

**THICKNESS MEASUREMENT USING DIGITAL CAMERA**

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in fulfillment of the requirements for the award of the degree of  
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**To my beloved family, friends & lecturers**

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## **ABSTRACT**

At present, some equipment in example printed solder paste thickness is measured using microscope and lighting and its accuracy is depending on operator skill. In this situation, the operator will be the main factor of the thickness measurement's accuracy. If the operator is not skilled enough to do these jobs, then the outcome of the measurement will be very terrible. Although the operator is skilled enough, there are other factors need to be consider as a matter of fact that human will do mistake. This process can be done by installing a camera to replace the operator function. The camera will acts as a sensor, capture the image of the object, and then processed by Matrox Imaging Library (MIL) and Visual Basic 6 software. Prior to that, Calibration and Measurement Module is very essential in this project. This software was successfully developed and test result was obtained.

## ABSTRAK

Dewasa ini, beberapa peralatan misalnya 'printed solder paste' yang mana ketebalannya diukur menggunakan mikroskop dan pengcahayaan dan kejituan bacaannya ditentukan berdasarkan kemahiran pengendalinya. Dalam soal ini, pengendali tersebut memainkan peranan penting dalam menentukan kejituan bacaan ukuran ketebalan 'printed solder paste'. Jika pengendali tersebut tidak begitu mahir, sudah tentu keputusan bacaan tersebut sangat mengecewakan. Walaupun pengendali tersebut mahir, terdapat factor-faktor lain yang perlu diteliti kerana sebagai seorang insan, manusia tidak akan terlepas dari melakukan kesilapan. Proses ini dapat diatasi dengan menggunakan aplikasi kamera menggantikan fungsi pengendali. Kamera tersebut akan bertindak sebagai 'sensor', menangkap gambar objek berkenaan, dan kemudian imej tersebut akan diproses menggunakan perisian 'Matrox Imaging Library' (MIL) dan 'Visual Basic 6'. Menjadi keutamaan dalam hal ini adalah modul kalibrasi dan modul pengukuran. Perisian ini telah berjaya diusahakan dan keputusan telah berjaya dicapai.

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## CHAPTER 1

### INTRODUCTION

#### 1.1 OVERVIEW

At present, some equipment in example printed solder paste thickness is measure using microscope and lighting and its accuracy is depending on operator skill. In this situation, the operator will be the main factor of the thickness measurement's accuracy. If the operator is not skilled enough to do these jobs, then the outcome of the measurement will be very terrible. Although the operator is skilled enough, there are other factors need to be consider as a matter of fact that human will do mistake.

This process can be done by installing a camera to replace the operator function. The camera will capture the image of the object's thickness, and then the image will be processed and analyzed. Figure 1.1 shows the basic block diagram of the thickness measurement program.

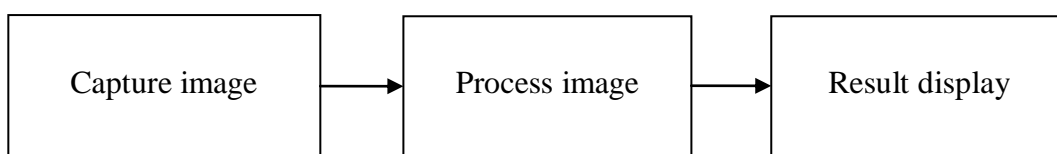


Figure 1.1: Block Diagram of the System Using Camera Sensor

## **1.2 RESEARCH OBJECTIVES**

This study attempts to achieve the following objective:

- i. To study on image processing using Visual Basic 6.0 and MATROX Imaging Library.
- ii. To develop a program that could measure the thickness of an object using digital camera, Visual Basic 6.0 and MATROX Imaging Library.

## **1.3 SCOPE OF PROJECT**

This project is focused to develop and build a program that could measure the thickness of an object by using Matrox Imaging Library and Visual Basic 6.0. Therefore, this project will cover the scope as follow:

- i. The usage of camera sensor as replacement of the operator function.
- ii. To develop a program that can perform a calibration and measurement job.
- iii. To determine the accuracy of this program.

