Optical Coherence Microscopy

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3/2/2019

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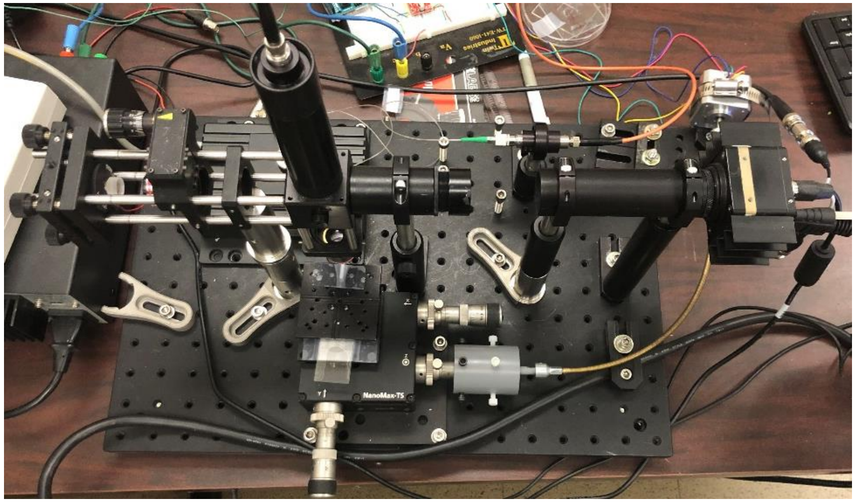
Project Goal

- Optical Coherence Microscope
  - Traditional microscope requires sample to be sliced in many layers.
  - Optical Coherence Microscope can image multiple layers without slicing sample.
- 3D visualization
  - The OCM can produce an image stack of an object
  - Convert image stack into 3D visualization
- The goal of this project is to develop the instrumentation control for an Optical Coherence Microscope (OCM) and create 3D visualization of imaged objects.

https://cdn.britannica.com/s:300x300/50/114750-004-0DB8E7A1.jpg



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Performance Criteria

Specification	Requirement
Lateral Resolution	<5 μm
Axial Resolution	<3 μm
Field of View	2x2 mm
Imaging Depth	1 mm
Frames Per Second	30

