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Research paper

A Broad Survey on Performance Analysis of Number Plate Recognition from Stationary Images and Video Sequences

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Abstract

Licensed Number plate recognition plays vital role in smart cities for maintaining Law & Order and traffic management. NPR based system mainly involves four stages namely 1) Image capture & Pre-Processing 2) Number plate area determination 3) Character Segmentations 4) Recognition of all character. This survey paper extensively analyzed the method of extraction of number plate, its platform, performance and execution time. With the development of Multilayer Perceptron Network accuracy and time in image processing has been achieved up to a great instant. Hence this analysis will help the precise assessment in establishing research and enable developers to assess which strategies are aggressive in present environment.

Keywords: ***Image Processing: Multilayer Perceptron: Neural Network: Performance Analysis: Optical Character Recognition (OCR)***

1. Introduction

Information technology is rapidly advancing with respect to automated system. Transport surveillance has been developed tremendously from simple to intelligent transport system which industry needed in the era of development. There are many needs due to which NPR system has evolved and now equipped with the latest technology. Requirement like traffic surveillance, Toll Payments, parking fees payments, stolen car recovery & on road Fatalities etc are some very urgent needs from society which require an intelligent solution to resolve number plate recognition rapidly. Number plate image segmentation is most challenging task in image processing for image analysis pattern recognition and computer vision [1][2].

2. Number Plate Recognition

Number Plate Recognition (NPR) based system mainly involves four stages namely 1) Image capture & Pre-Processing 2) Number plate area determination 3) Character Segmentations 4) Recognition of all character. Image processing technique is mainly used in first three stages on stationary image and frames sequence from video, whose calculation depend upon on the error recognition and true recognition rate and lastly recognition is done through various approaches [5].

2.1. Image Capture and Pre-Processing

After Image Capture, pre-processing of number plate is performed through many ways [5]. It is required to improve quality of image such as complex backgrounds, low lightening, damage or dirty plates (defects on the plate surface) shadow and to remove noise from image.

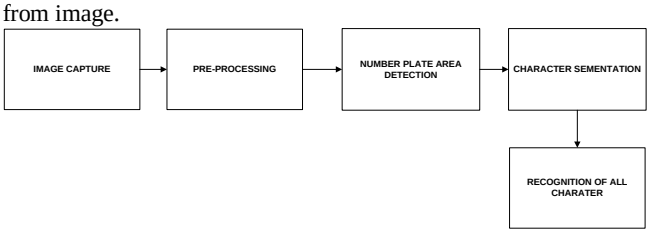


Fig. 1: Basic Block Diagram of NPR System

The Grey level methods are recommended widely because the use of color–based method has become very limited [6]. Otsu binarization method is used mainly for two reasons, one to highlight characters and other to suppress background noise [3]. Different techniques have been developed utilizing vector quantization, the Hough transform, Gabor transform and wavelet examination for this reason [7]. There are numerous areas with high densities of dark pixels on a white background in the NP region and recognized it utilizing adaptive vector quantization, Hough Transform on image edges [8].

2.2. Number Plate Area Determination

Our objective at this phase is to identify the Number Plate area from the original image utilizing edge-based image processing scheme. To handle this various method are developed for image enhancement like morphological methods, Canny edge detection, OCR etc [14]. Optical character recognition OCR is used for number plate area determination. It recognizes printed or written character by computer. OCR engines turn images of machine printed characters into machine-readable characters. This is done by photo scanning of text character by character, analysis of the scanned in image and then conversion of character image into

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character code. As there are many ways for NP area determination like Vertical edge detection for finding pixels with sharp changes in brightness along with skew correction for tilted image.



(a) (b)

Fig. 2: (a) Tilted Image (b) Skew corrected image after Horizontal and Vertical correction

2.3. Character Segmentation

Character segmentation is one of the most important step in NPR for all further steps. If it fails, NPR immediately gives the wrong results. In Threshold method image of number plate is converted into black and white ("zero" & "One") using threshold value. If pixel value is lower than threshold value, the new pixel value will be '0' else '1' for pixel with the value above the threshold value Otsu's Method [3]. Character segmentation is required to perform character recognition, which fully depends upon isolated character. Characters which are wrongly segmented are not likely to be identified successfully. Most of the recognition errors in NPR are not because of missing identification of character but due to segmentation error. In [17] they have utilized top-hat transformation and otsu threshold for segmentation.

