

# Pluck & Dispense System for Microscopy



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BME 295: Senior Design

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**Customer:** Lisa DeLouise

# Problem Statement

- The Pluck & Dispense System (PDSys™) is a microfluidic robotic device designed to image, analyze, and transfer cells from microbubble arrays into new culture environments
- Due to the small size of the microbubbles and capillary tube, manual cell transfer using the PDSys™ is extremely slow and tedious
- New software and technology needed to be implemented to allow the device to transfer cells autonomously



Pluck and Dispense System [1]

# Project Background

## Senior Design Objectives:

- Automate the z-capillary descent and xy-stage motion control
- Improve GUI

## Target Consumer:

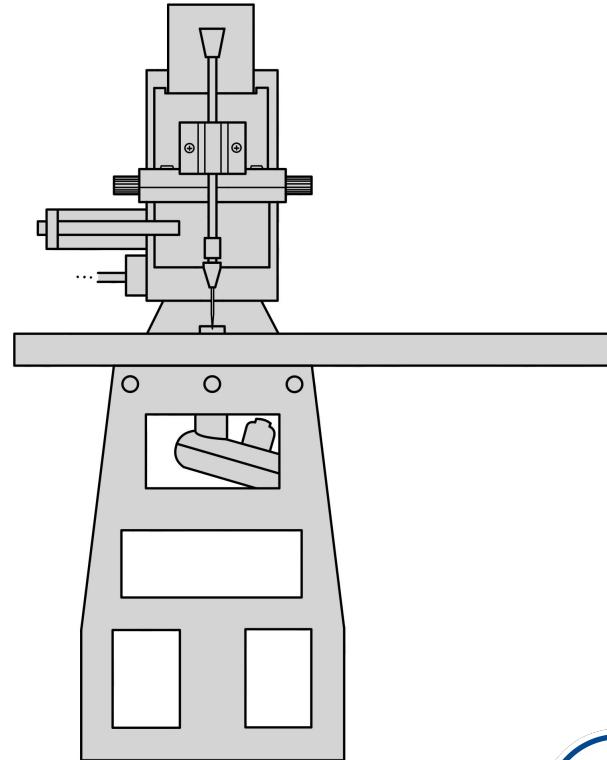
- Small pharmaceutical companies and academic labs

## Potential Applications:

- Cell line research
- Monoclonal antibody discovery
- Toxicology testing

## Target Market Price:

- 5-10x lower than competitors



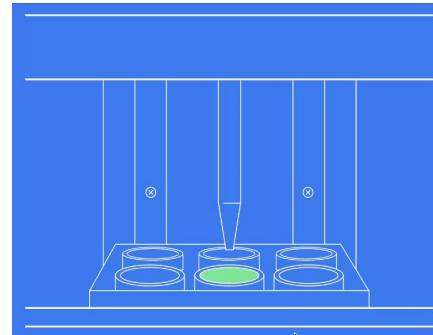
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# Competitors

Product	Company	Price [1]
CellCelector Flex [2]	Sartorius AG	\$400-500k
Cellgent [3]	Cell X Technologies	\$750k-1M
CELL HANDLER [4]	Yamaha Motor Co., Ltd	\$300-400k



CellCelector Flex [2]

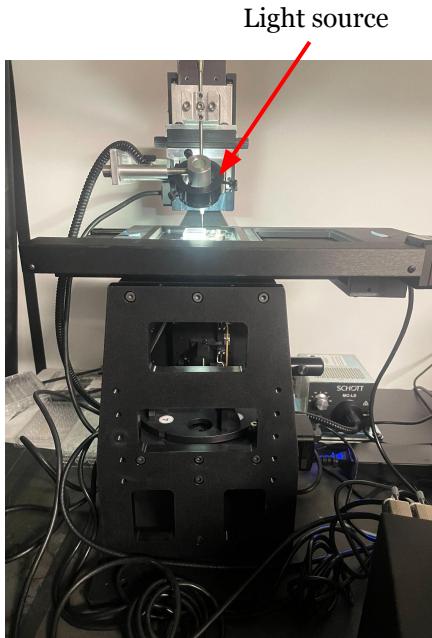


Cellgent [3]