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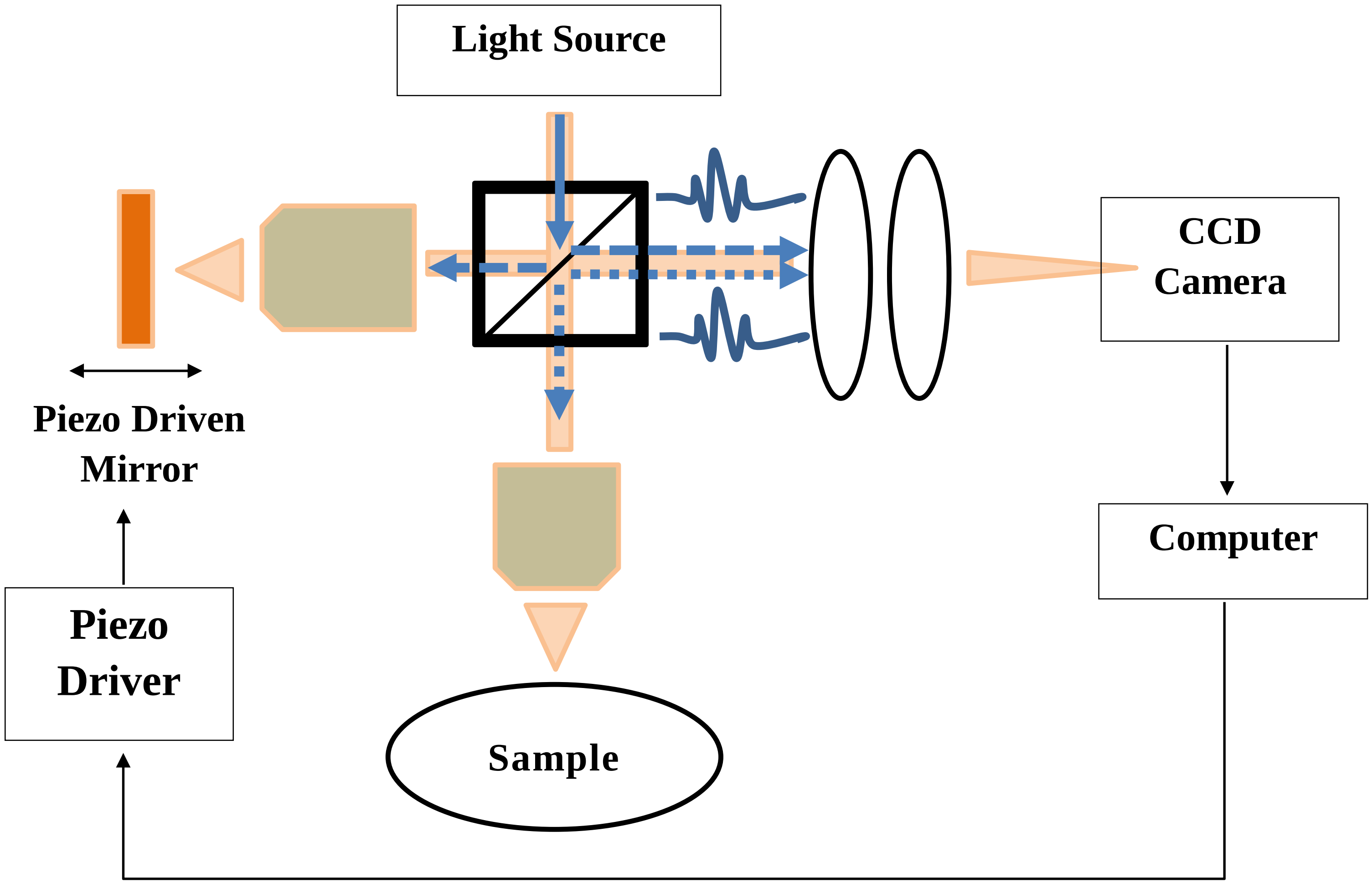
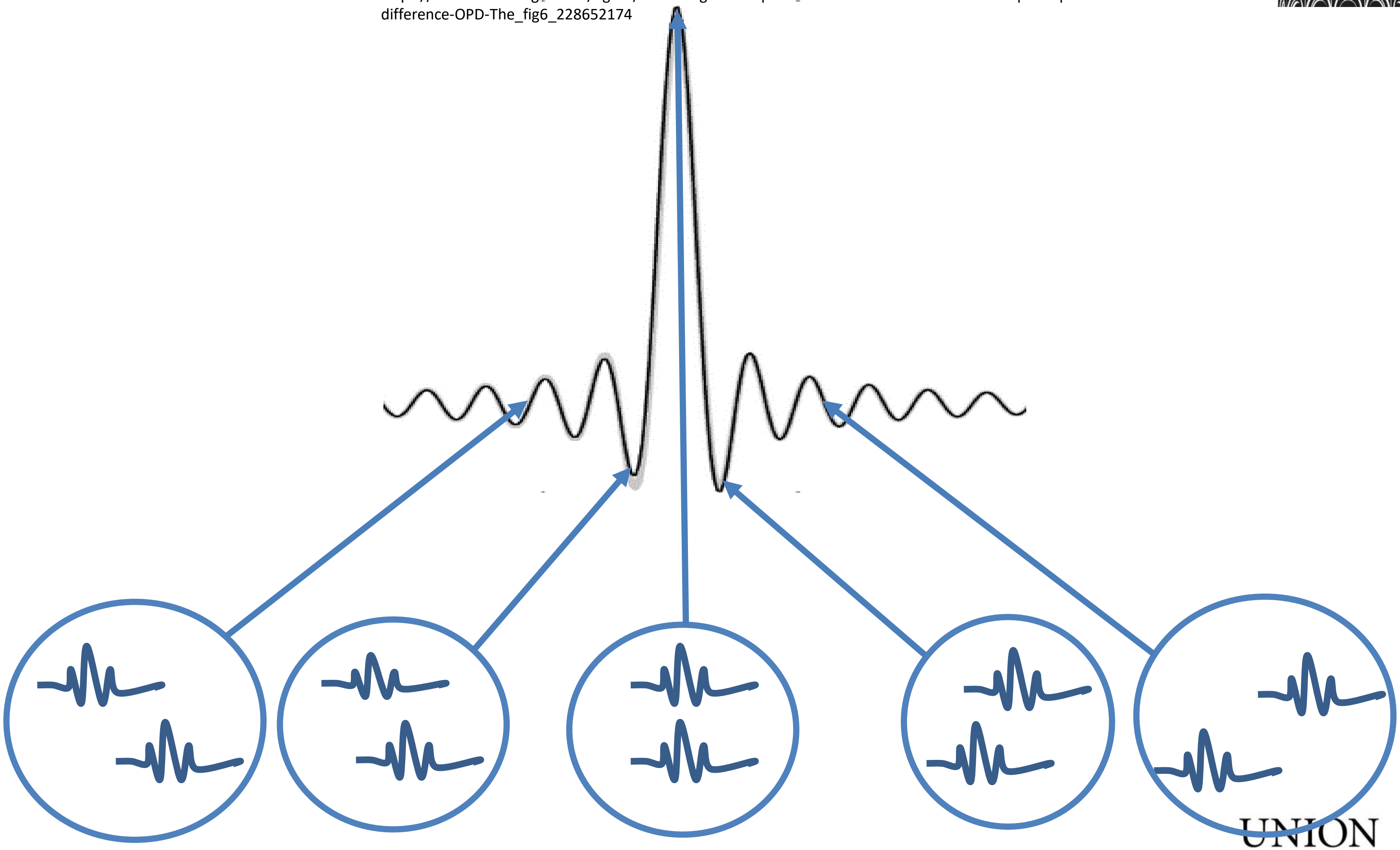
Optical Coherence Microscope Block Diagram



