Image Analysis Algorithms for Recognition Systems

R. Al-Hmouz
Department of Electrical and Computer Engineering
King Abdulaziz University
Jeddah, Saudi Arabia

K. Aboura
College of Business Administration
University of Dammam
Dammam, Saudi Arabia

Abstract: We describe a series of algorithms for recognition in image analysis. In management support systems using image object recognition, the intelligence resides in the statistical algorithms rather than in the image processing. Image processing transforms information from the real world into image data represented by matrices. The manipulation of these real valued matrices requires mathematical and statistical solutions in order to locate objects in the images and reach conclusions regarding problem targets. We describe a number of solutions, from the initial thresholding step to localization and recognition of image elements. Some of these techniques use frequency signals from the images which we analyze through the Discrete Fourier Transform. These algorithms, along with many others in the business of visual surveillance, provide the effectiveness for an ever prevalent form of building and properties management.

Keywords: image Analysis, probabilistic modelling, signal processing

1. Introduction

In this article, we use the problem of License Plate Recognition (LPR) to highlight a number of algorithms that can be used in image analysis problems. In management support systems using image object recognition, the intelligence resides in the statistical algorithms rather than in the image processing. Image processing transforms information from the real world into image data represented by matrices. The manipulation of these real valued matrices requires mathematical and statistical solutions in order to locate objects in the images and reach conclusions regarding problem targets. We describe a number of statistical solutions, from the initial thresholding step to localization and recognition of image elements. Some of these techniques use frequency signals from the images which we analyze through the Discrete Fourier Transform. These algorithms, along with many others in the business of visual surveillance, provide the effectiveness for an ever prevalent form of vehicles, building and properties management. They can also be used in other areas. For example, Optical character recognition (OCR) is the technology of identifying written or printed text that are included in images using image-processing algorithms. OCR is a well-explored problem. It has been used and commercialized in many applications that include LPR, libraries, banks, converting document into text searchable
document in scanner and sorting mail in post offices. Some of our solutions apply in such contexts.

2. License Plate Recognition

Many around the world contributed to research in license plate recognition. LPR systems are in use in several countries and Britain has an extensive ANPR (Automatic Number Plate Recognition) CCTV network. Such achievements took many years of research. However, the problem remains difficult to solve perfectly. For example, in many countries the law still requires the plate number of an infringing car to be recognized visually. This reliability issue keeps the LPR problem an active research topic of interest. LPR uses video captured images to automatically identify vehicles through their license plate. LPR finds applications in theft prevention, parking lot management, hotels and property management, traffic laws enforcement, border control etc. There are other methods to identify cars such as transponders, bar-coded labels and radio-frequency tags. License plate reading remains however the way a vehicle is identified. LPR attempts to make the reading automatic by processing sets of images captured by cameras. There are three steps in the process; (1) detecting a vehicle, (2) triggering the captures of images related to that vehicle and (3) treating those images for recognition of the characters in the license plate. The capture of the images, their transfer in digital form to a processor and the coordination of all tasks in a LPR system is a feasible engineering problem. The processing of images for recognition is where research starts. LPR has three main parts; (1) localization of license plate from image, (2) segmentation of characters from localized license plate region and (3) recognition of those characters. These steps are performed automatically by software and therefore require intelligent algorithms to achieve a high reliability.

Plate localization is the first step in LPR. It aims to locate the license plate of the vehicle in an image. Some of the existing methods are morphological operations, edge detection, corner detection, sliding concentric windows, fuzzy logic, spatial variance method, Hough transform, neural networks, mean shift algorithm, Fourier transform, Gabor transform, Wavelet transform, the generalized symmetry transform, the genetic algorithm and the adaptive boosting (AdaBoost) algorithm. The second task in LPR is to extract the characters from the localized license plate region. The most common method is the projection method. First, the image is thresholded, reduced from a color or gray-scale image to a black and white (background/foreground) image. The projection method then counts the number of foreground pixels vertically and horizontally in the license plate area to separate and extract the characters. Other methods and variants include, thin window scanning, local vector quantization, scale shape analysis, Laplacian transform, Hough transform and Markov Random fields. The final task in LPR is the recognition of characters. An optical character recognition (OCR) algorithm is used to recognize characters in regions of the image. A series of approaches were developed. The most common ones are the correlation-based template matching, and neural networks. Other methods are feature based, use pattern mapping or are based on the Hausdorff distance. Binary classifiers are used as well as the Hidden Markov model (HMM) and probabilistic modeling (Aboura, 2007). All three steps in LPR rely on thresholding, or binarization, of the original image. A common approach is the well cited Otsu method (Otsu, 1979). The Otsu method performs rather poorly in LPR if applied to the
whole image. The resulting binary image often doesn’t show the license plate characters as foreground. In Aboura (2008a), this topic is discussed and a new thresholding method is introduced. We review some of the statistical and signal processing methods that address the above problems.

