UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF 3D DEFECT DETECTION SYSTEM OF AUTOMOTIVE PARTS USING IMAGE PROCESSING APPROACH

This report is submitted in accordance with requirement of the University Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Hons). The member of the supervisory committee is as follow:

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ABSTRAK

Pemprosesan Imej adalah salah satu teknik untuk mengekstrak ciri penting dari data gambar, keterangan, tafsiran atau pemahaman pemandangan dapat diberikan oleh kamera. Gambar diubah menjadi array bilangan bulat kecil, yang disebut piksel, mewakili sifat fizikal seperti cahaya pemandangan, disimpan dalam memori digital, dan diproses oleh komputer atau perkakasan digital lain. Pemeriksaan manual mengalami kesukaran untuk mencari kecacatan pada bahagian automotif kerana tidak cukup cahaya dan menghabiskan terlalu banyak masa untuk memeriksa bahagian tersebut. Kajian ini bertujuan untuk memberi tumpuan kepada menentukan jenis kecacatan 3D pada bahagian automotif menggunakan teknik pemprosesan gambar. Projek ini bertujuan untuk merancang algoritma untuk kecacatan 3D menggunakan teknik pemprosesan gambar. Perisian Image Processing Toolbox adalah sekumpulan rutin yang memperluas kemampuan persekitaran pengaturcaraan MATLAB. Kotak alat menyokong pelbagai tugas pemprosesan gambar. Kemudian, menggunakan matriks kekeliruan untuk menganalisis kecekapan mengembangkan algoritma dari segi ketepatan dan masa pemprosesan. Kaedah untuk projek ini dengan menggunakan kamera industri HD CMOS dan MATLAB untuk mengesan kecacatan pada bahagian automotif. Kaedah untuk memproses gambar adalah pra-pemprosesan gambar, elemen pengesanan dan pengesanan kecacatan. Hasil yang diharapkan untuk projek ini dapat menentukan kecacatan 3D pada bahagian automotif. Ia membantu mengurangkan kecacatan 3D pada bahagian ketika menggunakan teknik pemprosesan gambar. Kaedah dan Antaramuka Pengguna Grafik (GUI) untuk projek ini dijana menggunakan program MATLAB Simulink. Sebanyak 100 sampel komponen telah diperiksa, dan ketepatan yang diperoleh ialah 94 % dengan pengurangan masa pemprosesan selama 94.92 saat. Untuk meningkatkan kualiti pemeriksaan, persekitaran pemeriksaan mesti diuruskan melalui kawalan pencahayaan. Untuk meningkatkan prestasi dan menjadikan sistem lebih berharga kepada organisasi, kapasiti sistem ini untuk mengenal pasti ralat 3D mungkin ditingkatkan.

ABSTRACT

Image Processing is one of the techniques to extract an important feature from image data, description, interpretation or understanding of the scene can be provided by the camera. The image is converted to an array of small integers, called pixels, representing a physical property such as scene radiance, stored in a digital memory, and processed by a computer or other digital hardware. Manual inspection it has difficulties to find the defects on automotive parts because not enough light and spend too much time to inspect the parts. This study aims to focus on determining the type of 3D defects on automotive parts using image processing techniques. This project aims to design an algorithm for the 3D defect using image processing techniques. Due to the Image Processing Toolbox software is a set of routines that extend the MATLAB programming environment's capabilities. The toolbox supports a wide range of image processing tasks. Then, using confusion matrix for analysing the efficiency of developed an algorithm in terms of accuracy and processing time. The method for this project by using HD CMOS industrial camera and MATLAB for detect the defect on automotive parts. The method for image processing is image pre – processing, detection element and defect detection. The expected result for this project can define 3D defect on automotive parts. It helps to reduce the 3D defect on parts when using image processing techniques. The method and Graphical User Interface (GUI) for this project are generated using the MATLAB Simulink programme. A total of 100 components samples were examined, and the accuracy obtained was 94 percent with a 94.92 second reduction in processing time. To increase the quality of the inspection, the inspection environment must be managed through lighting control. In order to improve performance and make the system more valuable to the organisation, this system's capacity to identify 3D errors may be increased.

DEDICATION

To my beloved parents Mohd Shaed Bin Supian and Nor Hasida Binti Mai

who for giving me moral support and motivation,

My supervisor Ir. Dr. Lokman Bin Abdullah,

who have helped me along the way by inspiring, advising, and encouraging me,

And myself.

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CHAPTER 1
INTRODUCTION

During the course of this final year project, this chapter will discuss the background of the study, problem statements, objectives and scope. The introduction describes the 3D defect detection system of injection molding mold using image processing approach and the method for preventive maintenance that can be constructed to enable stakeholders in making decisions which suitable algorithm and industrial camera for detect defects on injection molding process. In order to complete this project, image processing technology would be used to identify 3D defects in injection molding mold.

