MEASURING FULL-FIELD DEFORMATION OF HYPERELASTIC MATERIAL USING DIGITAL IMAGE CORRELATION

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Degree of Master of Science

Department of Civil Engineering

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Sri Lanka

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DECLARATION

I declare that this is my own work, and this thesis/dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief, it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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The above candidate has carried out research for the Masters thesis under my supervision.

Name of the supervisor: Dr. H. M. Y. C. Mallikarachchi

Signature of the supervisor: UOM Verified Signature Date: 22/03/2022

ABSTRACT

Digital image correlation, an optics-based strain measuring technique, has gained popularity during the last decade. The practice of employing digital image correlation-based measuring techniques in experiments has progressed dramatically owing to many incorporated sophistications: ease of use, greater precision, extensive measurement range, and stability of the results. While cutting-edge DIC measurement systems are commercially available, their high capital costs make them unaffordable for widespread usage. Several studies on establishing DIC-based measurement techniques with experimental validation have been undertaken over the years. The majority of prior DIC research concentrated on the testing of concrete, masonry, and metal alloy specimens, and little effort was made in assessing materials with substantial elongations.

This dissertation presents an innovative DIC-based measuring tool for capturing surface deformation information with better precision. The proposed system is composed of two commonly accessible digital cameras as well as MATLAB-based algorithms. Uniaxial tensile tests of latex specimens are used to demonstrate the aptness of the proposed approach in capturing substantial deformations, and displacement estimates are validated against Vernier Caliper readings. A secondary high-precision measuring tool, the Ncorr program, was used to validate the integrity of the results produced by this technique.

According to the comparison of results, it is proven that the system is capable of producing precise full-field displacement and strain maps with an apparent accuracy greater than 96 %. Furthermore, the similarity of the contour plots obtained using the proposed approach and outcomes of the Ncorr program verified the reliability of the proposed technique.

Keywords: Digital Image Correlation, 3D reconstruction, surface deformation information, latex

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LIST OF ABBREVIATIONS

DIC – Digital Image Correlation

FIB - Focused Ion Beam

WTP - Water Transfer Printing

SSD - Sum of Squared Difference

FAST - Features from Accelerated Segment Test

SIFT - Scale Invariant Feature Transform

SURF - Speeded-Up Robust Features

BRISK - Binary Robust Invariant Scalable Keypoints

PNG – Portable Network Graphics

JPEG-LS - Joint Photographic Experts Group - Lossless

CCD – Charge – Coupled Device

CMOS - Complementary Metal–Oxide–Semiconductor

SGM - Semi Global Matching

RoI – Region of Interest

NaN – Not a Number

LAR - Least Absolute Residuals

SSE - Sum of Squares Error

RMSE - Root Mean Squared Error

SSR - Sum of Squares of Regression

SST - Sum of Squares Total

RANSAC - Random Sample Consensus

LIST OF APPENDICES