Comparison of Various Edge Detection Filters for ANPR

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Abstract— **Automatic Number Plate Recognition (ANPR) can be identified as a technology which has been developed mainly based on Image Processing methodologies. It is being widely used in identifying vehicles in applications such as red-light enforcement, over speeding, bus lane control, motorway road tolling, border control and access/parking control. However axioms of ANPR rest on Image processing approaches such as binary conversion, morphological functions, filtering and edge detection algorithms. By researching on the solutions which have been suggested through numerous approaches to implement ANPR, this paper will focus on edge detection methodologies. A comparison is made between the edge detection filters Sobel, Canny, Gabor and Log-Gabor, using a variation of preprocessing techniques and using template matching as character recognition method. The algorithms are compared for accuracy as well as processing times. It is observed that as an all-round algorithm, Log-Gabor outperforms others. In terms of processing time, it is second only to Sobel. It has not been used in ANPR and hence has been identified as a suitable candidate for ANPR.**

Keywords—**Edge detection, ANPR, number plate recognition, Sobel edge detector, Canny edge detector, Gabor filter, Log-Gabor filter, template matching**

I. INTRODUCTION

Vehicle identification using Automatic Number Plate Recognition (ANPR) methods are widely being used in many applications. Hence, ANPR is no longer a new approach to the technology, rather a more common approach. Over the time, applications of the ANPR have spread into security establishment applications such as criminal activity monitoring and smuggling identification systems other than the widely used applications of traffic control and Tolling all around the world [1]. An important feature of the Number Plate Recognition system is to keep record of the vehicle's number plate image for other process if further required. Furthermore, ANPR technology does not require any additional installation in the vehicles, which differentiates it from other technological initiatives that may involve new installation, like driver carrying a transmitter manually or adding transmitter on the vehicle. ANPR technology is region specific, because of the differences in number plates across different regions; variations in size, font and color may exist [2, 3]. However, ANPR systems are based on Image processing or Image Sequence Processing; the latter will be gathered using any image capturing device.

The main process of plate recognition consists of steps such as Image Capturing, Pre-processing, Character Segmentation and Character Recognition [4]. If there is identification or verification process involved with application, the system will need to be connected to the respective database in order to achieve required outcome. Among these main steps, the most significant part is usually the image preprocessing step which enhances/improves the input image to a level that characters can be segmented in a correct method. Therefore, the reliability and accuracy of the ANPR systems rely on the methods that are used in preprocessing.

Based on the importance of the pre-processing steps used in approaches to ANPR, the aim of this paper is to compare various edge detection filters involved in the process of plate recognition. Edge detection can be identified as a sub-process of the pre-processing techniques that can be applied to an input image-tasks such as gray scaling, binary conversion, noise removal, performing morphological functions to recreate or develop the images acquired- can be considered as some of the other tasks which can be performed before an image is passed through edge detection in the preprocessing phase. By applying edge detection filters, the image is converted into an image with boundaries of the objects which exist in input image. This narrows down the process of identifying characters so that the objects identified through processing boundaries can be used to segment the characters, which are then used in character-recognition.

Mainly four different edge detection filters will be used in turn by applying them on same input image; the results will be compared. Sobel, Canny, Gabor and Log-Gabor edge detection filters are the four candidate methods which will be analyzed. These are the filters/algorithms normally used in APNR. It may be noted that other preprocessing steps such as noise removal and performing morphological functions as well as character segmentation and character recognition will be same.

II. LITERATURE REVIEW

Previous research studies on Sobel, Canny, Gabor and Log-Gabor Filters have been carried out. However, these 4 have not been compared side-by-side. Some information of these filters as well as relevant research is discussed:

A. Sobel Edge Detector

It is also known as 'Sobel-Feldman operator' since the algorithm was developed by Irwin Sobel and Gary Feldman

978-1-5090-2000-3/16/$31.00 ©2016 IEEE

[5]. This algorithm acts as a discrete differentiation operator, while computing an approximation of the gradient of the image intensity. Hence, this operator will build a gradient vector or a norm of the same in each point of the image as an output. The filter is convolved with the image in vertical and horizontal directions, making calculations simpler [6].