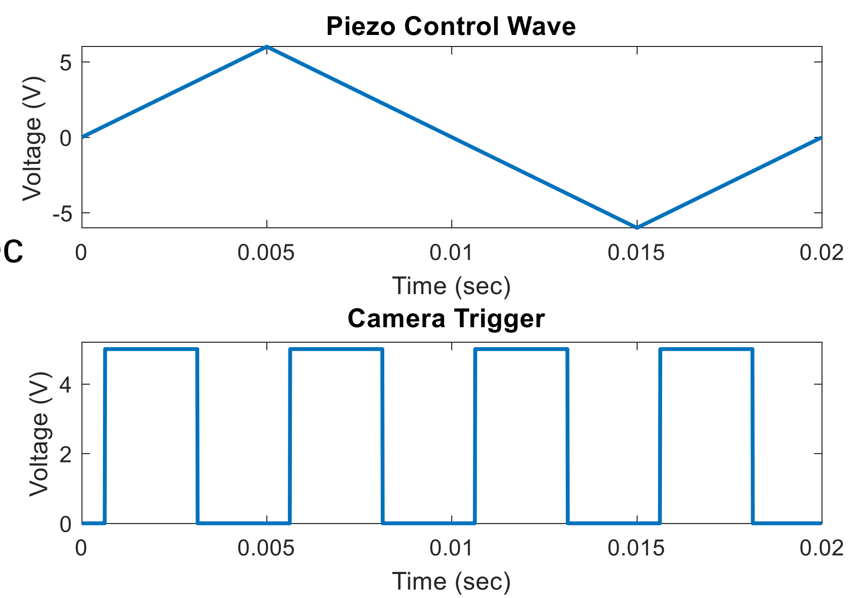
Light Interference

https://www.researchgate.net/figure/Interferogram-amplitude-or-contrast-as-a-function-of-optical-path-difference-OPD-The_fig6_228652174



Instrumentation Control

- Stage Control
  - Stepper motor attached to the depth control of the microscope stage with flexible shaft
  - The stepper motor is controlled by an Arduino uno that is front edge triggered
- Light Source
  - Superluminescent diode with a peak wave length of 780 nm and band width of 43 nm
- Camera Trigger
  - Pulse Wave
  - Phase of $\frac{\pi}{4}$
  - Pulse width of 0.25 msec
- Piezo Driver
  - Triangle wave
  - Period of 2 msec
  - Amplitude of 5 V



