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**EMBEDDED VISION SYSTEM DEVELOPMENT
USING 32-BIT SINGLE BOARD COMPUTER
AND GNU/LINUX**

by

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(0630210126)**

A thesis submitted
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TABLE OF CONTENTS

	Page
DECLARATION OF THESIS	i
PERMISSION TO USE	ii
APPROVAL AND DECLARATION SHEET	iii
ACKNOWLEDGEMENTS	iv
TABLE OF CONTENTS	vi
LIST OF TABLES	xii
LIST OF FIGURES	xiii
LIST OF ABBREVIATIONS	xvi
ABSTRAK (BM)	xix
ABSTRACT (ENGLISH)	xx

CHAPTER 1 INTRODUCTION

1.1	Overview	1
1.2	Problem Statement	2
1.3	Motivation	4
1.4	Research Objective	5
1.5	Research Scope	5
1.6	Thesis Outline	6

CHAPTER 2 LITERATURE REVIEW

2.1	Introduction	7
2.2	History of Smart Camera	8
2.3	Image Definition	10
2.3.1	Color Space	11
2.4	Image Processing	13
2.4.1	Motion Analysis	14
2.4.1.1	Background Subtraction – Frame Differencing	15
2.4.1.2	Segmentation – Thresholding	16
2.4.1.3	Convolution Matrix Filter	19
2.5	Embedded System Technologies	20
2.5.1	Common Characteristics of Smart Camera	21
2.5.2	Literature Survey on Smart Cameras as Embedded System	22
2.5.3	Smart Camera Applications	25
2.6	Traffic Surveillance	28
2.6.1	Applications of Smart Surveillance	28
2.6.2	The Smart Camera Operational Environment	30
2.7	Summary	31

CHAPTER 3 GNU/LINUX AND EMBEDDED SYSTEM

3.1	Introduction	33
3.2	GNU/Linux Operating System	34
3.2.1	Hardware System	35

3.2.1.1	Central Processing Unit	35
3.2.1.2	Memory	35
3.2.1.3	Buses	36
3.2.1.4	Controllers and Peripherals	37
3.2.1.5	Address Spaces	37
3.2.1.6	Timers	38
3.2.2	Linux Kernel	38
3.2.2.1	Memory Management	38
3.2.2.2	Processes	39
3.2.2.3	Device Drivers	39
3.2.2.4	File Systems	40
3.3	Embedded System	43
3.3.1	Desktop GNU/Linux vs. Embedded GNU/Linux Operating System	44
3.4	Image Acquisition and Processing in Embedded Device	46
3.5	Hardware Platforms for Embedded System	49
3.5.1	Single Board Computer (SBC)	49
3.5.1.1	x86-based SBC Product Features	51
3.5.1.2	ARM-based SBC Product Features	51
3.6	Summary	52

CHAPTER 4 HARDWARE PLATFORMS

4.1	Introduction	53
4.2	Overview of the Embedded Vision System	53

4.3	Embedded Vision System Hardware Components	55
4.3.1	Single Board Computer (SBC)	56
4.3.2	Logitech Quick Cam Pro 4000	57
4.3.3	Compact Flash Memory Card	58
4.3.4	PCMCIA Wireless Network Card	59
4.4	Hardware Setup	60
4.4.1	TS5500 SBC Configuration	60
4.4.1.1	Serial Communication	61
4.4.1.2	Network Setup	61
4.4.2	Integration and Configuration of USB Webcam	62
4.4.2.1	Linux Hardware Compatibility	63
4.4.2.2	Logitech QuickCam Communicate STX Webcam Setup on Desktop PC RedHat 8.1	66
4.4.2.3	Logitech QuickCam Pro 4000 Webcam Setup on Desktop PC RedHat 7.3 – Kernel Recompile	67
4.4.2.4	Logitech QuickCam Pro 4000 Webcam Setup on TS5500 SBC	69
4.5	Summary	69