B. Canny Edge Detector

Developed by John F. Canny [7], Canny operator was used to detect wide range of edges in an image with the help of a multi stage algorithm. In order to meet the criterions of capturing edges with a minimum error rate, detected edge point should be accurately localized at the center of the edge by the operator and an edge should be marked only once whilst preventing false edges being created. Canny used calculus of variations to build the functionality required. Through this, Canny edge detection algorithm was developed using main steps as application of Gaussian filter for noise removal, intensity gradient calculation, application of non-maximum suppression, application of double threshold and finally tracking edges through hysteresis [8].

C. Gabor Edge Detector

It is a linear filter proposed by Dennis Gabor for edge detection for image processing applications [9]. Gabor filter was developed according to similar effects of the human visual system with respect to Frequency and Orientation representations. Hence they have been found to be particularly appropriate for texture representation and discrimination [10]. Further to that, Gabor filter can be identified as a Gaussian kernel function modulated by a sinusoidal plane wave when considering 2D applications with respect to spatial domain [11].

D. Log-Gabor Edge Detector

When compared with the Gabor Edge Detector, Log-Gabor Edge detector was built with the solutions for main limitations which exist in Gabor; the maximum bandwidth limitations and limitations in broad spectral information when considering maximal spatial localization. Hence Log-Gabor edge detection has been introduced with the ability to be constructed with arbitrary bandwidth and the bandwidth can be optimized to produce a filter with minimal spatial extent [12]. It was proposed by D. Field [13].

E. Pros and Cons of the Edge detection methods

Table I compares the pros and cons of the four candidate algorithms/filters.

TABLE I. PROS AND CONS OF THE EDGE DETECTION METHODS [14]

Method	Pros	Cons
Sobel Edge Detection	•Ease of application •Ability to detect edges along with the orientation as well	• Responsive to noise existence •Less accuracy in detection
Canny Edge Detection	•Use of probability theorems in computing error rate •Localizing and responsive ability •Enhanced SNR •Tolerance to existence of noise	•Computational complexity involved in edge detection •Existence of false zero crossings when measuring edges
Gabor Edge Detector	•Accuracy in locating edges •Involving a wide area of pixels	•Less responsive to variations of gray intensity levels when detecting edges of curves and corners • DC component exists
Log-Gabor Edge Detector	• Ability to detect edges along with the orientation as well •Built with fixed features for every direction • 0 DC component	•Considers existing edges as well when performing detection •Responsive to noise existence

III. EXPERIMENTAL SETUP

Other than the section of edge detection process all the other sections were kept unchanged when comparing the results of the edge detection filters. Hence, noise reduction under preprocessing and character segmentation and character recognition was kept unchanged. Process maps provided under Figure 1 and Figure 2 will give a better idea of how the program structure was made to test the image samples of number plates using each edge detection methodology.

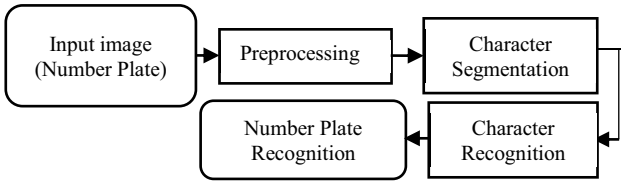


Fig. 1. Software Block Diagram

A. Software Block Diagram

Software block diagram can be built according to the sequence of the processes, starting from the extraction of Number Plate image and ending on recognition as output. Input image can be taken from any suitable image acquisition camera with required quality.

In this work, images which have already been acquired will be used as inputs. Preprocessing will be done to prepare the image in a way that the characters can be easily segmented. Character segmentation will be completed according to the connected objects which exist in preprocessed image. Finally, character recognition will be completed by matching the segmented objects with a template of characters. Since edge detection is a part of the preprocessing stage, the above block diagram can be further divided into sub processes considering the Preprocessing task, as shown in Figure 2.

For this work, only Edge detection section will be changed in order to meet our goal of comparing the effect of edge detection filters in ANPR.

B. Software Implementation

All the testing and experimentation were carried out using Matlab®, so the software implementation was through Matlab scripts to run simulations of the procedures of number plate recognitions.