2.4. Recognition of All Character

The last stage of NPR should be able to manage successfully any difficulty that may occur due to incorrectly segmented character from character segmentation. For character recognition many techniques like template matching using correlation, common pattern-matching technique, numerous algorithms, artificial neural network and computational intelligence architecture are used.

Template Matching

Template matching is a high level machine vision technique for detection and recognition of objects in computer vision community. Many techniques like Grayscale based matching, Naïve template matching, image correlation matching pattern correlation matching, edge based matching, image correlation matching etc have developed [20].

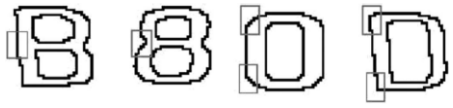


Fig 3: Distinguishing parts of ambiguous characters

Neural Network

Artificial intelligence (AI), deep learning, and neural networks represent exciting and powerful machine learning-based techniques used to resolve many challenges from the real-world [11]. A Neural Network (NN), is a numerical model or computational model that tries to repeat the structure or potentially practical neural networks. NN is an information organizing perspective that is blended by the way trademark material frameworks, for instance, the brain, process information. The key piece of this viewpoint is the novel structure of the data preparing system. It is made out of a broad number of fundamentally interconnected preparing portions (neurons) working as one to manage particular issues like pattern matching [9]. NNs, similar to individuals, learn by case. A NN is proposed for a particular application, for example, handwriting recognition , number plate recognition, diagram recognition or information game-plan, through a learning technique [4].

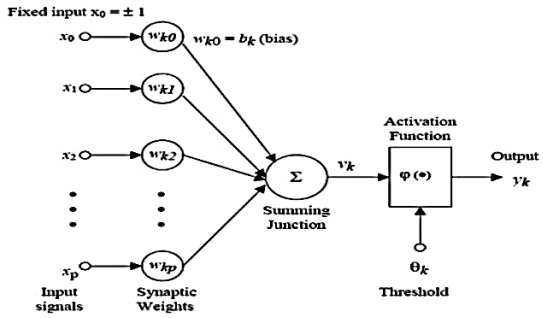


Fig 4: Artificial Neural Network

Back Propagation Network

BPN is used for training artificial neural network with mathematical foundation [18]. Back-propagation algorithm is intended for multilayer perception (MLP) to settle and register its parameters to limit a suitable cost capacity of its yield. The approach utilized in multi-layer forward network with gradient descent based on delta-learning rule alongside a guided training scheme [4]. The readiness algorithm of back propagation incorporates four stages:

1. Initialization of weights (some little arbitrary esteem)
2. Feed forward
3. Back propagation of mistakes (target - output)
4. Update the weights and inclinations

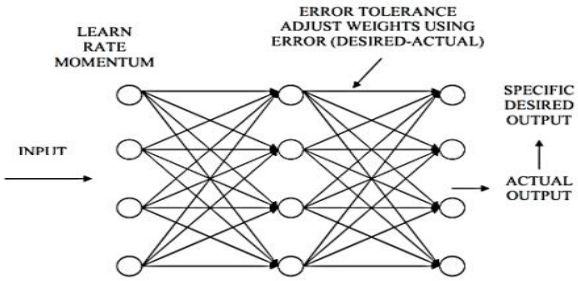


Fig 5: (a) Back Propagation network

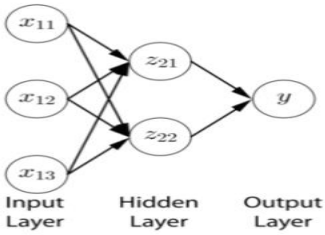


Fig 5: (b) Hidden Layer

The back propagation architecture is multilayered (hidden layer in between input layer and output layer) and designed in manage forward outline with the ability to send back the bungle between the genuine yield and the target yield regards. Each layer contains interconnected components that carry on like delicate straight classifiers. Every component figures a weighted entirety of the sources of info and changes the aggregate through a nonlinear squashing capacity. The learning is satisfied by cycles of altering the weights on every connection in order to limit a target work that was prevalently the mean square mistake between Back propagation was utilized to ascertain the slope of the target work.