CHAPTER 5 SOFTWARE DEVELOPMENT

5.1	Introduction	70
5.2	Overview of the Embedded Vision System	71
5.3	Embedded Vision System Software Design	73
5.3.1	Image Acquisition Module	73

5.3.2	Image Processing and Object Detection Module	79
5.3.2.1	Color Space Conversion	80
5.3.2.2	Motion Analysis Technique	84
5.3.3	Data Transmission Module	92
5.3.3.1	Shared Memory	93
5.3.3.2	Sockets	94
5.3.4	Stationary Vehicle Detection	100
5.3.4.1	Assumption / Claims	100
5.4	Summary	102

CHAPTER 6 RESULTS AND ANALYSIS

6.1	Introduction	104
6.2	Evaluation Environment	105
6.3	Hardware Performance Analysis	106
6.3.1	Overall Execution Time for Embedded Vision System Operations	107
6.3.2	Image Processing Process Execution Time	109
6.3.3	Usage of Shared Memory	115
6.3.4	Performance Evaluation for TS7200 ARM9 SBC	117
6.4	Image Processing Algorithms	121
6.4.1	Color Space Conversion	122
6.4.2	Motion Analysis Techniques	128
6.4.2.1	Frame Differencing	128
6.4.2.2	Thresholding	132

6.4.2.3	Convolution Matrix Filtering	134
6.5	Stationary Vehicle Detection	135
6.6	Summary	140
CHAPTER 7	CONCLUSION	
7.1	Introduction	142
7.2	Future Work	145
7.3	Contribution	145
REFERENCES		146
PUBLICATIONS		153
APPENDICES		
Appendix A	PPM / PGM / PBM Image Files	154
Appendix B	Color Space	160
Appendix C	YUV to RGB Color Space Conversion	165

LIST OF TABLES

Table	Name	Page
2.1	Technologies in intelligent network cameras	27
3.1	Subdirectories of the root directory	42
4.1	List of drivers for Logitech camera	64
4.2	Logitech camera supported driver	65
4.3	USB webcam model and Linux V4L device driver	65
4.4	Results for testing and configuration of different webcams with different GNU/Linux OS and kernel versions	66
5.1	Video picture palette fields and description	79
6.1	Comparison of desktop PC and SBC specifications	108
6.2	Overall processing time in SBC and Desktop PC	108
6.3	Processes in image processing algorithm	110
6.4	Operations per second, processing time and processing time differences between SBC and desktop PC	114
6.5	Comparison of image reading with and without the use of shared memory	115
6.6	Overall processing time comparison based on different hardware platform shared memory usage	116
6.7	Time difference in processing speed between two single board computers	119
6.8	RGB and Greyscale value for the selected pixel	127
6.9	Detection results for different image samples	139

LIST OF FIGURES

Figure	Name	Page
2.1	Color space conversion in different devices	12
2.2	Image to be thresholded and brightness histogram of the image	18
2.3	Bi-modal intensity distributions	18
2.4	SmartCam prototype developed by researcher from Graz University of Technology	24
2.5	Another prototype architecture of the smart camera including the CMOS image sensor, the DSP-based processing unit and the Ethernet network connection	25
2.6	Smart camera prototype called MeshEye™ mote	25
2.7	Intelligent network security system	26
3.1	Linux file system layout	41
4.1	Embedded vision system hardware components	55
4.2	Hardware architecture of the embedded vision system	56
4.3	TS5500 Single Board Computer	58
4.4	Logitech QuickCam Pro 4000 Web Camera	59
4.5	Compact Flash Memory Card	60
4.6	Wireless PC Card	60
4.7	PWC core modules	68
4.8	PWCX decompressor module	69
4.9	Options supplied to PWC module	69
5.1	Embedded vision system software design flowchart	73
5.2	Embedded vision system software design modules	74
5.3	Capturing process block diagram	76

