Panoramic Digital Image Correlation in Blood Vessels

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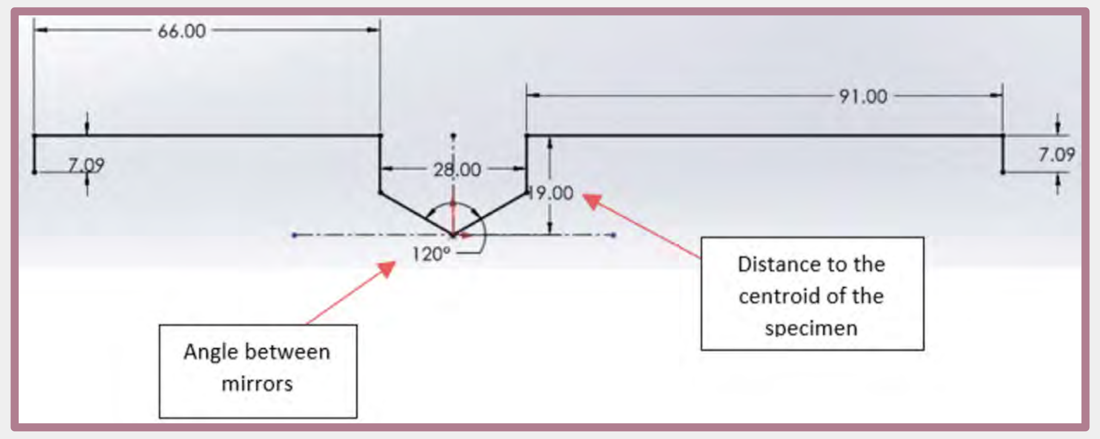
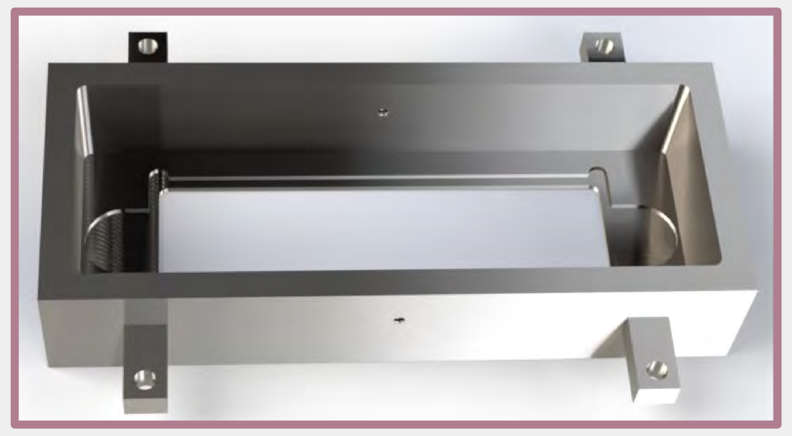
1 Bracket

