Introduction

Background

Infrared lasers can penetrate through different human tissues by different portion. One obvious application of this property is Optical Coherence Tomography (OCT). By building a interferometer with such laser, early detection of melanoma may be achieved.

Theory

When light beam is split and recombined together in an interferometer, an interference pattern (see Figure 1) can be observed if the path difference of the two light beams is within the coherence length of the laser. Thus, an interferometer can create images of objects only at certain depth. Tomography of objects can be therefore created when moving the translational stage to different depth.

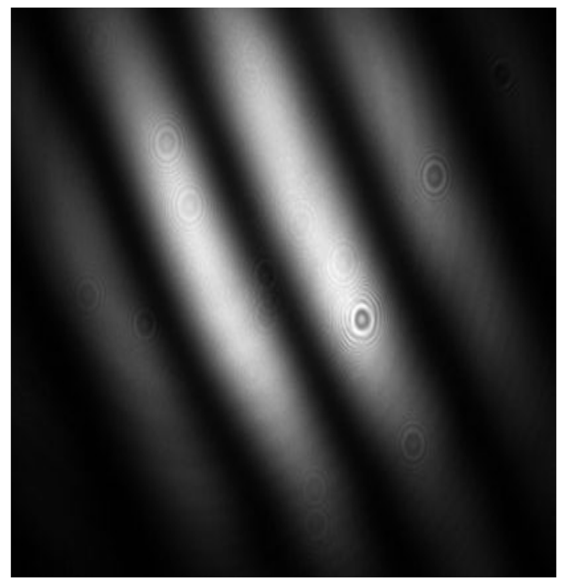

Figure 1: (above) Interference pattern detected by a CCD camera.

Purpose

With a Michelson interferometer and He-Ne laser, we can detect changes in path difference due to the displacement of piezoelectric actuator.

Setup/Equipment

Michelson Interferometer
See Figure 2

Laser
JDSU He-Ne Laser

Beam Splitter
See Figure 2

Translation Stage
Newport 423 Series Translation Stage with Mounted Mirror

Piezoelectric Actuator
Thorlabs 100 V Piezoelectric Actuator

Power Supply
[Agilent Power Supply]

Multimeter
Agilent 34401A Multimeter

Detector
Thorlabs DET110

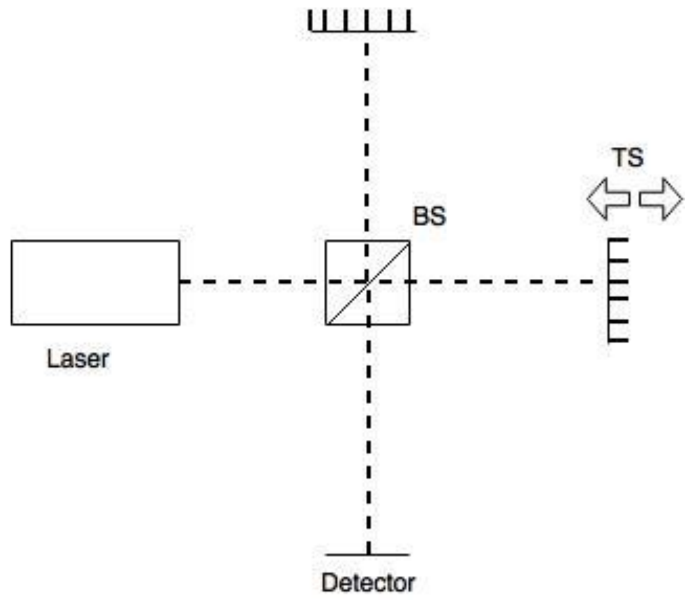

Figure 2: (above) The Michelson Interferometer creates an interference pattern that can be detected.

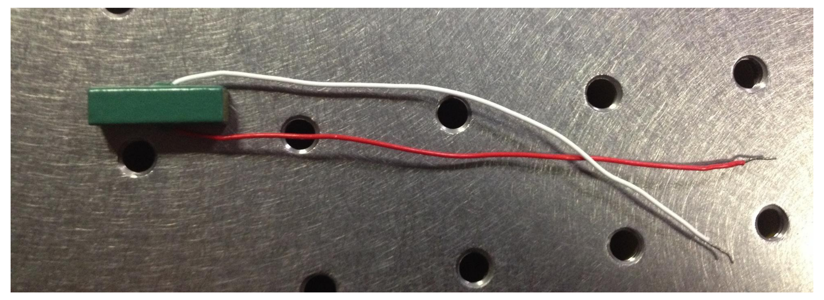

Figure 3: (above) The piezoelectric actuator is placed so an increase or decrease in voltage from the power supply results in a displacement of the translation stage.