5.4	Image processing technique performs on the captured image	80
5.5	Grayscale charts illustrating the differences between the mixture of RGB, CMY, CMYK and black only	83
5.6	A 10 ×10 matrix filter is used to locate the region of interest in the threshold image	89
5.7	Predefine region is assigned along the road	89
5.8	Flowchart for client-server sockets	98
5.9	Flowchart for client socket	99
5.10	Flowchart for server socket	100
5.11	Examples of a monitoring area	101
5.12	Region of interest in the monitoring area	102
6.1	A snippets of time measurement program	106
6.2	Image samples used in image processing algorithm evaluation	111
6.3	Graph for processing time for image processing algorithm using image sample 01	112
6.4	Graph for processing time for image processing algorithm using image sample 02	112
6.5	Graph for processing time for image processing algorithm using image sample 03	113
6.6	Overall processing speed comparison on different hardware platform based on usage of shared memory	117
6.7	Processing speed comparison based on different hardware platform	118
6.8	Performance comparison based on operations per second (OPS)	120
6.9	RGB and Greyscale images from color space conversion	123
6.10	Red component for RGB image and the corresponding histogram	124
6.11	Green component for RGB image and the corresponding histogram	124
6.12	Blue component for RGB image and the corresponding histogram	125
6.13	Greyscale image and the corresponding histogram	126

6.14	(a) Background image, (c) input image 1, (e) input image 2, (b),(d),(f) the corresponding histogram of the greyscale image	129
6.15	(a) Image obtain after frame difference between input image 1 and background image is done, (c) image obtain after frame difference between input image 2 and background image is done, (b) and (d) the corresponding histogram	131
6.16	Figure 6.16: (a) Grayscale input image 1 after thresholding process, (c) grayscale input image 2 after thresholding process, (e) the resulting grayscale image after frame differencing is done on image (a) and (c), (b), (d) and (f) the corresponding binary image	133
6.17	(a) Marked area in the image indicates a stationary vehicle is successfully detected by the system, (b) marked area is shown in greyscale image	135
6.18	(a) Image is crop to marked area (b) cropped image shown in Grayscale	136
6.19	Some sample of road images for stationary vehicle detection evaluation	138
6.20	Example of successful vehicle detection results	140
6.21	Example of failed vehicle detection results	141

LIST OF ABBREVIATIONS

AFVR	<i>Automatic Forensic Video Retrieval</i>
ANSI	<i>American National Standards Institute</i>
BIOS	<i>Basic Input/Output System</i>
CCD	<i>Charge-Coupled Device</i>
CCTV	<i>Closed Circuit Television</i>
CMOS	<i>Complementary Metal Oxide Semiconductor</i>
COTS	<i>Commercial Off The Shelf</i>
CPU	<i>Central Processing Unit</i>
DHCP	<i>Dynamic Host Configuration Protocol</i>
DSL	<i>Digital Subscriber Line</i>
DSP	<i>Digital Signal Processing</i>
DVR	<i>Digital Video Recorders</i>
EXT2	<i>Second Extended Filesystem</i>
FPGA	<i>Field-Programmable Gate Array</i>
FTP	<i>File Transfer Protocol</i>
GNU	<i>GNU is Not Unix</i>
GPL	<i>General Public License</i>
GUI	<i>Graphical User Interface</i>
IC	<i>Integrated Circuit</i>
IDE	<i>Integrated Drive Electronics</i>
ISA	<i>Industry Standard Architecture</i>

