (MM) is a theory and technique for the analysis and processing of geometrical structures, based on set theory, lattice theory, topology, and random functions. MM is most commonly applied to digital images, but it can be employed as well on graphs, surface meshes, solids, and many other spatial structures.

Topological and geometrical continuous-space concepts such as size, shape, convexity, connectivity, and geodesic distance, can be characterized by MM on both continuous and discrete spaces. MM is also the foundation of morphological image processing, which consists of a set of operators that transform images according to the above characterizations. MM was originally developed for binary images, and was later extended to grayscale functions and images. The subsequent generalization to complete lattices is widely accepted today as MM's theoretical foundation.

#### B. Binary morphology:

In binary morphology, an image is viewed as a subset of an Euclidean space  $R^d$  or the integer grid  $Z^d$ , for some dimension  $d$ .

#### C. Structuring element:

The basic idea in binary morphology is to probe an image with a simple, pre-defined shape, drawing conclusions on how this shape fits or misses the shapes in the image. This simple "probe" is called structuring element, and is itself a binary image (i.e., a subset of the space or grid). Here are some examples of widely used structuring elements (denoted by B):

1. Let  $E = R^2$ ; B is an open disk of radius  $r$ , centered at the origin.
2. Let  $E = Z^2$ ; B is a 3x3 square, that is,  $B = \{(-1,-1), (-1,0), (-1,1), (0,-1), (0,0), (0,1), (1,-1), (1,0), (1,1)\}$ .
3. Let  $E = Z^2$ ; B is the "cross" given by:  $B = \{(-1,0), (0,-1), (0,0), (0,1), (1,0)\}$ .

### IV. CONNECTED COMPONENT ANALYSIS TECHNIQUE

All systems relying on CCAT is the sensitivity to negative or positive noise that may cause some symbols to be connected to other objects or broken into smaller objects. Connectivity is also affected by many causes such as bullets, dirt, aging, occlusion, shadows, or due to image processing operations like dilation and erosion.

The first scan performs the temporary labelling to each foreground region pixels by checking their connectivity of the scanned image. When a foreground pixel with two or more than two foreground neighbouring pixels carrying the same label is found, the labels associated with those pixels are registered as being equivalent. That means these regions are from the same object. The handling of equivalent labels and merging thereafter is the most complex task.

The first scan gives temporary labels to the foreground pixels according to their connectivity. The connectivity check can be done with the help of either a 4-connectivity or 8-connectivity approach. 8-connectivity approach is used. Here, the idea is to label the whole blob at a time to avoid the label redundancies.

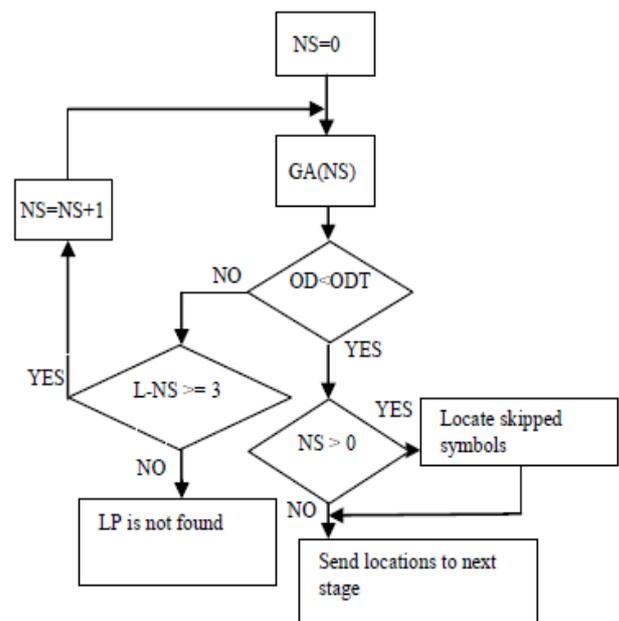


Fig 2: Flow Chart for detecting LP's symbol.

This number is initialized to zero in the first run of the GA and according to the optimum OD threshold value (ODT), a decision is made either to accept the selected chromosome or to increase the NS argument and execute a further run of the GA. Depending on the number of LP symbols (L) under consideration, the skipping number NS can reach to a maximum value given that  $L-NS \geq 3$ . If NS is greater than zero then NS random numbers having values between 1 and L are generated inside the OD evaluation function, and the corresponding error distances are skipped.