1.1 Background of the study

The purpose of this report to discuss on 3D defect detection system on injection molding mold using image processing approach. As we known, in manufacturing technology nowadays injection molding process is the most important used for produce complex part and mechanical properties of several kinds. So, to improve quality of the product image processing technique will be used for 3D defects detection and it can be performed without the direct participation of human beings. This method is being used to manufacture products of higher quality at reduced rates, most industries strive to improve performance and efficiency, boost productivity, reduce costs and improve quality.

Nowadays, defect detection is becoming increasingly crucial in industral development as artificial intelligence technology advances and industrial product quality criteria improve. Visual defect detection is a useful method for detecting and classifying defects in variety of industrial products and defect detection system improves the quality of the product (Norhashimah Mohd Saad et al., 2019). Besides that, many researches proposed to develop a technique for quantitative 3D estimation and characteristic identification of

material surface defects is proposed, it converts defect detection from simple image detection to 3D detection. The type of defect detection it's enclosing the defective area is derived from the defect image segmentation findings, whichnot only enhances detection accuracy and also increase the detection speed (Yulong Zong, 2021).

Based on previous research, the traditional method that used manual defect detection it remains high costing, low efficiency and it cannot fulfill the demands of mass production in the current era. So that, image processing was being used to create a defect detecting system and it provides low cost, high speed, high accuracy, high performance and high quality of the products. Here, there are many methods on the basis of the most effective algorithm for processing an accordance with the desired image. Therefore, it can help on focusing the type of defects and the defective area. According to J.Y. Lee et al. (2017) defect on injection molding process was detected which is scratches, nicks, sink mark, mark broken and pollution. Several studies on identying and defining steel surface defects have been released. Evaluation of the quality problem are required a different inspection techniques and the tooling (Ozseven, 2019). Thus, automated inspection was using computer vision to monitor the product's quality during the injection molding process. Threfore, this method is monitoring the system that impoves the quality of the product that produced. Joseph C. Chen (2020) an artificial neural network (ANN) was presented online defect detection system with regard to real – time data that extracted from in – mold temperature and pessure sensors. ANN has a high prediction accuracy of 98.34% and the defect detection accuracy is 94.4%. Moreover, it can be easily for detecting others quality of the characteristics of injection molding and it would be useful for intelligent injection molding advancements. The processing of pixel and other knowledge discovery will only be focused on the defect's area of focus. This method is significantly easier to use because it eliminates the need for very complicated algorithms. Futhermore, it can be performed on a genuine image, preventing the loss of pixel information.

In injection molding process, application of machine learning techniques have been used in injection molding quality prediction. According to Hail Jung and Junsu Jeon (2021) one of the issues in the injection molding industry is predicting and understanding what influences the quality of the molding products. By using machine learning techniques it utilize several algorithms to test and compared in terms of performances in

quality prediction. Machine learning alorithms have a tree – based algorithms, regression – based algorithms and autoencoder, when comparing accuracy and precision, it found machine learning models represent the complicated relation and that autoencoder outperforms.

Thus, the proposal of this project development of 3D defect detection system of injection molding mold using image processing approach. By carrying out this study, it can helps to identify and detect the defective area in the mold by using the suitable and efficient method and thebest algorithm for image processing techniques for the 3D defect. The implementation of the 3D defect detection system is applied to the injection molding industry by using image processing techniques.

1.2 Problem Statement

The injection molding process has become one of the most widely utilised methods in recent years due to its ability to make complex parts in large quantities. The quality about of produced product is determined not only by the machine's performance, but also by the mold conditions. Preventive maintenance is critical for the mold's long-term survival because it works with high temperatures and forces. Tooling necessitates the use of technology capable of detecting problem, as the mold is composed of steel, making it more difficult to locate the problematic area with sufficient lighting. Several issues, such as rusted molds or dented pieces it will result in defetive parts being manufactured as a result of this issue. As a result, it will take a long time to stop production in order to unload the mold from the machine for maintenance, which will have an impact on productivity.

1.3 Objectives

The study's objectives are as follows:

i. To identify the different types of 3D defects in automotive parts.
ii. To create an algorithm for the 3D defect using image processing techniques.
iii. To analyse the efficiency of developed an algorithm in terms of accuracy and processing time.

1.4 Scope

The scope of the research is as follow:

i. The study are focuses on 3D defects detection on automotive part using image processing approach and consistent with previous research.
ii. Designation an algorithm using MATLAB Simulink software for 3D defect detection.
iii. The creation of algorithm for the effectiveness of this technique that have been used in term of accuracy (pixels) and processing time (sec).
iv. The study was conducted on the plastic injection molding industry's Quality Control Department's In – Process Quality Control (IPQC) region.
v. Study duration for final year project 1 and 2 in conducting this research is limited.