- Two mirrors placed on a 120° bracket beneath the specimen
- Adjustable vertex



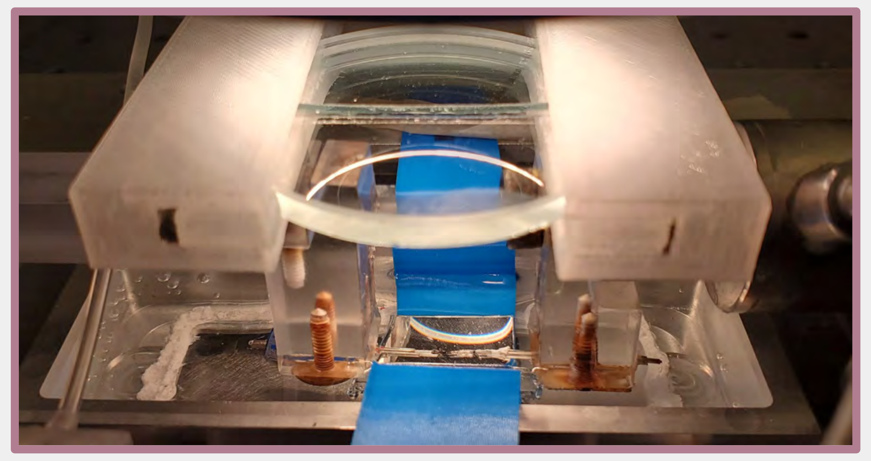
2 Bath

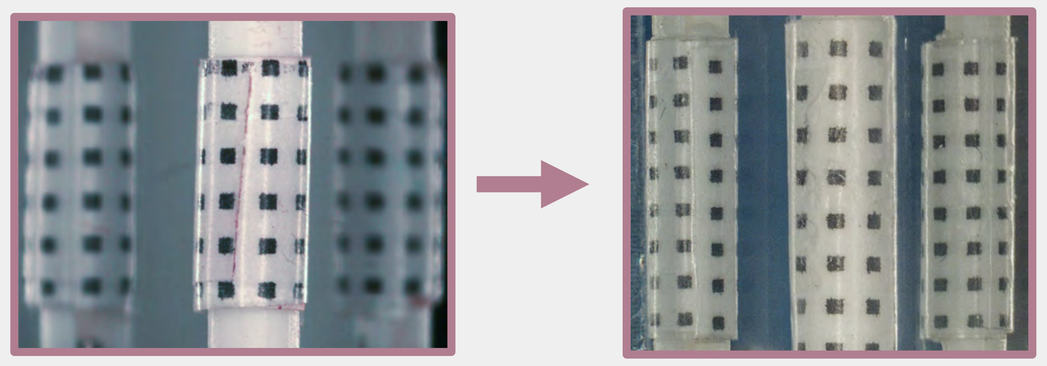
- Vessels must be submerged in saline solution during test
- Depth accommodates bracket



3 Optics

- Difficult to focus on specimen and reflections simultaneously
- Split diopter lens magnifies reflections
- Lens halves slide along a track to align the split directly above the specimen
- Scissor jack moves the lens to adjust focus