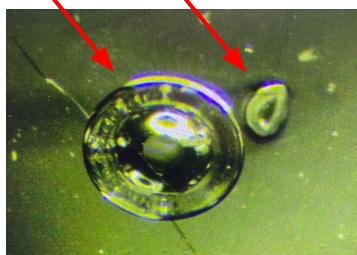


CELL HANDLER [4]

# Original PDSys™ Components



Light source      Microbubble      Capillary tip

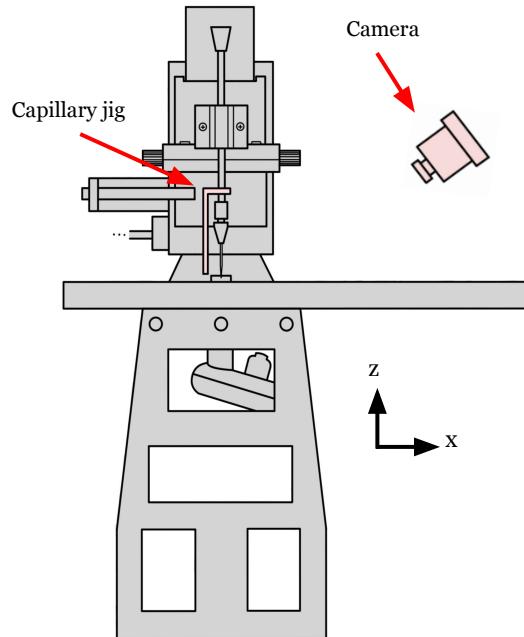


## Original PDSys™ Part List

Part	Retailer	Description	Cost
ProScan III Package	Prior Scientific Instruments	Inverted microscope, motorized XY stage, z-axis motion arm, filter wheel, focus mechanism, Joystick	~\$55k*
CellTram 4r Oil	Eppendorf	A hydraulic, oil filled microinjector used to manually aspirate and dispense cells [2]	\$3,944

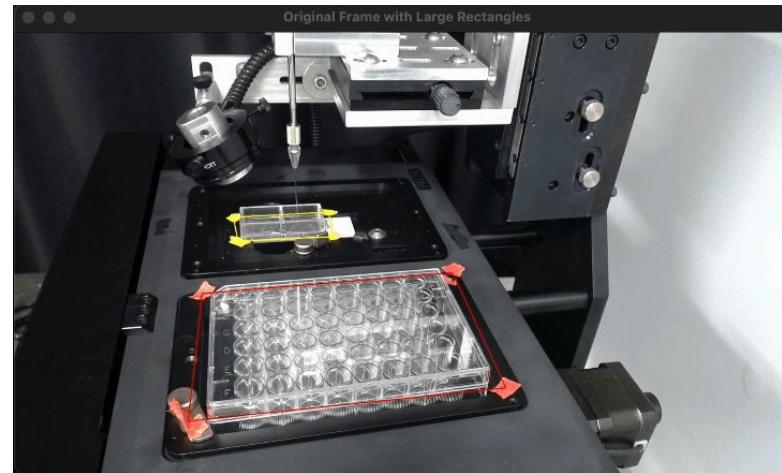
\*According to Dr. DeLouise, all of the ProScan III components and accessories cost about \$55k combined.

# First Prototype



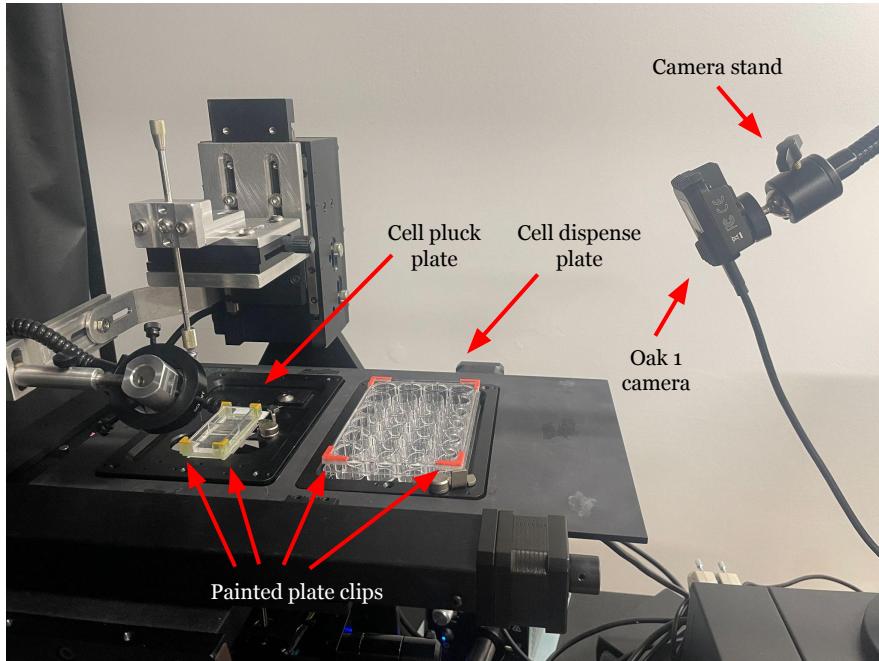
## Components Added by Senior Design Team:

- Webcam
- Webcam stand
- Colored masking tape
- Capillary jig (planned but not implemented)



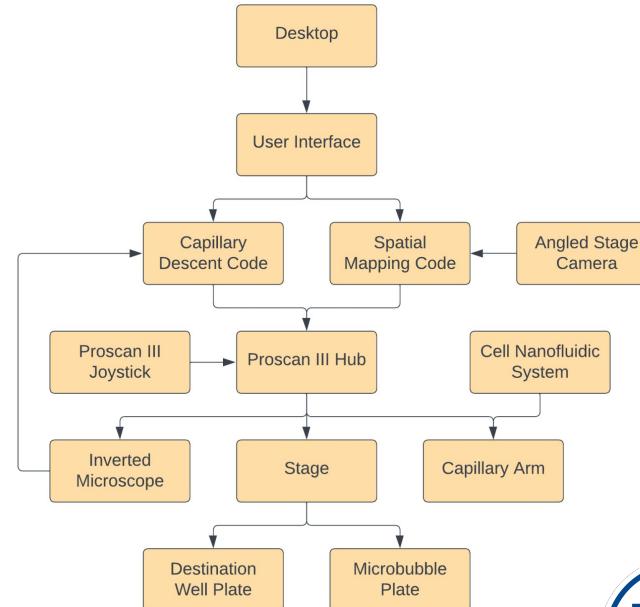
Spatial mapping camera feed using colored tape as corner markers

# Final Prototype



## Components Added by Senior Design Team:

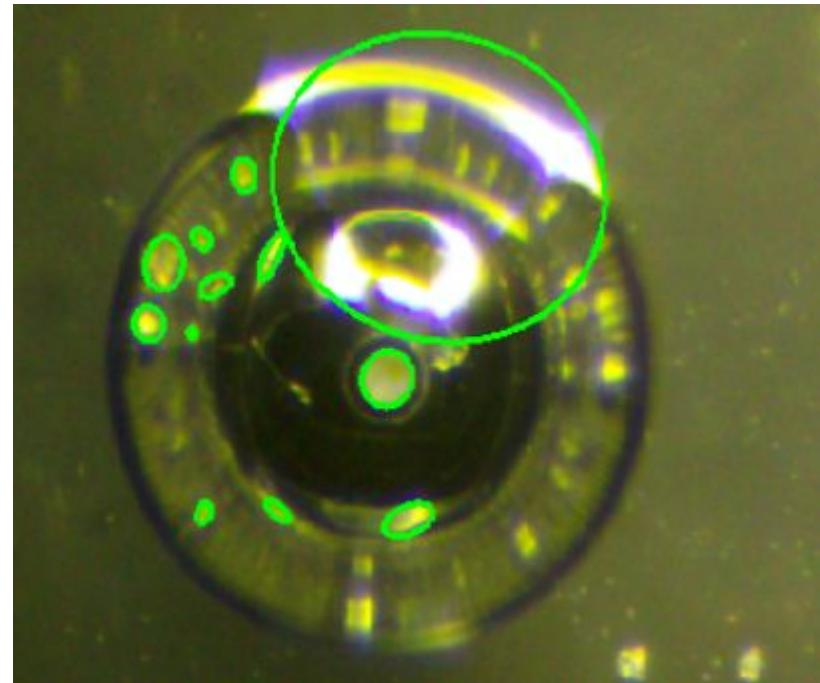
- OAK-1 camera
- Webcam stand
- Plate clips



