UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Development of Vision System Using MATLAB

Thesis submitted in accordance with the requirements of the
Universiti Teknikal Malaysia Melaka for the Degree of
Bachelor of Engineering (Honours) Manufacturing (Robotic and Automation)

By

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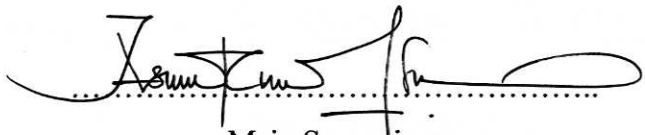
APPROVAL

This thesis submitted to the senate of UTeM and has been accepted as partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering(Robotic and Automation). The members of the supervisory committee are as follow:



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I hereby, declare this thesis entitled "Development of Vision System Using MATLAB" is the results of my own research except as cited in the reference.

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ABSTRACT

Vision system is one of the most approached systems in industrial automation for replacing manual inspection procedure done by human inspector. A machine vision system is use in many applications such as parts sortation, defect detection, object recognition and parts counting. A vision system consists of image acquisition and image analysis procedure to obtain and manipulate the image into a decision. In order to develop a vision system, full understanding regarding how the system works is the most important aspect. Programming software is required in order to execute the image acquisition and image analysis algorithm. In this project, MATLAB platform is used to program the entire algorithm furthermore implementing Graphical User Interface to communicate between the vision system and the user. The system also communicates through serial communication in order to integrate with automated conveyor system that controlled by microcontroller. The system is intensively tested in order to obtain the desired inspection accuracy. A full programming documentation will be done based on programming body modification and improvement. This will be done due to the fact that further improvement of this project will need the coding history on how the algorithm being developed thus documentation is the common practice in programming stage. The vision system developed only possessed 80% accuracy. Enhancement on image processing algorithm can greatly contributes to improvements. The further improvements can be made through lighting design, adding image enhancement algorithm and decision algorithm. Hence, deep understanding of vision system work flow will be obtained thus enhancing advanced sensory application.

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

ADC	-	Analog To Digital Converter
AGV	-	Automated Guided Vehicles
AIA	-	Automated Imaging Association
BASIC	-	Beginner's All-purpose Symbolic Instruction Code
CCTV	-	Closed Circuit Television
C	-	C Programming language
C++	-	C++ Programming language
CCD	-	Charge Coupled Device
CMOS	-	Complementary metal–oxide–semiconductor
COM	-	Programming language
CPU	-	Central Processing Unit
F	-	Intensity
FORTRAN	-	Programming language
GUI	-	Graphical User Interface
GUIDE	-	Graphical User Interface Design Environment
Java	-	Programming language
JIT	-	Just In Time
KUTKM	-	Kolej Universiti Teknikal Kebangsaan Malaysia
LED	-	Light Emitting Diode
MATLAB	-	MATrix LABoratory
M x N	-	Matrix size M by N
NOR	-	Logical operation
OR	-	Logical operation
PC	-	Personal Computer
RGB	-	Red Blue Green

SIMULINK	-	Block software
US$	-	United States Dollar
USB	-	Universal Serial Bus
x,y	-	Spatial coordinates
PBASIC	-	Parallax BASIC language

CHAPTER 1
INTRODUCTION TO VISION SYSTEM

A vision system can be defined as the automatic acquisition and analysis of images to obtain desired data for controlling a specific activity. The vision system is a new trend to advanced sensory either in robotics and manufacturing processes. By studying and understanding how the system works and the programming method, one can enhance their knowledge on the new state of the art technology. Machine vision system is implemented in automated processes of in line inspection and quality control and will be further discuss in later chapter.

The MATLAB platform has complicate algorithm embedded in functions that ready to be call in programming body. Other advantage of the MATLAB is capability to program both in textual programming environment and visual programming environment as well. Hence this will simplify the process of coding the machine vision software. The image acquisition toolbox and image processing toolbox are the toolboxes commonly use to assist the image acquisition and image analysis. Through the thesis, readers will understand the importance of machine vision and how its function.

