EMBEDDED SYSTEM FOR FACE IDENTIFICATION BASED ON IRIS DETECTION

By

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LIST OF ABBREVIATIONS

API	*Application Programming Interface*
ATM	*Asynchronous Transfer Mode*
BIOI^{2}D	*Biometric Identification System Based On Iris Detection*
CCD	*Charge Coupled Device*
CF	*Compact Flash*
CMOS	*Complementary Metal Oxide Semiconductor*
CPU	*Central Processing Unit*
DHCP	*Dynamic Host Configuration Protocol*
DSP	*Digital Signal Processor*
ECG	*Electrocardiogram*
EOS	*Embedded Operating System*
FDM	*Fused Deposition Modeling*
FPGA	*Field-Programmable Gate Array*
FTP	*File Transfer Protocol*
GNU	*A Computer Operating System Composed Entirely Of Free Software*
GPL	*General Public Licence*
GPRS	*General Packet Radio Service*
GSM	*Global System For Mobile Communication*
GUI	*Graphical User Interface*
HCI	*Human Computer Interaction*
IC	*Integrated Circuit*
IPC	*Inter-Process Communication*
ioctl	*Input/Output Control*
JVM	*Java Virtual Machine*
LAN	*Local-Area Network*
LCD	*Liquid Crystal Display*
LSI	*Large Scale Integrated*
Netpbm	*An Open Source Package Of Graphics Programs And A Programming Library, Used Mainly In The Unix World*
OOP	*Object Oriented Program*
OPS	*Operation Perseconds*
OS	*Operating System*

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*
PIN	*Personal Identification Number*
PNM	*Portable Any Map*
PPM	*Portable Pixel Map*
RAM	*Random Access Memory*
RISC	*Reduced Instructions Set Computer*
ROM	*Read-Only Memory*
SBC	*Single Board Computer*
SCP	*Secure Copy*
SCSI	*Small Computer System Interface*
SHM	*Shared Memory*
SOC	*System On A Chip*
SSD	*Solid State Disk*
SSH	*Secure Shell*
TCP/IP	*Transmission Control Protocol/Internet Protocol*
UDP/IP	*User Datagram Protocol/Internet Protocol*
UNIX	*A Computer Operating System*
USB	*Universal Serial Bus*
VGA	*Video Graphics Array*
VHDL	*VHSIC Hardware Description Language*
VHSIC	*Very-High-Speed Integrated Circuits*
WAN	*Wide Area Network*
WAP	*Wireless Application Protocol*

SISTEM TERBENAM UNTUK PENGECAMAN WAJAH BERASASKAN PENGESANAN ANAK MATA

ABSTRAK

Kajian ini memperincikan rekabentuk dan perlaksanaan Sistem Terbenam untuk Pengecaman Biometrik berasaskan Pengesanan Anak Mata (BIOI^{2}D). Sistem ini menggunakan Komputer Sistem Terbenam (SBC) dengan mengeksploitasikan Sistem Pengoperasian GNU/Linux yang membenarkan penggunaan sumber-sumber terbuka seperti perpustakaan, pemacu *kernel* dan pengkompil GNU C dalam pembangunan dan perlaksanaannya. Sistem BIOI^{2}D ini direkabentuk untuk beroperasi secara sistem masa nyata dengan melaksanakan proses-proses seperti berikut: pengambilan imej muka, pemprosesan imej muka dan suai padan dengan pengkalan data dengan menggunakan nombor pengenalan pengguna untuk mempercepatkan tugas-tugas pemprosesan. Komponen utama untuk Pembaca Muka adalah Komputer Sistem Terbenam (SBC) x86 model TS-5500. Komponen lain yang diintegrasikan kepada Komputer Sistem Terbenam ini adalah panel LCD, Kamera Web sambungan USB, Kad Kilat Kompak, Kad Rangkaian Tanpa Wayar PCMCIA dan papan kekunci. Perisisan sistem BIOI^{2}D ini dirangka dalam lima (5) modul iaitu Pengantaramuka Pengguna, Perolehan Imej, Pra-pemprosesan Imej, Rangkaian dan Pengecaman Biometrik. Pembangunan modul Pengantaramuka Pengguna melibatkan integrasi panel LCD dan papan kekunci matrik dengan system Pembaca Muka. Modul Perolehan Imej dibangunkan dengan menggunakan perpustakaan *video4Linux*. Sistem BIOI^{2}D ini beroperasi secara masa nyata dimana memerlukan pengenalan identiti sesebuah muka. Perisian pengecaman muka ini akan mengenalpasti muka seseorang berdasarkan imej yang diperolehi. Proses Pra-pemprosesan Imej diaplikasikan keatas imej yang diperolehi untuk membuang latar belakang imej dan mempertingkatkan kontras setempat. Teknik-teknik pra-pemprosesan imej yang dilaksanakan adalah pertukaran format warna, teknik analisa gerakan, penyamaan histogram dan pengubahan saiz imej. Modul Pengecaman Imej adalah terdiri daripada sistem pengenalan muka berasaskan pengukuran anak mata dimana sistem ini berasaskan suaipadan secara bertemplat. Imej muka hasil daripada modul Pra-pemprosesan Imej digunakan sebagai imej masukan untuk modul Pengecaman Imej. Proses pengenalan imej dilaksanakan secara suai padan langsung berdasarkan nombor pengenalan pengguna untuk mengurangkan masa pemprosesan seterusnya mempertingkatkan kecekapan sistem ini. Penilaian yang dijalankan keatas sistem ini memfokuskan pengukuran prestasi perkakasan, proses pemprosesan imej dan proses pengecaman biometrik. Hasil terhadap kajian yang dijalankan keatas 100 imej muka daripada 10 orang menunjukkan kadar kejayaan bagi sistem pengecaman biometrik adalah 73% dan peratusan padanan yang boleh disandarkan dan digunakan sebagai penanda aras untuk melaksanakan sistem ini adalah 98%. Penyelidikan ini menunjukkan bahawa teknologi pemprosesan terbenam, khususnya pemproses x86 TS-5500 komputer sistem terbenam (SBC), telah dibangunkan dengan sempurna dan menjadikannya bermanfaat untuk melaksanakan sistem pandangan berkomputer yang berkeupayaan untuk sistem terbenam iaitu pengecaman biometrik berasaskan pengesanan anak mata.

