DEVELOPMENT OF DIGITAL IMAGE CORRELATION (DIC) ON CARBON STRUCTURE

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A thesis submitted
in fulfilment of the requirements for the degree of
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DECLARATION

I declare that this Choose an item. entitled "Development of Digital Image Correlation (DIC) on Carbon Structure" 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 : Nanthavan

Name : NANTHAVAN A/L SUKUMARAN

Date : 18/01/2022

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours.

Signature :

Supervisor Name : TS. DR. AHMAD FUAD BIN AB GHANI

Date : 18/01/2022

DEDICATION

To my beloved family and friends who have been my source of strength and inspiration and gave me support in terms of moral, spiritual, and emotional.

To my supervisor Ts. Dr. Ahmad Fuad Bin Ab Ghani for guiding and supporting me in completing the thesis.

ABSTRACT

The digital image correlation approach for strain assessment is a non-contact approach. The goal of this study was to measure the strain of the carbon fiber layer by non-contact method. The goal was to see how well a strain measuring method worked by analysing photos taken with a DSLR camera. The photos of carbon fiber layer processed with the Mathlab R2021a programme. The change in length in the y coordinate of the photographs was used to determine strain. The experimental and literature values were found to be in good agreement. The modulus of elasticity of the stell of the carbon fiber layer was estimated from the strain curves, and the findings were compared by the value given by universal testing machine (UTM) by doing tensile test. The findings show the results of the carbon of the carbon fiber layer's strain measurements by using Ncorr Matlab.

ABSTRAK

Pendekatan korelasi imej digital untuk penilaian terikan ialah pendekatan bukan hubungan. Matlamat kajian ini adalah untuk mengukur terikan lapisan gentian karbon dengan kaedah bukan sentuhan. Matlamatnya adalah untuk melihat sejauh mana kaedah pengukuran terikan berfungsi dengan menganalisis foto yang diambil dengan kamera DSLR. Foto lapisan gentian karbon yang diproses dengan program Mathlab R2021a. Perubahan panjang dalam koordinat y gambar digunakan untuk menentukan terikan. Nilai eksperimen dan literatur didapati dalam persetujuan yang baik. Modulus keanjalan stell lapisan gentian karbon dianggarkan daripada lengkung terikan, dan dapatan dibandingkan dengan nilai yang diberikan oleh "universal testing machine" (UTM) dengan melakukan ujian tegangan. Dapatan menunjukkan hasil pengukuran terikan karbon lapisan gentian karbon dengan menggunakan Ncorr Matlab.

ACKNOWLEDGEMENTS

First and foremost, I would like to thank and honour by God's grace, for everything that I have earned since the beginning of my creation. I would like to express my gratitude for offering the study forum to the Universiti Teknikal Malaysia Melaka (UTeM). My sincere thanks go to my main supervisor, Ts. Dr. Ahmad Fuad Bin Ab Ghani, for taking me under his wing and giving me with all the resources I needed to not only complete this research, but also to further develop my character and knowledge. I'd also want to express my gratitude to Dr. Azazi Bin Ngatiman, my colleague mentor, who assisted and collaborated with me throughout the project. Thank you to my family back home for their sacrifices as well as their unwavering encouragement and support in guiding me to success. Last but not least, I want to express my gratitude to all of my friends and supporters who encouraged and supported me during the completion of my Final Year Project.

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LIST OF SYMBOLS AND ABBREVIATIONS

DIC	-	Digital Image Correlation
BC	-	Before Christ
FEA	-	Finite element analysis
OSHA	-	Occupational Safety and Health Administration
ASTM		American Society for Testing and Materials
UTM		Universal Testing Machine

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Strain analysis (also known as stress analysis) is a branch of engineering that use a variety of techniques to determine the strains in materials and structures that are exposed to forces. Strain define as physical term describes internal forces that nearby other material that exert on each other. Whereas strain is a measure of the material's deformation. The convergence of strain analysis, fatigue analysis, and accelerated durability testing gives an indicator of device structural reliability. Finite element analysis (FEA) on a high-performance computer system is commonly used for stress analysis. In general, DIC works by comparing the structure of speckle patterns on deformed and formed samples. For this, black patch of colour is sprayed on specimens in a specified pattern. The digital camera system tracks these colours as they deform. Furthermore, the fundamental advantage of this approach is that it is geometry-independent and can be used to a variety of forms to provide information on deformation behaviour of components in real-world applications (Z.Q. Yue, S. Chen, 2003)

