www.ijecs.in

International Journal Of Engineering And Computer Science ISSN:2319-7242

Volume 2 Issue 4 April, 2013 Page No. 1330-1337

"Artificial Vision System for Automatic Number Plate Identification"

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Abstract:- *During the recent years, Intelligent Transportation Systems (ITS) are having a wide impact in people's life as their scope is to improve transportation safety and mobility and to enhance productivity through the use of advanced technologies. License Plate Recognition (LPR) is an integral part of ITS. The popularity of License Plate Recognition System is mainly because of its Successful applications in Traffic congestion and monitoring, Revenue control related to road usage, Campus security Systems, Access Control Systems, etc*

In this paper, a algorithm for vehicle license plate identification is proposed, on the basis of a image segmentation technique and connected component analysis in conjunction with character recognition Neural Network. The algorithm was tested gray level vehicle images of different backgrounds .The camera focused in the plate, while the angle of view and the distance from the vehicle varied according to the experimental setup. In the first image enhancement is performed. Then it is used for edge detection. After edge detection series detect the license plate number. Character segmentation is done using line scanning technique. In addition to the algorithms based on gray-level image processing, color information of license plates also plays an important role in license plates localization, where the unique color or color combination between the license plates and vehicle bodies are considered as the key feature to locate the license plates. The mechanism is able to deal with difficulties raised from illumination variance, noise distortion ,and complex and dirty backgrounds. Numerous captured images including various types of vehicles with different lighting and noise effects have been handled. A study of the different parameters of the training and recognition phases showed that the proposed system reaches promising results in most cases and can achieve high success rates location has been confirmed by the experiments.

Keywords: License Number Identification, Image Processing, License Plate Locating, Segmentation, Feature Extraction, Character Recognition, Artificial Neural Network.

1. Introduction

A license plate recognition system is an automatic system that is able to recognize a license plate number, extracted from an image device. Such system is useful in many fields and places: parking lots, private and public entrances, border control, theft and vandalism control.This paper presents a neural network based artificial vision system -Visicar - and its applications. The system is able to analyse the image of a car given by a camera, locate the registration plate and recognise the registration number of the car. The paper describes in details various practical problems encountered in implementing this particular application and the methods used to solve them. Automatic optical character recognition (OCR) systems play a central role in almost all license plate recognition (LPR) systems. License plates that contain characters require the use of a specially designed system that integrates an OCR system with an LPR system.

However such combined systems have received less research attention. This paper investigates the use of neural networks to construct an automatic OCR system to be part of an LPR system. Neural networks have been employed to perform both feature extraction and recognition tasks. A comparison study on the use of different types of neural networks is conducted. Considered network types include associative memory, perceptron, multilayer, and Kohonen maps. Implemented neural-based OCR systems have been tested on a large database of 6,720 character images. They were manually extracted form 1,120 actual license plate images that were captured at various illumination, size, rotation and viewpoint conditions. Experiments demonstrated the superiority of multilayer networks over other tested types. This paper presents a real-time and robust method for license plate location and recognition. After adjusting the image intensity values, an optimal adaptive threshold is found to detect car edges and then the algorithm uses morphological operators to make candidate regions. Features of each region are to be extracted in order to correctly differentiate the license plate regions from other candidates. It was done by analysis of percentage of Rectangularity of plate. Using color filter makes the algorithm more robust on license plate localization (LPL). The algorithm can efficiently determine and adjust the plate rotation in skewed images. The Binary unit uses Otsu method to find the optimal adaptive threshold corresponding to the intensity of image. To segment the characters of the license plate, a segmentation algorithm based on the profile is proposed. In the following, an optical character recognition (OCR) engine has then been proposed.

2. Related work

A License plate recognition applies image processing and character recognition technology to identify vehicles by automatically reading their license plates Optical character recognition has always been investigated during the recent years, within the context of pattern recognition [1], [2]. The broad interest lies mostly in the diversity and multitude of the problems that may be solved (for different language sets), and also to the ability to integrate advanced machine intelligence techniques for that purpose; thus, a number of applications has appeared [3], [4].