EMBEDDED SYSTEM FOR FACE IDENTIFICATION BASED ON IRIS DETECTION

ABSTRACT

This research describes the design and implementation of an Embedded System for Biometric Identification based on Iris Detection (BIOI^{2}D). It is based on single board computer (SBC) and utilizing GNU/Linux operating system (OS) which allows the use of open source resources such as libraries, kernels drivers and GNU C compiler in developing and implementing this system. The BIOI^{2}D is designed to operate in real-time mode to execute these following tasks: face (image) capture, preprocessing and matching with database using predetermine user identification number to reduce the processing tasks. The main component for Face Reader is a x86 Single Board Computer (SBC) TS-5500. Other components connected to the SBC consist of LCD Panel, USB Web Camera, Compact Flash Card, PCMCIA Wireless Network Card and keypad. BIOI^{2}D software design is structured in five modules namely as User Interface, Image Acquisition, Image Preprocessing, Network and Biometric Identification. The development of user interface module involves the integration of LCD panel and matrix keypad with the Face Reader system. Image Acquisition Module is developed by utilizing the video4Linux API. BIOI^{2}D is designed to operate in real-time mode, which requires the face identification and recognition software to identify the person face from the captured image. The image preprocessing processes are used to perform initial processing to the captured image by removing background and increased the local contrast. The image preprocessing technique performs are the colour space conversion, motion analysis technique, histogram equalization and image scaling. Biometric identification module is a face recognition system based on iris detection. The recognition system is based on template matching. Output image from the image preprocessing module is used as an input face image for biometric identification module. The recognition process is done one-to-one matching (direct matching) by using user ID to reduced processing time, thus increase the efficiency of the system. The system evaluations are focusing on hardware performance, image preprocessing process and face identification process. Experiment with set of test images consist of 100 images of 10 persons shows the successful rate for the face identification system is 73% and percentage of matching that is reliable and should be used as a threshold for system implementation is 98%. This thesis demonstrate that embedded processing technology, in particular the x86 processor TS-5500 SBC, has been developed well enough to make it useable for implementing a computer vision system adequate for embedded system for biometric identification based on iris detection.

CHAPTER 1

INTRODUCTION

1.1 Overview

Biometrics refers to automatic identification of a person based on his or her physiological or behavioral characteristics which provides a reliable and secure user authentication for the increased security requirements of our information society than traditional identification methods such as passwords and PINs (Jain et al., 2000). Organizations are looking to automate identity authentication systems to improve customer satisfaction and operating efficiency as well as to save critical resources due to the fact show that identity fraud in welfare disbursements, credit card transactions, cellular phone calls, and ATM withdrawals totals over $6 billion each year (Jain et al., 1998). Furthermore, as people become more connected electronically, the ability to achieve a highly accurate automatic personal identification system is substantially more critical.

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 opened new challenges and development of advanced 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 (Badlishah et al., 2006a).

The new generation of embedded systems can capitalize on embedding a full-featured operating system especially GNU/Linux OS bringing a wide selection of capabilities from which to choose inclusive of all the standard IO and built in wireless Internet connectivity by providing TCP/IP stack. Only a few years ago, embedded operating systems typically were found only at the high end of the embedded system spectrum (Richard, 2004). One of the strength of GNU/Linux OS is that it supports many processor architectures thus enable engineer to choose from varieties of processors available in the market (Badlishah et al., 2006b). GNU/Linux OS is therefore seen as the obvious candidate for various embedded applications. More embedded system companies development such as Curtiss-Wright Embedded Computing (Curtiss, n.d.), Technologic Systems Inc. (Technologic, n.d.), Emac Inc. (Emac, n.d.), etc. comes with SDK which consist of open source GNU C compiler.

