UNIVERSITI PUTRA MALAYSIA

REAL TIME PLATE RECOGNITION FOR MOTORCYCLE USING FIELD PROGRAMMABLE GATE ARRAY

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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Chair : Roslina binti Mohd Sidek, PhD
Institute : Institute of Advanced Technology

The aim of this project is to develop motorcycle plate image detection and recognition framework for traffic offender using Field Programmable Gate Array (FPGA). The proposed system has processing time of 33.3 milliseconds in various critical conditions, such as daylight, rainy daylight and night. Currently, the available technology is lacking due to the system implementation is not robust and less efficient. Benchmarking study for fast processing system showed FPGA can carry out real-time processing at 128 × 128 resolution video sequences at 30 frames per second (fps). Therefore FPGA was selected to improve the plate number recognition for motorcycle. Comparison between hardware (FPGA) and software (MATLAB) implementation of edge detection was also performed. Currently, the time for processing motorcycle plate image using software is 52 milliseconds. To meet the processing time constraints for the developed framework, it is important to quantify the reduction of processing time that can be achieved if the framework component are embedded into hardware-based platform such as FPGA. MATLAB-Simulink was selected for designing the detection system. This system was designed to detect static images and moving objects in critical condition from 5 to 15 meters distances. Then, the detection system was implemented on the FPGA for the detection and recognition process. The output image was analyzed by comparing the accuracy of bounding box and edges displayed in different conditions, threshold levels, resolutions and distances.

From this proposed system, the daylight condition at 5 meter distance gives the highest accuracy of 99% at threshold level ranging from 2 – 10. In addition, the highest resolutions accuracy is 99% at 1024 ×768 pixels. This comparable with the output from Matlab Simulink system that shows the best accuracy of 99% at threshold level 2 and resolution pixel 1024 ×768 pixels. The second best conditions is rainy daylight, in which the threshold accuracy is 99% at level 10 with 99% resolution accuracy at 1024 ×768 pixels. From the analysis, it can be concluded that daylight is the best condition in detecting the motorcycle images, followed by rainy daylight and night conditions. The speed to process the image is 30 frames per second, which is 58 % faster than images processed by Matlab Simulink. Thus, this proposed system on FPGA is more flexible, efficient and robust for real time plate recognition for motorcycle. This study can be implemented to efficiently identify road traffic offenders and improve visual driver support system in the future.

Abstrak tesis yang dikemukakan kepada SenatUniversiti Putra Malaysia
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PENGECAMAN PLAT MOTORSIKAL PADA MASA NYATA MENGGUNAKAN FIELD PROGRAMMABLE GATE ARRAY

Oleh

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Matlamat projek ini adalah untuk membangunkan rangka pengesanan imej dan pengecaman plat motosikal bagi pesalah trafik dengan menggunakan Field Programmable Gate Array (FPGA). Sistem yang dicadangkan mempunyai masa pemprosesan 33.3 milisaat dalam pelbagai keadaan kritikal seperti cahaya siang, hujan siang dan malam. Pada masa kini, teknologi yang sedia ada mempunyai kekurangan kerana sistem yang digunakan tidak relevan dalam pelbagai keadaan dan kurang efisien. Kajian penanda aras menunjukkan Field Programmable Gate Array mampu memproses imej bersaiz 128 × 128 resolusi dalam masa 30 frame per saat (fps). Oleh yang demikian, perbandingan antara platform perkakasan dan perisian bagi mengesan imej motosikal juga telah dibuat. Pada masa ini, pemprosesan imej yang menggunakan perisian mampu memproses imej plat motosikal dalam masa 52 milisaat. Bagi memenuhi proses kekangan masa untuk rangka kerja yang dibangunkan, adalah penting untuk mengukur pengurangan masa pemprosesan yang boleh dicapai jika komponen rangka kerja terbenam ke platform berasaskan perkakasan seperti Field Programmable Gate Array (FPGA). MATLAB-Simulink telah dipilih di dalam mereka bentuk sistem pengesanan. Sistem ini telah direka untuk mengesan imej-imej pegun dan objek bergerak dalam keadaan yang dipilih. Sistem ini dirancang untuk mengesan gambar statik dan objek bergerak dalam keadaan kritikal dari jarak 5 hingga 15 meter. Kemudian, sistem pengesanan dilaksanakan pada FPGA untuk proses pengesanan dan pengecaman. Imej output dianalisis dengan membandingkan ketepatan kotak sempadan dan tepi yang dipaparkan dalam keadaan, tahap ambang, resolusi dan jarak yang berbeza.

