Design and Implementation of Embedded Vision-Based Tracking System using FPGA-SoC

By

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نَرۡفَعُ دَرَجَٰتٖ مَّن نَّشَآءُۗ وَفَوۡقَ كُلِّ ذِي عِلۡمٍ عَلِيمٞ ٧٦ (سورة يوسف)

((الْحَـــمْدُ لِلَّهِ الَّذِي بِنِعْمَتِـهِ تَتِمُّ الصَّـالِحَاتُ))

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LIST OF ABBREVIATIONS

HDL	Hardware Description Language.
CPU	Central Processing Unit.
ASIC	Application-Specific Integrated Circuit.
FPGA	Field-Programmable Gate Array.
CAD	Computer-Aided Design.
LCD	Liquid Crystal Display.
ALU	Arithmetic Logic Unit.
VHDL	VHSIC Hardware Description Language.
PLL	Phase Locked Loop.
RAM	Random-Access Memory.
SRAM	Complex Programmable Logic Device.
DDR SDRAM	Double Data Rate Synchronous Dynamic Random-Access Memory.
SRAM	Static Random-Access Memory.
VGA	Video Graphics Array.
SOPC	System-on-a-programmable-chip.
I/O	Input/Output.
PROM	Programmable Read-Only Memory.
IC	Integrated Circuit.
SIMD	Single Instruction Multiple Data.
GUI	Graphical User Interface.
RTL	Register Transfer Level.
FPS	Frame Per Second.
HPS	Hard Processor System.

SMC	Sequential Monte Carlo Methods.
PDF	Probability density function.
SIMD	Single Instruction Multiple Data.
ASSP	Application-Specific Standard Product.
MPGAs	Mask-Programmable Gate Arrays.
PLDs	Programmable Logic Devices.
PLA	Programmable Logic Array.
FPD	Field-Programmable Device.
DSP	Digital Signal Processing.
IDE	Integrated Development Environment.
VIP	Video and Image Processing.
GPS	Global positioning system.
HMM	Hidden Markov Models.
RGB	Red, Green, Blue.
IP	Intellectual Property.

Reka bentuk dan Pelaksanaan terbenam Vision Berdasarkan Sistem Pengesanan Menggunakan FPGA-SoC

ABSTRAK

Perlaksanaan sistem pengesanan berasaskan daya penglihatan telah menjadi aplikasi penting dalam bidang daya penglihatan dan sistem pengawasan terbenam. Pengesanan objek adalah komponen utama dalam daya penglihatan terbenam yang sangat bermanfaat dalam beberapa aplikasi seperti kenderaan tanpa pemandu, pengawasan, kawalan lalu lintas automatik, analisis imej bioperubatan dan robot pintar. Oleh yang sedemikian, ramai penyelidik mencadangkan pedekatan daya penglihatan pengesanan terbenam yang berbeza. Walau bagaimanapun, beberapa kajian berkenaan mengalami pelbagai masalah yang telah disebabkan oleh kekerapan pergerakan kamera, perubahan mendadak dalam pola-pola penampilan kedua-dua objek dan tempat kejadian, yang menjadikan pengesanan objek sesuatu yang mencabar. Projek ini mengetengahkan satu isu penting iaitu pengesanan objek berganda. Salah satu masalah yang dihadapi oleh penyelidik adalah pengesanan objek berganda sebagaimana yang diketengahkan dalam projek ini. Oleh yang demikian, projek ini mereka bentuk dan melaksanakan pendeliti pengesanan berasaskan daya penglihatan terbenam objek pelbagai (warna) menggunakan FPGA-SoC. Kaedah yang dicadangkan telah menerima pakai sistem pengesanan penglihatan secara pasif yang berdasarkan platform DE1-SoC dan kamera D5M. Setiap bentuk yang dirakam oleh kamera diproses untuk mengesan objek sasaran menggunakan pendekatan berasaskan warna. Evolusi cadangan kaedah telah dilakukan berdasarkan sepuluh eksperimen bagi dua objek yang berlainan (warna merah dan warna biru). Kesimpulannya, sistem pengesanan terbenam yang pasif telah mengesan pelbagai objek dari arah yang berbeza berdasarkan beberapa ukuran sudut. Jarak pengesanan berbilang objek (warna) telah mencapai sehingga 30 meter untuk objek yang bersaiz 15 × 15 cm. Projek ini menunjukkan hasil prestasi yang lancar kerana DE1-SoC mempunyai keupayaan untuk menjalankan tugas-tugas dalam keadaan selari dan frekuensi yang tinggi sehingga 1.6 GHz. Jumlah sumber daripada unsur-unsur logik (LEs) yang telah digunakan dalam projek ini adalah 9076 unsur.