LAN	<i>Local Area Network</i>
LCD	<i>Liquid Crystal Display</i>
LED	<i>Light Emitting Diode</i>
LSI	<i>Large-Scale Integrated</i>
MS-DOS	<i>Microsoft Disk Operating System</i>
NTSC	<i>National Television System Committee</i>
OCR	<i>Optical Character Recognition</i>
OS	<i>Operating System</i>
OSS	<i>Open Source Software</i>
PAL	<i>Phase Alternating Line</i>
PAM	<i>Portable Arbitrary Map</i>
PBM	<i>Portable Bit Map</i>
PCI	<i>Peripheral Component Interconnect</i>
PCMCIA	<i>Personal Computer Memory Card International Association</i>
PDA	<i>Personal Digital Assistant</i>
PGM	<i>Portable Gray Map</i>
PNM	<i>Portable Any Map</i>
PPM	<i>Portable Pixel Map</i>
PTZ	<i>Pan-Tilt-Zooming</i>
RAM	<i>Random Access Memory</i>
RISC	<i>Reduced Instruction Set Computer</i>
ROM	<i>Read-Only Memory</i>
RTC	<i>Real Time Clock</i>

SBC	<i>Single Board Computer</i>
SCP	<i>Secure Copy</i>
SCSI	<i>Small Computer System Interface</i>
SDRAM	<i>Synchronous Dynamic RAM</i>
SMTP	<i>Simple Mail Transfer Protocol</i>
SSH	<i>Secure Shell</i>
TCP/IP	<i>Transmission Control Protocol/Internet Protocol</i>
TS	<i>Technologic Systems</i>
UDP	<i>User Datagram Protocol</i>
USB	<i>Universal Serial Bus</i>
VLSI	<i>Very Large Scale Integration</i>
VGA	<i>Video Graphics Array</i>
WEP	<i>Wired Equivalent Privacy</i>

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PEMBANGUNAN SISTEM PENGLIHATAN TERBENAM MENGGUNAKAN 32-BIT KOMPUTER SISTEM TERBENAM DAN GNU/LINUX

ABSTRAK

Penyelidikan ini mendalami penggunaan teknologi sistem terbenam dalam menghasilkan sistem penglihatan untuk membantu dalam proses pemantauan video trafik. Peningkatan kemampuan kuasa pemproses dan cip memori, kesediaan sistem operasi masa nyata, algoritma pintar yang kurang kompleks dan perisian pembangunan sistem terkini adalah faktor utama yang memungkinkan pembangunan sistem ini. Bidang aplikasi penting di mana sistem penglihatan terbenam berpotensi menggantikan kebanyakan kamera dipasaran dan penyelesaian komputer lain adalah pemantauan trafik visual. Sistem pemantauan video digital yang sedia ada hanya menyediakan infrastruktur untuk menangkap, menyimpan dan menghantar video, tetapi meninggalkan tugas mengesan ancaman kepada manusia. Penghasilan sistem penglihatan terbenam mampu mengurangkan keperluan meneliti video yang terpaksa dilakukan oleh manusia seterusnya menghasilkan sistem yang lebih dipercayai. Sistem ini akan mengesan kenderaan pegun yang berada di dalam kawasan pantauan dan menghantar informasi tersebut kepada operator secara automatik. Pembangunan sistem penglihatan terbenam ini dibahagikan kepada dua fasa utama iaitu integrasi perkakasan dan pembangunan perisian. Komponen utama dalam rekabentuk Sistem Penglihatan Terbenam ini adalah Komputer Sistem Terbenam x86 model TS-5500, kamera web Logitech QuickCam Pro 4000, kad memori kilat kompak, kad rangkaian tanpa wayar PCMCIA dan sebuah komputer meja. Pemilihan Komputer Sistem Terbenam x86 dibuat kerana ia mempunyai kelebihan dalam fungsi saiz, kelajuan, boleh dibawa kemana-mana, kos dan penggunaan kuasa yang rendah, tahan lasak dan disokong oleh sistem operasi GNU/Linux. Keseluruhan rekabentuk perisian dibahagikan kepada tiga modul iaitu modul Perolehan Imej, Pemprosesan Imej dan Pengenalpastian Objek, dan Transmisi Data. Algoritma pemprosesan imej meliputi perubahan format warna dan teknik analisa pergerakan. Untuk menganalisa pergerakan, pembezaan imej, pengambungan imej dan teknik penyaringan konvolusi matrik diaplikasikan untuk mengesan dan menganalisa pergerakan di dalam rentetan imej. Penilaian dilakukan terhadap masa pemprosesan yang di ambil untuk melengkapkan keseluruhan operasi kamera pintar dan pemprosesan imej, memantau penggunaan unit pemprosesan pusat di dalam pemproses Komputer Sistem Terbenam ketika pelaksanaan program, dan mengamati prestasi sistem yang dilaksanakan menggunakan platform perkakasan yang berbeza. Keseluruhan masa pemprosesan bagi sistem penglihatan terbenam menggunakan Komputer Sistem Terbenam adalah 38.82 saat dibandingkan dengan 6.09 saat jika menggunakan komputer meja. Kelajuan pemproses di dalam unit pemprosesan pusat dan saiz memori jangka pendek adalah faktor utama yang mempengaruhi prestasi sistem penglihatan terbenam. Perbandingan kelajuan pemprosesan di antara Komputer Sistem Terbenam TS5500 dan TS7200 dijalankan dan keputusan menunjukkan bahawa TS7200 memproses dua kali ganda lebih laju berbanding TS5500. Walau bagaimanapun, ketidaksesuaian pemacu kamera menghalang penggunaan TS7200 sebagai platform perkakasan. Penemuan ketara telah diperolehi dalam penyelidikan ini di mana penggunaan perkongsian memori terbukti menjimatkan hampir separuh masa keseluruhan pemprosesan. Proses mengesan kenderaan pegun dilaksanakan di atas sistem penglihatan terbenam untuk menilai ketepatan pengesanan yang dibuat oleh sistem tersebut. Analisa ini dijalankan menggunakan 50 sampel imej jalan. Melalui analisa ini, kadar kejayaan bagi pengesanan kenderaan pegun adalah 72%.