Dari sistem yang dicadangkan ini, keadaan siang hari pada jarak 5 meter memberikan ketepatan tertinggi 99% pada tahap ambang batas antara 2 - 10. Di samping itu, ketepatan resolusi tertinggi adalah 99% pada 1024 × 768 piksel. Ini setanding dengan output dari sistem Matlab Simulink yang menunjukkan ketepatan terbaik 99% pada tahap ambang 2 dan piksel resolusi 1024 × 768 piksel. Keadaan terbaik kedua adalah hujan siang, di mana ketepatan ambang adalah 99% pada tahap 10 dengan ketepatan resolusi 99% pada 1024 × 768 piksel. Dari analisis tersebut, dapat disimpulkan bahawa siang hari adalah keadaan terbaik dalam mengesan gambar motosikal, diikuti dengan keadaan hujan siang dan malam. Kelajuan untuk memproses gambar adalah 30 bingkai sesaat, yang mana ianya 58% lebih cepat daripada gambar yang diproses oleh Matlab Simulink. Oleh itu, sistem yang dicadangkan pada FPGA ini lebih fleksibel, cekap dan mantap untuk pengecaman plat masa nyata untuk motosikal. Kajian ini dapat dilaksanakan untuk mengenal pasti pesalah lalu lintas jalan raya dengan berkesan dan meningkatkan sistem sokongan pemandu visual pada masa akan datang.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

AI	Artificial Intelligent
JPJ	Department of Malaysia Road Transport
PDRM	Royal Malaysia Police
ALPR	Automatic License Plate Recognition
IoT	Internet of Things
AES	Automatic Enforcement System
FPGA	Field Programmable Gate Array
HOG	Histogram of Oriented Gradient
CNN	Convolutional Neural Networks
RCNN	Region Based Convolutional Neural Networks
SVM	Support Vector Machine
ADAS	Advanced Driving Assistant System
TSR	Traffic Sign Recognition System
MATLAB	Matrix Laboratory
CPU	Central Processing Unit
GHz	Gigahertz
RAM	Random Access Memory
GPU	Graphic Processing Unit
GB	Gigabyte
MB	Megabyte
IIMAP	Integrated Memory Array Processor
PC	Personal Computer
CCD	Charge Couple Device
MHz	Megahertz
RGB	Red, Green, Blue
SURF	Speed Up Robust Features
LBB	Local Binary Pattern
MLP	Multilayer Perceptron Network
RBFN	Radial Basic Function Network
LPR	License Plate Recognition
ECU	Engine Control Unit
HSYNC	Horizontal Synchronization
VSYNC	Vertical Synchronization
PNG	Portable Networks Graphic
ROI	Region of Interest
DVI	Digital Visual Interface
IP	Internet Protocol
FMC	FPGA Mezzanine Card
CAT 6 CABLE	Category 6 Cable
SCCB	Serial Camera Control Bus
I2C	Inter-Integrated Circuit
HDR	High Dynamic Range
PLB	Processor Local Bus
EDK	Embedded Development Kit
VGA	Video Graphic Array

LUT	Look-Up Table
IO	Input Output
IOB	Input Output Block
BRAM	Block Random Access Memory
GCLK	Global Clock
DCM	Digital Clock Manager
DSP	Digital Signal Processor
USB	Universal Serial Bus
OS	Operating System
ID	Identification
RTL	Register-Transfer Level
DUT	Device Under Test
DCLL	Dual Connector Component Labeling

CHAPTER 1

INTRODUCTION

This chapter elaborates on overview, problem statement, objectives, scope of research, contributions and organizations of the thesis.

1.1 Overview

Traffic violation is the main issue contributing to accident in the developed country. Automatic licence plate recognition (ALPR) system combining electronics, communications, information, network technologies, internet of things (IoT) and so on is developed to improve traffic problems. Most of systems applied in ALPR system need to identify the vehicles beforehand. One of effective and useful identification methods is licence plate recognition through digital image processing. Motorcyclists occasionally violate the traffic law and ride in dangerous situation such as not wearing helmet, violating red light and illegal racing. These are risky behaviours that often occur and cause tremendous traffic problems. Thus, this project aims to develop methods to extract and recognize license plates of motorcycles for traffic offender. Image detection process is to classify an object whether it is presence or absence in an image. The presence of the object can be verified based on its position and edge boundary.

Field-Programmable Gate Array (FPGA) has an ability in parallel computation. This advantage shows FPGA can increase the video frame rate and improve the transmission stability of video data. Compared with CPU, the characteristics of FPGA parallel computation can greatly increase the data throughput rate. MATLAB is a convenient tool for image processing and image evaluations such as image enhancement and graphing. MATLAB with programmable and graphics processors has capability for fast binary representation and manipulation.