## **1.4 PROBLEM STATEMENT**

Before starting the project, we must take note about the problem of the earlier thickness measurement technique which is the measurement is done by operator using the lighting and microscope. Table 1.1 shows the problem of the previous technique and the solution in order to improve the measurement results.

Table 1.1: Problem statement

Problem	Solution
1. Accuracy of thickness measurement depends on operator skills.	1. Replace operator function by using camera. 2. By using image processing, the accuracy of measurement will increase.

This study aims to seek the following

research question:

- i. How to process the captured image?
- ii. How to measure the thickness?
- iii. How to define the accuracy of this program?

## 1.5 THESIS ORGANIZATION

This thesis consists of five chapters. This chapter discuss about overview of project, objective research, project scope, problem statement and thesis organization.

Chapter 2 contains a detailed description of image processing by using Visual Basic 6 and Matrox Imaging Library. It will explain about the concept of image processing, the application of this system and the involved component in this project.

Chapter 3 includes the project methodology. It will explain how the project is organized and the flow of process in completing this project. Also in this topic discusses the methodology of the system, software design and the step to develop the system.

Chapter 4 will be discussing about the result obtained in this project and a discussion about the result.

Finally, the conclusions for this project are presented in chapter 5. This chapter also discusses about the recommendation for the project and for the future development.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 INTRODUCTION**

Image Processing provides a comprehensive set of reference-standard algorithms and graphical tools for image processing, analysis, visualization, and algorithm development. You can restore noisy or degraded images, enhance images for improved intelligibility, extract features, analyze shapes and textures, and register two images. Image Processing Toolbox supports engineers and scientists in areas such as biometrics, remote sensing, surveillance, gene expression, microscopy, semiconductor testing, image sensor design, colour science, and materials science.

It also facilitates the learning and teaching of image processing techniques. Image processing is any form of signal processing for which the input is an image, such as photographs or frames of video the output of image processing can be either an image or a set of characteristics or parameters related to the image. Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it.



## 2.2 VISUAL BASIC 6.0

Visual Basic (VB) is a third-generation event driven programming language and associated development environment from Microsoft for its COM programming model. Visual Basic was derived from BASIC and enables the rapid application development (RAD) of graphical user interface (GUI) applications, access to databases using DAO, RDO, or ADO, and creation of ActiveX controls and objects. Scripting languages such as VBA and VBScript are syntactically similar to Visual Basic, but perform differently. A programmer can put together an application using the components provided with Visual Basic itself. Programs written in Visual Basic can also use the Windows API, but doing so requires external function declarations.

Visual Basic was designed to be easy to learn and use. The language not only allows programmers to create simple GUI applications, but can also develop complex applications. Programming in VB is a combination of visually arranging components or controls on a form, specifying attributes and actions of those components, and writing additional lines of code for more functionality. Since default attributes and actions are defined for the components, a simple program can be created without the programmer having to write many lines of code.

Forms are created using drag-and-drop techniques. A tool is used to place controls (e.g., text boxes, buttons, etc.) on the form (window). Controls have attributes and event handlers associated with them. Default values are provided when the control is created, but may be changed by the programmer. Many attribute values can be modified during run time based on user actions or changes in the environment, providing a dynamic application. For example, code can be inserted into the form resize event handler to reposition a control so that it remains centered on the form, expands to fill up the form, etc. By inserting code into the event handler for a keypress in a text box, the program can automatically translate the case of the text being entered, or even prevent certain characters from being inserted [1].

### **2.3 MATROX IMAGING LIBRARY**

Matrox Imaging Library (MIL) is a hardware-independent library divided into different modules based on functionality. Where it have a lot of function of image processing such as blob analysis, OCR, pattern matching and lot more. Matrox Imaging Library is an extended toolbox for Visual Basic 6.0 where the command language for Matrox is in Visual Basic 6.0 and C++.

MIL is a comprehensive collection of software tools for developing industrial imaging applications. MIL includes tools for every step in the process: from application feasibility, to prototyping, through to development and ultimately deployment. The toolkit features interactive software and programming functions for image capture, processing, analysis, annotation, display and archiving.

