Faculty of Electrical Engineering

VISION BASED MULTI SENSOR FEEDBACK SYSTEM FOR ROBOT SYSTEM WITH INTELLIGENT

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DECLARATION

I declare that this thesis entitled "Vision Based Multi Sensor Feedback System for Robot System with Intelligent" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature: .....

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Date : 15/10/2009

DEDICATION

To my beloved parent and family, Muslims and all human kind

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ABSTRACT

This research studies the machine vision system and how it may be integrated to assist a robot system with artificial intelligent (AI). This research focuses on building a vision-based feedback system for robotics application that consists of image processor and two vision-based sensor devices. A robot manipulator controller will drive a single arm industrial robot according to the input from vision system. The feedback system also feeds the Artificial Intelligent program necessary information to make the right decision, which is based on rules of a popular game, Tic-Tac-Toe. One of the advantages of this research is that it only uses a low resolution camera and image processing software generated by the algorithms itself without additional sensors such as sonar or IR sensor. This research developed an improved technique for object recognition and space occupancies determination which not affected by the orientation of the subject. This project also implements colored object recognition technique using its color and size without edge detection process along with a self-calibration technique for detecting object location without any parameter of the camera by using only two reference points. Finally, a set of experiments to validate the proposed algorithms has been conducted. The algorithms function with success rate from 74% up to 100% and could handle the orientation of a tilted object up to 45 degrees. The result from this research may be used in manufacturing plant for a robot system equipped with machine vision and artificial intelligent.

ABSTRAK

Penyelidikan ini mengkaji tentang sistem penglihatan mesin dan bagaimana ia boleh diintegrasi bagi membantu sebuah sistem robot berkepintaran tiruan (AI). Penyelidikan ini menumpu pada pembinaan sistem suap balik berasaskan keupayaan melihat untuk aplikasi robot meliputi pemproses imej dan penderia berasaskan penglihatan. Sebuah pengawal robot akan memacu sebuah robot industri mengikut masukan dari system penglihatan. Sistem suap balik ini juga menyalurkan kepada program berkepintaran pintar maklumat yang perlu untuk membuat keputusan yang betul berasaskan peraturan permainan terkenal, Tic-Tac-Toe. Salah satu kelebihan penyelidikan ini ialah ia hanya menggunakan kamera beresolusi rendah dan pemproses imej yang dijana dari algoritma-algoritma yang dibangunkan, tanpa penderiaan tambahan seperti sonar dan infra merah. Penyelidikan ini membangunkan teknik-teknik yang dipertingkatkan untuk pengesanan objek dan kepenggunaan ruang yang tidak terkesan dengan orentasi objek. Projek ini turut menggunakan teknik pengesanan objek berwarna melalui warna dan saiznya tanpa process pengesanan sisi disamping proses penentukuran sendiri bagi mengenalpasti lokasi objek yang telah dikesan, tanpa memerlukan sebarang parameter kamera, dengan menggunakan dua titik rujukan. Akhir sekali, satu siri eksperimen dijalankan untuk memastikan kesahan algoritma-algoritma yang dicadangkan. Algoritma-algoritma ini telah berfungsi dengan jayanya dengan kadar kebolehjayaan dari 74% sehingga 100% dan mampu menangani orentasi dengan kecenderungan sehingga 45 darjah. Hasil penyelidikan ini dapat digunakan di kilang pembuatan untuk sistem robot yang dilengkapi penglihatan mesin dan berkepintaran tiruan.

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CHAPTER 1

INTRODUCTION

1.1 Background

Moving in an unknown environment is an experience for all animated systems. This is made possible because the visual information data stream holds a large number of useful parameters that all these system interpret and translate into actions as well as into behaviours. It is now well accepted that the use of vision systems coupled with a robot manipulator can considerably improve their robustness and efficiency and allow the realization of complex industrial tasks when a trained single robot manipulator is likely to fail. As the concept of reconfigurable manipulators has been recently developed to facilitate the combination of manipulators structures to best suit specific tasks, robot vision has been very helpful in making it successful (Jamaluddin, et al., 2006).

