

Pneumatic Stimulus Generation and Automated User Interface Design for Optical Elastography of Skin



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Abstract

The aim of this project is to develop an electro-mechanical device that will deliver a controlled sinusoidal air stimulus to the skin under test, as well as a graphical user interface (GUI) that will control the stimulus device and data collection.

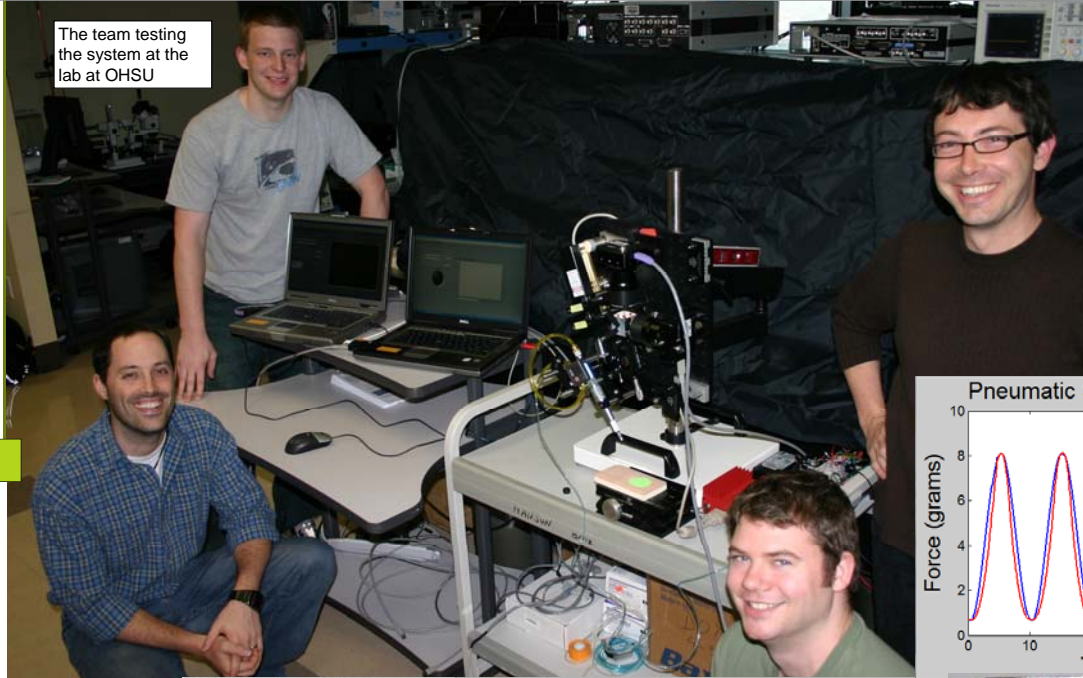
For the pneumatic stimulus, the general requirements are for a non-contact means of deflecting the skin by using 7-20 grams of force at a few centimeters distance. This deflection will be created by applying a pneumatic stimulus (preferably sinusoidal) in the range of .2Hz-5Hz. Using an EVP Control Valve and hardware developed to drive the valve, a sinusoidal output was achieved at the desired level of force.

For data collection through a GUI, it is critical that the laser speckle is recorded using two cameras, with their start recording times synchronized to less than 50 ms, with an approximate frame rate of 200 fps. Using LabVIEW to control video recording through two computers, a GUI was developed that achieves a maximum deviation of 20.6 ms at a frame rate of 194 fps.

Introduction to Optical Elastography

Optical elastography is an image processing method that relies on variations in the local mechanical properties of biological tissues as the contrast mechanism for image formation. The method images the strains in the tissue produced by some external stimulus by quantifying the magnitude of the dynamic shift in a back-reflected laser speckle pattern from the skin. The magnitude of the shift reflects the local stiffness of the tissue [1].

The elastic properties of skin are a reflection of its health. Therefore, measurements of these elastic properties can be used as an indicator of various pathologies or injuries. Our goal is to find a way to mechanically stimulate the skin without coming into direct contact, and measure its deflection using laser speckle techniques.

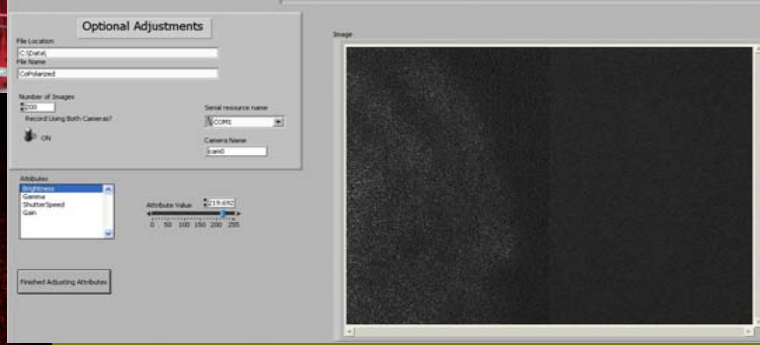


The team testing the system at the lab at OHSU



Example laser speckle pattern.

Graphical User Interface



Graphical User Interface

Using LabVIEW, a user interface was developed to control the entire test procedure, which includes:

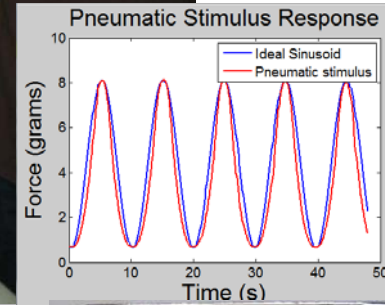
- Synchronized image recording from two CCD cameras operating at 200 fps on two independent computers
- Remote operation of Pneumatic device

Pneumatic Stimulus

The EVP Series Electronic Proportional Control Valve provides control of air or gas flow, and varies the output flow based on the current input to the solenoid.

The valve is a 50/50 nickel / iron disk with 3 fingers that holds a black Buna-N Fluorocarbon seal. The solenoid generates a magnetic field which attracts the nickel / iron disk, but the key to making it linearly proportional to current is a concave housing just below the solenoid. The outer edges of the disk stay in place as the inner portion with the 3 fingers flex upwards as pulled by the magnetic field allowing the seal to lift up. The full range of motion is only 7/1000ths of an inch, or 177.8 microns.

By programming a microcontroller to apply signals to the EVP shown to the right, an accurate pneumatic sinusoid was achieved.



Conclusion

Pneumatic Stimulus

After testing air control devices such as a peristaltic pump, digital mass flow controller, and an EVP, it was found that EVP flow control produces a sinusoid with the least distortion.

Graphical User Interface

Collecting synchronized data from CCD cameras at high frame rates is a challenge using standard lab computers:

- In order to maintain high accuracy in data collection, processing cycles are devoted to the cameras during data collection.
- An RS-232c interface was developed to accurately synchronize the recording process, with minimal deviation in recording timing.

Summary

With the improvements made in data collection and pneumatic stimulus, the optical elastography test is a more efficient way of measuring the elastic properties of the skin.



Analog circuit designed to create a sinusoidal air flow with variable amplitude and frequency.

References

Above image shows the speckle pattern as it would appear on the patients skin

[1] S. Kirkpatrick, R. Wang, D. Duncan, M Kulesz-Martin, and K. Lee, "Imaging the mechanical stiffness of skin lesions by in vivo acousto-optical elastography," Optics Express **14**, 9770-9780 (2006)