These tools are designed to enhance productivity, thereby reducing the time and effort required to bring your solution to market. Image capture, processing and analysis operations have the accuracy and robustness needed to tackle the most demanding applications. These operations are also carefully optimized for speed to address the severe time constraints encountered in many applications [2].

### **2.4 IMAGE ANALYSIS SOFTWARE**

Several companies have developed extensive sets of image processing and analysis tools suitable for many applications. Examples of these are Optimas<sup>®</sup> software from Optimas and Visilog from Noesis Vision. Image analysis software targeted at specific applications includes Optimas XCaliper<sup>™</sup> for industrial inspection and VisionBlox<sup>™</sup> from Integral Vision for building machine-vision systems.

Since image analysis is the key function that machine-vision systems must perform, selecting the right package for your application is paramount. Dennis Flanagan,

imaging products manager at Optimas, even suggests that you select the vision software tools before you choose the appropriate vision hardware.

"In selecting vision software, first make sure the tools you need are there," said Mr. Flanagan. "Complete vision software should include tools for edge detection, gauging, blob analysis, template matching, pattern detection, optical character recognition (OCR) and color analysis. The software must offer controls and parameters so you can 'tune' the software to meet your performance and accuracy requirements.

"For example, if you need to find edges or align parts that are rotated, make sure the tools can find features at any angle of rotation," Mr. Flanagan continued. "For proper interplay with the vision hardware, the software must also be capable of using the hardware manufacturer's library, and the software and hardware suppliers you select should have a history of working together."

"Since most image analysis software packages have scores of man-years in development behind them, they're very successful in everything they do," said Mr. Wilson. Consequently, the important area to probe is what they don't do. Again, you must evaluate image analysis software in the context of the application.

"As a case in point, LCD panel inspection requires great dynamic range (10-bit digitization or better because of the need to detect small contrast differences). It requires high resolution, perhaps more than  $2k \times 2k$  pixels per image. And it needs large-kernel ( $9 \times 9$  and larger) convolutions. Anyone prototyping an LCD inspection system should make sure that these features are available, starting with the camera and working back into the analysis software. Discard software packages that can't handle any one of these functions," Mr. Wilson concluded.

After you determine that the software has the features you require, decide whether you will always run the software on the same platform. If not, the degree to which the software is device-independent must be considered.

For instance, the Matrox MIL imaging library may be used with all Matrox frame grabbers as well as image processors. This capability allows you to choose between host-based and processor-based systems and to move code from one to the other, offering a range of performance levels for various applications, commented Mr. Albanese [3].

## **2.5 IMAGE PROCESSING**

Extensive set of imaging primitives including point-to-point, statistical, filtering, morphological, geometric transformations, FFT and segmentation.

Point to point -

- i. Manual or automatic thresholding (binarizing, clipping)
- ii. Arithmetic operations: add, subtract, multiply, integer divide, fixedpoint divide (two images or an image and constant), negate, absolute value, copy image (conditional, mask, etc.), clear buffer to a constant
- iii. Logical operations: NOT, AND, NAND, OR, XOR, NOR, or XNOR (two images or an image and a constant)
- iv. Comparative (minimum/maximum)
- v. Shifting
- vi. LUT mapping
- vii. Frame averaging

Statistics -

- i. Intensity histogram
- ii. Minimum/maximum pixel values
- iii. Locate certain pixel values
- iv. Count differences between two images
- v. 2D to 1D projection
- vi. Histogram equalization

Filtering -

- i. Noise removal and image smoothing: low-pass spatial filter (Gaussian), rank (median) filter

- ii. Edge enhancement: sharpen, sharpen with increased contrast
- iii. edge detection (extraction): horizontal, vertical, Sobel,
- iv. Laplacian, compass gradient
- v. Customizable filters with kernels of any size

#### Morphological operations -

- i. Erosion, dilation, opening, closing, thinning (skeleton), thickening, "hit or miss", binary matching, zone of influence, distance and labeling
- ii. Customizable morphological operators with structuring elements of any shape and size

#### Geometric transformations -

- i. Image resizing (nearest neighbor or interpolated)
- ii. Image rotation (nearest neighbor or interpolated)
- iii. Sub-pixel translation
- iv. Polar coordinates conversion (from Cartesian to polar coordinates and vice-versa)
- v. Warping using first order polynomial or look-up table (LUT) based method:
  - a. First order polynomial warping: translation, rotation, scaling, and shearing effects
  - b. LUT-based warping: perspective mapping, translation, rotation, scaling, shearing and four-corner effects, 2nd and 3rd order transformations (radial, barrel, pincushion lens distortions) and custom transformations

#### FFT -

- i. Transform images from spatial to frequency domain and vice-versa for frequency domain analysis.
- ii. Results provided in real and imaginary form or as power spectrum (scaled to display range) and phase ( $^{\circ}$ ).