The steps involved in recognition of the license plate are acquisition, candidate region extraction, segmentation, and recognition. There is batch of literature in this area. Some of the related work is as follows: [3] has developed sensing system, which uses two CCDs (Charge Coupled Devices) and a prism to capture the image. [8] has proposed method heart extracting characters without prior knowledge of their position and size.[7] has discussed the recognition of individual Arabic and Latin characters. Their approach identifies the characters based on the number of black pixel rows and columns of the character and comparison of those values to a set of templates or signatures in the database. [10], [3] have used template matching. In the proposed system high resolution digital camera is used for heart acquisition. The intelligent visual systems are requested more and more in applications to industrial and deprived calling: biometrics, ordering of robots [12], substitution of a handicap, plays virtual, they make use of the last scientific projections in vision by computer [13], artificial training [14] and pattern recognition [15].rtificial Neural Network (ANN).

3.OCR system

A typical OCR system as shown in Figure 1 consists of three main building blocks. The first block is preprocessing that includes, if necessary, removing noise, enhancing the image, converting into binary, and normalizing. The second block is feature extraction. The purpose of this block is to generate a set of numbers (or features) that uniquely describe the image. Some commonly used features include horizontal and vertical projection histograms, moment-based features such as Zernike moments, and structural features . The last block is classification. The aim of this block is to assign an image to a specific class based on its features. Classification methods are very diverse but conventional character classifiers include statistical, neural , and fuzzy .

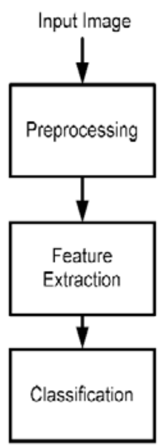

Fig.1. A general structure of an OCR system.

A general structure of an OCR system. Neural networks have been successfully used as classifiers in numerous applications. They can be also used to automatically extract features because of their excellent adoption capabilities. Both feature exaction and classification blocks of an OCR system can be replaced by a single neural network that can internally learn suitable features and classify them accordingly during usual network training algorithm. Thus the lengthy processes of selecting, computing, and evaluating features are completely eliminated. English OCR systems for VLPR have received a great deal of research and development in the past two decades. License plates in most world countries contain unique sets of characters of Latin capital alphabet (A-Z) and/or Arabic numbers (0-9). Commercial VLPR products are also available. On the other hand more than twenty countries in Middle East and North Africa where Arabic is the first language use different license plate structures. They 603 contain isolated Arabic letters and/or Indian numbers . Indian numerals have been adopted by Arabs along time ago. Thus building an OCR for such non-Latin character sets is extremely important. Accordingly the focus of this paper is restricted to license plates that contain Indian numbers which have received less research attention. Currently these types of plates exist in many other countries including Egypt and Kuwait. OCR systems for such characters are developed using neural networks and tested on a large database.

4. Security problems

This section describes briefly some situations in which non-trivial security problems can be solved by using such an artificial vision system. Parking areas with no special security requirements. It might seem that such areas do not require *any* security system. In reality, fraudulent practice is rather common and brings important losses to companies which manage parking areas and garages. A common fraudulent practice is to use two cars in order to occupy permanently a space in a parking lot. One can enter in the car park with a car A (a Ferrari for instance) and obtain a ticket TA stamped with the time of entrance T1. At any later date, the same person can enter with a car B (an old Mini for instance) obtain a ticket TB stamped with the time of entrance T2. Then, the person can leave car B in the car park, and leave the car park at time T2+e with car A and ticket TB, paying just the minimum amount due for the time e. Later on, car A will be deposited again in the car park with a ticket TA' which will be used to exit the car park with car B. The process is then repeated, always swapping cars and exiting the car park with the most recent ticket. Thus, an expensive Ferrari can be kept in a safe car park for unlimited lengths of time, almost free, with huge losses for the car park company. Another typical situation is that of a car theft. A thief can enter a car park with their own car A obtaining a ticket TA, steal a very expensive car B and leave quietly with the stolen car and the ticket TA. This type of fraud brings huge losses for car park companies materialised in high insurance costs. One can imagine a system which recognises automatically the car number plate when the car enters them parking area and stores somehow the registration number on the ticket. Later, when the car leaves the parking lot, the system can check the correspondence between the information on the ticket and the registration number of the car. It is easy to appreciate that such a system would eliminate completely both fraud situations described above or at least, reduce their number. Parking areas with security requirements. In these situations, such a system adds a further level of security by granting entrance only to registered vehicles. Toll payment. A system able to recognise registration plates can be used to identify vehicles which transit through the toll gates. Such a system can be used to achieve two types of goals. Firstly, the system can be used in conjunction with a database containing registration data and owners' information in order to debit the amount due directly into the car owner's account. This can greatly reduce the running costs of the toll bridge or motorway by reducing or eliminating the need for a human presence. Secondly, such a system can be used as a back-up system which deals only with fraudulent vehicles. For instance, in Italy, the motorway system is run by a private company called "Autostrade spa". This company has perfected a remote sensing system called "Telepass" which is able to identify certain vehicles which are fitted with a special device. Those vehicles are allowed to transit without stopping through certain dedicated channels at the toll gates, thus eliminating queuing. However, fraudulent users can transit those dedicated channels without having the device fitted to their cars thus trying to avoid paying the toll. In such cases, a Visicar-like system can be triggered. The system would automatically identify the car and, in conjunction with a database, can identify the owner of the car and even issue a fine. Restricted access areas. The system can be used to identify the abuses in any situation in which the traffic is restricted. For instance, the historical centres of cities like Rome, Florence, etc. are closed to the public traffic. Nonetheless, many people just ignore this and transit the respective areas. Reinforcing the law is very difficult due to the great number of points of access in such areas. Theoretically, each such point would necessitate a traffic warden. A Visicar-like system can substitute a human presence and still detect any instances of breaking the law. Railway traffic control and management. Artificial vision systems placed in various strategic positions can yield important data which can be important for the control of the railway traffic.

