Studying Cell Behaviors in Microtissues using a LabChip

May1634

The team

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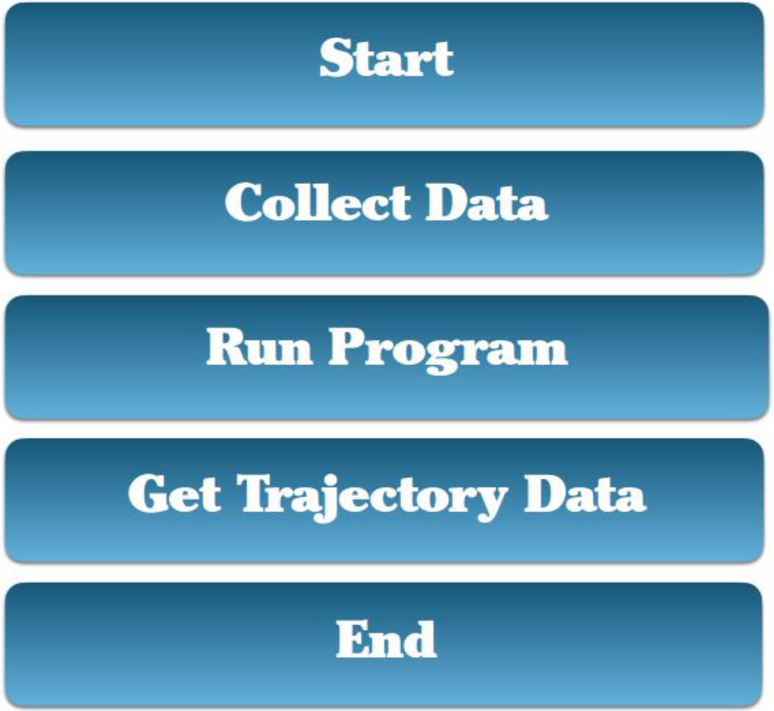
Project Statement

This project is to design a Matlab program to assist with cell behavior studies on our client's LabChip device.

The program must track migration of one or multiple cells in arrayed microtissues formed by a polymer microfluidic chip developed in the lab (LabChip).

The program must have a graphical user interface and track the cell migration using images from an optical microscope as input data.

General Process:



Start

Collect Data

Run Program

Get Trajectory Data

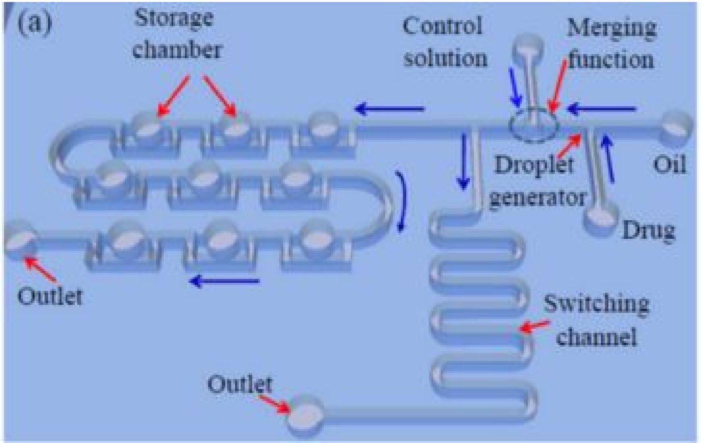
End

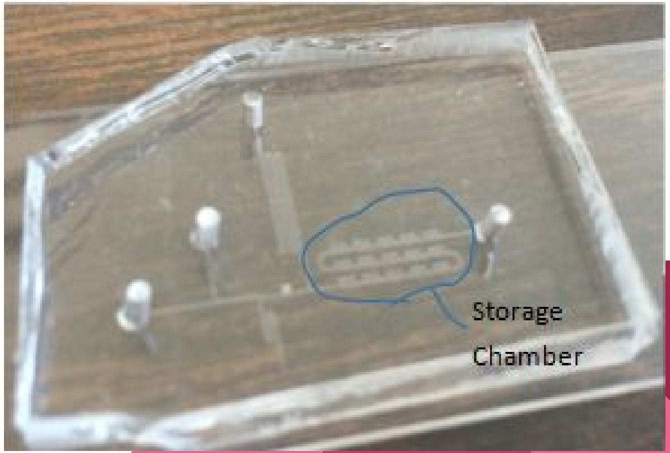
Detailed description

Hardware:

Droplets & Chips

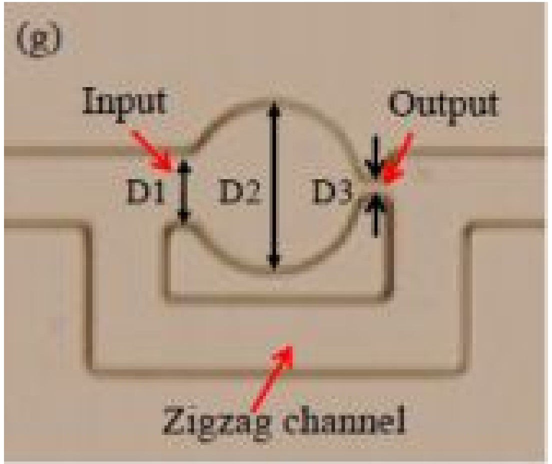
The input for our collection data will be the cells within the droplets that will be collected in the storage chambers. After the droplets with the cells are formed, individual droplets are stored in the chambers.
After the droplets have been stored, the microscope is used to analyze the behavior of the cells in the microtissue. The output of this experiment will be videos and image stacks that record the behavior of the cells.





Width of the chips

- D1 = 50 μm
- D2 = 120 μm
- D3 = 10 μm
- Thickness = 50 μm



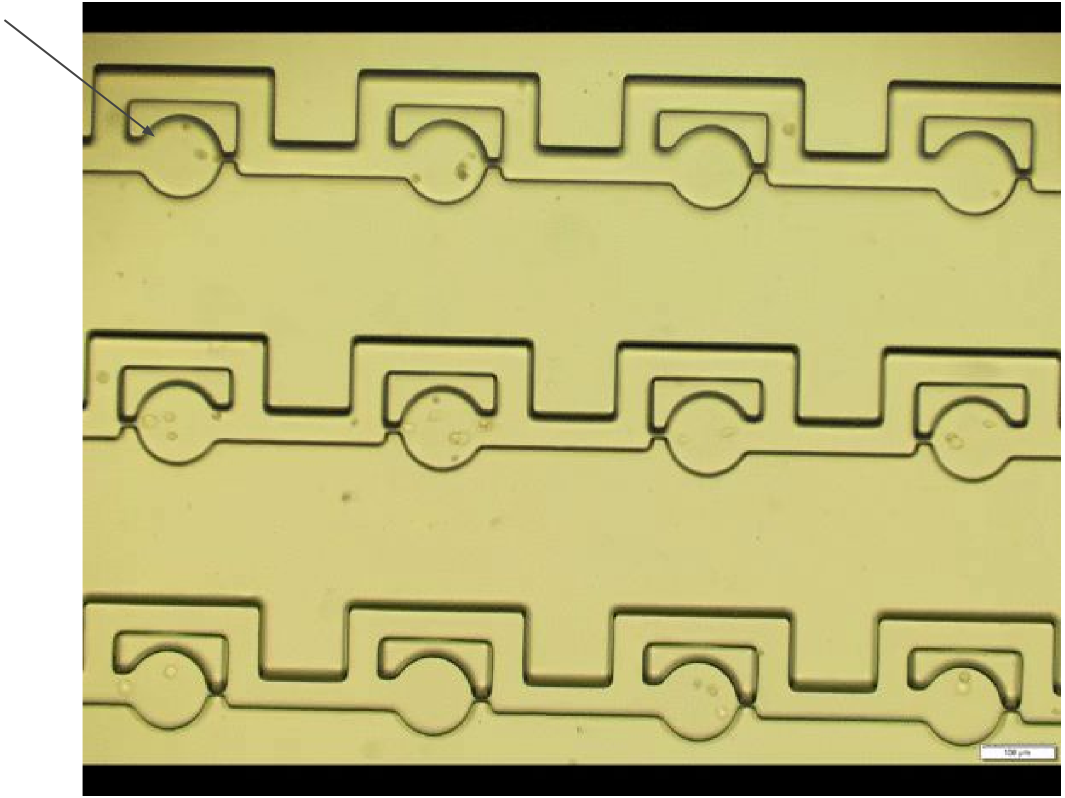
Detailed description(cont’d)

Matlab Program

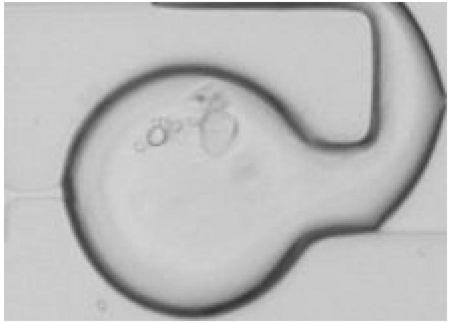
The input for the Matlab Program will be the output from the data collection, which are the images of the chambers on the chip. The program will analyze the behavior and the migration of the cells in the microtissue by determining the location of the cells in the chamber.

The output of the final Matlab program in the system will be the plots of the graphs, and the calculation results. The trajectories will be plotted with a set of plots for trajectory relative to the chambers and a set of origin-centered plots to show trajectory relative to the other cell trajectories.

