VISION-BASED FOR THE RECOGNITION AND IDENTIFICATION OF THE EDGE OF A TOOTH SAW BUTT JOINT SHAPE

MUHAMMAD SHADIQ BIN LAGANI

BACHELOR OF MECHATRONICS ENGINEERING WITH HONOURS
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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MUHAMMAD SHADIQ BIN LAGANI

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DECLARATION

I declare that this thesis entitled "VISION-BASED FOR THE RECOGNITION AND IDENTIFICATION OF THE EDGE OF A TOOTH SAW BUTT JOINT SHAPE" 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 : .....

Name : .....

Date : .....

APPROVAL

I hereby declare that I have checked this report entitled "VISION-BASED FOR THE RECOGNITION AND IDENTIFICATION OF THE EDGE OF A TOOTH SAW BUTT JOINT SHAPE" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Mechatronics Engineering with Honours

Signature : .....

Supervisor Name : .....

Date : .....

DEDICATIONS

To my beloved mother and father, the most hardworking and loving people I have ever known.

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ABSTRACT

Nowadays, the most well-known autonomous method in recognizing and identifying the edge of a butt joint implements the usage of vision sensor or laser-assisted vision sensor because of its performance and robustness compared to a manual approach. The most common vision sensors that are used are charge-coupled device (CCD) and complementary metal-oxide semiconductor (CMOS) cameras. This research paper presents the development of a vision-based method to recognize and identify the edge of a tooth saw butt joint shape and evaluation of the accuracy and repeatability of the proposed method. CMOS camera is used in this research because of its high readout speed and inexpensive cost over the CCD camera. The methodology for the digital image processing of the recognition and identification of the edge of a tooth saw butt joint shape comprises of four processes: (1) image pre-processing (2) image segmentation (3) morphological image processing (4) edge butt joint feature points representation and description. The feature points of the edge of a tooth saw butt joint shape which is the start point, supporting point 1 & 2 and the end point is in x and y coordinates of the pixel value image captured by the camera. All the variables in the image processing such as, the threshold values for the edge detection techniques to convert the original image to binary image, the size of the structuring element of the morphological operation dilation and the minimum quality for corner detection is determined and compared to find the most suitable value. The process of the recognition and identification of the edge of a tooth saw butt joint shape is done using different edge detection techniques such as Sobel, Prewitt, Roberts and Canny edge detection technique. The average readings for the feature points is compared to the original points. The comparison shows the accuracy of each method. The average readings are used to calculate standard deviation to show each method's repeatability. The findings suggest that Canny edge detection technique is the most accurate method and all the techniques has a high repeatability due to the reliability of the variables determined and procedures done.

ABSTRAK

Pada masa kini, kaedah yang sering digunakan dalam mengenalpasti dan mengiktiraf garisan alur antara dua bahan mengadaptasikan penggunaan sensor penglihatan atau sensor penglihatan dengan bantuan laser disebabkan prestasinya yang tinggi dan binaan yang kuat berbanding kaedah manual. Sensor penglihatan yang sering digunakan ialah kamera peranti pengawal pasangan (CCD) dan semikonduktor logam-oksida pelengkap (CMOS). Kertas penyelidikan ini menerangkan tentang penciptaan kaedah menggunakan sebuah sistem penglihatan untuk mengenalpasti dan mengiktiraf garisan alur antara dua bahan berbentuk gigi gergaji dan membuat penilaian kebolehulangan dan ketepatan terhadap kaedah yang dicadangkan. Kamera CMOS digunakan dalam projek ini disebabkan masa pemprosesan yang cepat dan mempunyai kos yang rendah baik berbanding kamera CCD. Metodologi pemprosesan dalam mengenalpasti dan mengiktiraf garisan alur antara dua bahan berbentuk gigi gergaji terdiri dari empat proses iaitu: (1) pemprosesan imej (2) segmentasi imej (3) pemprosesan imej morfologi (4) mengenal pasti titik kriteria pinggir antara dua bahan berbentuk gigi gergaji. Titik-titik kriteria garisan alur dua bahan berbentuk gigi gergaji dilabelkan "start point", "supporting point 1", "supporting point 2" dan "end point" dalam bentuk koordinat piksel x dan y. Semua pemboleh-ubah seperti dalam proses pemprosesan imej ditentukan dan dibandingkan untuk mencari nilai yang paling tepat. Proses digunakan adalah beberapa teknik seperti Sobel, Prewitt, Roberts Operator dan Canny Edge Detector. Nilai purata dalam bentuk koordinat piksel "start point", "supporting point 1", "supporting point 2" dan "end point" dibandingkan dengan titik sebenar alur bahan bentuk gigi gergaji. Perbandingan tersebut menunjukkan ketepatan setiap satu kaedah yang dilakukan. Nilai purata dari kaedah yang dipilih akan digunakan untuk menunjukkan keboleh-ulangan setiap kaedah tersebut. Kaedah Canny Edge Detection memberi keputusan yang menghampiri bacaan titik-titik kriteria garisan alur tersebut dan kesemua teknik menunjukkan tahap keboleh-ulangan yang tinggi.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Overview