5The functioning of the system

The main steps of the processing are: image acquisition and enhancement, plate location and segmentation, character segmentation, character recognition, character validation and registration number validation . Each of these steps will be described in detail in the following

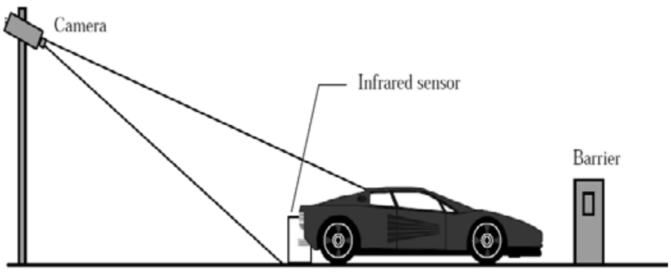

Fig. 2. The system setup for a parking lot

Fig3. Selecting of license plate.

5.1Plate location approach

The approach used for the plate location was to scan the image horizontally looking for repeating contrast changes on a scale of 15 pixels3 and more. This approach uses the assumptions that the contrast between the characters and the background of the plate is sufficiently good, that there are at least 3-4 characters on a plate and that the characters have a minimum vertical size of about 15 pixels.

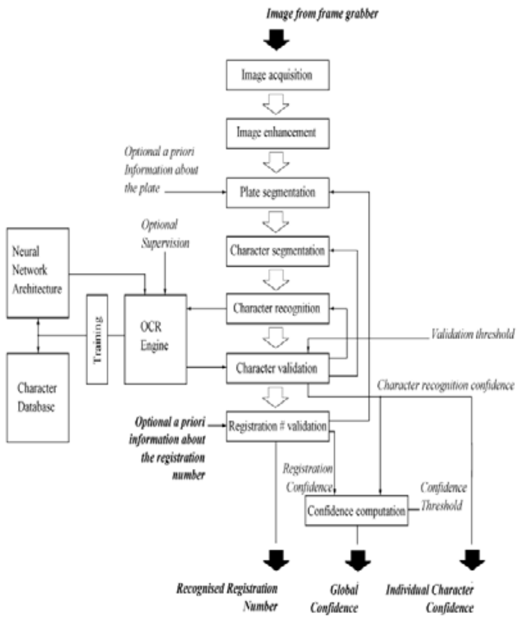

Fig. 4. The block structure of the system

5.1.2Processing

A gaussian blur filter is applied to eliminate the fine grain noise.where gamma and beta are calculated so that the stretched histogram will extend on the entire range of grey levels available. Subsequently, the program scans the image looking for areas with high contrast gradients at the given scale of about 15 pixels.

The resulting image is scanned again looking for concentrations of such high contrast gradient areas. Any concentration of such areas which can be approximated by a rectangle will be signaled as an interest zone. All subsequent processing will be performed in turn on each interest zone.