3. Related Work

Y. Shima [9] reported a technique that is fit for extraction of number plate region in the car image fetched at various distances from its back side. The system examines the input image and distinguishes the region of the number plate. The number plate location is fetched by utilizing dilation morphology and the number of connected components in the region and scoring based on the height width ratio. In this image extractor pre-trained convolution neural network is used as a classifier, support vector machine is used. The algorithm was implemented by C++ in morphological image processing in MATLAB and deep learning with pre-trained Convolution neural network. Edge detection for Morphological image processing was depending upon on connected components. Based on the outcomes, approaches are suited for rear image. The number plate extraction, rate of success was 89.7% among 126 sample images.

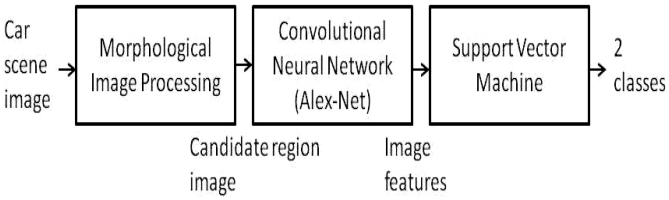


Fig. 6 : A flow of number plate image extraction using deep learning.



(a) Input color image



(b) Gray Image



(c) Detected edge Image



(d) Binary edge



(f) Extracted number plate



(e) Dilated Image

Fig. 7: (a) (b) (c) (d) (e) (f) Example of processed image.

Türkyılmaz, İ. and Kaçan, K in [11] their research work image processing algorithms are used to enhance image by improving system performance. The license plate location (rectangular shape) is fetched by utilizing edge based image processing approaches on the binarized image. The region of plate is prepared for the character segmentation with the help of skew correction phase. Vertical projection is used for characters separation. Character recognition is achieved by segmented characters with the help of thinning process. A three layer feedforwarded artificial Neural network utilizing back propagation learning algorithm is designed with the help of character recognition stage for 357 test images in data set taken under specified conditions. Results show a success rate of 97% with system processing time duration is 60ms in all images.

Table 1: Performance of the LPRS

LPRS stage	Number of images/ success	Performance (%)
LP region determination	357/357	100
Character segmentation	357/357	100
Character recognition	357/346	96.92

B. V. Kakani, D. Gandhi and S. Jani, [12] used a blend of algorithm for Localization & computation of different OCR algorithm for recognition of license plate. After processing 300 images of different characters for training of neural network with input comprises of 30 neuron and output 36 neuron.

Table 2: Comparative analysis of different method for localization Algorithm.

Algorithm	Accuracy	Computation Period	Comments
Projection Technique	89%	0.91s	Effective for different styles of NP
Morphological Operation	96.7%	0.54s	Effective on noisy images
Feedback selflearning and Hybrid binarization	97.1	% 0.51s	High complexity, low resolution images required
Feature salience	97.3%	0.23s	High resolution, low noise images required.

They have trained ANN for 300 iteration which took around 15 seconds to complete by using FFBPNN for learning and logsigmoid function at the hidden layer. The proposed algorithm designed after all the work gave an accuracy of 94.45% in less than 1 second is claimed.

Table 3: Different Calculations of OCR algorithms.

Algorithm	Computational time (ms)	Detection rate (%)
i-novel	470	73%
Template matching	1000	94%
Width analysis	430	86%
ANN using template Matching	176 (post training)	89.4%
ANN using feature Extraction	**75 (post training)**	**92.2%**

JosephTarigan Nadia Ryanda Diedan and YayaSuryana [17] they have used top-hat transformation and otsu threshold with Genetic Algorithm in optimising the number of hidden neuron, learning rate and momentum rate on BPNN that is applied on NPR. They analysed 220 photos with various lightening condition and plate condition as the sample for recognition. They found 85.97% success rate in whole characters recognition and 97.18% in single character recognition accuracy by using GA in BPNN.

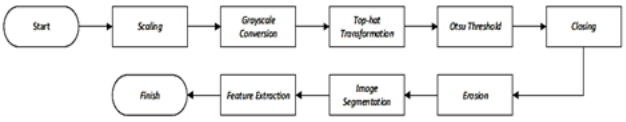
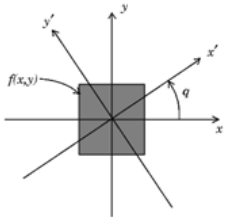


Fig 8: Pre-processing flow

N. Wang, X. Zhu and J. Zhang [18] have developed Set of Algorithms for Chinese Number plate's segmentation and recognition. Four algorithms of image pre-processing, number plate location, number plate segmentation and character recognition are developed. Specifically they have developed a formula for number plate

location as per Chinese plate standard and use radon transform to correct license plate image. In this training model is generated using the character segmentation image by BPNN. Finally 11 Number plates have been correctly verified out of 13 which give 84.62% number plate recognition rate. Out of 91 characters 89 have been recognized correctly with gives 97.80% character recognition rate.

