Faculty of Electronic and Computer Engineering

AUTOMATED DEFORM DETECTION FOR AUTOMOTIVE BODY PANELS USING IMAGE PROCESSING TECHNIQUES

Muhammad Zuhair Bolqiah Bin Edris

Master of Science in Electronic Engineering

2016

AUTOMATED DEFORM DETECTION FOR AUTOMOTIVE BODY PANELS USING IMAGE PROCESSING TECHNIQUES

MUHAMMAD ZUHAIR BOLQIAH BIN EDRIS

A thesis submitted
in fulfilment of the requirements for the degree of Master of Science
in Electronic Engineering

Faculty of Electronic and Computer Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2016

DECLARATION

I declare that this thesis entitled “Automated Deformation Detection on Automotive Body Panels Using Neural Network Based Segmentation” 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 the candidature of any other degree.

Signature :.....

Name :MUHAMMAD ZUHAIR BOLQIAH BIN EDRIS

Date :.....

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Electronic Engineering.

Signature :….....

Name :ASSOC. PROF. DR. ZAHRILADHA BIN ZAKARIA

Date :….....

DEDICATION

Dedicated to ALLAH S.W.T, my beloved parents; Mr Edris Bin Yahya and Mrs Mashkurah Binti Hasbullah and the rest of my family members for your infinite and unfading love, sacrifice, patience, encouragement and support.

ABSTRACT

The demand for automotive industry has been rapidly increasing as the number of consumer increases. In order to ensure the quality of their product, the manufacturers need to minimalize any deformation that occurs to their products. Early deformation detection on the automotive body panels manufactured must be conducted in order to rectify the problem. Automated deformation detection was designed to replace manual labour and this technique is found to be more accurate and effective. This thesis proposed a method to detect the deformation that occurs on the automotive body panel surface while in assembly lines. Three-dimensional data is acquired from the body panels as an input for deformation detection system. The data is converted in two-dimensional data image by using scatter data interpolation. Gradient filtering is used to identify the gradient energy value yield from the surface by using two types of kernels. Background illumination correction is implemented in order to reduce unwanted regions in the image. The prepared images undergo segmentation stage by recognizing the deformation in each threshold value by using Artificial Neural Network. The threshold value has been assigned with range between 0.0001 until 0.2000 where the threshold value is increased by 0.0001 in iteration. The Gabors' Wavelet is used to extract the features of the segmented candidates and as the input for the artificial neural network. A fuzzy logic decision rule is used to classify the types of deformations that have been obtained from the artificial neural network outputs. The depth of the deformation is then computed by subtracting the maximum and minimum values of the segmented candidates. Several test units were purposely built with deforms in order to test the proposed method. The mean accuracy of the NN recognition with Gabors' Features Extraction was recorded at 99.50 %. The segmentation on flat surface was recorded with lowest accuracy percentage of 68.81 %, then followed by the car door and the curved surface with accuracy percentage recorded at 70.39 % and 79.03 % respectively. The detection accuracy percentage was found to be 100 % where all the deformed location was able to be detected.