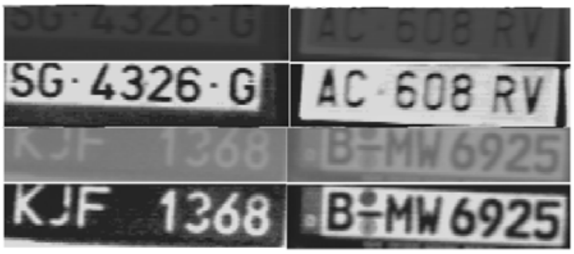

Fig. 5 Some processing of interest areas.

5.2.1Plate segmentation approach

The plate segmentation is performed using a differential gradient edge detection approach. The processing speed is improved by approximating the magnitude of the local edge with the maximum of the absolute values of the gradients on the x and y directions. The reliability is improved by gaussian filtering the edge image and averaging over different edge sensitivities. This approach made the assumptions that the area of the interest zone which actually contains the characters is characterised by a high spatial gradient of intensity .

5.2.2. Processing

First, the system performs a sobel operation with average preserving templates for vertical and horizontal edges. The result of this operation is binarised with a given threshold and filtered with a gaussian filter. The result is binarised again. Lateral histograms are calculated by projecting vertically and horizontally the resulting binary image. These two lateral histograms will show the number of white pixels (corresponding to edges in the original image) for each vertical and horizontal co-ordinate. The above steps are repeated a given number of times using different thresholds in the binarisation step, and average horizontal and vertical histograms are calculated. These histograms are smoothed with a one dimensional gaussian filtering. The averaging will increase the signal/noise ratio eliminating a lot of noise and preserving only those edges coming from salient features of the image. Usually, the system performs between 9 and 16 sobel-gauss-threshold cycles. Experiments showed that this averaged sobel-gauss thresholding combination is essential and it is able to eliminate many problems like non-uniform illumination, reflections, dirt, etc. The exact number of cycles is decided by the system on an ad-hoc basis depending on the quality of the image and the results obtained.

6.Character segmentation approach

The character segmentation is performed in the following two steps:

1·Find the number and location of the horizontal group(s) using binarisation and lateral histogram analysis.

2·For each horizontal group, find the number and location of the characters which form the group using lateral histogram analysis.

The lateral histogram analysis approach was considered the most suitable for this particular application because the edges of the characters can be blurred, noise of various types can partially cover characters or make connections between different characters and/or characters and borders. In all these situations, classical methods based on morphological analysis of the characters and edge detection showed to be rather unreliable.

***7.* Processing steps**

7.1 Binarisation of the interest zone.

Theoretically, the interest zone contains a number of characters of one colour (e.g. black) on a background of a different colour (e.g. white). However, the colours are not known and can vary from one plate to another. Furthermore, usually there are gradients of colour and/or intensity both on the characters and in the background. In order to ease the burden of subsequent character segmentation and recognition, it is useful to normalise the interest zone transforming it into a standard binary image with (say) white characters on a black background.In an ideal case, the histogram of the gray level image of the interest zone is bimodal, having a peak which corresponds to the background colour and another peak for the foreground (character) colour. If a significant minimum is found in-between the two peaks, it can be chosen as the required threshold value. Usually, it is known whether the objects of interest are dark on a light background or light on a dark background. However, in this particular application, this information is not available and further analysis is necessary to decide whether an inversion of the image is necessary.

7.2Character recognition processing

No particular assumptions have been made for the character recognition stage. This stage uses a trainable recognition engine based on a neural network.

Each character area is divided into 8x16 smaller rectangles. For each such rectangle, an average intensity value is calculated and this value will be fed to one input of the OCR engine. The OCR engine was designed as an inter-changeable plug-in module. This allows the user to choose an OCR engine which is suited to their particular application and to upgrade it easily in the future. At present, there are several versions of this OCR engine. One of them is based on a fully connected feedforward artificial neural network with sigmoidal activation functions. This network can be trained off-line with various training algorithms such as error backpropagat. The standard backpropagation network used had an architecture with 3 layers and 129, 20 and 36 neurons on the input, hidden and output layers respectively.