1.2 Problem Statement

In general, two (2) traditional techniques widely used for user authentication solution are knowledge-based and token-based automatic personal identification (Miller, 1994). Knowledge-based approach use something that user's know to make a personal identification, such as a password or a personal identification number (PIN). This approach is commonly used in electronic access control system. Token-based approaches is prevalent in banking, corporate network, and government applications;

use something that user's have to make a personal identification, such as a passport, driver's license, ID card, credit card, or keys.

These traditional approaches suffer from several disadvantages. As an example tokens, may be lost, stolen, forgotten, or misplaced, and PIN may be forgotten by a valid user or guessed by an impostor. Because knowledge-based and token-based approaches are unable to differentiate between an authorized person and an impostor who fraudulently acquires the token or knowledge of the authorized person (Miller, 1994), they are unsatisfactory means of achieving the security requirements of our electronically interconnected information society.

Biometrics, which refer to the automatic recognition of people based on their distinctive physiological (e.g., face, fingerprint, iris, retina, hand geometry, voice) and behavioral (e.g., signature, gait) characteristics, could form a component of effective user identification solutions, because they intrinsically and reliably represent the individual's bodily identity (Jain, 2002). Biometric characteristics cannot be lost or forgotten; they are quite difficult to copy, share, and distribute; and they require the person being authenticated to be physically present at the time and point of authentication (Aaraj et al., 2006).

The face recognition algorithm based on iris detection method software is developed by Assoc. Prof. Dr. Mohd Rizon Muhamed Juhari. The proposed system is to identify the unknown person in face image for which the position, scale and image-plane rotation of the face are unknown and this identification system is based on template

matching (Rizon et al., 2003). The software is coded using GNU C compiler and run under Linux desktop system.

Aside from technologies to measure new biometrics, research trend are now looking at introducing innovations that fall beyond the recognition system itself. In another words, once the data have been collected, research are put on how will it be archived, compared, transmitted, used in reports and to control a process. Other goal is to make implementation of biometrics a less expensive option through downsizing them and making them portable.

The development and implementation of biometric identification system using low end embedded platform such as FPGAs are severely constrained in their limited processing capabilities, limited memory, limited power source, and algorithms for biometric identification that provide sufficient accuracy tend to be computationally expensive, leading to unacceptable authentication times. This means that achieving acceptable performance often comes at the cost of degradation in the quality of results.

1.3 Motivation

The focus on this research is to develop, implement and analyse an embedded system for biometric identification based on iris detection using single board computer (SBC) and GNU/Linux to replace conventional smart card reader system for security. This system which includes a *Face Reader* to capture and analyze a person faces for authentication purposes. The overall development of face recognition system includes hardware and software implementation. An embedded single board computer (SBC)

with GNU/Linux Operating System which utilizes open source technology kernel, libraries and GNU C compiler is an alternative low cost solution system.

Efficiency of size, weight, cost, interchangeability, and consistency are the major factors (Hoopes et al., 2003) which leads to the selection of SBC as the hardware platform for the system. The SBC standard, a commonly-used robotic development platform (Krishnan, 1999)(Sukhatme, 1999), specifies a main board of approximately 4 by 4 inches that houses a processor, memory and the basic chipset needed to function as a standalone embedded computer capable of functioning with only a separate power supply and whatever outside input or output devices the application calls for. The SBC allows the use of an 802.11b and wired Ethernet connection transmission to provide high-speed two way communications link between the system and PC Database Server.

The SBC itself is portable and can be used for various purposes such as network based identification system on human face, robot vision platform and embedded web server. Utilizing Linux based SBC allow us to manipulate the availability of open source resources such as libraries, kernels and drivers in developing and implementing this system. The SBC used in this development comes with TS-Linux OS which also include TCP/IP network protocol with wireless as well as wired network interface. This allows network centric application to be easily developed and implemented.

1.4 Research Objective

The objectives of this research are:

i. To develop and evaluate a face reader system

ii. To configure and integrate external devices to the main board.

iii. To develop image acquisition, image pre-processing, communication and user interface software based on SBC and GNU/Linux system.

iv. To analyse the performance in comparison to a desktop pc to determine the feasibility of the system.

1.5 Research Scope

This research focus on the development, implementation and analysis of an embedded system for biometric identification based on iris detection using single board computer (SBC) and GNU/Linux OS. The overall system development includes hardware integration and software implementation. It has been shown that embedded single board computers (SBC) with GNU/Linux OS are the cost effective way to develop high-end embedded system. The development includes finding the compatible external devices I/O which can be integrated with the SBC such as USB webcam, LCD panel and matrix keypad. Integrating and implementing the system to work accordingly involves the installation of suitable device driver module to the TS-Linux OS and also involve a compilation of a kernel by considering the version of Linux kernel and libraries.