Digital image correlation (DIC) ability to capture full field stress makes it ideal for the analysis of stress concentration in non-uniform cross section. Digital image correlation (DIC) is based on determining a correlation coefficient from pixel intensity array subsets on numerous matching pictures and deriving the deformation mapping function that connects them. The displacements of regions in a picture are monitored across a succession of photos in this way, and the strain is determined consequently. In this new era of vast technology new developments in computer technology and high-resolution digital cameras for static as well as dynamic applications, this measurement method as broadened and digital image correlation (DIC) techniques have proven to be a flexible and useful tool for deformation analysis (Fabienne Lagattu, 2004). The techniques are a fast, robust, highly scalable, and accurate method for determining both the surface profile of a two-dimensional object and the displacements on the surface of the object. This technique has been used successfully for large deformation measurements. In view of its simplicity, the technique has been extended to study the deformation at multiple length scale.

Carbon material have been widely used in aerospace specifically in carbon structure in the form of carbon fiber layer. This is because carbon is flexible, and chemically stable, meanwhile it has standard for resistance capacity. Carbon fiber layer significantly used in inner section of fuselage, main body, wing and tail (Fiber, 2019). In addition, usage of carbon as structure reinforcement can reduce cost and project duration because of high strength of the carbon in the reinforcement will ovoid need of additional anchoring works.

1.2 Problem Statement

For calculating the strain of the specimen, is challenging by using manual calculation. Here Digital Image Correlation (DIC) helps to calculate the strain of the specimen. For strain, the digital image correlation approach is commonly utilized. Measurement in a variety of scientific and engineering fields Compared to other optical approaches, this approach has several benefits. According to certain study, DIC provides the following advantages: -

- To calculate the strain value, no complex fringe pattern analysis or light wave reconstruction is required.

- Handling is not complicated.

- On the specimen, there is no localized stress concentration.

- Resolution is better comparing other optical measurements.

As a result, confirmation that digital image correlation (DIC) can be utilized for a larger variety of materials, with a particular focus on carbon, is required. This is because carbon is widely used in daily basis from household to industry. Precise measurement of strain is much required. In this study, the photos captured during the strain test in this study were captured using a consumer version of high-definition video with the purpose of selecting carbon as the primary material.

1.3 Research Objective

Based on the background and problem statement listed, the objectives of this research study are as follows:

a) To determine strain reaction on carbon specimen by using a Digital Image Correlation (DIC) and universal testing machine (UTM) based on ASTM d3039.

b) To obtain reading by non-contact experiment process Ncorr and tensile test.

1.4 Scope of Research

The scope of this research are as follows:

- This project mainly focuses on strain reaction of the specimen using the digital image correlation (DIC) method.
- The carbon fiber layer specimen of the experiment is used to obtained the strain.
- The main parameters that will be of attention during the study is the strain values.
- The values will be determined by using Digital Image Correlation (DIC) method from Matlab merge of Ncorr.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Chapter 2 of this project has been split into sections that assist readers with a deeper grasp of the study of the Digital Image Correlation (DIC). Chapter 2 is made up of summaries of papers written by various authors on pertinent topics. This will help to make the knowledge gained from this research more useful.

2.2 Digital Image Correlation Method

The DIC technique has been used since the early 1980s and comes in a variety of versions. The 2-dimensional DIC technique is the topic of this work, and it includes using a single camera, tripod, external light and Ncorr software to measure displacement and strain in a plane. This method has the advantage of using only one camera, lowering equipment costs, and allowing for the incorporation of additional measurements. However, it has one big drawback: all displacements and strain must occur inside a single stationary measuring plane, otherwise severe errors in findings would follow (Pan Bing, 2011)