This chapter presents the project background on the recognition and identification of the edge of a tooth saw butt joint shape using a vision-based approach, motivation of the project, problem statement that leads to the proposal of the project, objectives as the guideline throughout the project, scope covering the limitation in terms of measurable outcomes and the outline of the project.

1.2 Project Background

The application of a vision-based system in manufacturing industries has increased the productivity, quality control and had given a competitive edge to the industries applying it. The general functions of a vision-based system during manufacturing processes are capturing and acquiring the desired image containing a region of interest for analysis purposes, identifying and describing the distinct features within the region of interest inside the image. The environmental surrounding during the process must be considered in the vision-based system to achieve a consistent outcome. Illumination techniques, for example, structured lighting can be applied to control the environmental surrounding by illuminating the region of interest with uniform illumination. After a proper illumination technique is introduced, image sensing will be the next step to obtain a good quality image. After the image is sensed, digitization will take place in order to convert the image into digital value so it can be read and displayed by machines used in the manufacturing processes. Lastly, digital image processing techniques are used to obtain the desired final image state for the manufacturing processes [1,2].

One of the manufacturing activities that apply this technology is metal butt joint recognition or seam weld tracking which commonly seen in robotic welding application [3]. Basically, a butt joint is the union of two materials, which in robotic

welding process, a metal material joined in parallel which forms a discontinuity of boundary between both of the material where the robot will weld it together. There are various butt joint shapes such as straight, curved, tooth saw and et cetera [4]. This discontinuity represents an edge where it can be detected by a vision-based system and represented and described using digital image processing techniques. When the image of the edge is obtained, digital image processing techniques can be applied such as, image segmentation, morphological image processing and representation and description of image. Those techniques can filter the image from unwanted information, such as noise and reflections, convert image to binary image for further analysis and extraction of features, such as the shape of the butt joint respectively [1,2].

In this project, a vision-based approach to recognize and identify the edge of a tooth saw butt joint shape is developed. The image containing the edge of the tooth saw butt joint shape is captured, digitized and processed using digital image processing techniques. The image is segmented and analyzed to extract the tooth saw shape feature in coordinates pixel value. The accuracy and repeatability of the approach will then be tested.

1.3 Motivation

The implementation of machine vision in manufacturing processes has become a global trend in the industrial automation due to its beneficial aspect in terms of production and economic benefits. The increasing on high demands in productions and skilled laborers in today's competitive global market also leads to the increase of application of machine vision. By implementing a vision-based system to the machines operated in manufacturing processes, it can reduce the downside of the current manually operated machines [4,5,6].

According to VDMA Machine Vision Association, the sales within the machine vision market in Germany has risen by 8% as of 2016 up to 2.2 billion euros. The graph shows a significant increasing trend from the year 2010 until 2016. The cause of the increasing trend according to [7], is the widespread of machine vision technologies onto new application worldwide. Figure 1.1 shows the graph of German machine vision industry sales [7].