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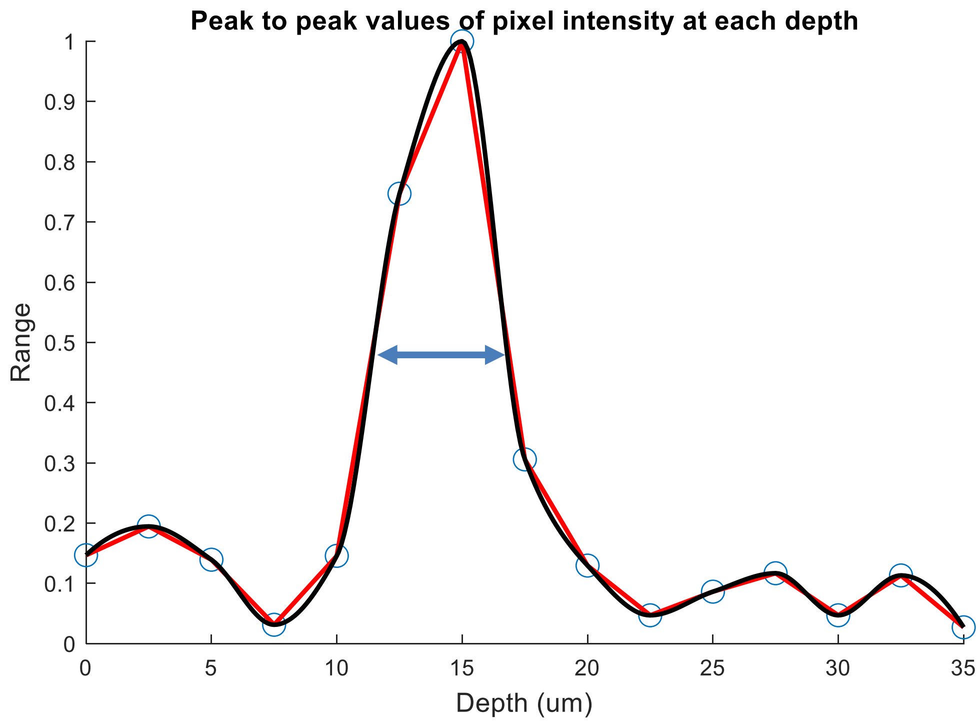
Axial Resolution

- The axial resolution is the resolution of the microscope between depths
  - The resolution is the full width half max (FWHM) of the peak to peak values of the pixel intensity at varying depth
  - The experimental value was found to be 5.28 μm
  - The data acquisition was limited by the control of the stage depth

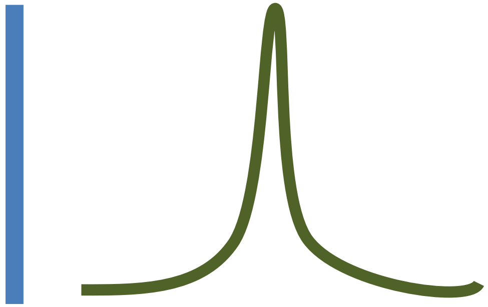


Lateral Resolution

- The lateral resolution is found using the full width half max of the line spread function (LSF) of a USAF resolution test chart

USAF Resolution Test Chart Group 2 Element 1

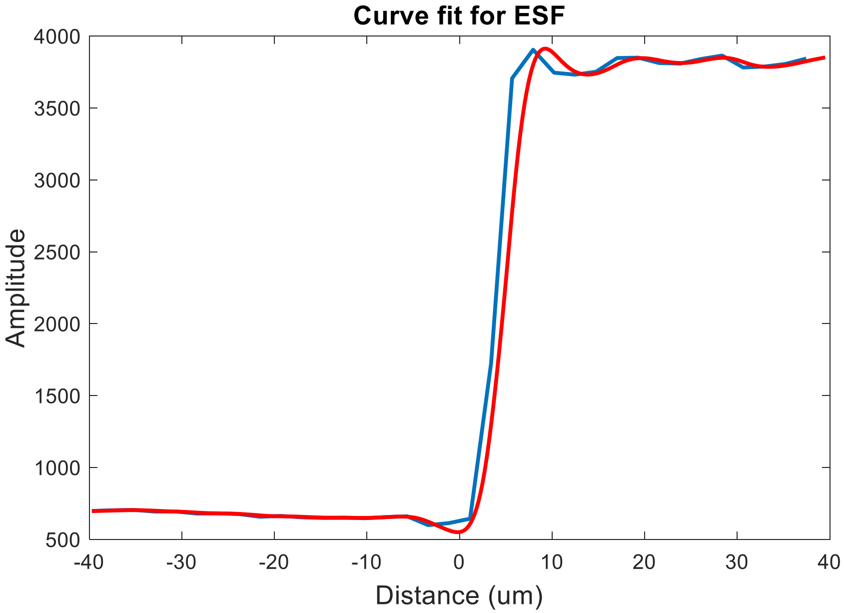
Edge Spread Function (ESF)

