Faculty of Information and Communication Technology

TEMPLATE NEURAL PARTICLE OPTIMIZATION FOR VEHICLE LICENSE PLATE RECOGNITION

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DECLARATION

I declare that this thesis entitle "Template Neural Particle Optimization for Vehicle License Plate Recognition" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……..

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APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Information and Communication Technology.

Signature	:	……..
Supervisor Name	:	**PM DR ABD SAMAD BIN HASAN BASARI**
Date	:	…….....

DEDICATION

This thesis is dedicated to my family especially my parent for always supporting me throughout all these years.

ABSTRACT

The need for vehicle recognition has emerged from cases such as security, smart toll collections and traffic monitoring systems. This type of applications produces high demands especially on the accuracy of license plate recognition (LPR). The challenge of LPR is to select the best method for recognizing characters. Since the importance of LPR arises over times, there is a need to find the best alternative to overcome the problem. The detection and extraction of license plate is conventionally based on image processing methods. The image processing method in license plate recognition generally comprises of five stages including pre-processing, morphological operation, feature extraction, segmentation and character recognition. Pre-processing is an initial step in image processing to improve image quality for more suitability in visualizing perception or computational processing while filtering is required to solve contrast enhancement, noise suppression, blurry issue and data reduction. Feature extraction is applied to locate accurately the license plate position and segmentation is used to find and segment the isolated characters on the plates, without losing features of the characters. Finally, character recognition determines each character, identity and displays it into machine readable form. This study introduces five methods of character recognition namely template matching (TM), back-propagation neural network (BPNN), Particle Swarm Optimization neural network (PSONN), hybrid of TM with BPNN (TM-BPNN) and hybrid of TM with PSONN (TM-PSONN). PSONN is proposed as an alternative to train feed-forward neural network, while TM-BPNN and TM-PSONN are proposed to produce a better recognition result. The performance evaluation is carried out based on mean squared error, processing time, number of training iteration, correlation value and percentage of accuracy. The performance of the selected methods was analyzed by making use real images of 300 vehicles. The hybrid of TM-BPNN gives the highest recognition result with 94% accuracy, followed by the hybrid of TM-PSONN with 91.3%, TM with 77.3%, BPNN with 61.7% and lastly PSONN with 37.7%.

ABSTRAK

Keperluan dalam mengenalpasti kenderaan kian meluas dalam pelbagai kes seperti keselamatan, kutipan tol pintar dan sistem pemantauan trafik. Perihal ini menyebabkan peningkatan permintaan terutamanya pada ketepatan mengenalpasti nombor plat kenderaan. Cabaran dalam mengenalpasti nombor plat kenderaan adalah untuk memilih kaedah yang terbaik dalam mengenalpasti aksara. Oleh kerana kepentingan dalam mengenalpasti nombor plat kenderaan kian meningkat, terdapat keperluan untuk mencari alternatif terbaik bagi menyelesaikan masalah ini. Pengesanan dan pengekstrakan nombor plat kenderaan secara konversional adalah berdasarkan teknik pemprosesan imej. Kaedah pemprosesan imej dalam sistem pengenalpastian nombor plat kenderaan umumnya terdiri daripada lima peringkat termasuk pra-pemprosesan, penapisan, pengekstrakan ciri, segmentasi dan pengecaman aksara. Pra-pemprosesan adalah langkah awal pemprosesan imej bertujuan untuk meningkatkan kualiti imej agar ianya menjadi lebih sesuai dengan persepsi visual atau pemprosesan komputer manakala penapisan diperlukan untuk menyelesaikan perbezaan ketara dalam peningkatan pixel, membuang data yang tidak berguna, menyelesaikan isu kekaburan dan bagi tujuan pengurangan data. Pengekstrakan ciri digunakan untuk mengesan dengan tepat kedudukan nombor plat kenderaan dan segmentasi digunakan untuk mencari dan mengasingkan setiap aksara pada nombor plat kenderaan tanpa menghilangkan ciri-ciri setiap aksara. Akhir sekali, pengecaman aksara akan menentukan identiti setiap aksara dan memaparkannya ke dalam bentuk yang boleh dibaca oleh mesin. Kajian ini memperkenalkan lima kaedah bagi pengecaman aksara iaitu pemadanan templat (TM), rangkaian neural perambatan balik (BPNN), rangkaian neural Particle Swarm Optimization (PSONN), hibrid TM bersama BPNN (TM-BPNN) dan hibrid TM bersama PSONN (TM-PSONN). PSONN dicadangkan sebagai alternatif untuk melatih rangkaian neural suap hadapan manakala TM-BPNN dan TM-PSONN dicadangkan untuk menghasilkan hasil pengenalpastian yang lebih baik. Penilaian prestasi yang dicadangkan adalah berdasarkan jumlah ralat kuasa dua, masa pemprosesan, jumlah pusingan latihan, nilai korelasi dan peratusan ketepatan. Prestasi kaedah telah dianalisa berdasarkan penggunaan 300 imej sebenar kenderaan. Hibrid TM-BPNN memberikan keputusan pengenalpastian tertinggi iaitu sebanyak 94%, diikuti oleh hibrid TM-PSONN sebanyak 91.3%, TM sebanyak 77.3%, BPNN sebanyak 61.7% dan yang terakhir iaitu PSONN sebanyak 37.7%.