This project will present development of vision system using MATLAB released 6.5.1 for programming platform. This system used low cost instrumentations and cheap to build and easy to be implemented. This system will capable of conducting online inspection procedures on a product going through conveyor at the end of a process.

1.1 Problem Statement

In order to develop a vision system, a programming platform is needed in order to convey the desired image analysis and decision that will be taken based on the results. There are two options to develop a vision system. The most popular yet expensive way to develop the vision system is using visual programming environment such as National Instrument's IMAQ Vision software. However, this software is not available in the college's laboratory.

Even though the visual programming environment possessed advantages over simply image analysis and programming steps, there are drawbacks such as flexibility for integration with other analysis and harder to manipulate for more advance analysis. Furthermore, this kind of platform has lack of support compared to the MATLAB that being in the market for long time and has tons of forum discussing about MATLAB's solution.

The second option to develop a vision system using programming platform is using the textual programming environment. The textual programming environment is pure textual coding where as the language is much harder to master for a non-computer science student even though the textual programming platform has the most flexible integration with other application.

There is no way, a manufacturing student that doesn't have any deep understanding of complex coding use the textual programming environment such as C++ and BASIC language where the algorithm is in pure text coding.

1.2 Objectives

The main objective of this project is development of vision system through digital image processing using MATLAB platform. However, there are some additional objectives such as:

1. Develop a vision system with camera as image acquisition and MATLAB as coding platform.
2. Develop suitable algorithms to maximize inspection accuracy.

1.3 Scopes

In order to design successful vision system, scopes are required to assist and guide the development of the project. The scope should be identified and planned to achieve the objective of the project successfully on the time. The scopes for this project are:

(a) Collect Data:

Collect necessary data on machine vision system that currently being used in industry to get the overview the work flow of the system.

(b) Develop the image analysis algorithm:

The algorithm will be developed using simulation in the MATLAB using toolboxes to obtain the desired algorithm.

(c) Create the software:

Create a functional vision system software based on image analysis.

1.4 Project Overview

This project will consist of conveyor that will convey a part on a fixture (pallet). Then, this product undergoes a vision check that will check the part's surface and edge of the part. The stages are:

(a) Vision inspection stages. This is the most critical part of the module.

The vision inspection process will inspect the quality of the part's surface and

the edge shape and determine if the part is according to the inspection requirement.

(b) Developing system integration and interfacing stage. This automated module will be integrating machine elements, electronics and software. All the inputs from inspection processes are sent to the computer for further decision manipulation. The data from the dimension inspection will be connected to the microcontroller and then sent to the computer through serial port. While for the vision inspection, a webcam with 320X240 pixels will be connected to a computer using USB port. All the decision making are made by software that will be built based on MATLAB 6.5 toolboxes. The software will have a GUI to show options for user.

CHAPTER 2
LITERATURE REVIEW

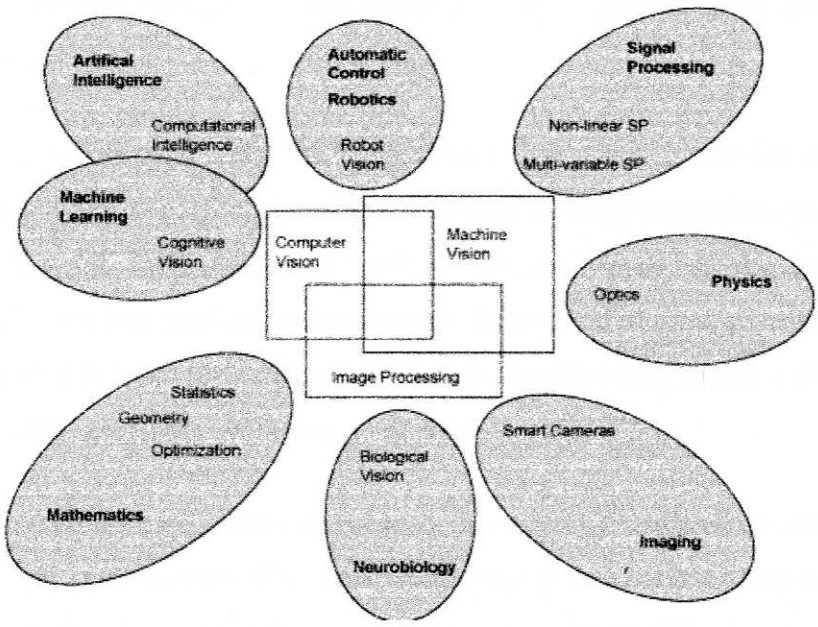

Figure 2.1: Relation between Computer vision and various other fields.