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$



(a) (b)

Fig 9: (a) (b) Radon Transform for number plate location

R. Shandilya and R. K. Sharma, [13] in used a simple and effective Image enhancement based on FPGA for Automatic Number Plate of vehicle detection. In this the most challenging problem for Number Plate identification is their image quality for all those images which are captured in low light during night, due to low visibility quality of all image got degraded and will be out of focus due to vehicle movement is considered as well. In this work techniques used for image enhancement such as contrast, brightness control and sharpness which are vital for noisy and blur image. The algorithm discussed has been implemented on Xilinx Virtex-V FPGA device. For proposed implementation evaluated average process delay is around 4ns with power 102mW.

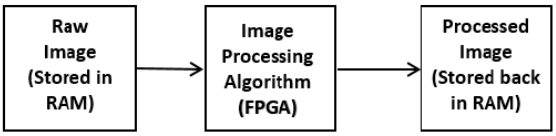


Fig10: Block diagram of Image Enhancement System

Table 4: Comparison of implemented architecture design with existing design

Architecture	M.Chandrashekar et. Al [8]	Wan Bing-jian et. Al [11]	Abduallah M. A. el. Al [6]	Proposed
Implementation	Infrared Image Enhancement using Successive Mean Quantization Transform	Plateau Histogram Equalization	Histogram Equalization	Sharpness Control & Histogram Equalization
Device	Xilinx Virtex E 2000 FPGA	EP1K1100QC208 of Altera Acexlk	Stratix II family chip type EP2S15F484C3	xc5vlx330-2ff1760 FPGA
Area	I/O cells 34 of 454 (7%), Block RAMs 48 of 56 (86%)	I/O cells 25 of 160 (40%), 32x1 RAMs 256	*	I/O cells 32 of 1200 (2.6%), Block RAMs 800 of 10,368 (7.7%)
Time Period	*	108.807ns	0.262ms	4ns
Power	*	*	*	102mW

S. S. Omran and J. A. Jarallah in [14] reported a system of automatic license plates identification among three different style Iraqi car license plate. Three styles of license plate were distinguished by their plate size. The templates matching and correlation approach was used with optical character recognition OCR for plate recognition by segmenting each character, number and word into sub images. For thresholding they have used Otsus mehod and morphological operations to enhance the image. The system is analyzed over 40 images and finally it gives 87.5% for extraction of plate region and approx 85.7% for the recognition unit accurate, giving the overall system performance of 86.6% recognition rate.

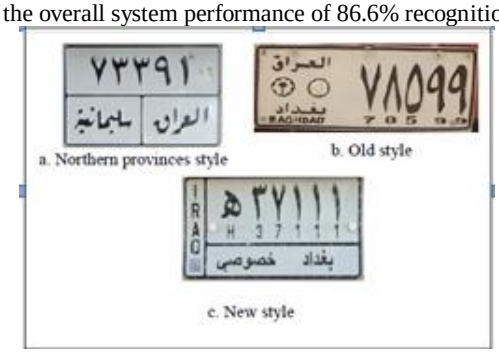


Fig.11 (a) Iraqi car license plate types

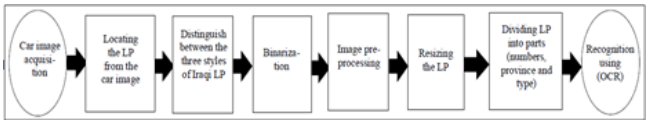


Fig.11: (b) The main stages of the proposed systemare

A. Y. Felix, A. Jesudoss and J. A. Mayan, in [15] used Adaptive Histogram Equalization , active contour method for region separation Optical Character Recognition to recognize the characters and Neural Network for Monitoring entry and exit using license plate recognition. They have used Deep Neural Network approach for classification and extracting the text as an alphanumeric character and comparing the text with the predefined table created in MYSQL server. In the proposed system they applied extraction of characters from the license plate and changing the status accordingly with comparing to the table works with an 100% accuracy level.