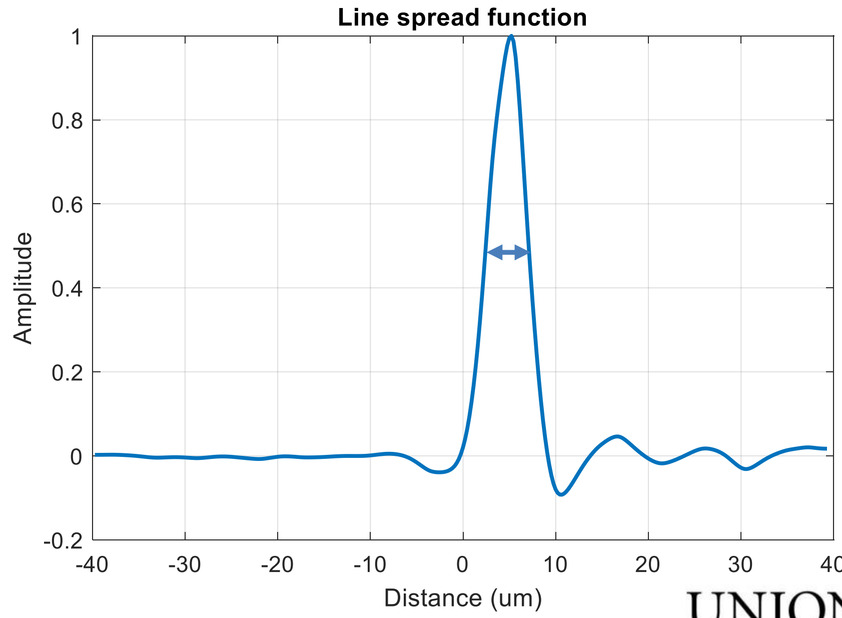


Line Spread Function (LSF)

Lateral Resolution Results

- Lateral Resolution
  - Find the pixel step
  - Determine the Edge Spread Function (ESF)
  - Curve fit the ESF
  - Calculate and plot the LSF
  - Determine FWHM
- Calculated 4.4µm Actual 4.54µm





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Images from Optical Coherence Microscope