The labelling operation scans the image moving along the row until it comes to the point P, for which  $S = \{255\}$ . When this is true, it checks the four neighbours of which Based on that information, the labelling of P occurs as follows, If all four neighbours are '0' assign a new label to P, and increment the label, Else If only one neighbour has  $S = \{255\}$  assigns its label to P Else (i.e., more than one of the neighbours has  $S = \{255\}$ ) Assign one of the labels to P.

Here, note that the relation between the pixels that are expressed through a "label value" in the labelled image depends on the value of the label. That means the two pixels from Background, labelled as  $lp$  is not necessarily to be connected, but the two pixels labelled  $lp$  from the foreground region are to be connected.

#### A. Local Region Descriptors

The Labelled objects within a sign are applied to measure its characteristics which are useful to recognize a sign with stored templates. The following features are extracted, Area, Orientation, Height, width, Eccentricity, Major axis Length, Minor axis length, perimeter and Equivalent diameter.

#### B. K-Nearest Neighbor

In pattern recognition, the k-nearest neighbor algorithm (k-NN) is a method for classifying objects based on closest training examples in the feature space. k-NN is a type of instance-based learning, or lazy learning where the function is only approximated locally and all computation is deferred until classification. The k-Nearest Neighbor algorithm is amongst the simplest of all machine learning algorithms.

The same method can be used for regression, by simply assigning the property value for the object to be the average of the values of its k nearest neighbors. It can be useful to weight the contributions of the neighbors, so that the nearer neighbors contribute more to the average than the more distant ones. (A common weighting scheme is to give each neighbor a weight of  $1/d$ , where d is the distance to the neighbor. This scheme is a generalization of linear interpolation.)

The neighbors are taken from a set of objects for which the correct classification (or, in the case of regression, the value of the property) is known. This can be thought of as the training set for the algorithm, though no explicit training step is required. The k-nearest neighbor algorithm is sensitive to the local structure of the data. Nearest Neighbor rules in effect implicitly compute the decision boundary. It is also possible to compute the decision boundary explicitly, and to do so efficiently, so that the computational complexity is a function of the boundary complexity.

#### C. Parameter Selection

The best choice of k depends upon the data; generally, larger values of k reduce the effect of noise on the classification, but make boundaries between classes less distinct. A good k can be selected by various heuristic techniques, for example, cross-validation. The special case where the class is predicted to be the class of the closest training sample (i.e. when  $k = 1$ ) is called the Nearest Neighbor algorithm.

The accuracy of the k-NN algorithm can be severely degraded by the presence of noisy or irrelevant features, or if the feature scales are not consistent with their importance. Much research effort has been put into selecting or scaling features to improve classification. A particularly popular approach is the use of evolutionary algorithms to optimize feature scaling another popular approach is to scale features by the mutual information of the training data with the training classes.

In binary (two class) classification problems, it is helpful to choose k to be an odd number as this avoids tied votes. One popular way of choosing the empirically optimal k in this setting is via bootstrap method. Data

reduction is one of the most important problems for work with huge data sets. Usually, only some the data points are needed for accurate classification. Those data are called the prototypes and can be found as follows:

1. Select the class-outliers, that is, training data that are classified incorrectly by kNN (for a given k).
2. Separate the rest of the data into two sets: (i) the prototypes that are used for the classification decisions and the absorbed points that can be correctly classified by kNN using prototypes and can be removed from the training set.

#### D. Algorithm Description

The training phase for kNN consists of simply storing all known instances and their class labels. A tabular representation can be used, or a specialized structure such as a kd-tree. If we want to tune the value of 'k' and/or perform feature selection, n-fold cross-validation can be used on the training dataset. The testing phase for a new instance 't', given a known set 'T' is as follows:

1. Compute the distance between 't' and each instance in 'T'.
2. Sort the distances in increasing numerical order and pick the first 'k' elements.
3. Compute and return the most frequent class in the 'k' nearest neighbours, optionally weighting each instance's class by the inverse of its distance to 't'.

#### V. SIMULATION ALGORITHM AND RESULTS

The entire system has been implemented using MATLAB. One experiment was carried out and it was done on a LP dataset composed of car images acquired at various camera-to-object relative positions in different lighting conditions. There are seven primary algorithms that the software requires for identifying a license plate:

1. Plate localization – responsible for finding and isolating the plate on the picture.
2. Plate orientation and sizing – compensates for the skew of the plate and adjusts the dimensions to the required size.
3. Normalization – adjusts the brightness and contrast of the image.
4. Character segmentation – finds the individual characters on the plates.
5. Optical character recognition.
6. Syntactical/Geometrical analysis – check characters and positions against country-specific rules.
7. The averaging of the recognised value over multiple fields/images to produce a more reliable or confident result. Especially since any single image may contain a reflected light flare, be partially obscured or other temporary effect.