This chapter discuss the previous research done in areas similar to this project. Among others are vision systems, artificial intelligent, sensor integration, data fusion, multi sensor system, vision sensor and machine vision. This chapter also provide briefs discussion on the research objectives, motivation, scopes and contribution of this research. At the end of this chapter, advantages of multi sensor system will be discussed as it is very important for decision made throughout this research.

1.2 Motivation of Research

A significant part of artificial intelligence for industrial robotics deals with planning or deliberation for system which can perform mechanical actions such as moving a robot arm through some space and to recognize features of any objects that are being processed at real time. As robotic and automation system is widely used and exposed to many types of failure, input data provided by a vision sensor can greatly help the system to reduce their possibilities of failure and provides some abilities to work on widely area of task and assignment.

An industrial robot will need the ability to recognize current condition of their subject rapidly for maximum effectiveness in a particular situation to respond in any environment and react accordingly to fulfil their task. Introducing multi-sensor feedback system simply improves the efficiency of the robot as it improves the understanding of the system about the objects that are being process in robust conditions and for variety of tasks. At this point, an effective robot vision system with multi-sensor feedback system has to be considered to apply for industries.

Robotizing a plant usually cost a lot of initial capital. This is due to the fact that industrial robots are very expensive especially if they are imported. While cost to obtain robots could hardly be reduced, the supporting systems cost, such as sensors system, can be reduce by using cheap sensors couple with a great image processing technique.

This system has been designed to work with a commercial image processor which can process data from a set of multi vision sensors setup to provide sufficient information on

the features of the subject that being process for a robot controller. The system will be designed to enable the robot to recognize the subject features and current condition that relevant to the database or rules that being imply with the task, based on the input provided by a series of low resolution camera.

In summary, the motivation for this project is the desire to have a feedback system with intelligent for robot system, which is able to recognize object and its current condition and could comprehend the lack of capability of low-resolution camera and maintained the quality or reliability of the program output. It has to provide reliable input to facilitate the robot to make essential decision to work efficiently and intelligently towards its current condition and process. All of these are to be achieved using vision sensory alone, subject to certain limitations as discussed later.

1.3 Objective of Research

In its simplest terms, the objective of this research is to build a vision system that could assist a robotic system to make right decision and run its operations according to its pre-programmed task by enabling it to recognize objects with different colours from two sources of image. The vision system should enable the recognition of the different colour of the objects and provide the coordinates of the object. The system will also have the ability to recognize the relevant condition of the objects' position in its environment.

The vision system will have to be able to do the following items:

1. Providing information regarding both the location of a point or subject and the specific features of the subject and its surrounding such that relevant to the process conducted by the robot.
2. Recognize the conditions of the identified object and its related environment, which will help a robot system with artificial intelligence (AI) making necessary decision.
3. Working with images that must not be taken by the system in real time but "on-event" which allowed the use of non-high speed communication medium between camera and image processor. The image-processing program must have the ability to comprehend the lack of capability of typical computer camera (web cam) and maintained the quality or reliability of the program output.

1.4 Multi Sensors Configuration

Single sensor systems are limited in their ability to sense and identify meaningful features under varying conditions. A single source of information can only provide partial information about an environment, and that information is usually insufficient to constrain possible interpretations and to resolve ambiguities. Introducing multi-sensor feedback system provides the opportunity to have another dimension of the subject which cannot be covered by single sensor and simply improved the understanding of the system on the object.

The output from a single sensor is relatively simple to interpret, but the user of such a system must rely completely on the accuracy and integrity of that data. Multi sensor

systems enable the robot to carry more difficult and detail task in a robust environment as the robot can understand the relevant parameter better and response more accurate according to the pre-programmed assignment. Autonomous operation designer can program the robot with lesser complicated program considering that up to date object and obstacle position can be acquired successfully by their feedback system.

1.5 Scope of Research

The scope of the research can be described into the following parts:

1. Develop a program using image processor to process images taken from two cameras to recognize object in picking area and placing place according to its colour and size.
2. Construct a system to identify the position of identified object and provide the information in a meaningful form that will help the robot do its tasks based on AI program.
3. Investigate the effects of brightness in the working environment to the vision system

1.6 Literature Review

1.6.1 Vision System

Robots in science fiction have exhibited considerable visual acuity and high-level reasoning. For example, the android played by Robin Williams in the movie The Bi-Centennial Man was capable of human-like behaviour and developed skills in sculpting and woodwork that require extremely good vision as well as perceptual understanding. The current state of the art is far less impressive than these fictional robots.