Design and Implementation of Embedded Vision Based Tracking System Using FPGA-SoC

ABSTRACT

An implemented vision based tracking system has become an important application of embedded in the field of vision and surveillance systems. Object tracking is a fundamental component of embedded vision that is very beneficial in several applications such as unmanned vehicles, surveillance, automated traffic control, biomedical image analysis and intelligent robots. That is why many of researchers have been suggested different embedded vision tracking approaches. However, some of these studies suffer from numerous problems have been manipulated such as many camera motion, abrupt changes in the appearance patterns of both the object and the scene, therefore object tracking is a challenging problem. This project addressing a significant issue namely multiple objects tracking. One of significant problems that are faced the researchers is multiple objects tracking which is addressed in this project. Therefore, this project is designing and implementing an embedded vision based for multiple object (color) tracking system using FPGA-SoC. The proposed method has adopted a passive tracking vision system based on platform DE1-SoC and D5M camera. Every frame captured by the camera is processed to detect the targeted object using color based approach. The evolution of proposed method have been done based on ten experiments for two different objects (red color and blue color). As a results, the passive tracking embedded system have been tracked multi objects in different direction vision based on several angles measurements. The tracking distance of multiple objects (colors) was reached up to 30 meter for sized 15×15 cm object shape. The project is presented a smooth performance because of the DE1-SoC has the capability to carry out tasks in parallel and at a high frequency up to 1.6 GHz. The resources total of logic elements (LEs) were used in this project 9076 elements.

CHAPTER 1

INTRODUCTION

1.1 Overview

The technology of embedded vision systems has now become one of the most important research areas in the world. Embedded vision tracking systems were invented to overcome resource issues as they have the capability to carry out tasks that cannot be achieved by humans, leading to increase in population growth. Thus this development of tracking vision is help to expand a human's work envelope in various areas. The tracking system vision object real time emerges as one of the major computing vision tasks, it is used in many applications such as motion tracking, surveillance systems.

Therefore, the tracking task have been becomes significantly harder to achieve when the targeted object changes its color condition and appearance dynamically. In addition, a vital parameter of tracking is the computational complexity which figures out if the tracker is be utilised as a part of a real-time application.

In this project vision embedded system the used of two main parts are platform DE1-SoC and D5M camera. The tracking vision embedded systems have been studied and applied by many sectors including industry, hobbyists and research laboratories, there are generally two types of tracking, normal cameras, such as the D5M and thermal cameras.

Currently, surveillance cameras are highly requested for public security. They can detect wanted persons, have been used on public roads and have both civilian and military applications. In this field embedded systems have become important in the development of advanced specialised monitoring such as highways, (Peliti, Rosa, Oriolo, & Vendittelli, 2012).

This vision embedded system have some of advantages are Due to the emergence of very powerful, low-cost and energy-efficient processors, it has become possible to incorporate practical computer vision capabilities into embedded systems, mobile devices, PCs and the cloud over the next few years there will be a rapid proliferation of embedded vision technology into many kinds of systems.

Finally, in this project embedded vision tracking systems was discussed some of overview about it. Topics will be addressed in the coming chapters.