ABSTRAK

Permintaan terhadap industri permotoran semakin tinggi ekoran bilangan pengguna yang semakin meningkat. Bagi menjamin kualiti produk, pengeluar perlu mengambil langkah untuk mengurangkan kecacatan pada penghasilan produk. Pengesanan awal terhadap kecacatan pada permukaan produk perlu dijalankan untuk mengelak sebarang masalah. Pengesan kecacatan telah direka untuk mengambil alih tugas buruh dan didapati teknik ini lebih berkesan dan efektif. Tesis ini mencadangkan satu kaedah untuk mengesan sebarang kecacatan pada permukaan produk permotoran di peringkat pengeluaran. Data tiga dimensi akan diambil daripada panel badan kenderaan sebagai input kepada sistem pengesan kecacatan tersebut. Data ini akan di ubah kedalam bentuk imej dua dimensi menggunakan kaedah interpolasi taburan data. Penapisan kecerunan dengan menggunakan dua jenis kernel telah pun digunakan untuk mengenalpasti nilai tenaga kecerunan yang diperoleh daripada permukaan kenderaan. Pembetulan pencahayaan latar belakang telah pun dilaksanakan untuk mengurangkan kawasan yang tidak dikehendaki pada imej. Imej yang telah tersedia akan melalui peringkat segmentasi dengan mengenalpasti kecacatan di setiap nilai ambang menggunakan rangkaian neural buatan. Lingkungan nilai ambang yang ditetapkan ialah diantara 0.0001 sehingga 0.2000 dengan penigkatan sebanyak 0.0001 di setiap lelaran. Penggunaan kaedah wavelet Gabor untuk mengekstrak ciri-ciri pada imej yang telah disegmentasi sebagai input kepada rangkaian neural buatan. Peraturan keputusan logik kabur telah digunakan untuk menentukan jenis kelas kecacatan yang telah diperolehi daripada rangkaian neural buatan. Setelah itu, kedalaman kecacatan dikira dengan menolak nilai maksimum dan minimum yang diperoleh daripada imej yang telah disegmentasi. Beberapa unit ujian dengan kecacatan telah dibuat secara sengaja untuk menilai kaedah yang telah dicadangkan. Nilai pukul rata ketepatan pengenalpastian rangkaian neural dengan pengekstrak ciri wavelet Gabor telah dicatatkan pada 99.50 %. Segmentasi pada sampel permukaan rata dicatatkan dengan peratusan terendah pada nilai 68.81 %, diikuti oleh sampel pintu kereta dan permukaan melengkung dengan peratusan ketepatan masing-masing dicatatkan pada 70.39 % dan 79.03 %. Peratusan ketepatan pengesanan adalah 100 % di mana semua lokasi kecacatan dapat dikesan.

ACKNOWLEDGMENT

First and foremost, I would like to give my highest gratitude to the Allah S.W.T for His blessings that I have now completed my Master of Science in Electronic Engineering. Special thanks also dedicated to my supervisors Associate Professor Dr. Zahriladha Bin Zakaria, Dr. Saeed Jawad and Mr. Mohd Shahril Izuan Bin Mohd Zin for their supervisions during the duration of my research. They have helped and guided me very well regarding useful informations and research techniques in order for me to complete this research project.

Special dedications also to the authority of University Teknikal Malaysia Melaka, especially to the Faculty of Electronic and Computer Engineering for the university research grant. The faculty had also provided useful and conductive facilities for me to conduct my research works.

At last, I would like to extend my gratitude to my parents; Mr. Edris Bin Yahya and Mashkurah Binti Hasbullah, my siblings, and my friends for their encouragement, love and motivations throughout my whole journey. Once again, thank you so much.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

ACC	-	Accuracy
AUC	-	Area Under Curve
CBR	-	Case-Based Reasoning
CCD	-	Couple-Charge Device
FN	-	False Negative
FNR	-	False Negative Rate
FP	-	False Positive
FPR	-	False Positive Rate
GLCM	-	Grey-Level Co-Occurrence Matrix
GPU	-	Graphic Processing Unit
KNN	-	K-Nearest Neighbour
MA	-	Miss-classified Area
MLP	-	Multi-Layer Perceptron
NEFCLASS	-	Neuro-Fuzzy Classification
NN	-	Neural Network
RGB	-	Red, Green And Blue
ROI	-	Region Of Interest
SIFT	-	Scaled Invariant Feature Transform
SVM	-	Support Vector Machine

TN	-	True Negative
TP	-	True Positive
TPR	-	True Positive Rate
UWT	-	Undecimated Wavelet Transform

LIST OF SYMBOLS

$\cong$	-	Approximation
$\otimes$	-	Convolution
δ	-	Delta
z	-	Depth Axis
e	-	Epsilon
∇	-	Gradient
x	-	Horizontal Axis
I	-	Image
$\bullet$	-	Morphological Closing
$\oplus$	-	Morphological Dilation
$\ominus$	-	Morphological Erosion
$\circ$	-	Morphological Opening
P	-	Point
H	-	Structural Element
Σ	-	Sum
y	-	Vertical Axis
w	-	Weight

LIST OF PUBLICATIONS

The research papers produced and published during the course of this research are as follows:

1. **Edris, M. Z. B.**, Zakaria, Z., Zin, M. S. I. M. and Jawad, M. S., 2016. Automated Deform Detection on Automotive Body Panels Using Gradient Filtering and Fuzzy C-Mean Segmentation. *Jurnal Teknologi. (Scopus) (Published)*

2. **Edris, M. Z. B.**, Zin, M. S. I. M., Zakaria, Z. and Jawad, M. S., 2016. Automated Deform Detection On Automotive Body Panels Using Classifiers Based Segmentation. *Journal Of Theoretical And Applied Information Technology, Vol. 89. (Scopus) (Published)*