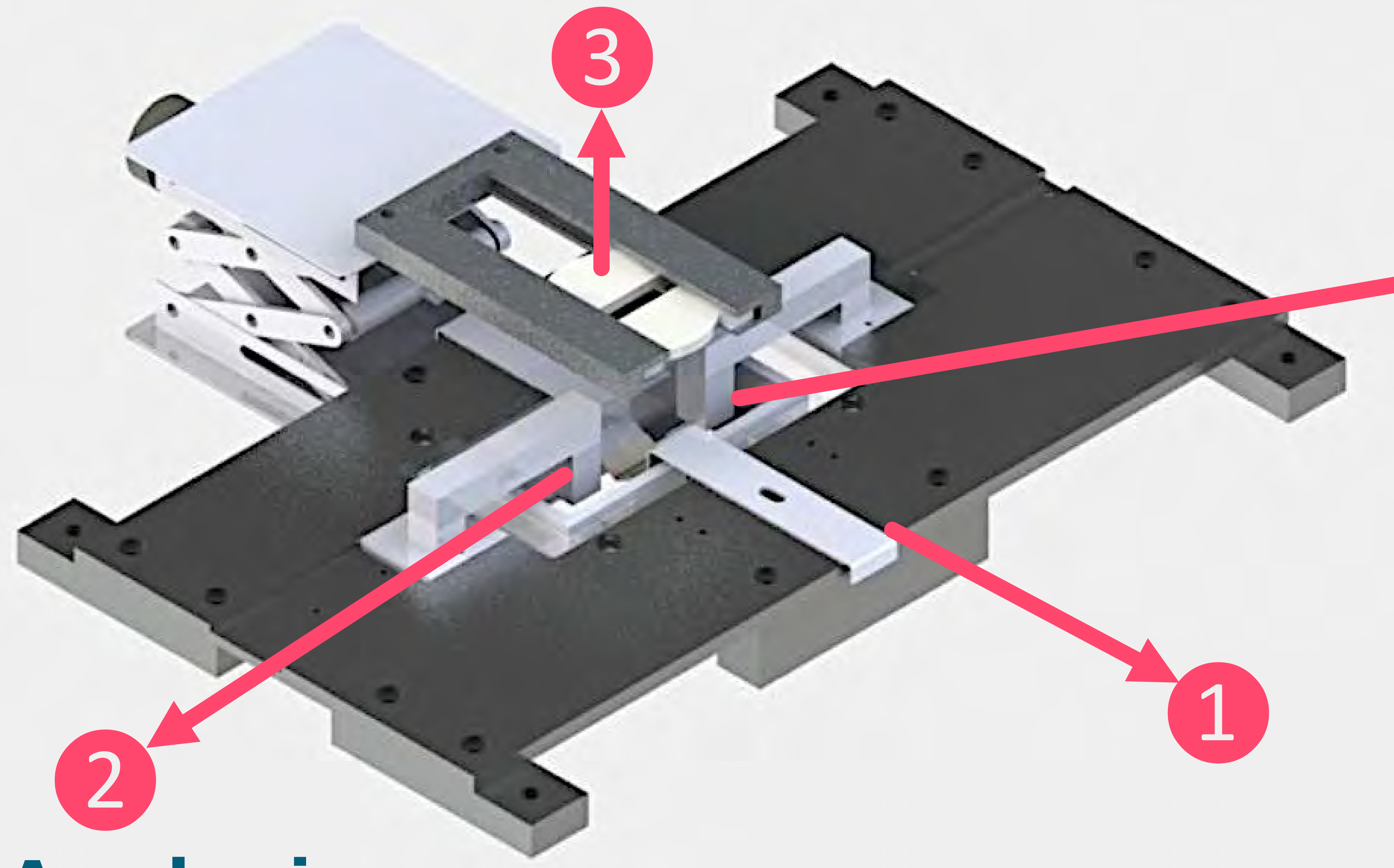


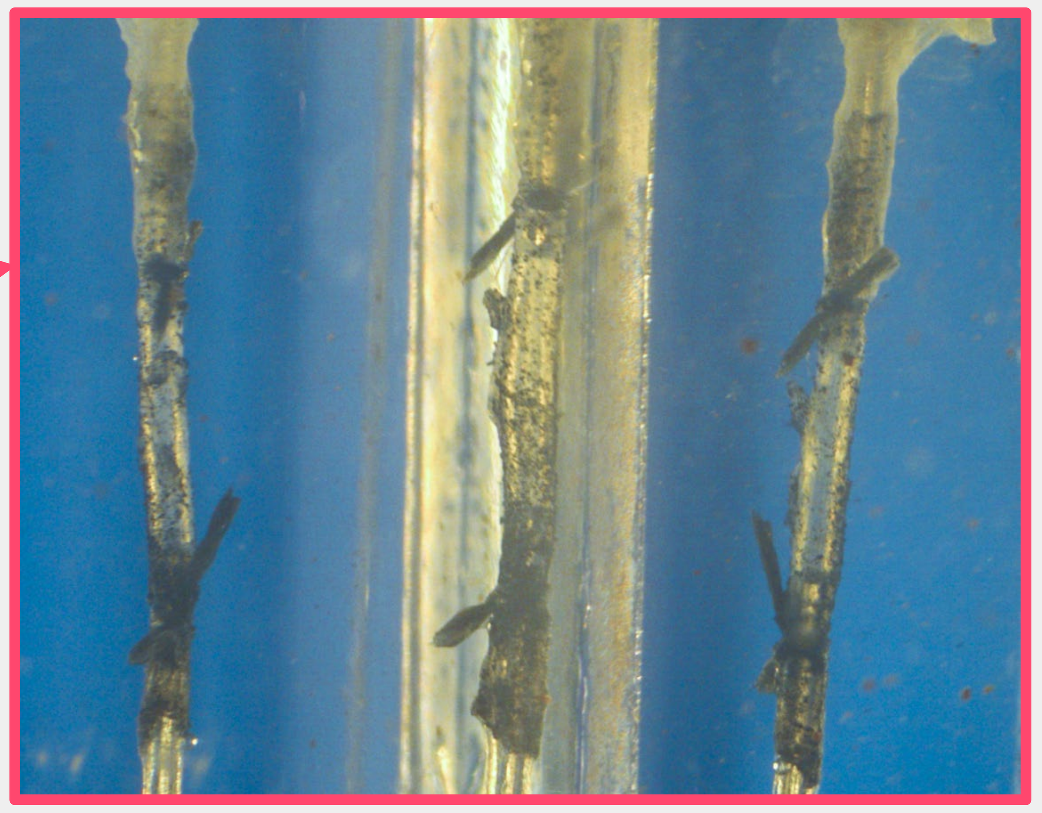
Introduction

The Head Injury and Vessel Biomechanics Lab aims to analyze and characterize injury-induced changes in cerebral vessel behavior. Research conducted by Dr. Monson strives to help those impacted by brain injuries. Dr. Monson's lab performs tension tests on vessels to simulate head trauma and gathers stretch values using digital image correlation (DIC) techniques. DIC tracks patterns on a specimen as it deforms. It analyzes the elongation between points in the pattern to calculate the stretch of the specimen.

Problem

The current tester only gathers stretch values from one view of the blood vessel, which limits the usefulness of the data. To address this issue, we must modify the tester to gather and analyze three-dimensional stretch values around the entire circumference of the blood vessel during testing. This will enable us to better understand the biomechanical properties of cerebral vessels and their response to head trauma, ultimately leading to improved treatments and outcomes for patients.