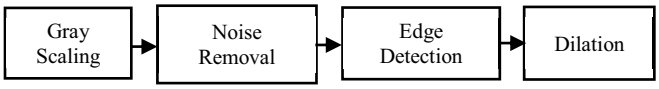


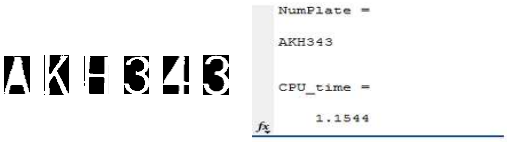
Fig. 2. Sub processes division of preprocessing task

According to the software block diagram, first step is to read the image of the number plate. This was completed using 'imread' command. Afterwards 'rgb2gray' command was used to obtain the grayscale image as the first step of pre-processing. Then noise removal was performed using median filter with a window of 3, this was done through command 'medfilt2', followed by thresholding. Upon completion of the above pre-processing steps, edge detection filter was applied and then the resulting image was made to undergo a dilating process with use of 'imdilate' command as the final step in image preprocessing.

These preprocessed images through each edge detection filter will then be used to segement the characters using 'regionprops' function and then through a template matching process, characters will be recognized; The segmented characters are fed into template matching which is an effective algorithm for recognition of characters. The character images are compared to the ones in the pre-built database and best matching character from database is selected. In order to measure the best match and similarity, a statistical method (correlation) is used; it was developed by Horowitz [15]. Final output of the script will print the recognized characters in the command window of Matlab with CPU time consumed. All these steps are summarized in Figure 3.

(a) Input image (b) Gray scale image (c) Edges detected before noise removal

(d) Thresholding applied (e) Edges after processing (f) Dilated image



(g) Character segmentation (h) Number plate extracted & processing time

Fig. 3. Software implementation of Algorithm from image (a)-(h)

Fig. 4. Sobel edge detection, dilation, character segmentation and character recognition with processing time

Figure 4 depicts the steps involved with Sobel edge detection until the character recognition, using an image under normal light illumination conditions; the same is repeated for other filters as well, in order to compare performance.

IV. RESULTS

The algorithms were tested for different light illumination conditions. After testing the images without applying noise reduction and thresholding, it was observed that the edges detected by Gabor and Log-Gabor were more clear and were segmented properly, than Sobel and Canny filters. Observations after applying thresholding only showed excellent results for all the filters; relatively Log-Gabor filter consumed lesser time than Gabor. Overall, Sobel filter has low processing time as compared to other three filters.

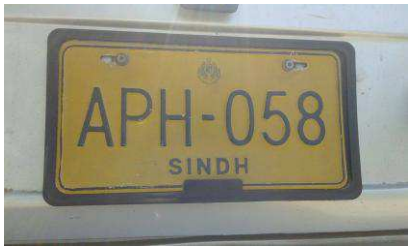


Fig. 5. Input image for testing low light illumination

Fig. 6. Edges detection, character segmentation and number plate recognition using Sobel, Canny, Gabor and Log Gabor filter respectively, for low light illumination input image

TABLE II. CPU Time Recorded (Average Values)

Edge Detection Filter	Sobel	Canny	Gabor	Log-Gabor
CPU Time	1.2480	1.7628	3.8594	1.5156

With these observations, we applied all the edge detection filters by first performing noise reduction and thresholding; accurate results were achieved for all, showing that all of them can be considered for ANPR, depending upon the application being used for, at cost of time consumption and best fit for application.

Thereafter, a low light illumination number plate image was tested (shown in Figure 5). The above procedure was repeated for different edge detection filters. All filters were successful in extracting accurate characters. The results are shown in Figure 6. The time taken to process the outputs was captured as well, which can be also considered as the CPU time. Table 2 shows the average values of the CPU processing time for all candidates. It was observed that Sobel and Log-Gabor filters took the least time in producing outputs.

V. Conclusions

This research paper presented a comparison of different edge detection filters. Pre-acquired images of number plates were used as inputs. Pre-processing involved combinations of thresholding and noise removal. Segmented characters were matched with the database characters using template matching method for recognition of plate characters.

It may kindly be noted that ANPR is region specific; we carried out these tests using Sindh, Pakistan car number plates with different light illumination conditions. The results achieved, with applying all pre-processing steps mentioned, showed above 97% of accurate number plate recognition accuracy for all the filters being used as edge detection tools, having different processing times. The results are encouraging as the 'being-researched' Log-Gabor filter can provide best results for character recognition in ANPR, with less time consumption. Also, Lag-Gabor has no DC component problem which exists in Gabor filter.

The Log-Gabor filter has not been used in ANPR, as per existing knowledge and these results support its case as a suitable candidate.

VI. Future Work

In future studies the algorithm used can be redesigned for multinational car number plates. Also, this work can be extended to further analysis of Log-Gabor filter as a suitable candidate for OCR.

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