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LIST OF ABBREVIATIONS

ALPR	:	Automatic License Plate Recognition
ANN	:	Artificial Neural Network
ASCII	:	American Standard Code for Information Interchange
BPNN	:	Back-propagation Neural Network
CCA	:	Connected Component Analysis
EA	:	Evolutionary Algorithm
GA	:	Genetic Algorithm
GNN	:	Genetic Neural Network
HSV	:	hue-saturation-value
HTML	:	Hypertext Markup Language
IMF	:	intrinsic mode functions
ITM	:	Intelligent template matching
JPEG	:	Joint Photographic Experts Group
LPR	:	License Plate Recognition
LVQ	:	learning vector quantization
MLP	:	Multilayer Perceptron
MSE	:	Mean Square Error
NN	:	Neural Network
OCR	:	Optical Character Recognition
PNN	:	Probabilistic Neural Network
PSO	:	Particle Swarm Optimization
PSONN	:	Particle Swarm Optimization Neural Network

RBF	:	Radial Basis Function
RGB	:	Red Green Blue
ROI	:	Region of Interest
SOM	:	Self-organized map
SSE	:	Sum Square Error
SURF	:	Speeded-Up Robust Features

LIST OF PUBLICATIONS

Published in Journal

1. Nuzulha Khilwani Ibrahim, Emaliana Kasmuri, Norazira A Jalil, Mohd Adili Norasikin, Sazilah Salam, Mohamad Riduwan M.D. Nawawi, "A Review on License Plate recognition with Experiments for Malaysia Case Study," Middle-East Journal of Scientific Research, vol. 14, no. 3, pp. 409-422, 2013.
2. Norazira A. Jalil, Abd Samad Hasan Basari, Sazilah Salam, Nuzulha Khilwani Ibrahim, "The Utilization of Template Matching Method for License Plate Recognition," International Review on Computers and Software, vol. 9, no. 2, pp. 384-389, 2014.
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Seminar/Workshop/Conference Papers

1. Nuzulha Khilwani Ibrahim, Emaliana Kasmuri, Norazira A Jalil, Mohd Adili Norasikin, Sazilah Salam, Mohamad Riduwan M.D. Nawawi, "License Plate Recognition (LPR): A Review with Experiments for Malaysia Case Study," The Proceeding of International Conference on Soft Computing and Sotware Engineering, vol. 3, no. 3, pp. 83-93, 2013.

CHAPTER 1

INTRODUCTION

1.1 Backgrounds

With increasing number of vehicles on roads, it is getting difficult to manually enforce laws and traffic rules for smooth traffic flow. Thus, in order to automate these processes and make them more effective, a system is required to easily identify a vehicle. Therefore, the implementation of license plate recognition (LPR) helps to solve such problems. License plate detection and recognition applies image processing and character recognition to identify vehicles by automatically reading their images. The main application of LPR include private parking lot management (Polycarpou et al., 2013; Angeline et al., 2009; Kumar, 2009), traffic managing, automatic traffic ticket issuing, toll collection (Ashtari et al., 2014; Goel and Dabas, 2013) and security enforcement (Du et al., 2013; Vandini, 2014).