1.5 Significance of study

The following are the highlights of the important research:

i. Learn how to discover 3D defects on injection molding mold using image processing methods to improve the current problem.
ii. Developed a new techniques by using confusion matrix based on previous research.
iii. Using MATLAB Simulink software, create an algorithm based on the key factors that have been mentioned.

1.6 Organization of Final Year Project

a) The study's firsrt chapter is an overview. The study's background, problem statements, objectives and scopes are all addressed. By the completion of this project, all of the objectives should have been met.
b) The literature review is covered in Chapter 2. It provides a comprehensive explanation of the study using prvious data and journals, with a focus on the critically factor recycling in Malaysia and mathematical formulation used to create the model.
c) The study's methodology is covered in Chapter 3. It outlined the best strategy for gathering data in order to construct a new consumer product attractiveness index.

1.7 Summary

The background of the study, problem statements, objevctives, scope, the significant of the study, the organization of the final year project and the summary are included in Chapter 1 it consist of 7 sub – chapter. The study's background outlines, how to identify defective area and the techniques that have been used and compares it to the injection molding mold to develop a 3D defect detection by using an image proccessing techniques. Next is sub – chapter of problem statement, in order to proceeed through the research thoroughly, it is nessary to have a sound problem statement based on real – world difficulties in the industries. Then, by the end of the study, there are three main objectives that must be met. In terms the scope, it identifies the most important aspects of establishing a new design an algorithm on which studies should be focused. The significance of study explain the main points. Finally, the organization provides an explanation of the summary.

CHAPTER 2
LITERATURE REVIEW

This chapter discusses how the previous researhers compiled a summary of following articles, journals, websites and books which is related with the title. Image processing, injection molding molds, 3D defects, preventive maintenance and quality control are some of the sub – topics that are covered in this chapter.

2.1 Image Processing

Image processing is a technique for performing operations on an image in order to improve it or extract important information. It is a sort of signal processing whereby the input is an image and the output is either an image or the image's features. Image processing is indeed one of the fastest – growing technologies out there now. It is also a focus of research in engineering and computer science.

2.1.1 Definition of Image Processing

Image processing is a collection of algorithms for evaluating, improving, compressing and rebuilding images. Its an essential components are importing, which involves scanning and digital imaging to acquire an image, analysis and transformation of the image uing highly specialized software applications and output. It is an important component of computer vision that is used in numerous real-world applications like as robots, self-driving automobiles, and object detection (Dr. PL. Chithra & P.Bhavani, 2019). Image processing enables us to change and manipulate millions of photos at once, extracting valuable information from them. It has a wide range of uses in practically every industry.

2.1.2 Importance of Digital Image Processing

The advancement of visual information for human interpretation, as well as the processing of image data for storage, transmission, and representation for autonomous machine perception, are generating knowledge about digital image processing algorithms (Ravindra, 2010). Therefore, digital image processing techniques allow for the computer – assisted transformation of digital images. Pre – processing, augmentation and visualization or otherwise information extraction are the three general processes that all sorts of data must go through when using digital techniques. According to the Sangwook Lee, 2010; the benefits of advanced technology, such as precision, objectivity, speed, and consistency, are the primary reasons to rely on it. These particular advantages have prompted state agencies to focus their efforts on addressing the flaws in current inspection processes. Hence, comparison to human visual inspections, digital image processing inspections can deliver more accurate technical specifications. Whereas conventional inspection greatly depends on individual skills, inspection results are prone to inaccuracy and can differ slightly amongst inspectors. Personal opinions, work experiences, and the volume of work of the inspectors can all influence the outcome.