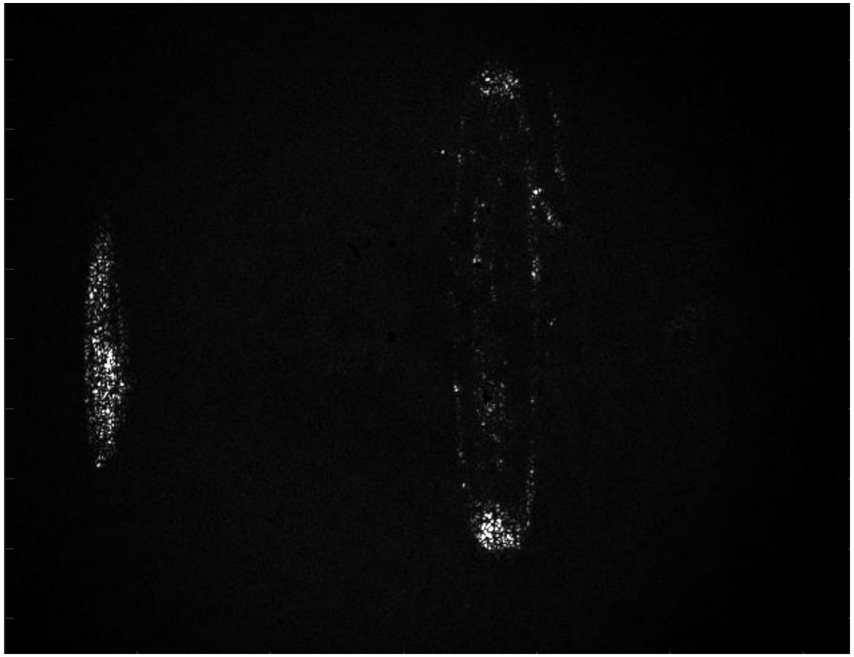

Image of Nylon Screw Taken with OCM

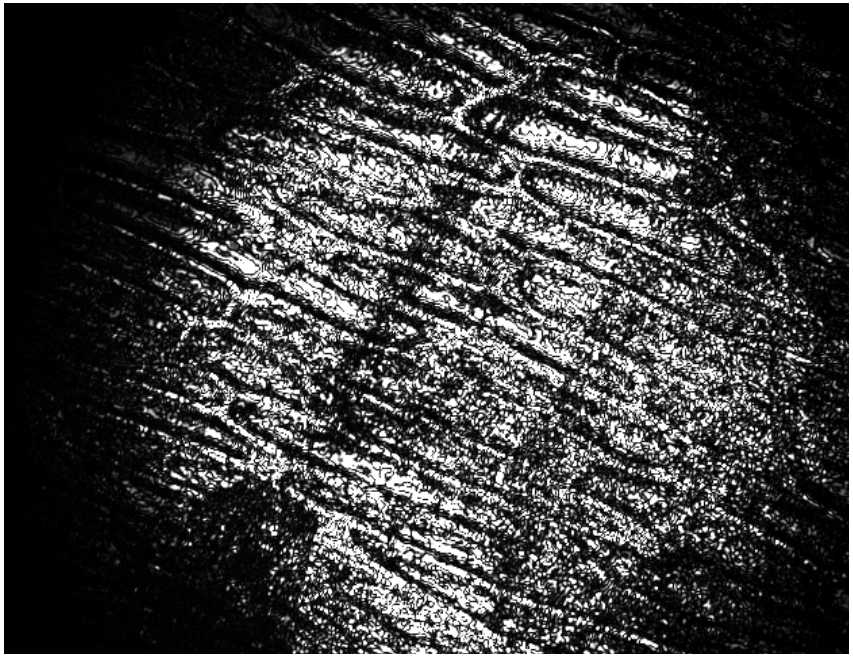

Image of Onion Epithelium Taken with OCM

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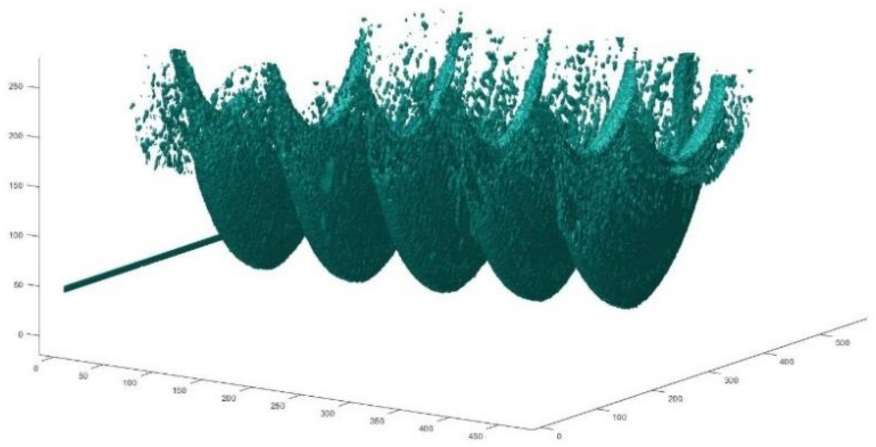
3D Visualization

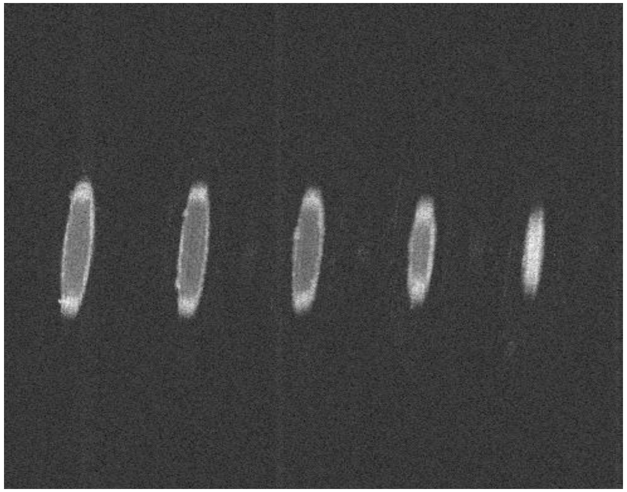
- The goal is to visualize an image stack in 3D
- 4 steps to convert the image matrix into 3D:
  1. Scale the images
  2. Filter the images
  3. Binarize the images
  4. Create visualization

https://images.homedepot-static.com/productImages/d6df67cc-de1c-4298-9958-0509f51acdb1/svn/machine-screws-814618-64_400_compressed.jpg