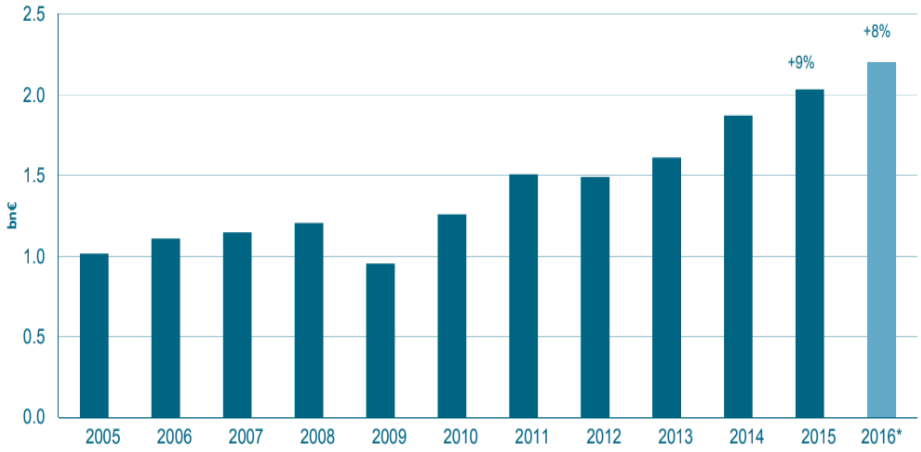

Figure 1.1 German machine vision industry sales [7]

Figure 1.2 shows the customers of VDMA Machine Vision Association based on industries sectors. By evaluating each individual sectors on 2014 and 2015, the VDMA determined that automotive industries are the most common customer with a percentage of 22% of the total earnings. Semiconductor industries is the second common customer, 13% total earnings. Other manufacturing industries has a percentage of 8% out of the total earnings [7].

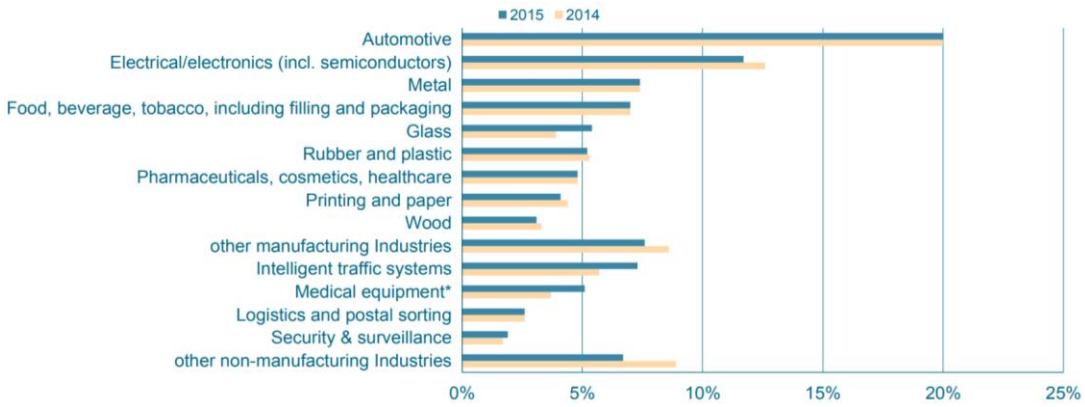

Figure 1.2 VDMA Machine Vision Association customers based on industries section [7]

Machine vision-based system application in manufacturing process which includes the recognition of edge butt joint shape for robotic welding has a proven potential of increasing in terms of economy aspect. The vision-based system aids the robotic welding in identifying its weld seams easily and autonomously.

1.4 Problem Statement

Today's current method in recognizing and identifying the edge of a tooth saw butt joint shape in manufacturing processes, mainly in modern robotic welding are using manual operation which is by depending on human observations. The robot is customized and calibrated using "teach and playback" techniques by skilled human operators each time a new edge of tooth saw butt joint shape with different measurements is introduced. Through this repetitive process, it can be time consuming causing the rate of production of the industry using this current method to have a low rate of production. The complexity shape of the edge of a tooth saw butt joint also contribute in the time consumption of operation. It also increases cost to hire several skilled operators to operate the robot manually [4,5,6].

In order to solve the problem, a fundamental machine vision engineering knowledge is required. A vision-based system with good illumination source can be applied to the robotic welding enabling it to recognize and identify the feature points (start, supporting and end) of the edge of the tooth saw butt joint shape automatically. By doing so, the duration of operation in recognition of the edge of the tooth saw butt joint shape will be brief. The implementation of the vision-based system will also reduce the cost required to hire many skilled operators.