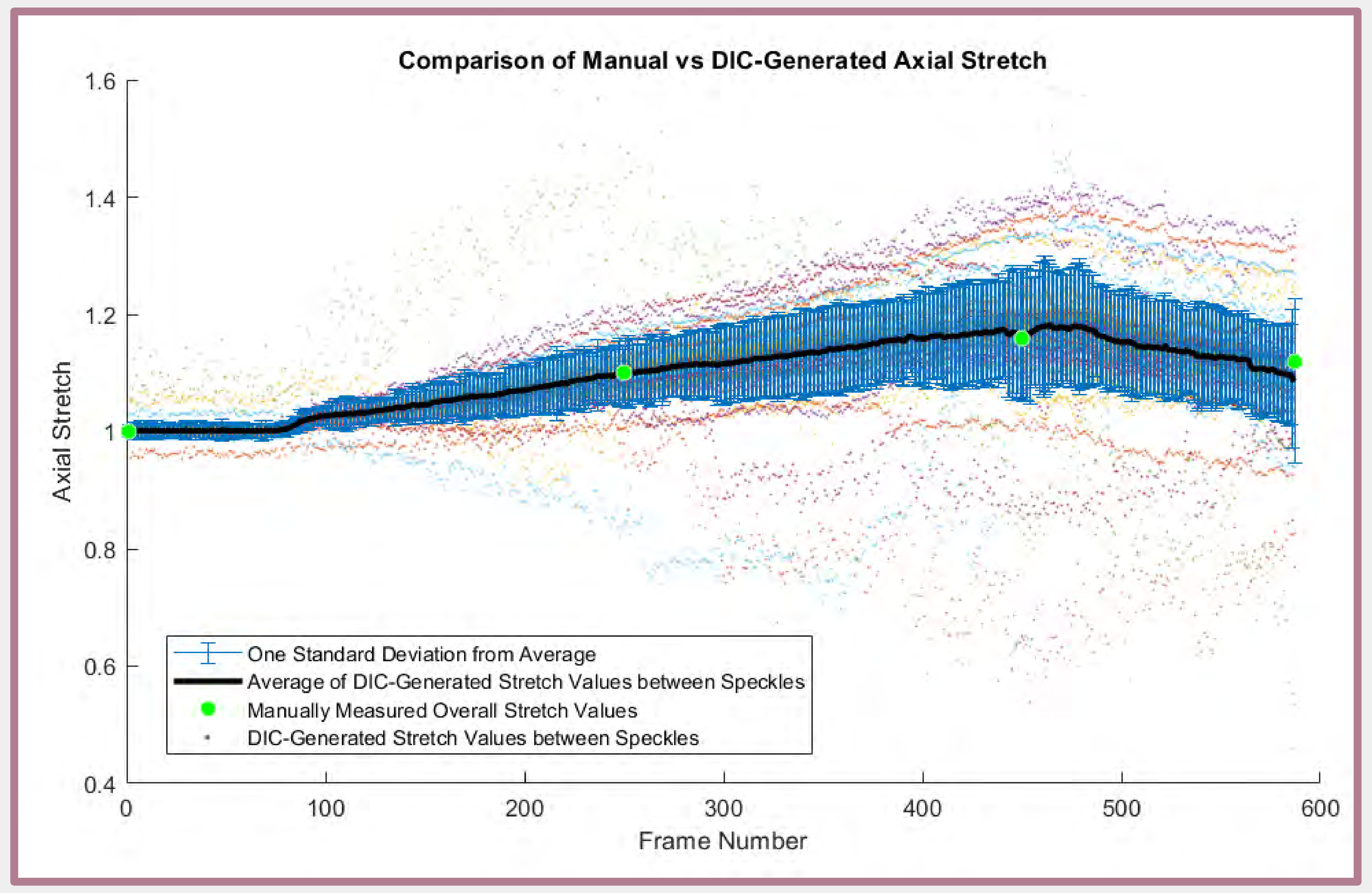
ABOVE: An example image taken with a small blood vessel in the improved testing apparatus

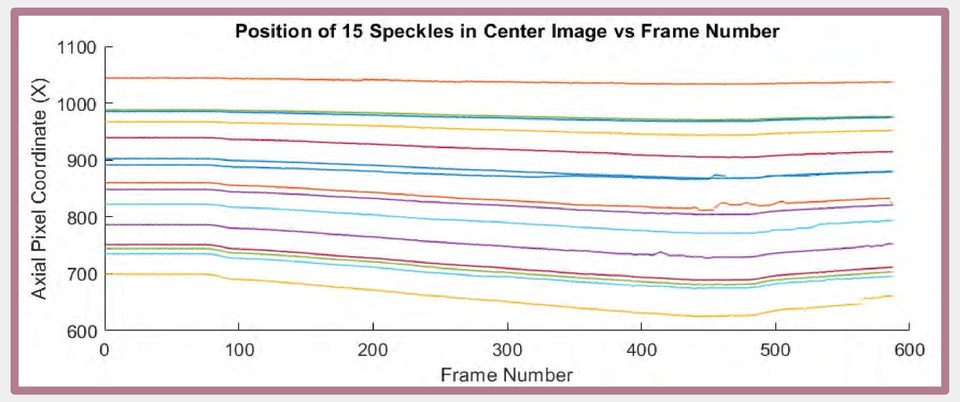
Analysis

A tension test was performed on a charcoal-speckled blood vessel. The manually calculated stretch values must be within one standard deviation of the stretch values from the DIC software.

RIGHT: Stretch values in this graph are calculated by dividing the distance between each point per frame by the distance in the first frame.
Manually measured values are calculated by measuring the length of the blood vessel in different frames and dividing them by the original length.