# Capillary Descent

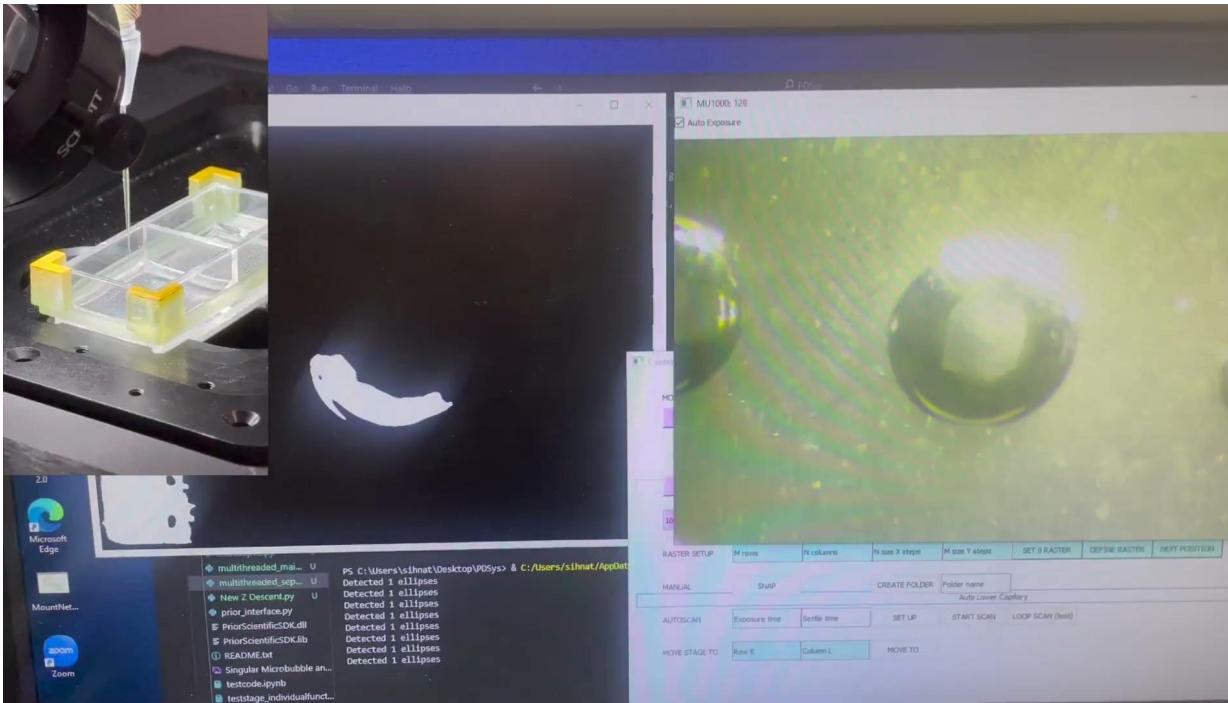
## Software Functionality

1. Screen Capture
2. Smoothing
3. Canny Edge Detection and Simple Approximation
4. Filter ellipses
  - a. Size
  - b. Distance from center
5. Drawing remaining ellipses
6. Lower capillary at constant rate
7. Stop when two ellipses are detected (capillary and microbubble)