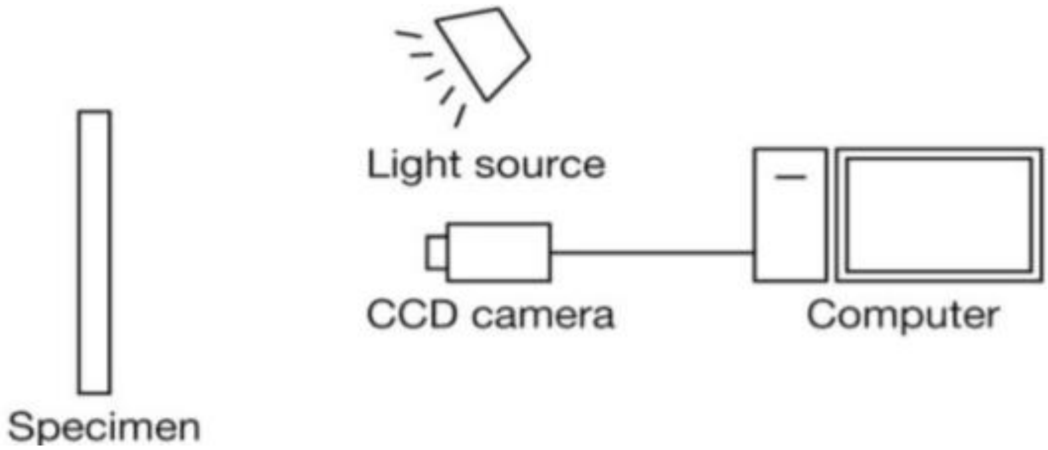

Figure 2.1 Digital image correlation to set up strain measurement (Yoneyama, Satoru, 2009)

Researchers have utilized the DIC approach to detect axial strain for artificially and experimentally created pictures in the past, with various degrees of success. Smith et al., 1998 reported a strain reading standard deviation of 100. Despite the employment of a concentric lens to reduce out-of-plane distortion, the camera resolution of 640x480 pixels had a detrimental impact on measurement accuracy. When measuring strain, displacement errors caused by the DIC method are typically fractions of a pixel, and the influence of this mistake can be mitigated by employing a longer gauge length to yield a smaller strain error. As a result, higher resolution cameras (such as those employed in this study) improve measurement accuracy by allowing for longer gauge lengths.(Z.Q. Yue, S. Chen, 2003) achieved mean strain errors of 210, however they employed a lower resolution camera (1317 x 1035 pixels) and a less precise sub-pixel interpolation approach, comparable to (Z.Q. Yue, S. Chen, 2003) also utilized a lens with a rather short focal length of 55 mm. The focal length of the lens has a big role in strain measurement accuracy. Smaller mistakes are associated with longer focal lengths.

Measurement of displacements and strains has long been a key issue in material characteristics such as material strengths and fracture characteristics, as well as in experimental stress analysis. Optical methods including moiré interferometry, holography, and speckle interferometry have been demonstrated to be effective in analysing macroscopic characteristics and are used in a variety of applications. Fringe pattern processing is time consuming and labour intensive. This technical challenge has piqued the interest of numerous academics, and automated processes have been devised to automate the data processing from fringe patterns.

The DIC approach was developed by Sutton et al.,(Tsuji N, 2002) and Bruck et al.,(Z. A. Z. M. D. A. Shibkov AA, 2011) over the previous two decades. It was used to calculate stresses and displacements. Microscopic strain measurements in electronic packaging (R. Schwab and V. Ruff, 2012), strain fields in polyurethane foam plastic materials and assessment of their mechanical characteristics (Z, 2007) are only a few of the applications. This approach has even been used to assess the condition of conservation of mural frescoes in situ (L. E. Han BQ, 2005). The advantages of this computer vision technology include a simple architecture and direct sensing. As previously stated, the DIC approach employs two pictures acquired by a solid-state video camera to represent the states of the object prior to and after deformation. To discover the minor changes between the two digitized pictures, an algorithm based on mutual correlation coefficient or other statistical functions was used to correlate them.

