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

by

NUR FARHAN BINTI KAHAR
(0630210126)

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Author's full name	:	NUR FARHAN BINTI KAHAR
Date of birth	:	8 NOVEMBER 1983
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APPROVAL AND DECLARATION SHEET

This thesis titled Embedded Vision System Development Using 32-Bit Single Board Computer and GNU/Linux was prepared and submitted by Nur Farhan Binti Kahar (Matrix Number: 0630210126) and has been found satisfactory in terms of scope, quality and presentation as partial fulfillment of the requirement for the award of degree of Master of Science (Computer Engineering) in University Malaysia Perlis (UniMAP). The members of the Supervisory committee are as follows:

R. BADLISHAH BIN AHMAD, Ph. D.
Associate Professor
School of Computer and Communication Engineering
University Malaysia Perlis
(Head Supervisor)

ZULKIFLI BIN HUSIN, M.Sc.
Lecturer
School of Computer and Communication Engineering
University Malaysia Perlis
(Co-Supervisor)

Check and Approved by

…………………………………………………….
(ASSOCIATE PROFESSOR DR. R. BADLISHAH BIN AHMAD)
Dean / Head Supervisor
School of Computer and Communication Engineering
Universiti Malaysia Perlis

(Date: …………………….)

School of Computer and Communication Engineering
Universiti Malaysia Perlis

2010

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NUR FARHAN BINTI KAHAR
UNIVERSITI MALAYSIA PERLIS
an_kahar@hotmail.com

TABLE OF CONTENTS

CHAPTER 2 LITERATURE REVIEW

CHAPTER 3 GNU/LINUX AND EMBEDDED SYSTEM

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

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

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

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

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 pamantauan 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 pengubahan format warna dan teknik analisa pergerakan. Untuk menganalisa pergerakan, pembezaan imej, pengambangan 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 perlaksanaan 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.