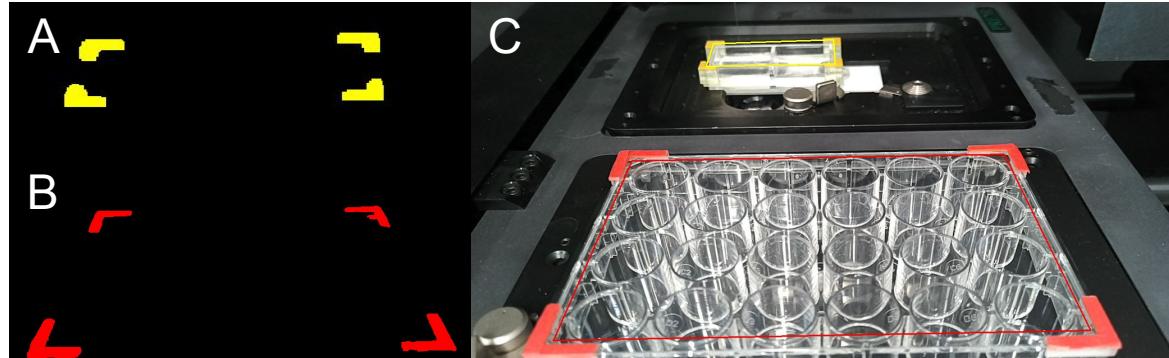
Pre-processed Microbubble

# Capillary Descent



# Spatial Mapping

- **Calculate Angle of Depression:** Calculate and return the angle of depression in degrees based on height and horizontal distance.
- **Find Colored Objects:** Convert image to HSV color space, applies a color threshold to isolate objects of specific colors, and use morphological operations to clean up the mask. Identify contours of these objects.
- **Calculate Centers:** Compute the centroid of each contour that meets a minimum area requirement, identifying the center of each object.



Yellow Mask (A), Red Mask (B), and Polygons (C)

- **Draw Polygon with Measurements:** Use convex hull to draw a polygon around identified centers, then calculates and displays the length of each side in millimeters, adjusting for camera angle.
- **Main Loop:** Processes frames from the camera, applying undistortion and identifying objects by color. It makes a map using the dimensions of objects defined by color and displays results.
- **Display and Exit:** Shows different masks and processed images, and allows exit on key press.

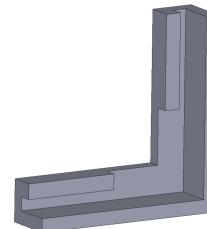
# Plate Clip Design and Production

## Current Part Specifications:

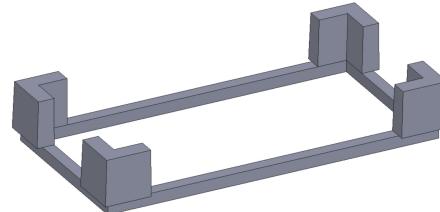
- Production method: 3D printing
- Material: Clear V4 Resin
- Printer: Form3+ printer

## Production Costs:

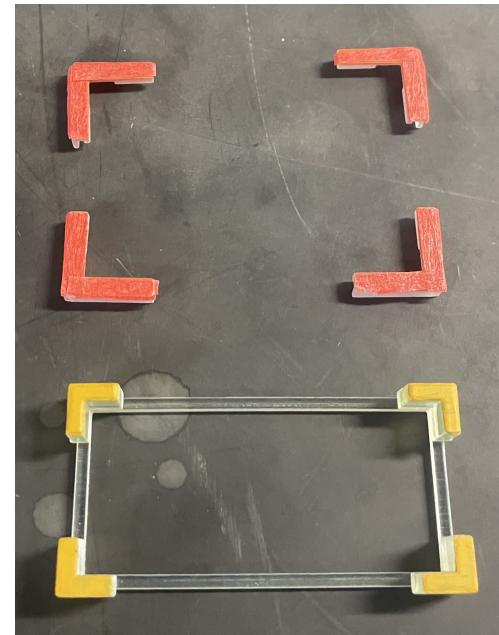
- 1 Liter Clear V4 Resin: \$149
- Print used 13 mL resin
- Cost per mL: \$0.149
- **Total Cost: \$1.94**