EMBEDDED VISION SYSTEM DEVELOPMENT USING 32-BIT SINGLE BOARD COMPUTER AND GNU/LINUX

ABSTRACT

This research explores the usage of embedded system technology in developing a vision system to aid the process of monitoring traffic surveillance video. The increasing affordability of powerful processors and memory chips, availability of real-time operating systems, low complexity intelligent algorithms and the coming-of-age of system development software are the key factor that makes this development possible. An important application area where embedded vision system can potentially and advantageously replace most known cameras and computer solutions is visual traffic surveillance. Existing digital video surveillance systems provide the infrastructure only to capture, store and distribute video, while leaving the task of threat detection exclusively to human operators. The implementation of embedded vision system could reduce the need for human video scanning and has the additional effect of a more reliable system. This system will detect any existing stationary vehicle in its monitoring area and automatically convey the information to the operators. The development of embedded vision system is divided into two major phases which are the hardware integration and the software development. The main component for Embedded Vision System hardware design is an x86 TS5500 Single Board Computer (SBC), Logitech QuickCam Pro 4000 webcam, compact flash memory card, PCMCIA wireless network card, and a Desktop PC. The selection of x86 SBC is because of the function of size, speed, functionality, portability, lower cost, lower power consumption, ruggedness and supported by GNU/Linux OS. The overall software design is divided into three modules which are Image Acquisition, Image Processing and Object Detection, and Data Transmission module. The image processing algorithm includes color space conversion and motion analysis technique. In motion analysis, frame differencing, thresholding and convolution matrix filtering techniques are applied to detect and analyze movement in image sequence. Evaluations is performed on the processing time taken for overall smart camera operation and image processing process, monitoring the CPU utilization on the SBC's processor during the program execution and observing the performance of the system implemented on different hardware platform. Overall embedded vision system processing time in SBC is 38.82 seconds compared to 6.09 seconds in desktop PC. The CPU processing speed and the size of short term memory (RAM) are the key factors that influence the performance of the embedded vision system. Processing speed comparison between TS5500 and TS7200 is being made and the result shows that TS7200 executes twice faster than TS5500. However, unsuitable camera driver obstruct the usage of TS7200 as the hardware platform. A significant discovery has been made in this research where the usage of shared memory is proven to save almost half of overall execution time for the embedded vision system. The stationary vehicle detection process is executed on the embedded vision system to evaluate the accuracy of detection made by the system. The experiment is made by using fifty samples of road image. From this experiment, the successful rate for stationary vehicle detection is 72%.