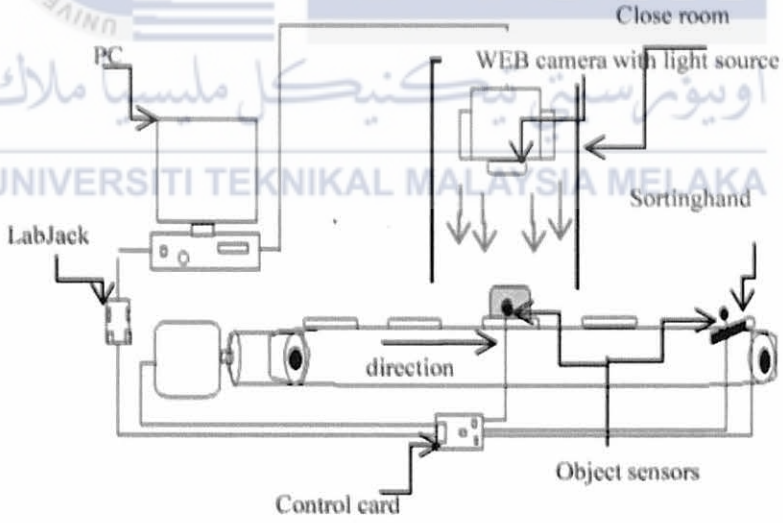

Figure 1: Image Processing Techniques

Furthermore, the major aim is to demonstrate the use of certain measures at the fundamental level in different fields of digital image processing, including certain image enhancement, image restoration, image denoising, and edge detection, and to make the selection of statistical parameters for a specific image processing technique easier (Vijay and Gupta, 2012). Eventhough, digital image processing can be defined image in two –

dimensional function which is $f(x, y)$ and three – dimensional function to detect defects. Study by Michal Vargar (2016), both 2D and 3D vision systems are used in modern industry for automated construction, product inspection, and quality control. The addition of the third coordinate – depth – distinguishes 2D and 3D vision. This information can be obtained by a variety of methods, ranging from stereoscopy (the use of two precisely aligned cameras) to laser scanning of the surroundings, each with its own set of benefits and drawbacks. The use of numerous 3D imaging technologies in concert can typically eliminate drawbacks.

Shreyas Fadnavis (2014), due to wide range of applications, digital image processing is a subsection of digital signal processing that has achieved remarkable development in a variety of disciplines. The method of processing an image using computer algorithms to improve the many features of any particular image is known as digital image processing. As a result, the most essential component of image processing is the different strategies that may be used to increase the quality of an image. Based on the previous research, manual inspection is expensive, time-consuming, and occasionally inaccurate, and manual inspection for intricate geometries is extremely difficult. In rare circumstances, the procedure is even damaging. Human judgement is, once again, based on prior experience and information. If there is a progressive change in structure in some detection tasks, or if the observer agrees that the problem exists but cannot identify it, Quality control and management for sensitive industrial products can be accomplished utilising 2D or 3D image processing to meet these challenges.

2.1.3 Image Processing Techniques

Based on the previous studies, have many image processing approaches that have been utilised in the manufacturing industry to detect faults. As previously stated, prior to the adoption of image processing in the manufacturing industry, traditional techniques of manual defect detection were expensive, inefficient, and unable to satisfy the demands of modern mass production. Therefore, when comparing traditional techniques and image processing techniques for defect detection, image defect detection is a combination of artificial intelligence, neurobiology, computer science, image processing, pattern recognition, and other applied fields. But, it not only acquires low deduction and high accuracy it also has ability to adapt towards modern mass production. The application of

image processing techniques in industrial online detection has yielded significant economic and social benefits. As is well known, there are numerous industries throughout the world, including wood, steel, plastic, food, medicine, and many more, image processing techniques can detect the defects in all of them.

Image processing approach is one of the quality inspection techniques for examples an adaptive thresholding, grey level occurrence matrix, morphological operation and an Otsu's Thresholding for defect detection that have been developed by earlier studies. Because these three categories are the key concerns for bottle inspection in the beverage manufacturing industry, there are various sorts of focus in the image processing technique, such as shape, colour, and level defects. Based on image pocessing approach, one of the most crucial procedures in picture analysis is the region based process. The fundamental idea of this technique is to minimise and compress picture data in order to make image analysis easier. The thresholding-based technique and the clustering-based technique are the two categories of image segmentation techniques. The global thresholding and the local thresholding techniques are two types of thresholding-based techniques. The global thresholding can be set manually or automatically, but the local thresholding is calculated by computing the local intensity of each pixel of each threshold value. The clustering approach is mostly used to analyse high – dimensional measurement patterns in images. It used to group pixels in an image that have similar characteristics. The shape, colour, and level of the image bottle are among the three sorts of quality inspections examined in this study (Norhashimaah Mohd Saad et al., 2019).

Surface detect defection (SDD) process have a different steps, the defect that was investigated, the method that was used, and the expected outcomes. Figure 2 shown the process of surface detect defection, which is data acquisition, pre – processing, feature extraction and defect detection. Data acquisition, when images from the production line are captured, these two techniques are used. Lighting is used to decrease the detrimental impacts of ambient lighting on surface defect detection and to prevent shading by maintaining a consistent light source. The camera is used to capture images that are illuminated by a steady light source. The camera can be utilised as a regular camera for basic activities as well as an array camera for professional and industrial applications. Then, pre – processing to remove the elements of the data that will have an impact on the outcome likes filtering away parts of the image that does not have an effect on the result