BELOW: The axial positions of 15 speckles throughout the stretch test



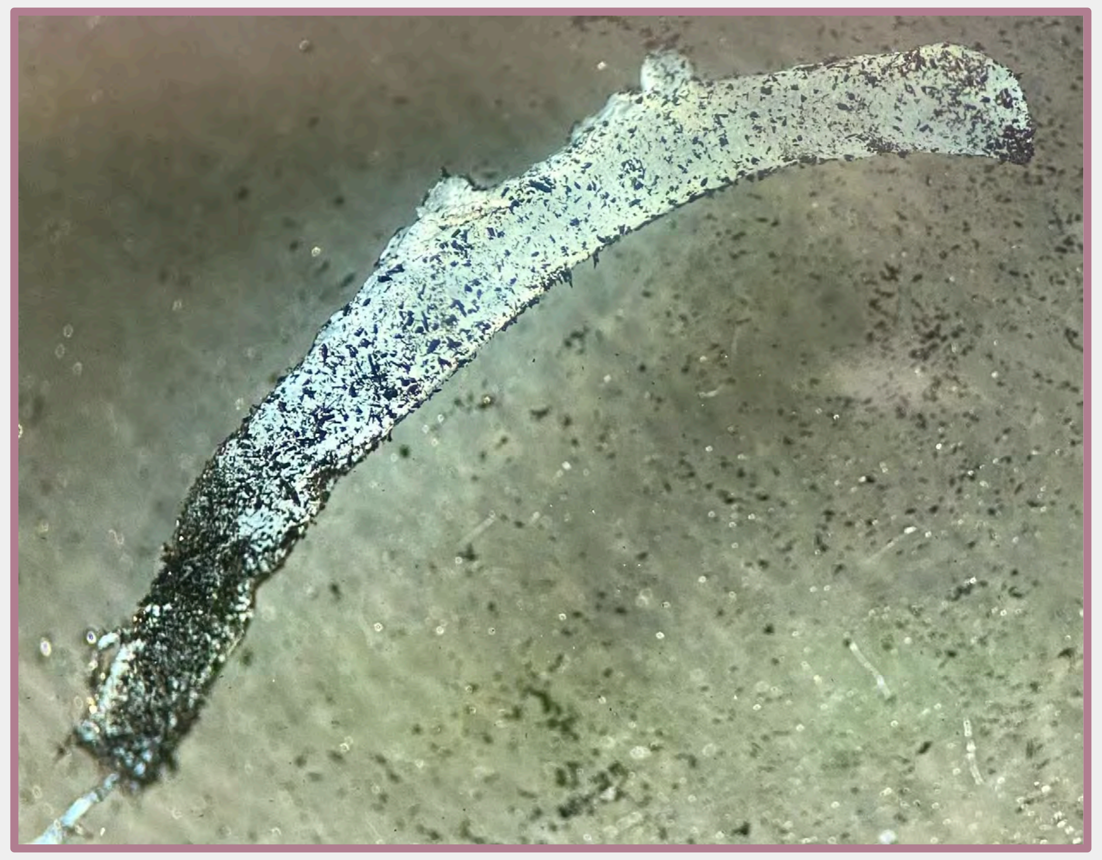


Conclusion

The results demonstrate that the updated testing apparatus and DIC software provide highly accurate tracking of stretch data around the entire circumference of a blood vessel. Remarkably, even with just 15 tracked speckles, the manually measured points match the DIC-generated data average within one standard deviation. These findings highlight the potential of the technology to greatly enhance our understanding of blood vessel stretch and its implications for head trauma. To maximize the precision of this technique, it's recommended to increase the number of speckles tracked and evaluated.

Speckling

- Application of a random, high-contrast pattern on the surface area of a specimen
- Speckle pattern must accurately mirror specimen behavior
- Activated charcoal powder has an excellent speckle size, adheres strongly to the vessel, creates a high-density pattern, and maintains all these characteristics while submerged in saline solution



Processing

- A video of the tension test is input into DLTdv8
- Video evaluated as 3 separate 2D views
- Selected speckle's position is tracked throughout the test