#### Segmentation -

- i. Powerful watershed grayscale morphology operator for difficult blob segmentation. Function used in conjunction with other MIL functions to label and/or segment connected blobs.
- ii. Regular and straight watershed (particle separation).
- iii. Regular watershed and catchment basin (segment blobs from background) [4].

## 2.6 MIL'S IMAGE PROCESSING

Pictures, or images, are important sources of information for interpretation and analysis. These might be images of a building undergoing renovations, a planet's surface transmitted from a spacecraft, plant cells magnified with a microscope, or electronic circuitry. Human analysis of these images or objects presents inherent difficulties: the visual inspection process is time-consuming and subject to inconsistent interpretations and assessments. Computers, on the other hand, are ideal for performing these tasks. In order for computers to process images, the images must be numerically represented. This process is known as image digitization.

Modern digital technology has made it possible to manipulate multi-dimensional signals with systems that range from simple digital circuits to advanced parallel computers. The goals of this manipulation can be divided into three categories:

- i. Image processing : image in image out
- ii. Image analysis : image in measurements out
- iii. Image understanding : image in high-level description out

Once images are represented digitally, computers can reliably automate the extraction of useful information through the use of digital image processing. Digital image processing performs various types of image enhancements, distortion corrections, and measurements.

MIL provides a comprehensive set of image processing operations. There are two main types of image processing operations:

- i. Those that enhance or transform an image.

- ii. Those that analyze an image (that is, generate a numeric or graphic report that relates specific image information).

MIL supports such operations as:

- i. Point-to-point operations. These operations include constant thresholding, image comparison, image subtraction, and image mapping. They compute each pixel result as a function of the pixel value at a corresponding location in either one or two source images.
- ii. Statistical operations. These extract statistical information from a given image, such as the minimum or maximum image pixel value or a histogram. They condense a frame of pixels into a smaller, more functional set of values for analysis.
- iii. Spatial filtering operations. These operations are also known as convolution. They include operations that can enhance and smooth images, accentuate image edges, and remove 'noise' from an image. Most of these operations compute results based on an underlying neighborhood process: the weighted sum of a pixel value and its neighbors' values.
- iv. Morphological operations. These operations include erosion, dilation, opening, and closing of images. They compute new values according to geometric relationships and matches to known patterns in the input image.

## 2.7 IMAGE QUALITY

Prior to manipulating and extracting information from an image, many applications require that user obtain the best possible digital representation of it. Several factors affect the quality of an image. These include:

- i. Random noise. There are two main types of random noise:
  - a. Gaussian noise. When this type of noise is present, the exact value of any given pixel is different for each grabbed image; this type of noise adds to or subtracts from the actual pixel value.
  - b. Salt-and-pepper noise (also known as impulse or shot noise). This type of noise introduces pixels of arbitrary values (usually high-frequency values) that are generally noticeable because they are completely unrelated to the neighboring pixels.

Random noise can be caused, for example, by the camera or digitizer because electronic devices tend to generate a certain amount of noise. If the images were transmitted, the distance between the sending and the receiving devices also magnifies the random noise problem because of interference.

- ii. Systematic noise. Unlike random noise, this type of noise can be predicted, appearing as a group of pixels that should not be part of the actual image. This can be caused, for example, by the camera or digitizer or by uneven lighting. If the image was magnified, microscopic dust particles, on either the object or a camera lens, can appear to be part of the image.
- iii. Distortions. Distortions appear as geometric transforms of the actual image. These can be caused, for example, by the position of the camera relative to the object (not perpendicular), the curvature in the optical lenses, or a non-unity aspect ratio of an acquisition device.