Faculty of Electronic and Computer Engineering

AUTOMATED DEFORM DETECTION FOR AUTOMOTIVE BODY PANELS USING IMAGE PROCESSING TECHNIQUES

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AUTOMATED DEFORM DETECTION FOR AUTOMOTIVE BODY PANELS USING IMAGE PROCESSING TECHNIQUES

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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 :.................................................................

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Date : ............................................................................
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

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.

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

\( \approx \) - Approximation
\( \otimes \) - Convolution
\( \delta \) - Delta
\( z \) - Depth Axis
\( e \) - Epsilon
\( \nabla \) - Gradient
\( x \) - Horizontal Axis
\( I \) - Image
\( \bullet \) - Morphological Closing
\( \bigoplus \) - Morphological Dilation
\( \bigcirc \) - Morphological Erosion
\( \circ \) - Morphological Opening
\( P \) - Point
\( H \) - Structural Element
\( \Sigma \) - Sum
\( y \) - Vertical Axis
\( w \) - Weight
LIST OF PUBLICATIONS

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


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.

![Diagram of deformation detection system](image)

**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.