The complexity of each of these subsections of the program determines the accuracy of the system. During the third phase (normalization), some systems use edge detection techniques to increase the picture difference between the letters and the plate backing. A median filter may also be used to reduce the visual noise on the image.

## VI. RESULTS

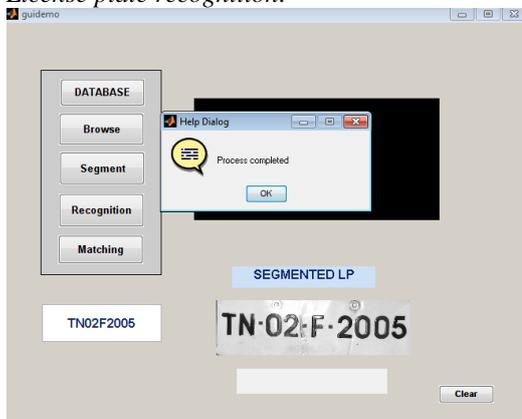
### Input image:



### License plate segmentation:



### License plate recognition:



### License plate authentication:



## VII. CONCLUSION

This system is a user friendly toll fee method which can accumulate time and condense traffic overcrowding at toll gates and give resolution for users to accomplish their destination without leftovers of time. It gives the toll authorities the suppleness to set variable pricing for toll services and thus a fair strategy of tax collection can be followed. This way there is no thrashing incurred by a person carrying a vacant vehicle. Here there is no cash transaction for the toll lanes, so cash handling is reduced. Thus difficulties with cash handling are eliminated and this way aid in improved review control by centralizing user accounts. Information such as vehicle count over the time of the day, date, time etc can be obtained due to the consumption of this technology. This helps in making decisions concerning the pricing strategies for the toll providers. It also helps conspirator to guesstimate the travel time that aid in scheming decisions.

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## REFERENCES

- [1] Y. Qiu, M. Sun, and W. Zhou, "License Plate Extraction Based on Vertical Edge Detection and Mathematical Morphology," International Conference on Computational Intelligence and Software Engineering, pp. 1-5., 11-13 Dec. 2009.
- [2] A. Ahmadyfard and V. Abolghasemi, "Detecting License Plate Using Texture and Color Information," IST 2008, International Symposium on Telecommunications, pp. 804-808, 2008.
- [3] G. Li, R. Yuan, Z. Yang, and X. Huang, "A Yellow License Plate Location Method Based on RGB Model of Color Image and Texture of Plate," Second Workshop on Digital Media and its Application in Museum & Heritages, pp. 42-46, 2007.
- [4] X. Shi, W. Zhao, Y. Shen, and O. Gervasi, "Automatic License Plate Recognition System Based on Color Image Processing," Lecture Notes on Computer Science, Springer-Verlag, vol. 3483, pp.1159 -1168, 2005.
- [5] M. Deriche, "GCC License Plates Detection and Recognition Using Morphological Filtering and Neural Networks," Int J. on Comp. Sci. and Info Security, IJCSIS, vol. 8, No. 8, pp. 263-269, Dec, 2010.
- [6] O. Villegas, D. Balderrama, H. Domínguez and V. Sánchez, "License Plate Recognition Using a Novel Fuzzy Multilayer Neural Network," International Journal of Computers", Issue 1, vol. 3, 2009.
- [7] S.H. Mohades Kasaei, S.M. Mohades Kasaei and S.A. Monadjemi, "A Novel Morphological Method for Detection and Recognition of Vehicle License Plate," American Journal of Applied Science, vol.6 no.12, pp. 2066-2070, 2009.
- [8] A. Theja, S. Jain, A. Aggarwal and V. Kandavli, "License Plate Extraction Using Adaptive Threshold and Line Grouping," International Conference on Signal Processing Systems (ICSPS), vol.1, no., pp. 211-214, 5-7 July 2010.
- [9] P. Tarabek, "Fast license plate detection based on edge density and integral edge image," International Conference on Applied Machine Intelligence and Informatics (SAMII), pp. 37 - 40, 2012.
- [10] www.ieee.org
- [11] www.researchgate.net