Can a pre-speckled encasement be used for vacuum loading, parallel to assessment via Digital Image Correlation?

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Abstract

A strength of Digital Image Correlation (DIC) is the potential manoeuvrability of the system, so long as the material can be loaded in some way for analysis [1]. This produces an interesting problem regarding how to deform a component in the field rather than in the controlled lab environment. Parallel to this limitation, there is an issue of a dependency on user capabilities with both the setup of the test and coupon preparation.
This investigation analysed the possibility of using a pre-speckled bag to encase and load multiple components of complex geometries, via the evacuation of internal air. Each coupon within the bag was either originally white in colour, or spray painted with a matt white acrylic paint. The reason for this was to increase contrast between the component and the black speckles upon the bag.
Results suggested that using the speckled bag, the algorithm was confident of strain mapping accurately for subsets larger than 31 pixels and could plot strain profiles for geometrically complex objects.

Introduction

As DIC requires a speckle pattern to analyse coupon strain it is a very important part of the test setup, but also an area that can be difficult to control between users. Much work has been conducted in the search for an optimum speckle pattern, with research into the ideal speckle size, density and pattern randomization [1-3]. Although work on speckle pattern optimisation has been intensive, the most common form of pattern creation is in the form of spray painting "by-eye". This raises the issue of variability between users, but also between coupons tested by the same user. Alternatively, a repeatable speckle can be achieved using pre-printed sheets of adhesive vinyl sheet bonded to the surface of a component, however complex geometries make this method difficult to implement due to folds occurring when placing a flat sheet across a non-planar surface. A reusable and flexible bag has the potential to fix both issues, as the bag can shape to the component, whilst the speckle pattern can be kept constant throughout testing.

Materials and Methodology

To understand the versatility of the test, five components have been tested for this investigation. These include a: lab coat, shoe, plastic hard hat, military helmet liner (coated white) and military helmet shell (coated white). These have been chosen as they have different structural stiffness and geometries. As the military test pieces are naturally white they have been spray coated with a matt white acrylic paint.
The bag used is produced by Viridescent®: it is a mixture of Polymide and Polyethelene and is 110 Microns thick. A black speckle pattern has been hand applied to the transparent bag, using a black fine tip Sharpie pen, producing an average speckle size of approximately 1 mm diameter. This aligns with the algorithm requirements for speckles to be larger than 5 pixels in diameter, along with spaces between pixels to be greater than 5 pixels [2].
Each specimen was placed in turn within the speckled bag, which contained a weight on each corner, to restrict movement to the top surface. The bag has two parallel plastic zip seals which were closed prior to evacuating air through the one-way valve. During the vacuum loading process, images were captured for DIC analysis.

Results

The left image of Fig. 1 is the raw picture taken by Vic-Snap 8. The greyscale image is from camera one of the pair of Manta G-917B ASG, 9 Megapixel cameras and shows a white lab coat inside the pre-speckled transparent vacuum bag. It is clear there is room for improvement, with the bag causing the high levels of reflection at locations of natural crimping. These high levels of refection result in the regions of saturation, such as the circled region in the right most image.
Although there is high reflectivity in areas, initial results suggest that DIC has the potential to capture strain and displacement maps of complex geometries using the vacuum bag. This is supported by the sigma plot on the right image, which indicates that for a subset of 61 pixels, the algorithm has a high confidence for pixel tracking – as indicated by the coupon majority being shown with a purple coloration.

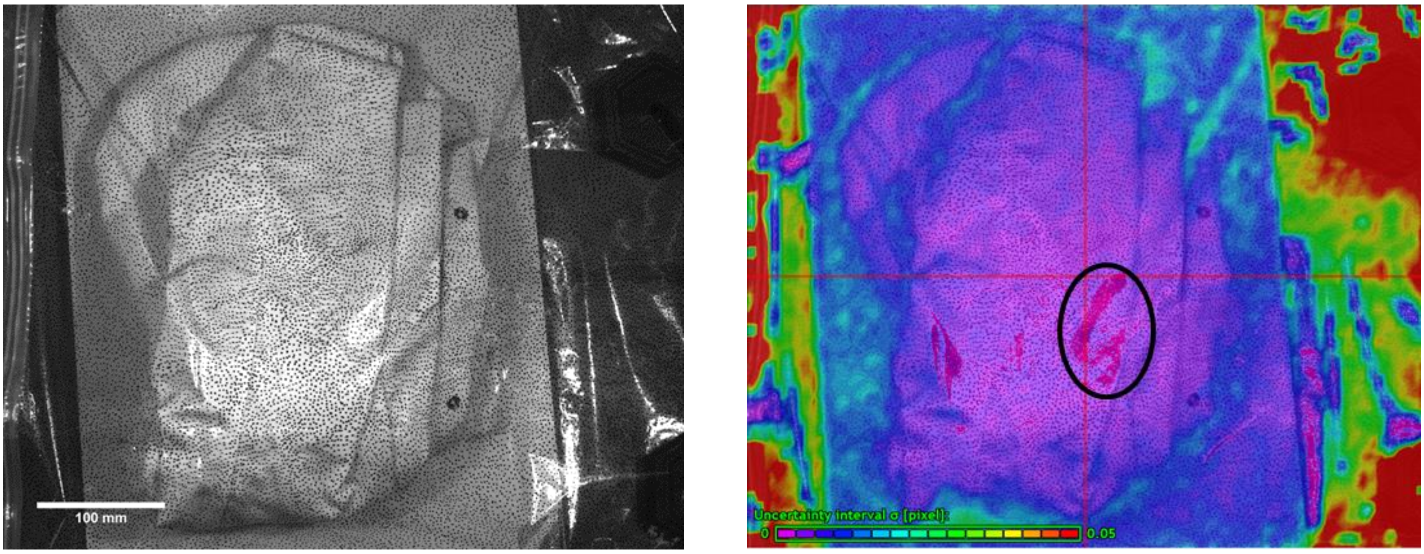

Fig. 1: Left, camera one image from Vic-Snap 8, of a lab coat placed within speckled vacuum bag. Right, the uncertainty estimate produced by Vic-Snap 8, for a step size of 61 pixels. The region highlighted with a black circle shows there is some oversaturation, caused by high reflectivity of the bag, to be taken into account.

Concluding remarks

A pre-speckled vacuum bag has been used as both the component speckle for analysis and as the method of loading. Early suggestions are that this method is capable of analysing strain profiles, but further work is needed in understanding whether the strains measured are representative of the component, or whether the bag is under strain irrespective of levels the coupon is under.
Along with this, finding a method of limiting high levels of reflection and creases in the bag is a necessity.

References

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