Piezoelectric Actuator

Prior to working with a piezoelectric actuator, had been using a micrometer with a stepper motor. This stepper motor moved in increments of 15.621±*.003 nm* .

To generate more data points per wavelength, we added the piezoelectric actuator which moved our translation stage in very fine increments, as can be seen in Table 1.

Voltage	Displacement (±10%)
100 V	15μm
1 V	150 nm
.1 V	15 nm

Table 1: (above) Expected displacement of the piezoelectric actuator determined by voltage according to Thorlabs.

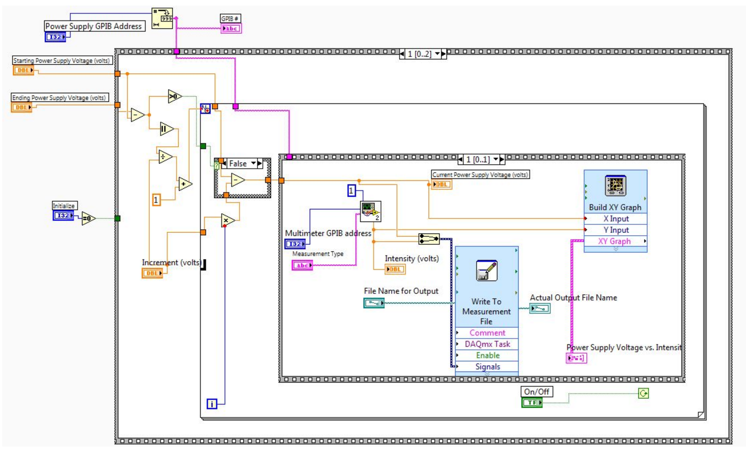

Figure 4: (above) One frame of a LabView VI created to change the voltage of the power supply controlling the piezoelectric actuator and graph displacement and voltage detected by the multimeter.

To collect data, we created a LabView VI that controls the voltage across the piezo by communicating to our Power Supply, and detects the voltage of a detected area of the interference pattern created by our interferometer. The results are graphed and saved in a txt. file.

From the data taken with our VI, graphed the change in voltage across the piezoelectric actuator per peak number. We expected to find a constant voltage interval that would match the values found in Table 1. Instead we found that when initially sending voltage across the piezoelectric actuator it took more volts than after being displaced several wavelengths.

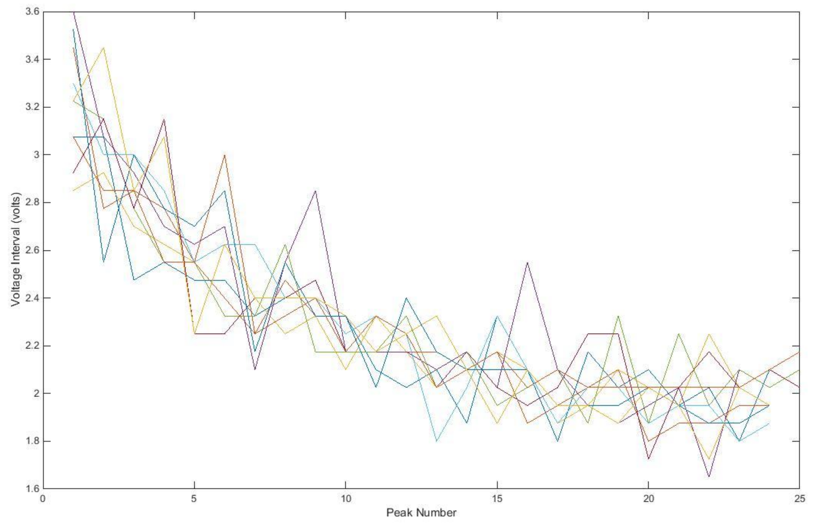

Figure 5: (above) Graph of the voltage interval between peaks found when using the piezoelectric actuator.

Hysteresis of the Piezoelectric Actuator

Regardless if the voltage over the actuator is increasing or decreasing, the voltage needed for the piezoelectric actuator to be displaced one wavelength is always decreasing. Such behavior can be possibly explained by hysteresis effect.

A typical piezoelectric actuator is built by series of parallel wafers. Because of this there can be delay between the change of voltage over the actuator and the displacement of the actuator.

To confirm this, we ran trials of voltage between 0 and 60 volts back and forth, recording the displacement by counting the multiples of the wavelength.

Figure 6 shows that, the rate of displacement decreases when voltage over the actuator changes, confirming the hysteresis effect of the Piezoelectric Actuator.