Machine vision can be defined as the acquisition of image data, followed by the processing and interpretation of these data by computer for some useful application. This is rapidly growing technology, with its principal applications in industrial inspection (Groover, 2000).

Machine vision system can be characterized as newly approach field and diverse. The machine system is now being used in many fields such as medical, industrial quality control, military, astronomy field and other fields as Figure 2.1.

The machine vision implementation in industrial quality control alone is growing. The facts supplied Automated Imaging Association (AIA) showed that global market for machine vision products primarily concentrates on the high developed industry regions in North America, Europe and Japan as well as the upcoming countries China, South Korea and Taiwan. According to the AIA, the worldwide machine vision market is expected to grow at an average of 11 percent as a minimum per year during the next five years. For 2004 the AIA estimated worldwide sales with machine vision products of about 7.2 Billions US$. By 2008 the worldwide turnover with machine vision products is expected to grow by 37 percent to reach 10.0 Billion US$ (Basler, 2006).

Even though earlier work exists in machine vision research, it was not until the late 1970's that a more focused study of the field started when computers could manage the processing of large data sets such as images. Many of the methods and applications regarding machine vision are still in the state of basic research, but more and more methods have found way into commercial products, where often constitute a part of a larger system which can solve complex tasks.

Although some machine vision algorithms have been developed to mimic human visual perception, a number of unique processing methods have been developed to process images and identify relevant image features in an effective and consistent manner. Machine vision and computer vision systems are capable of processing images consistently, but computer-based image processing systems are typically designed to perform single, repetitive tasks, and despite significant improvements in the field, no machine vision or computer vision system can yet match some capabilities of human vision in terms of image comprehension, tolerance to lighting variations and image degradation, parts' variability.

Machines vision is commonly use as automated inspection in electronics industry as small electronic components are not suitable to human vision inspection. The capability of machine vision camera to zoom in is the right choice for this kind of specific task.

To insure interchangeability and precision these products are to be 100% quality checked. As a consequence, the inspection process is often expensive and expensive. In a typical manufacturing plant, approximately 30% of all manufacturing tasks are related to inspection, of which 60% of inspection tasks are visual. The break down of typical defects found during visual inspection is approximately 30% part defects, 50% assembly defects (20% of which are incorrect parts or missing parts) and 20% soldering defects.

It should be noted that, in order to maintain a certain level of quality in electronics manufacturing process, an increase in the number of solder joints by a factor of 10 requires that the number of defects be reduced by a factor of 10. Therefore, the effectiveness of an inspection system used to control a process will have a direct impact on the quality of products shipped to customers. This places an extraordinary pressure on human inspectors who are trained to identify defective parts by visual examination (Edinbarough *et al.*2005). Machine Vision possessed a powerful tool to provide effectiveness of an inspection system that required quality control inspection and this will be further discussed in Chapter 2.2.

2.1 Machine Vision Fundamentals

This section will discuss the fundamentals of vision system. Vision systems are classified as being either 2D or 3D. The 2D is most appropriate for most industrial applications since many situations involved 2D scene.

The operation of a machine vision system can be divided into the following three functions (Groover, 2000):

(a) Image acquisition and digitization,
(b) Image processing and analysis and lastly
(c) Interpretation.