CHAPTER 1

INTRODUCTION

1.1 Overview

Situation awareness is the key to security. Awareness requires information that spans multiple scales of space and time (Hampapur et al., 2005). For the perspective of real-time threat detection, it is a well-known fact that human visual attention drops below acceptable levels even when trained personnel are assigned to the task of visual monitoring (Green, 1999). From the perspective of forensic investigation, the challenge of sifting through large collections of surveillance video tapes is even more tedious and error prone for a human investigator. Therefore, automatic video analysis technologies are applied to develop smart surveillance systems that can aid the human operator in both real-time threat detection and forensic investigatory tasks (Forensic Sciences, 1999).

Enormous change has occurred in the world of embedded systems driven by the advancement on the integrated circuit technology and the availability of open source. This has open new challenges and development of advance embedded system. This scenario is proven by the appearance of sophisticated new products such as PDAs and cell phones and by the continual increase in the amount of resources that can be packed into a small form factor which require significant high end skills and knowledge. More people are gearing up to acquire more skills and knowledge to keep in-front of the technologies to build advanced

embedded system using available Single Board Computer with 32 bit architectures (Ahmad, Mamat, Rosli, & Sudin, 2006).

Recent technological advances enables a new generation of smart cameras that represent a quantum leap in sophistication. While today's digital cameras capture images, smart cameras capture high-level descriptions of the scene and analyze what they see. These devices could support a wide variety of applications including human and animal detection, surveillance, motion analysis, and facial identification (Wolf, Ozer, & Lv, 2002a).

1.2 Problem Statement

A traffic incident is a nonrecurring event therefore, there is no advanced notice. Examples of traffic incidents include vehicle breakdowns, and accidents. Incidents have become one of the main causes of traffic congestion. As incidents cause more congestion, more congestion brings more incidents. Traffic incidents also have other impacts such as the risk of secondary crashes for other road users and those dealing with the incident and possible reductions in air quality due to increased fuel consumption caused by the congestion.

Surveillance is the monitoring of behavior, activities, or other changing information, usually of people and often in a surreptitious manner (PRLog, n.d.). Systems surveillance is the process of monitoring the behavior of people, objects or processes within systems for conformity to expected or desired norms in trusted systems for security or social control.

The word surveillance is commonly used to describe observation from a distance by means of electronic equipment or other technological means.

Existing digital video surveillance systems provide the infrastructure only to capture, store and distribute video, while leaving the task of threat detection exclusively to human operators. However, human monitoring of surveillance video is a very labor-intensive task. It is generally agreed that watching video feeds requires a higher level of visual attention than most every day tasks. Specifically vigilance, the ability to hold attention and to react to rarely occurring events, is extremely demanding and prone to error due to lapses in attention (Hampapur et al., 2005).

Therefore, an embedded vision system for traffic surveillance is developed to aid the process of monitoring surveillance video. It is an effective and practical way to assist human operators in doing such a tedious task as monitoring traffic and manually detecting events in the surveillance video. This system will automatically detect any existing stationary vehicle in its monitoring area and give reports and information on the situation to the operator.

Clearly, today's video surveillance systems while providing the basic functionality fall short of providing the level of information need to change the security paradigm from investigation to preemption. Video surveillance and machine vision systems are attracting growing academic and industrial interests recently. With the increasing availability of the inexpensive computing, video infrastructure and better video analysis technologies, smart surveillance systems will be ready to replace existing surveillance systems.