3. **Edris, M. Z. B.**, Jawad, M. S. and Zakaria, Z., 2016. Surface Defect Detection And Neural Network Recognition Of Automotive Body Panels. In: *Control System, Computing and Engineering (ICCSCE), 2015 IEEE International Conference on*, Batu Ferringhi. *(Published)*

CHAPTER 1

INTRODUCTION

1.0 Background

In automotive industries, the body panels manufacturing department plays an important role to manufacture automotive body panels such as doors, fenders, bonnet, deck lid, roof and side panels. The automotive body panels usually made from alloy because it is strong and malleable. The alloy sheet will undergo the powerful forming press by machines into the desired automotive panel shape. The heating process is involved to make the body panels more malleable. Due to the various processes involved in manufacturing automotive body panels as shown in Figure 1.1, there are possibilities that deformations will occur on the product. Therefore, at the end of this manufacturing process, the manufactured body panels will be inspected to identify the deformation that occurs on the end product.

Figure 1.1 The automotive manufacturing industries

Traditionally, the inspection process is conducted by human labours. It is conducted by rubbing on the surface of the body panel in order to determine texture deformations as shown in Figure 1.2. In this new era, the competition among manufacturers is high due to the increment of customers demand. Therefore, the production of body panels is increasing rapidly. Due to human limitation, the accuracy and effectiveness of the manufacturing process will be affected. So the quality control will not be reliable.

Figure 1.2 The body panel inspection by human workers

Automated deformation detection has been introduced to overcome this problem. Many methods were designed to guarantee the quality control in term of the accuracy of deformation detection, effectiveness and reliability. Most common deformations on the surface of the body panel are dings and dents. Before automotive body panels is assembled, the early detection must be conducted and any deformations must be identified and verified either it will be repaired or discard. The deformation detection system will notify the quality control department if there is any deformation that occurs on the surface.

The location and types of deformation are the important information to be relayed to the relevant department so that the recovery process can be done immediately.

There are various types of the deformation detection system set-up that has been designed according to the desired requirement. Figure 1.3 shows the designed deformation detection system set-up in manufacturing an automotive body panel.

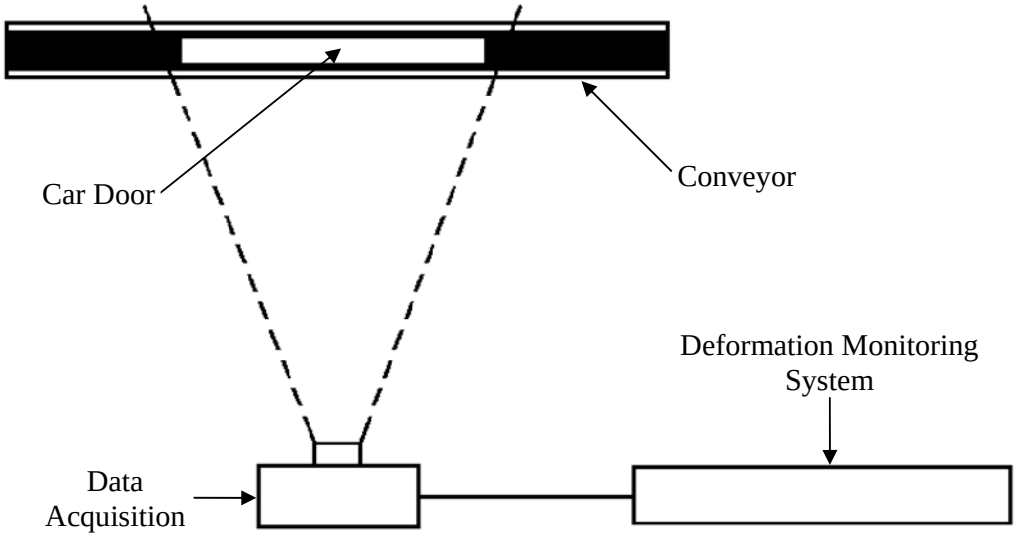

Figure 1.3 Schematic diagram of proposed deformation detection system

The deformation monitoring system is an important part of the deformation detection system where the deformation detection techniques are implemented in the system. Data from the data acquisition module is the input for the systems. Many types of data acquisition methods can be used such as camera or three-dimension scanners.