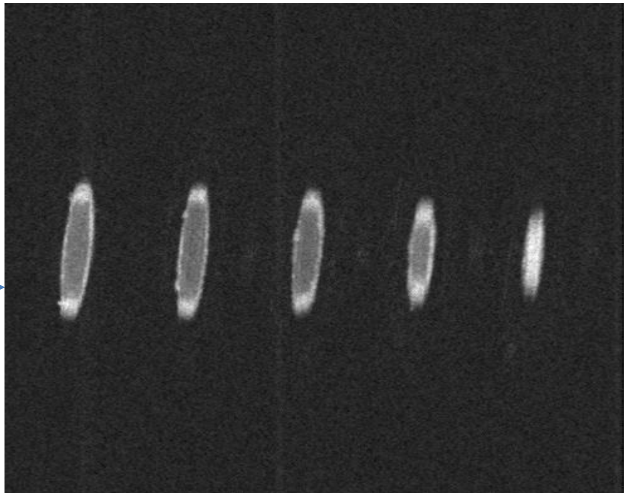


Nylon Screw Surface Visualization Using Matlab

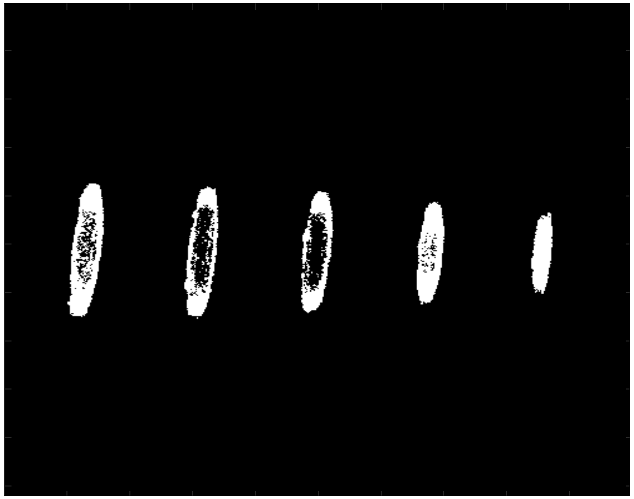
Scaled Data, Filtering, Binarization, 3D Visualization