Robot vision is a complex sensing process. It involves extracting, characterizing and interpreting information from images in order to identify or describe objects in environment. Vision systems should be able to acquire images, extract the relevant user-defined features just by processing the acquired images and return them through the available interface (Pire, et al., 2006).

There are many ways to implement object classification algorithms. In the pervious researchers they are based on colour histogram (Ching, et al., 2001)(Hideki, 2004), motion detection (Dedeoglu, 2004) and template matching (PerS, et al., 2002) but using colour to classify the objects is more practical compare motion or template matching. The reason is that there is no need for other information from other type of sensory pressure or sonar, or to train the template for matching process.

1.6.2 Artificial Intelligent

According to Online Dictionary of Library and Information Science 2002, artificial intelligence (AI) defined as mechanical and electronic devices and applications designed to closely mimic the human ability to learn, reason, and make decisions. AI is used in voice recognition technology, expert systems, natural language and foreign language processing, and robotics. In the field of artificial intelligence (AI) during the 80's and 90's of the last century, a chess computer was built and able to beat the greatest human chess players (world champions). In 1997 Deep Blue, a special high end computer consisting of more than 500 processors (with 480 of these processors were special purpose chips designed for computer chess) and was solely built for this task had beaten Garry Kasparov.

Intelligent robots are a machine that capable of extracting information from its environment and use the knowledge about its world to move safely in a meaningful and purposeful manner. Intelligent robots can be characterized by the ability to autonomously plan and execute motion sequences to achieve a goal specified by a human user without detailed instructions. Intelligent robots can also be characterized by the ability to operate in an uncertain, changing environment with the help of appropriate sensing, for example, computer vision. This is possible because of artificial intelligent.

1.6.3 Vision Sensor

A sensor can be classified according to its strengths relative to the task to be performed as well as to its limitations relative to that task. Among the factors influencing this categorization are the complexity of the individual sensor, observation errors caused by sensor placement, understanding of the implicit and explicit calibration constants, sensor noise, and an understanding of techniques for expressing sensor output in a common measurement system (Nashman, 1993).

Because the resolution of the captured image reduced, caused by widen area of interest; parallax errors, and robot hand obstructing the field of view, the usual approach of placing camera above the working area is of questionable value for various robotic applications. Mounting the vision sensor in the robot hand may be a better solution, which eliminates these problems. The digital image produced by a vision sensor is a mere numerical array which has to be further processed until an explicit and meaningful description of the visualized objects finally results. Digital image processing comprises more steps: pre-processing, segmentation, description, recognition and interpretation.

Trevor on his paper about collaborative map building using visual landmarks define that a world view is a 2D map of a portion of the real world that represents obstacles and clear space for the purposes of navigation (roaming without colliding with obstacles) and localization (determining where the robot is on the map) (Trevor, 2003). This definition does not specify the representation of the map, nor how the obstacles are recorded. It does, however, indicate that a world view is not a 3D representation. The world in this sense is two-dimensional, as is the case in most human-built structures. Furthermore, a world view does not imply a full perceptual model where the obstacles are recognized as instances of various objects, e.g. chair, filing cabinet, bookcase, etc.

1.6.4 Machine Vision

Much of the early work in the field of machine vision was driven by robot guidance applications. Back in the mid- to late-70s, the National Science Foundation of USA sponsored research at the Stanford Research Institute under Charles Rosen that led to the pioneering work in their global feature analysis algorithms. At the same time NSF sponsored Dr. John Birk's work at the University of Rhode Island for the classic "bin-picking" application. (Zuech, 2003)

Nello Zuech, President, Vision Systems International, conducts a forum with a few representatives of companies known to be of suppliers of machine vision systems for robot guidance applications. Steve Annen, Dr. G. Sudhir, and Manish Shelat, from Adept Technology, during the discussion, claimed that many robot companies are showing cameras mounted to robots and using the label "vision-guided robot" while in reality, these are simply inspection cameras mounted to a robot, sending position offsets from a