1.2 Problem Statement

Nowadays increasing global population growth the lack of public security is a serious problem. Recently, the tracking system has made growing interest to the current researcher with rigorous advancement has attained. Nevertheless, there are still many problems remain unresolved. In previous studies,(Andriluka, Mykhaylo, Stefan Roth, & Bernt Schiele, 2010) researchers have struggled to develop solutions to related problems such as abrupt changes in the appearance patterns of both the object and light reflection on the object, thus object tracking is a challenging problem.

According to a previous study has shown where tracking system is a multiple objects and more challenging than one object (Wenhan et al., 2014).

Furthermore, the multiple tracking object is one of the most difficult things because of multiple process for each frame need processing therefore delays processing data.

Without a doubt this is a serious problem in the multi-object tracking system causing the loss of the target when they are more than the target and thus less system efficiency and loss of time.

1.3 Objective

The objectives of this project are:

1. To design and implement a passive embedded based vision tracking system using FPGA-SoC with the following features:
    i. Multiple objects concurrently.
    ii. Multiple color detection.
2. To verify and improve images and video processing speed for better and faster throughput based on CAD tool and on FPGA board.

1.4 Scope of Project

In this project, the focus will mainly building a tracking vision embedded system multiple objects and multiple color by using a DE1-SoC platform, while other platforms such as Arduino and Raspberry Pi will not be taken into consideration. The main idea is to insulate the colours of the image, making the image grey, where colour has been defined, which allows for tracking of the objects after the image has been processed by the Particle filter. Further image and video analysis will not be taken into account as the process will take more time and it may require a higher performance chip such as the Cyclone V. The optimisation of logic elements is planned to be utilised up until the 50% level to demonstrate that the FPGA. The development of ARM-compatible software using an FPGA-adaptive board is not within the scope of this project because of the fact that the provided board does not have the system on Chip (SoC) integrated with the FPGA backbone.

The prototype is designed to have the capability of tracking multiple color with multiple object. An FPGA board system and a D5M camera were used as the main components. The reason that an FPGA was chosen as the primary computing platform is because it is adept at high-performance video processing tasks because of its capability to handle a large amount of data in parallel, allowing it to detect motion with a refresh rate of up to 1.6 GHz and to track moving objects such as a human.

1.5 Thesis Outline

Chapter 1 gives a brief prologue and introduction to the topic and the current issue. It also discusses the project's objective and scope of the project and desired result.

Chapter 2 describes the study of literature and some hypothesis with respect to the topic. Some related works done previously were being reviewed and researched in this chapter. The algorithms and techniques used from other journals, conferences and websites are briefly discussed in this chapter too.

Chapter 3 explains the research methodology for this project. Some architecture design, algorithm design and techniques to be used are briefly discussed in this chapter. The procedural and methodology to make this project complete have been considered in this chapter.

Chapter 4 describes the final result of the project and the discussion regarding the result. It also commenting on the result obtained, interpreting the meaning of result and explaining if there is any result out of expected.

Chapter 5 gives a conclusion regarding the objectives of the project. It also comments on how closely the measurements and calculations agree and summaries the prior reason for any discrepancies.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The tracking system is used for observing a moving object and supplying the location information of a model by timely ordered sequence. The tracking target may be divided into two main groups, dynamic objects and static objects. To implemented vision system is the initial step before proceeding to tracking algorithm. After reviewing reading materials such as journals and reference books, most of the research in tracking system or vision system is being done with FPGA technology. This is mainly because of the capability of FPGA doing parallel computing, which means works have been done faster (Rao, Patil, Babu, & Muthukumar, 2006).

In spite of the fact that object tracking has gotten significant consideration nowadays, as a rule that the sensors included are static and the accentuation is in the ideal of how to optimize the ability of processing of the ready, available and accessible data. As opposed to the utilization of static sensors, the sending of portable sensors for tracking provides huge favourable circumstances and advantages. For instance, a bigger territory have been secured without the need of broadening the quantity of hubs in the tracking system.

The thought of ideally picking the portable sensors‟ areas with a specific and goal to amplify data addition (otherwise called versatile tracking or dynamic observation) has been linked up to the issues of concurrent localization and mapping, cooperative localization, parameter estimation, as well as optimal sensor selection.