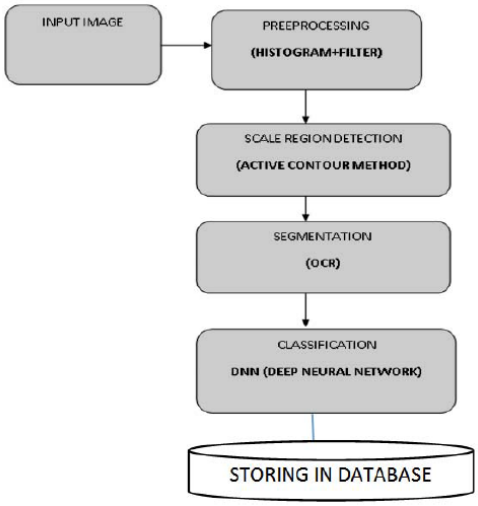


Fig 12: Block diagram of license plate recognition

A. Farhat *et al*., [16] have applied four algorithms for comparison of Qatari number plate's recognition system. Template matching and feature extraction such as (zoning, combined zoning and vector crossing) algorithms are used in this approach. A data set of 2790 segmented characters is used for all proposed algorithm which are verified and tested on MATLAB. Outcome have shown the higest recognition rate of 99.5% for the algorithm which are based on template matching and utilizes average processing time of 1.95ms for one image. It is observed that it is the most nose tolerant method and is the able to detect rotated characters. Which optimize the system complexity of the ANPR system as it might avoid the need for an extra pre-processing stage to adjust rotated Number Plates.

Table 5: Performance of Different OCR Algorithms

OCR Technique		Platform		Recognition Rate [%]	Processing Time per character [ms]
Proposed	Vector crossing	Intel Core i7 -4770s - 3.1 GHz 8 GB of RAM	MATLAB	90.43	1.33
	Zoning			85.27	1.33
	Zoning and vector crossing			90.43	1.46
	Correlation			99.50	1.95
Others	[1]	Dual Core - 2.4 GHz – 3 GB of RAM		97.3	8.4
	[6]	Intel Core i3 -2330M - 2.2GHz – 2 GB of RAM		97	Not available
	[7]			99	Not available

Mahamad A.K in [10] proposed an automatic inspection system to recognise Malaysian vehicle plate number using Lab-

VIEW software. In this paper they have used to approaches which contains two major modules. Firstly, to locate region of Interest (ROI) in captured image of license plate. Secondly, they have used concept of Optical Character Recognition (OCR) for Vehicle plate number recognition module to identify all individual character for each number plate which contains different alphanumerics. This system is tested for various implementations to ensure that the proposed method can be applied for real implementation. An intelligent OCR training interface has been used as library. The proposed system shows good performance for inspection and can recognise an alphabets and number of vehicle number plate.

Yo-Ping Huang, Shi-Yong Lai and Wei-Po Chuang [19] have designed a system to achieve automatic recognition of number plate which is intend to have high accuracy and reliability of number plate recognition. They reported a framework to identify the system of license number plate recognition in the captured image from a video. There are four major stages for recognition process. First, they have utilized gradient analysis and image processing approach which attempt to identify the most probable location of the license plate. Second, they have used cross-correlation to identify the tilt through skew correction of the license plate and it compute the vital image parameters which is required to normalize the position of license plate. Finally, for characters recognition they have utilized a template technique. Collectively all the previous steps are utilized to identify the probable license number plate. Hence the proposed system is successfully able to recognize the license number plate in only 1.5 seconds.

4. Conclusion

The main objective to discuss multiple techniques in this paper was to identify developments in Number plate recognition (NPR) system that involve fast processing, less computing power and which technique has best recognition rate with few restriction. Researchers have used Template matching, SVM, Canny edge detection, Neural Network, BPNN, Genetic Algorithm Feed forwarded Neural Network, fuzzy logic, FPGA to search for robust technique to recognize each character in number plate accurately. Undoubtedly in future Neural Network can bring high correctness rate with cent percent recognition accuracy. It ought to be observed that there are numerous commercial NPR systems whose analysis is beyond the scope in this research. That is only because of their commercial technology which is confidential and often results are overestimated for showoff purpose only. All the work which is discussed in this paper will surely support the practical performance evaluation to research forum globally and enables researchers to select which methods are best suited for which application in the field of number plate recognition.

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