For instance, with densely populated people, the city of Melaka is experiencing an increase in the number of vehicles. It is reported that the number of vehicles in Melaka has increased to 84% from January 2012 to December 2013 become 363,436 (Ministry of Transport, 2012). With increasing number of vehicles, one of the problems arises are parking space due to improper parking management (Golapan et al., 2013; Bulactial et al., 2013). Many local authorities had overseen the issue of parking. Due to that, parking has become a lucrative income to them but a burden to the user. Some of the parking areas are difficult to access and are not properly designed by the local authority (Caicedo and Diaz, 2013) that causes unpleasant experience to the drivers such as misguided parking signage,

unavailability of parking and parking ticket signage and parking runs by illegal operators. Figure 1.1 shows the unappealing and unnoticeable sign board for authorized parking coupon vendor.

Figure 1.1: Sign board for authorized parking coupon vendor

Thus, the introduction of automatic license plate recognition seems to give beneficial in solving those problems. Camera-based parking systems (Idris et al., 2009; Ichihashi et al., 2010) can provide a cost-effective solution to the sensing task while providing additional functionality for traffic law enforcement and surveillance. For parking application, the LPR system (Yigit, 2013) is used to calculate the parking fee by comparing the entry and exit times. The license plate is recognized and stored. Upon the exit, the license plate is read again and the user being charged for the duration of the parking.

With an increase demand on security awareness, the needs of vehicle identification technologies are extremely significant. License plate is employed as an access control for monitoring the unauthorized vehicles from entering the private areas (Patil and Bhonge, 2013; Anagnostopoulos, 2014). The gate is automatically opens for authorized members and thus replacing the assistance of a security guard.

Based on traffic analysis from The Malaysian Highway Authority (Lembaga Lebuhraya Malaysia, 2013), in 2013, the volume of traffic recorded on the highways of Malaysia was 1,641.37 million. This was an increase of 4.72% compared with 2012 when the volume recorded was 1,567.35 million. One of the critical parts in highways is toll stations, which are set up at the entrances and exits throughout the highways to collect charges based on travel distance and vehicle types. To facilitate the toll collection process while ensuring the smooth operation at each station, automatic license plate recognition can be deployed at these locations. The license plate is used to calculate a travel fee within a toll road or used for double checking the ticket (Mousa, 2012).

Each vehicle has unique license characters, which is written on its license plate. Each country has different standard and character's style in their license plates (Patil and Mane, 2013; Anishiya and Joans, 2011). This character distinguishes one vehicle from the other, which is useful especially when both are of the same model. An automated system can be implemented to identify the license plate of a vehicle and extract the characters from the region containing a license plate. Furthermore, the license plate characters can be used to retrieve more information about the vehicle and its owner (RAND Corporation, 2014), which can be used for further processing. Such an automated system should be small in size, portable and be able to process data at sufficient rate.

LPR highly depends on the quality of image. Noises in the plate image make the recognition become more difficult (Karthikeyan et al., 2013). Consequently, incorrect results may occur. Thus, image processing methods like image enhancement, edge detection, threshold, and filtering is necessary to locate and thus isolate the characters from the image in order to give better chance in getting correct recognition.

In order to successfully recognize the license plate characters, it is necessary to locate the exact location of license plate in the scene image provided by some acquisition

systems like a video or still camera. For example, with a whole front view of vehicle as an input image, only 10% (Medipally, 2010) of the image area is useful as the region of interest (in this case a license plate).

1.2 Problem Statements

The challenge of LPR is to select the best method for recognizing characters. Numerous methods have been developed but the performance varied due to many factors. Since the importance of LPR arises over times, there is a need to find the best method to overcome the problem. One of the common and simple recognition methods is by template matching.

