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Digital Image Correlation System Design, Verification and Analysis

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Final Report for 4600:480-001 Senior/Honor Design, Spring 2022

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Abstract

Two dimensional digital image correlation provides an accurate and effective way to capture strain data on test sections with unusual or oblique geometries. The system requires a camera to record video footage, alignment fixtures and software to convert the footage into strain values. The system works by capturing the video footage of a specific portion of the specimen and comparing the movement of selected pixels. This is all done in the software GOM Correlate and Tracker.

This test document outlines the setup, procedure, and validation steps to fulfill this goal. The setup involves a camera, tripod, blue lighting, and laser distance measurers. Then we discuss the steps to take once your video has been captured to postprocess. The process of setup, running a test, and analyzing the video was a system developed from scratch and required continuous improvement. Finally, once our system was verified as a class B extensometer, we were able to obtain real displacement data on a test specimen and correlated it with material data to present a real-world application. The result of this project is a fully functioning and adaptable digital image correlation system that LTA Galactic can utilize for testing purposes. The final presentation will be a full explanation on the system, how it works, the tests we've run with it to verify accuracy and the error analysis.

1. Introduction

Digital Image Correlation Basics

Two-Dimensional digital image correlation has huge advantages over traditional methods of capturing strain. Currently there are many ways to capture strain for testing purposes. These methods include strain gauges, external gauges, and laser extensometers. Each of these methods has pros and cons when it comes to ease of use, accuracy, and cost. The working principle of each one also is different which provides different ways of calculating error. Below, I will explain the current work done in the field of strain capturing technology.

"A strain gauge works on the principle of electrical conductance and its dependence on the conductor's geometry. Whenever a conductor is stretched within the limits of its elasticity, it doesn't break but gets narrower and longer. Similarly, when it is compressed, it gets shorter and broader, ultimately changing its resistance" [1]. The most common and inexpensive way to capture strain on a specimen is using a strain gauge. They physically attach to the test specimen and are readily available and inexpensive. However, strain gauges do have some limiting factors that inhibit them and make them not the best option. Strain gauges are very sensitive to temperature and need to be calibrated regularly. But the largest inhibiting factor is the manual application and the fact that they need to be applied in a triangular pattern. This usually means it requires many strain gauges to capture all planes of motion during testing.

A method of capturing strain that utilizes much better technology and accuracy is the laser extensometer. They are easy to set up, easy to test with and require very little preparation or costs once purchased. The limiting factor of a laser extensometer will be the small gauge length. The gauge length is the section in which the extensometer will be capturing material strain. The laser extensometer will typically not be able to be utilized on specimens with large gauge lengths or on specimens that are obscure geometries like netting.

DIC System Revision Background

After validation attempts of our system using real test samples, we have decided to update and improve our system. For our DIC system to accurately capture displacements, our current camera (Canon EOS R5) will not be the best solution. Graftek sells testing grade cameras at relatively low prices that possess high resolution for point tracking and lens to help eliminate barrel lens distortion. This camera has excellent resolution which will enable us to capture the points of interest and the lens has a high focal length more precisely which minimizes the barrel distortion.

The first system our team created had many small compounding issues that cascaded into errors during use. Our new system had much emphasis placed on accuracy and alignment to ensure no off-angle measurements were occurring and that we would obtain the highest quality results. The following report is organized as follows. Background into the first system created the shortcomings of the system and test data to prove it, the new system created the procedure to use the new system, verification data of the new system and finally the "real-world" use of the system to validate test specimen displacements.

Design

Overview: the following flow chart (Figure 1) is a tool used to organize the entire senior design project. A project with many facets and areas of work to be completed requires visuals and charts.