Digital image processing techniques is required to process the image captured by the vision-based system of the edge of a tooth saw butt joint shape which enables the feature points of the edge of a tooth saw to be extracted. The techniques consist of enhancement, segmentation, edge detection and morphological operation [8]. Hence, through those techniques, the feature points of the edge of a tooth saw butt joint shape can be described and presented.

1.5 Objective

The following objectives serve as a guideline throughout the project. There are four objectives in this project which are:

1. To develop a vision-based method in recognizing the edge of a tooth saw butt joint shape.
2. To identify the feature points of the edge of a tooth saw butt joint shape using vision-based operation.
3. To evaluate the accuracy of the identified feature points compared to its actual feature points.
4. To evaluate the repeatability of the developed method in identifying the feature points of the edge of a tooth saw butt joint shape.

1.6 Scope

This project is done in a controlled environment with only one source of illumination which is a uniform LED light source with a variable brightness of 50, 30 and 10 lumens. The vision sensor used is a CMOS camera with active resolution of 1280 x720 pixels, which is placed in a fixed position, 20 cm vertically from a work piece. The material of the work-piece is made from hard cardboard that is spray painted using silver paint color to imitate the reflection towards light behavior of an aluminum alloy sheet with dimensions 100mm × 100mm × 1mm thickness. A tooth-saw edge shape was cut in the middle of the hard cardboard to imitate an edge of a tooth-saw butt joint shape. The CMOS camera captures the work piece in digital image form which contains the the edge of the tooth saw butt joint shape. The image is then imported, processed and presented using the MATLAB Image Processing Toolbox software to identify feature points, start, supporting 1 & 2 and end points which represents the shape of an edge of a tooth saw butt joint. The methods used in order to detect the edges are Canny, Prewitt, Sobel and Roberts edge detector. The common application of this vision-based system is mostly used in robotic welding operation [3] but, in this project, it only covers until the identification and recognition of the pixel coordinates features of the edge of a tooth saw butt joint shape which will be in x and y axes pixel coordinates. There is no robot path planning for the implementation of robotic welding in this project.

1.7 Thesis Overview

This thesis comprises of five chapters. Chapter 1 introduces the project background, motivation, problem statement, objective and scope of this project.

Chapter 2 covers the theoretical background of the types of vision-based sensors, camera, illumination, digital image processing techniques and reviews on past research done by other researchers. This chapter also summarize the research gap based on the past researches.

Chapter 3 discusses the methodology used in the project. This chapter discusses on the experimental setup configuration, the digital image processing techniques used to identify the feature points of the tooth saw butt joint shape and the accuracy and repeatability evaluations.

Chapter 4 explains results and errors that will be obtained from the task and experiments done in Chapter 3 in forms of tables, figures and analysis based on the results obtained.

Chapter 5 concludes the research project that has been done in FYP 1 and FYP 2 and the future work that can be recommended and done in this project.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter provides a detailed explanation on vision-based sensors for butt joint edge detection including its devices and detection requirements. Having a brief explanation on the fundamentals of digital image processing in recognition and identification of the edge of a tooth saw butt joint shape. Reviews on previous researches and works related to the project are revised and presented on this chapter.

2.2 Vision Sensor

A vision-based sensor to recognize and identify the edge of a butt joint shape are a non-contact type sensor. The most commonly used sensor are vision sensor and laser assisted vision sensor. The general function of a vision sensor is to sense the existence, position and displacement of an object. The configuration of a vision sensor that is used consist of a camera and a filter [3].

As for the laser assisted vision sensor, the general function is quite similar to the typical vision sensor, except the configuration of the laser assisted vision contains an extra component which is a laser diode. The sensor is placed with the laser diode at a fixed angle to acquire the projection of laser diode accurately on the work piece. The laser diode produces light strips or light points which will then be examined by the camera. The function of the laser diode is to trace the edge of butt joint and guide the vision sensor along it which enable the vision sensor to identify the discontinuity of the edge of the butt joint with ease. By having the laser diode in assisting the sensor, it helps to reduce the complexity in operating the detection process, thus reducing in time consumption. Table 2.1 shows the summarized comparison between the two sensors based on its advantages and disadvantages [3].