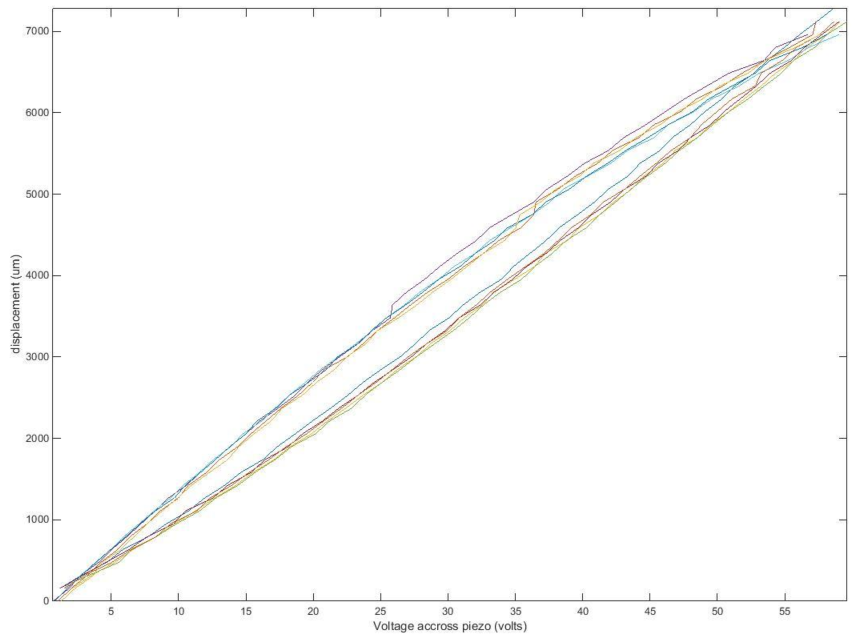

Figure 6: (above) Graph of the displacement of the piezoelectric actuator over the voltage across the piezoelectric actuator for trials with voltages between 0 and 60 volts.

In Figure 7, the maximum voltage reached was varied by 15 volts. The hysteresis effect can be observed for each trial.

The slope of displacement versus voltage decreases as the highest voltage over the actuator decreases.

This shows that the hysteresis effect tends to be weaker when the linear displacement of the actuator is less.

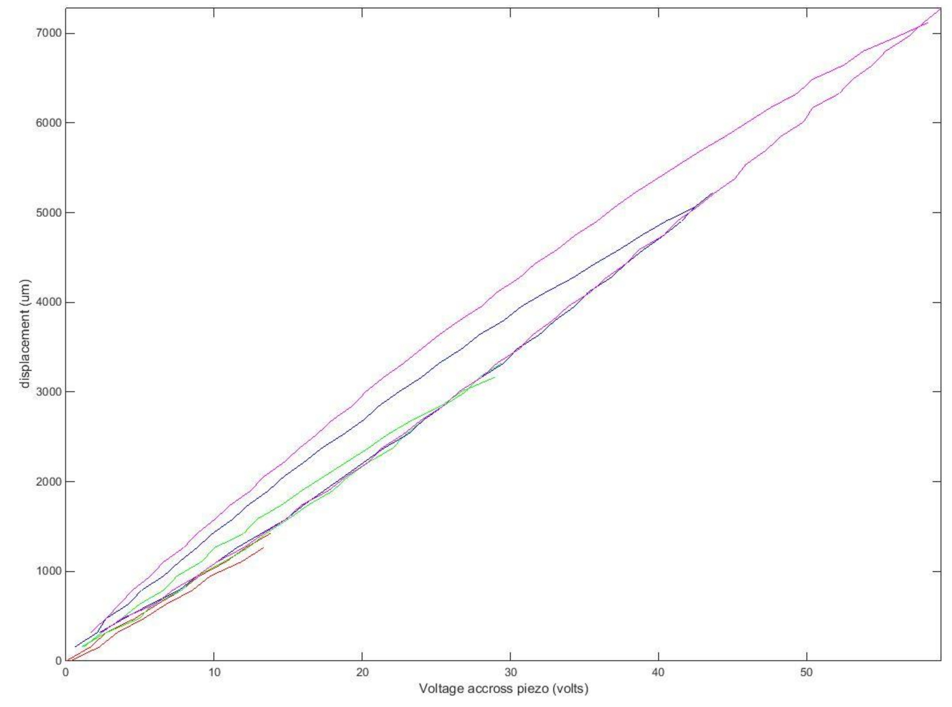

Figure 7: (above) Graph of the displacement of the piezoelectric actuator over the voltage across the piezoelectric actuator for trials of multiple voltage ranges.

Acknowledgements

Thanks to Dr. Steven Mellema for his guidance in our first research experience, the Gustavus Adolphus College F.Y.R.E. Program for funding our research, and all the Mellema lab students who have contributed to the project in the past.

Other / Further Areas

Our work with the piezoelectric actuator is part of a larger research project to build a modified Mach-Zehnder interferometer to detect a reflective object suspended in a scattering medium. We will continue work this fall to build this interferometer with the addition of an acoustic optical modulator and find the coherence length of a near infrared-diode laser.