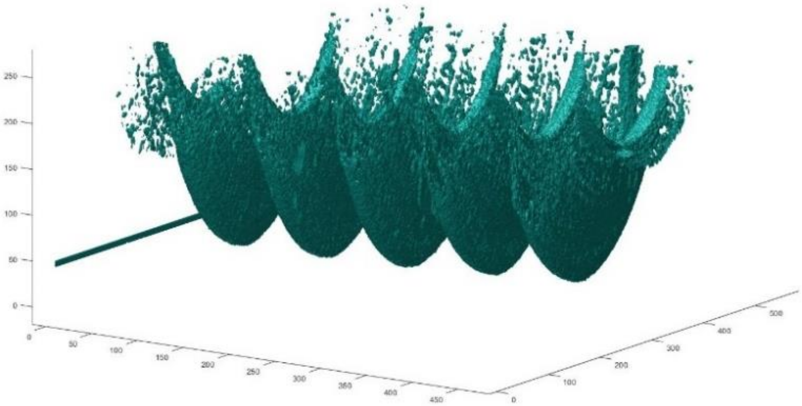
Step 1 Scaled Nylon Screw



Step 2 Filtered Nylon Screw

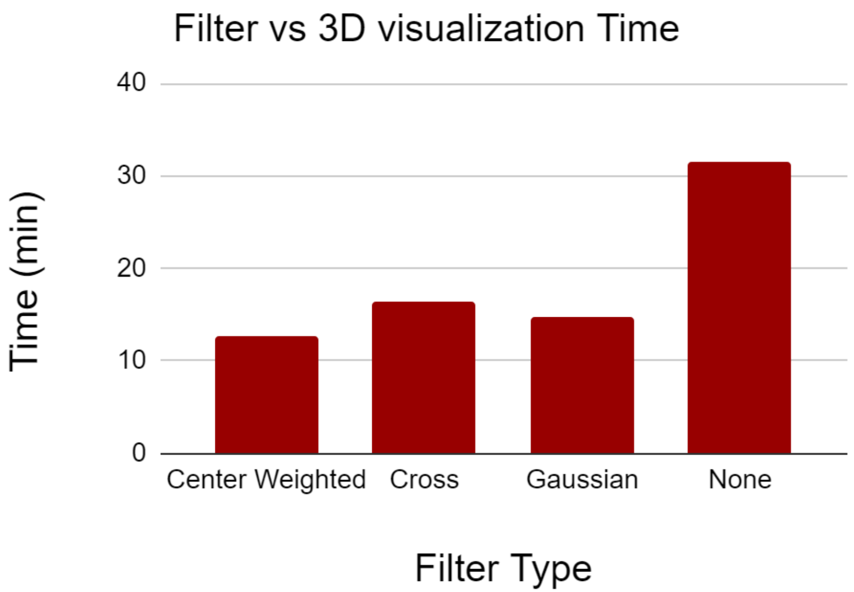


Step 3 Binarized Nylon Screw

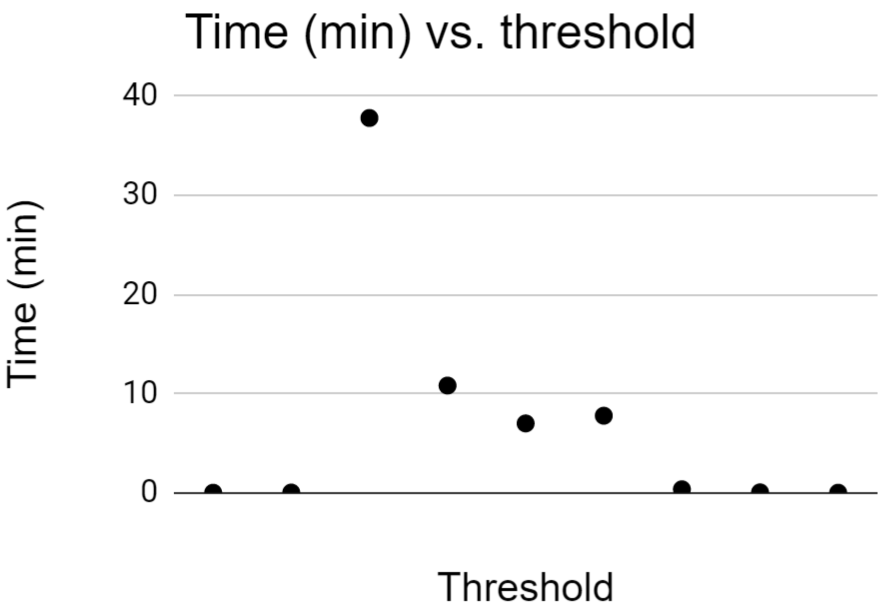


Step 4 Nylon Screw Surface Visualization Using Matlab

Processing Time

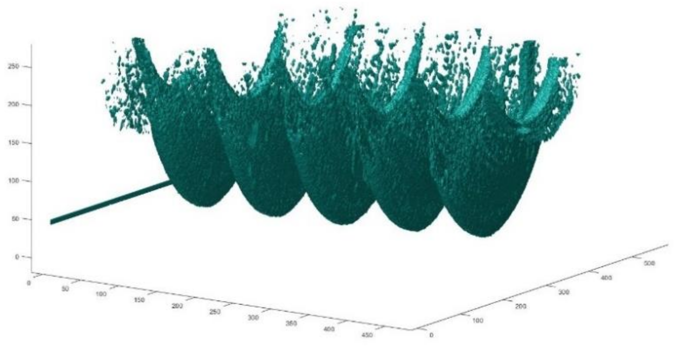


Graph of filters and their computation time in minutes

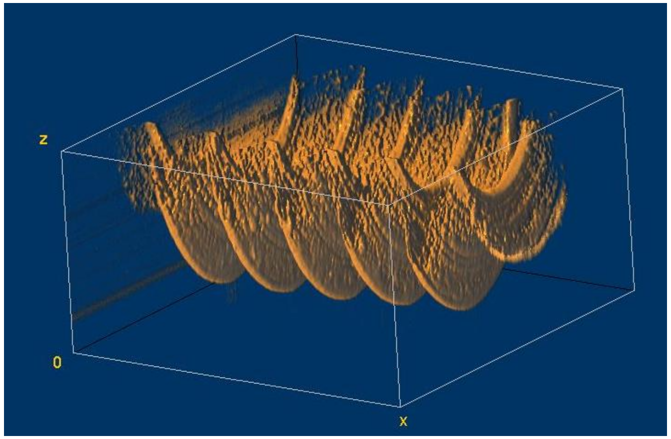


Graph Of Threshold Versus Computation Time
For A Center Weighted Filter

Our 3D visualization vs. ImageJ visualization



Nylon screw surface visualization using Matlab



Nylon screw surface visualization using ImageJ

Results

Specification	Requirement	
Lateral Resolution	<5 μm	✓
Axial Resolution	<3 μm	5.28 μm
Field of View	2x2 mm	✓
Imaging Depth	1 mm	Depends
Frames Per Second	30	25 FPS

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Continued Work

- Make the microscope controls more user friendly
- Add a free view mode in Matlab
- Image more objects
- Install GPU
- Parallelize code

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Acknowledgements

- SRG Grant
- Professor Buma
- Professor Cotter

Thank You