Basically, template matching used individual image as features. Recognition is performed by comparing an input character with a set of templates from alphanumeric database. Each comparison results in a similarity measure between the input characters with a set of templates. One measure increases the amount of similarity when a pixel in the input character is identical to the same pixel in the template image. If the pixels differ, the measure of similarity decreases. After all templates have been compared with the input character image, the character's identity is identified through the highest similarity measure value.

However, template matching totally depends on the quality and quantity of the character images on a template database (Perveen et al., 2013). The recognition performance may degrade by yielding poor quality characters. The quantity of character images in template database also plays the biggest role in determining the performance of template matching. The more number of character set will give better chance for correct recognition as there are more character images to be compared. Furthermore, the performance of template matching will increase by applying similar font between input

character images and templates characters. However, all the specification that leads to better performance of template matching result is time consuming (Khalil, 2010; Suvarna et al., 2013). Therefore, the enhancement of template matching is essential to provide a better performance in license plate recognition.

Therefore, many optimization methods have been proposed to solve the problem on template matching, such as Back-propagation Neural Network (BPNN) and Particle Swarm Optimization (PSO). BPNN learning algorithm is widely used in the neural network training. The advantages of BPNN are through its simplicity and reasonable speed (Devireddy and Rao, 2009). However, BPNN with gradient decent approached has some drawbacks such as the fact that performance depends on initial weights and that the likelihood of solution reaching global optimum is not assured. Besides, the BPNN algorithm has slow convergence rate (Gao et al., 2006).

PSO have been applied to Artificial Neural Network (ANN) applications as an alternative of back-propagation algorithm. Despite of its fast convergence speed, global search ability (Rakitianskaia, 2011) and generated high-quality solution compared to other stochastic methods (Abbas et al., 2013; Zhang, Zhang, Lok and Lyu, 2007) mentioned that the major drawback of PSO is slow fine tuning ability of solution quality. Moreover, PSO has high dependence on initial point and parameters which has caused the difficulty in finding their optimal design parameters and the stochastic characteristic of the final output (Tang and Bagchi, 2010).

Based on the review above, the problem statement can be listed as below:

1. The specification that leads to better performance of template matching is time consuming.
2. The performance of BPNN depends on initial weights and has slow convergence rate.

3. PSO has slow fine tuning ability and high dependence on initial parameters setting.

1.3 Research Questions

This research preliminary aim to identify license plate recognition using template matching method and develop an enhancement of license plate recognition methods based on artificial neural network (ANN). Based on the problem statements above, there are several research questions to be raised up. Therefore, the primary research questions of this research are as follows:

1. What is the problem of template matching method to license plate recognition?
2. What is the appropriate method that can be used to enhance license plate recognition?

1.4 Research Objectives

The primary aim of this research is to answer the primary research questions above, and hence the objectives are given as follows:

1. To identify issues on license plate recognition using template matching method.
2. To develop an enhanced license plate recognition method based on neural network (NN) and Particle Swarm Optimization (PSO).
3. To evaluate the performance of the enhanced license plate recognition methods using suitable performance measures.

From the research objectives that is listed above, the relations between problem statements, research questions and research objectives is described as in Table 1.1:

Table 1.1: Relations between Problem Statements, Research Questions and Research Objectives

Problem Statement	Research Question	Research Objective
There are some specifications that lead to better performance of template matching but it is time consuming.	What is the problem of template matching method to license plate recognition?	To identify issues on license plate recognition using template matching method.
The performance of BPNN depends on initial weights and has slow convergence rate.	What is the appropriate method that can be used to enhance license plate recognition?	To develop an enhanced license plate recognition method based on neural network (NN) and Particle Swarm Optimization (PSO).
PSO has slow fine tuning ability and high dependence on initial parameters setting.		To evaluate the performance of the enhanced license plate recognition methods using suitable performance measures.

1.5 Scopes of Study

In this study, there are limitations that have been identified in order to achieve the research objectives. Due to that, the limitations and assumption that have been considered throughout this study is as follows:

i. Image taken only when vehicle is stationary

ii. The vehicle license plate position should be captured center