Both FPGA and MATLAB have the ability to process an image. However, the study on the effectiveness to process real time motorcycle images in various conditions is still under on going. .Previous researcher detected motorcycle image based on helmet tracking, motorcyclist appearance and plate number for road safety application. Due to this scenario, the capability of tools used for motorcycle image processing in extreme conditions need to be enhanced in order for it to be reliable and accurate. These factors relate to motorcycle properties such as fast movement on the road, various shape and size that contribute to the challenges in detection and recognitions as compared to other vehicle.Available systems in the market also have limited capability in recognizing motorcycle plate number as they are mostly designed for object detection only and to alert driver during driving or riding. Therefore, it is important

to take a further step to develop a robust and efficient system for motorcycle plate detection.

1.2 Problem statement

FPGA is a suitable hardware deployed in recognition system with the cheapest investment. The advantage of FPGA is this device is friendly used where consumer can adjust and design the system based on their application. FPGA provides less power consumption and is compatible for long hour used duration. Moreover, with FPGA user can evaluate and verify its performance in terms of distance capability detection and variable works conditions. The conditions mean system can be implemented in daylight, rainy and night.

The existing types of system for traffic enforcement available nowadays are Automatic Enforcement System (AES), speed trap camera and traffic light camera. Detecting traffic offenders among motorcyclists is a challenging task for enforcement officer. The current practice such as running a roadblock to check the driver's license is not effective in dealing with this crisis. Traffic offender could escape from the roadblock conducted. In addition, manual inspection process such as license checking is slow. Motorcycle plates imaging is selected in this study because it is more complex to processed as compared to other vehicle imaging. Image detection and recognition have been applied for traffic enforcement to reducing road violation.

For the system to be relevant it must not only be able to detect motorcycle and to recognize the plate number, but the system must be portable and able to process data in real time. Several efforts have been made to develop automatic license plate detection system however, the available systems do not address important issues such as the effect of weather conditions (rainy), low contrast image environment (night) and the varying distance from camera due to moving object. Thus, robust license plate detection is needed for making an efficient automatic license plate recognition system. In addition, time required to process motorcycle image for detection process is also considered in this study since fast duration leads to good system performance.

1.3 Objective of the Study

The aim of this research is to recognize motorcycle plate number for various distances with acceptable quality in various lighting and weather conditions. The objectives of this research are

1. To develop motorcycle plate recognition system for real-time applications on FPGA
2. To optimize the quality of real time plate recognition images by comparing the system of FPGA and Matlab Simulink
3. To evaluate the performance of the plate detection and recognition system in terms of image quality

1.4 Scope of research

The scope of this research focuses on real-time plate recognition for Modenass Kriss motorcycle brand as a target candidate using FPGA. The selection of motorcycle target candidate is measured and label based on the group of black and white pixel component. The motorcycle selected is available in local Malaysia market which has small capacity speed and standard range size. The size of this type of motorcycle is 3.5 meter long and 1.5 meter width. Motorcycle with large capacity speed is not included in this study. In this study, all possible candidates are measured based on ratio of width and height of the object dimension. This study analyzes the capability of the system in detecting motorcycle image and processing the edge of motorcycle plate for different resolutions, as well as different lighting and weather conditions. The training output images of the sample collected were from 5, 10 and 15 meters based on the capability of measurement equipment used.

1.5 Contributions

A prototype system that can process edge of motorcycle image and plate recognition to help enforcement officer in detecting traffic offenders is developed. It can detect and recognize an object based on outline and boundaries and displayed on screen monitor. This system can store images and manipulate the image using Sobel operator to recognize the detail of object information, such as shape, size and gradient intensity. All information can be stored in database for further analysis. Enforcement officer can collaborate with system analyst who handles the registered data to trace the motorcycle owner. The main contribution of this thesis is to develop system that can detect and recognize motorcycle plate number in various lighting and weather conditions. It covers the ideas on;

1)The concept of using FPGA for license plate recognition, which allows to obtain an effective and high speed processing platform.

2) Evaluation of this concept is by implementing Sobel Edge algorithm in FPGA.

3) Measuring the distance between the camera and moving objects nearby region in the camera's field of view.

1.6 Organizations of thesis

The thesis includes five chapters. Chapter one explains the problem statement, and research objectives. It outlines the scope of this research. Chapter two discusses the previous researches related to this project and latest developments on this subject. Chapter three explains the methods and tools used in this research, experiment which includes type of image related to size and distances. The image data collected are divided in different environment and

transferred as image input into the hardware. Chapter four discusses the result of different conditions of images captured in the case study. Chapter five concludes the results and provides recommendation for future works.

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LIST OF PUBLICATIONS

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