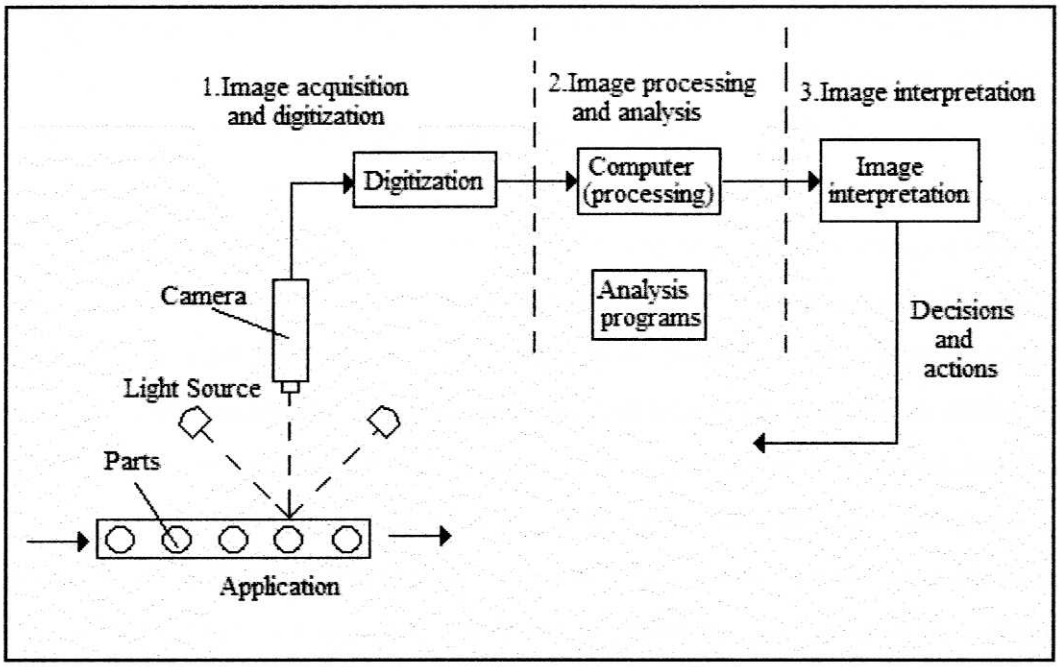

Figure 2.2: Machine Vision Process.

These functions and their relationship are illustrated schematically in Figure 2.2 .Firstly, image acquisition and digitization is accomplished using a video camera and digitizing system to store the image data for further analysis. The camera is focused on the subject of interest, and an image is obtained by dividing the viewing area into a matrix of pixels, in which each element has a value that is proportional to the light intensity of that portion of the scene.

In binary vision, the light intensity of each pixel is ultimately reduced to the either of two values, white or black, depending on whether the light intensity exceeds a given threshold level. A gray-scale system can determine not only and object's outline and area characteristics, but also its surface characteristics such as texture and color. Gray-scale vision system typically uses 4, 6 or 8 bits of memory. Eight bit corresponding to 2^8=256 intensity levels, which is generally more levels than the video camera, can really distinguish and certainly more than human eyes can distinguish.

Each set of digitized pixel values is referred to as a frame. Each frame is stored in a computer memory device called a frame buffer. Normally, the process of reading all the pixels values in a frame is performed with the frequency of 30 times per second.

The second function in the operation of a machine vision system is image processing and image analysis. A number of techniques have been developed for analyzing the image data in a machine vision. One category of techniques in image processing analysis is called segmentation. Segmentation techniques are intended to define and separate regions of interest within the image. Two of the common used segmentation techniques are thresholding and edge detection. Thresholding involves the conversion of each pixel intensity level into a binary value, representing black and white. This is done by comparing the intensity value of each pixel with a defined threshold value. If the intensity value of the pixel is greater than threshold value, the pixel will be assigned as white with value '1' and another way around with the intensity value less than threshold value that will be assigned as black with value '0'. Reducing image to binary image by using thresholding operator usually simplify normal problems of identifying in image.

Other segmentation technique is edge detection that can determine the location of boundaries between an object with its surrounding with an image. This can be achieved by identifying the contrast of intensity that exists between pixels at the border of a object. A number of edge detection operators have been developed such as Sobel's, Canny's and Prewitt's operators will discussed later in Digital Image Processing Chapter.

Another technique in image processing and analysis that usually implemented after segmentation is feature extraction. This technique used segmentation to retrieve object's features such as object's dimension, center of gravity and aspect ratio.

Lastly, the function of machine vision system is interpretation. The interpretation function is to recognize an object within the image, a task termed pattern recognition.