Destination Well Plate Clip  
SOLIDWORKS Model

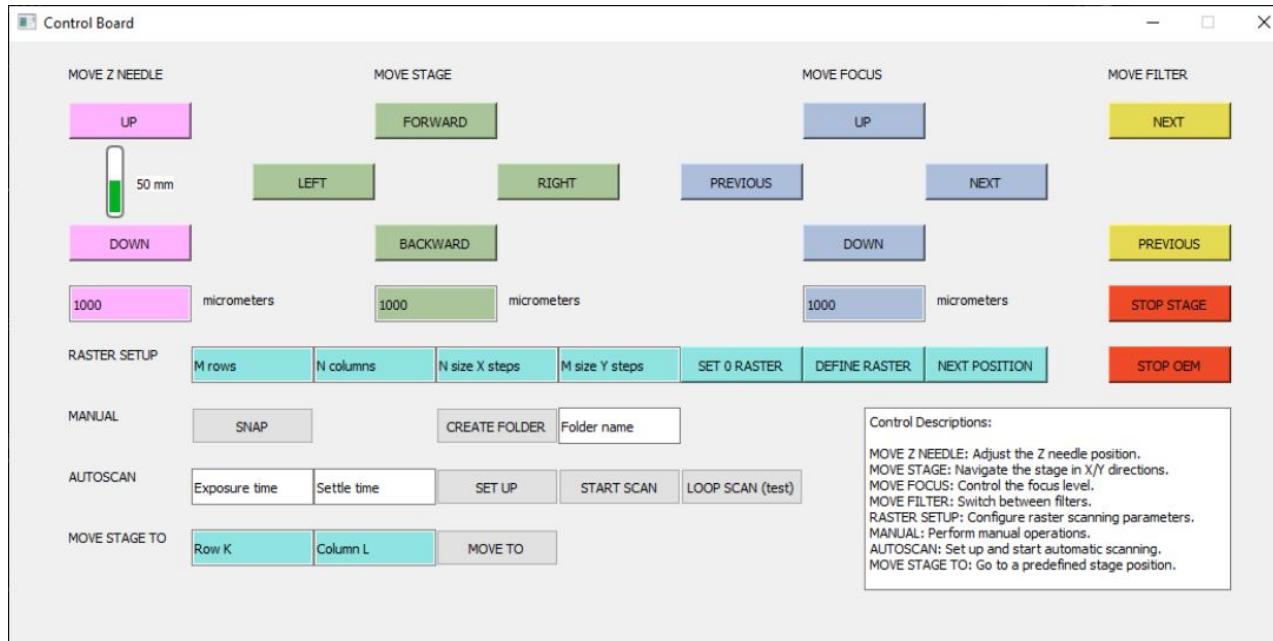


Microbubble Array Plate  
Clip SOLIDWORKS Model



Printed and Colored Plate Clips

# Updated User Interface



GUI used to manually control PDSys™

# Budget Used

Cost Breakdown for Cameras and Related Materials in USD		
Product Name	Cost per Unit	Total Cost with Tax
OAK-1 Camera	\$169.00	\$182.52
Plate Clips	\$1.94	\$2.10
Multi Colored Tape	\$7.62	\$8.23
Camera Stand	\$21.55	\$23.27
Total	\$200.11	\$216.12

*Tax estimated using NY total sales tax (~8%)*



Luxonis OAK-1 Camera [5]



Colored Masking Tape [6]

# Project Management and Challenges

## Organization

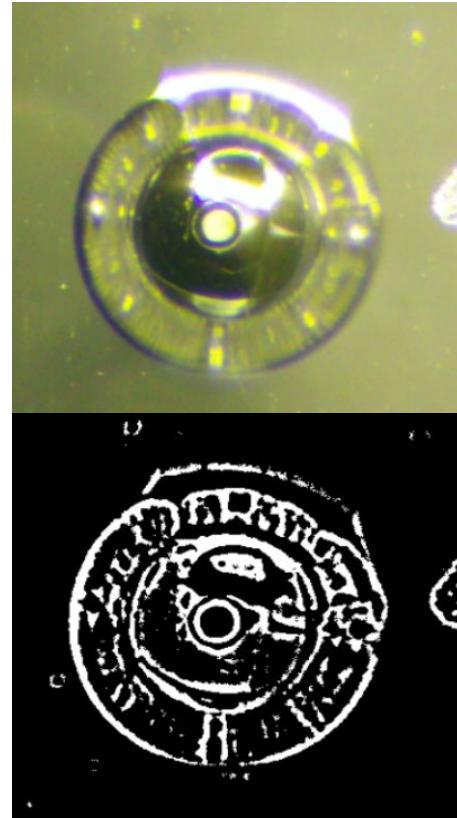
- Shared Codebase: Used GitHub for managing the shared codebase, ensuring all members could track updates.
- Code Commenting: Added comments to all code segments for clarity and easier maintenance.
- Documentation: Created detailed README files to explain project functionalities and interactions.

## Challenges

- Multithreading Necessity: Needed to integrate multithreading to run GUI and machine vision concurrently
- Code Organization: Initially lack of organization and documentation slowed progress
- System Stability: Minor vibrations affected system stability and capillary position

# Future Directions

- Implement Machine Learning
- Test with cells
- Automate the aspiration system
- Creation of new frame to minimize movement
- New thresholding



Adaptive Thresholding of Microbubble

# Acknowledgements

Customer: Dr. Lisa DeLouise

Supervisor: Dr. Whasil Lee

Project Management Liaison: Jazmin Phommavanh

Software Consultant: Keith Bozek

# Questions?