7.3 The algorithm

separate (region, C1=set of patterns in C1, C2=set of patterns in C2, factor) **is**
Build a subgoal S with patterns x1C1and x1C2 taken at random from C1 and C2. Delete x1C1and x1C2 from
C1 and C2.
Add a hidden unit and train it to separate x1C1and x1C2. Let h be the hyperplane which separates them.
For each pattern p in C1 U C2.
Add p to the current subgoal S
Save h in h_copy
Train with the current subgoal S
if not success **then**
Restore h from h_copy
Remove p from S
For each pattern p in C1 U C2 /* this is the check for global redundancy */
For each old_hyperplane in old_hp_set (the set of hyperplanes already positioned)
if p is classified differently by old_hyperplane and h **then**
/* the hyperplanes h and old_hyperplane are not redundant */
remove old_hyperplane from old_hp_set
if old_hp_set is not empty **then**
/* any of the hyperplanes in old_hp_set is redundant with h; pick up any of them */
h = any of the elements of old_hp_set
Let new_factor = factor **and** (h,'+')
If the positive half-space determined by new_factor contains only patterns in the same class Cj **then**
Classify new_factor as Cj
else
Delete from C1 and C2 all the patterns which are not in h+. Store the result in new_C1 and
new_C2.
Separate(h+, new_C1, new_C2, new_factor)
Let new_factor = factor **and** (h,'-')
If the negative half-space determined by new_factor contains only patterns in the same class Cj **then**
Classify new_factor as Cj
else
Delete from C1 and C2 all the patterns which are not in h-. Store the result in new_C1 and
new_C2.
Separate(h-, new_C1, new_C2, new_factor)

Fig.6. Character recognition algorithm.

8.The main features of the neural network based OCR engine are:

1.Controlled stability-plasticity behavior
2. Controlled reliability threshold
3Both off-line and on-line learning
4 Self assessment of the output reliability

The controlled stability-plasticity behaviour of the system is regulated through certain parameters which instruct the system what to do in the case a character is near the validation threshold. The user can choose a more stable behaviour when such patterns are just rejected or arerecognised with a low confidence level or a more plastic behaviour when such patterns are incorporated further training in the body of knowledge of the system. It is desirable to have a system which is more plastic at the beginning and more stable afterwards. Another important feature of the system is the fact that the reliability threshold can be controlled by the user. Thus, it is the user who decides how to settle the inherent trade-off between reliability and recognition rate. This

trade-off is always present because, for any system and any degree of training, there will always
be characters which are close to something known but yet not quite like it. For those characters the system has to decide whether to report them as recognised or simply reject them and it is important that this decision be taken by the user in accordance with the requirements of the particular application. If the optional supervision signal is active, the system can learn on-line, adding the current pattern to the training set. If the chosen training algorithm is the backpropagation, the recognition engine will change only the weight state.

8.1Character validation approach

The approach used for the validation of the recognition stage was to reject those patterns which are very different from anything known (far in input space from any trained pattern) and those patterns which fall near the boundary zones between different classes. Such an approach uses the implicit assumption that the samples used in the training set are uniformly distributed in the input space i.e. there is no large region containing valid patterns which is not represented in training set. In other words, it was assumed that the training set has been chosen properly and it is representative for the problem. Each time a character is submitted to the recognition engine, the result of the recognition is fed into a validation module which has the task to decide whether the recognition is sufficiently reliable. This decision is based on a validation threshold which is fed to the system as a parameter. Thus, the user can decide how the system should behave. A lower validation threshold means that the system would rather reject acharacter whose recognition is not sufficiently reliable. A higher validation threshold means that the validation module would accept more easily the decisions of the recognition module. The validation threshold in conjunction with the optional supervision signal can adjust both the reliability and the stability-plasticity behaviour of the system to the needs of any particular application. The validation module can signal back to the character recognition module and even further back to the
character segmentation module if the degree of confidence of the recognition is low recognition with a higher degree of confidence. These feedback connections and the iterative process they
allow can be particularly useful in those (very frequent) cases in which the plate is dirty or damaged or when the image quality is low due to poor atmospheric conditions.
The implementation of the validation mechanism depends on the chosen OCR engine.

9. Conclusions

There are frequent situations in which a system able to recognise registration numbers can be useful. This
paper presents few such situations, a system designed to satisfy the requirements, Visicar, and some
experimental results obtained with this system.
The main features of system presented are:

- ·Controlled stability-plasticity behaviour (optional external supervisory input)
- ·Controlled reliability threshold (optional external validation input)
- · Both off-line and on-line learning
- · Self assessment of the output reliability
- · High reliability based on multiple feedback

The system has been designed using a modular approach which allows easy upgrading and/or substituting of various sub-modules thus making it potentially suitable for a large range of vision applications. The performances of the system makes it a valid choice among its competitors especially in those situations when the cost of the application has to be maintained at reasonable levels. Furthermore, the modular architecture makes Visicar extremely flexible and versatile.

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