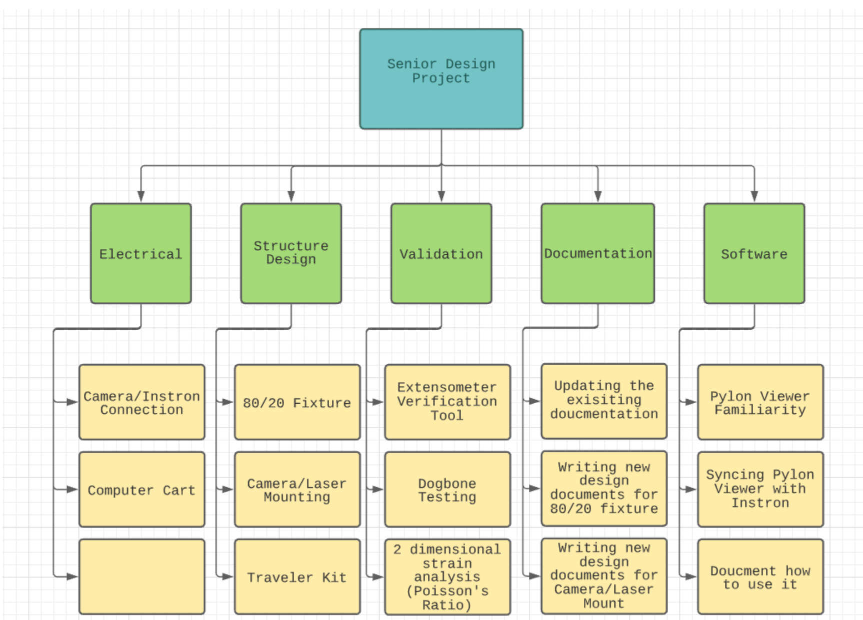

Figure 1. Flow Chart for organizing Senior Design Project

Conclusion

Our DIC design project accomplished many of the goals we set out to achieve. It is able to capture displacement data to a class B extensometer validating its use for testing in our company. The system was able to capture strain data on Aluminum dog bones and novel materials and translate the data into a software for our test engineers and designers to use. We are also able to find the limitations of our DIC system.

The limitation of our system, when utilizing Tracker software, is confined to larger displacements. Tracker software cannot accurately track small displacements witnessed on small displacement specimens. GOM Correlate is able to track these small displacements so it's recommended to use this software for smaller displacement specimens. Alternatively, one could use strain gauges or other strain devices.

5.1 Accomplishments

Our DIC system is a verified class B extensometer. This allows our company LTA to use the system knowing the error is relatively low. We're able to capture strain on specimens much larger and oddly shaped that do not fit inside test frames or experience non-uniform strain patterns.

5.2 Uncertainties

Like any extensometer system, there is uncertainty and error in the calculations and the system. Most of the error present in the system derives from human error. Tracker software requires human intervention to use and gather strain measurements from. Therefore it is very important to have proper training and accurate placement of calibration dots used in software.

5.3 Ethical considerations

There are not many ethical considerations present in this project. This system provides a large benefit to LTA and to the work engineers pursue.

5.4 Future work

For the future, our company LTA will be able to successfully use our DIC system for a variety of applications. Large scale systems can have point tracking capabilities and we'll be able to provide the design engineers accurate data. Much could be improved upon for the future though. One improvement is our laptop computer cart we created. The computer has much less RAM and Storage than what is desired for longer test runs, and the computer isn't able to process the large file sizes that those test runs output. Another improvement could be purchasing another camera or lens. Some microscopic lens' could capture the smaller displacements that are exhibited by metals or stiff materials. Or a lens with a large focal length could be used for a larger system where test specimens are on a larger magnitude (six-twenty ft in length). Lastly, more research into camera operation and parameter optimization could make a huge impact on the exporting and quality of data capturing. Our team has little background and experience in camera optimization so a little research was done for camera settings but future research and work could be done to optimize this process.

References

[1] Standard Practice for Verification and Classification of Extensometer Systems E86 - 13 / ASTM International / West Conshohocken, PA

[2] GOM Metrology, "Gom Metrology," *YouTube*, 2020. [Online]. Available: https://www.youtube.com/user/GOMMetrology. [Accessed: 10-Feb-2022].

Table 14 System Requirements and Verifications

Requirement	Verification	Verification status (Y or N)
1. Design Extensometer a. Mobile/Easy to Transport b. Can Obtain Large Displacements on oblique/non-typical specimens c. Passes Class list on ASTM Standard	1. Extensomer Verification Tool 2. 3D structure has been built	Y
2. Enable use for strain measurement w/ speckle pattern	3. Testing and the post processing with GOM	Y
3. Biaxial Measurement	4. No Verification has been done yet. Future work will consist of this	N
4. Glass door enabling measurements	5. No Verification has been done yet. Future work will consist of this	N