3. Methodology and Results

A variety of approaches have been proposed to localize a license plate in captured video images. Al-Hmouz and Aboura (2014) introduce a new approach of plate localization using a statistical analysis of Discrete Fourier Transform of the plate signal. The plate signal is represented by five statistics: strength of the signal, normalized maximum amplitude, frequency of maximum amplitude, frequency center and frequency spread. Combining with the color-based histogram thresholding (Aboura, 2008a), the method achieves 97.27% accuracy using plate signals from binary images. Fast Fourier Transform (FFT) is an efficient algorithm used in signal processing and partial differential equations. The idea is that license plate numbers show frequencies that lead themselves to a spectral analysis through the Fourier transform. Al-Hmouz and Aboura (2014) introduce a formal statistical analysis of the Fourier transform data from a systematic scanning of the image. The discrete Fourier transform is a transform of discrete-time signals. It is used in signal processing to analyze the frequencies contained in a sampled signal. Al-Hmouz and Aboura (2014) first use the Hysteresis thresholding (Canny, 1986) over scanned regions of the image to obtain a clear signal. They then improve the speed of the methodology and its accuracy by thresholding the whole image using the binarization approach of Aboura (2008a). Figure 1 shows the signal after a number of processing steps.

![Figure 1. Fast Fourier Transform of Signal S](image)

The behavior of the power spectrum of the scanned region shows a significant increase in magnitude at some frequencies for scanned regions that contain the license plate or parts of it. This is due to the periodicity in the signal generated by the characters of the license plate. A set of 5000 images was used as historical data. The images were taken at a parking lot entrance.
Each image was visually inspected for the existence of a car in it. For the image signal, 5 statistics were considered and used in a statistical model. A Bayesian analysis delivered high probability candidate regions in the image. To locate the license plate in one of the candidate regions, another probabilistic method was used that yielded the achieved accuracy. Al-Hmouz and Aboura (2014) used a global thresholding method to improve significantly the performance of a signal processing localization algorithm. This is in contrast to most methods that use a local thresholding approach in view of the fact that global thresholding is hard to perform adequately. The global thresholding method of Aboura (2008a) was effective in highlighting the signal of the license plate (Figure 2.a). An more effective global thresholding method experimented with consisted of the color-based method of Aboura (2008a) coupled with a range of techniques including clustering. In a striking result, all but the characters of the license plate remained as foreground in the thresholded image (Figure 2.b).

(a) 

![Global Thresholding Method](image1.png)

(b) 

![Experimental Method](image2.png)

Figure 2. Image Thresholded using (a) Global Thresholding Method  
(b) Experimental Method

Such an approach would eliminate the need for a localization algorithm and facilitate greatly the recognition of the characters. In most cases, only some of the characters or part of remained as
foreground. This still reduces considerably the localization of the license plate. This research was not completed and is a future direction of work. Finally, for character recognition, Aboura (2008b) presents a probabilistic method as a simple and inexpensive method to solve the relatively important recognition problem.

Conclusion

In this paper, we described a number of solutions that could be used in LPR system and we showed how effective to consider global thresholding algorithms in the LPR along with other techniques that uses frequency of signals from the images by means of the famous Discrete Fourier Transform in order to localize license plate. For further research, more probabilistic approaches can be investigated in the localization, segmentation and recognition of license plate

References

1. Aboura, K. (2007); Probabilistic Optical Character Recognition for License Plates Identification; Technical Report, School of Computing Communication, University of Technology Sydney
2. Aboura, K. (2008a); Automatic Thresholding of License Plate; International Journal of Automation and Control, Vol. 2, Nos. 2-3 (pp. 213-231)
4. Aboura, K. and R. Al-Hmouz (2007); Probabilistic License Plate Optical Character Recognition; Technical Report, School of Computing and Communication, University of Technology Sydney
6. Canny, J. (1986); A Computational Approach to Edge Detection, IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 8 , No. 6 (pp. 679-698)