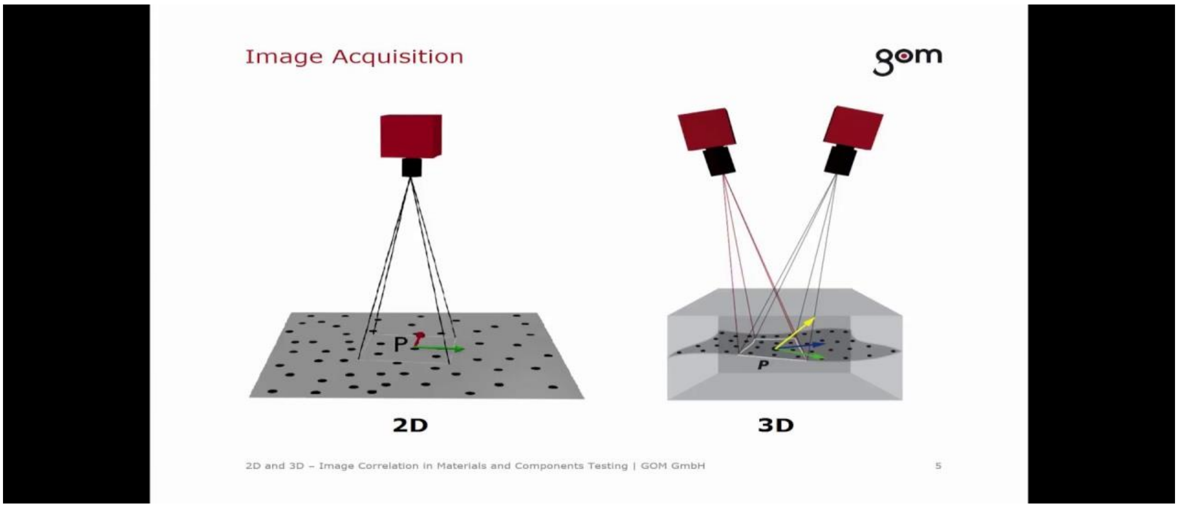

Figure 2.2 Differences Between 2D and 3D Digital Image Correlation

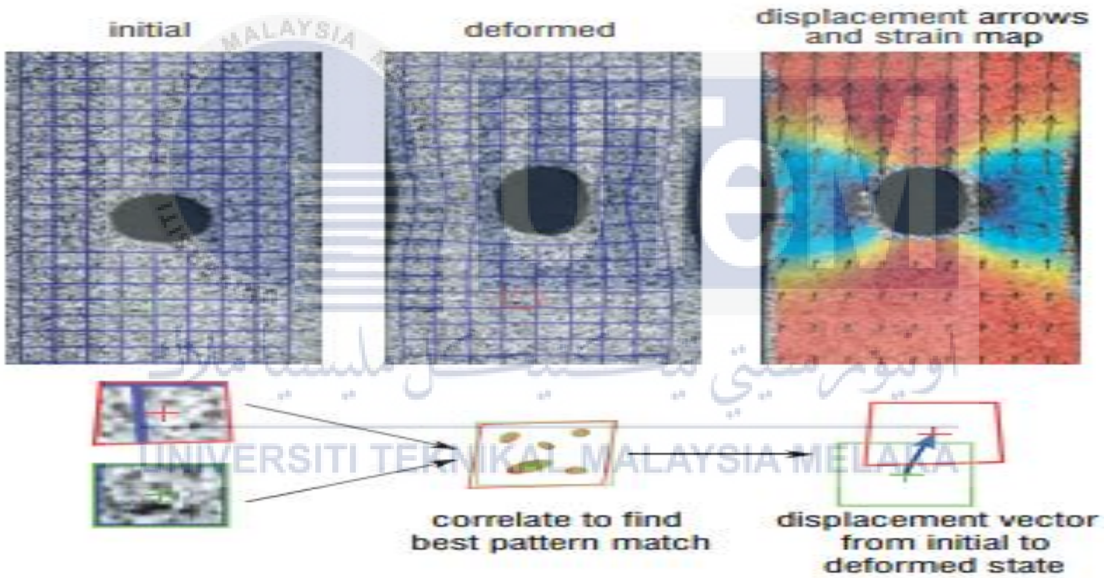

Figure 2.3 Process of Digital Image Correlation