Video/Image for the data



Plans for Analyzing the Cells



Working on the data:

Dye the cells, and track the movement of the color.

Collect the data with the Fluorescence Microscope.

Change the contrast of image data so we seperate cell and background in different color.

Working on the code:

Edge Detection

Dyeing the Cells

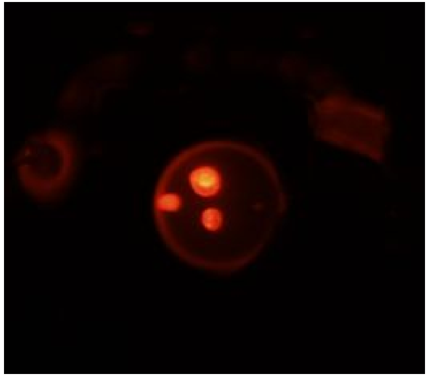
Workable? No

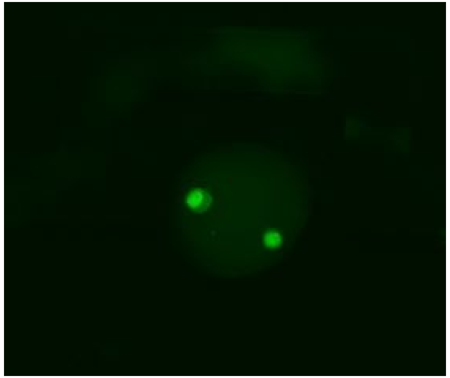
Reason: The data we get for dyeing the cells will be almost the same as the data without dyeing the cells.

Collect the data with the Fluorescence Microscope

Workable? Yes, but not beneficial

Reason: The cost of collecting the data by using the fluorescence microscope will be too expensive.

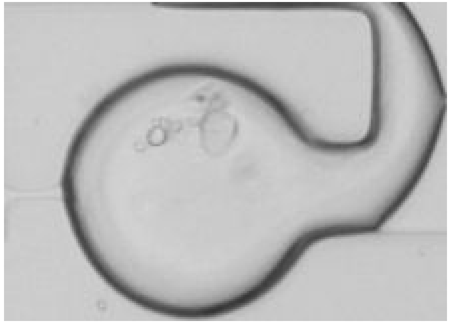




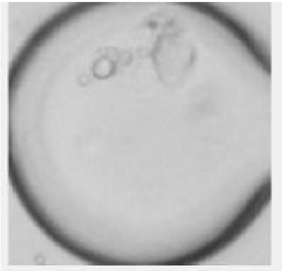
Change the Contrast of the Image Data

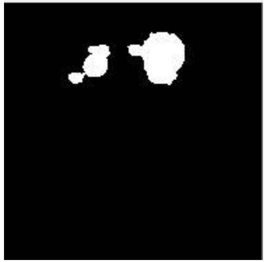
Workable? No

Reason: The color of the cells are too similiar to the background color. For this reason, the code will not detect the cells.



Edge Detection





Workable?
Yes. This is the plan we are working with right now.

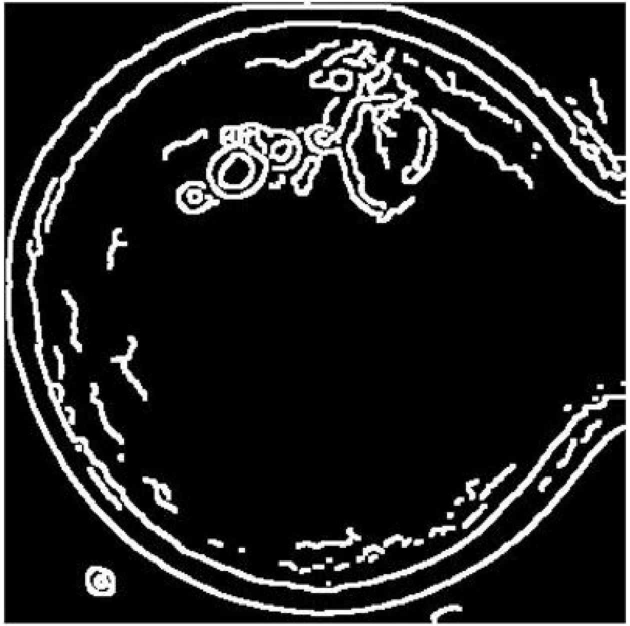
How?

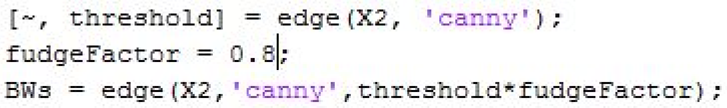
Detect the chamber we are focusing on and then detect the edge of the cells within that chamber.

Fill up the cells according to the edge of the cells.

Clear out the unexpected items in the chamber and the border of the chamber.

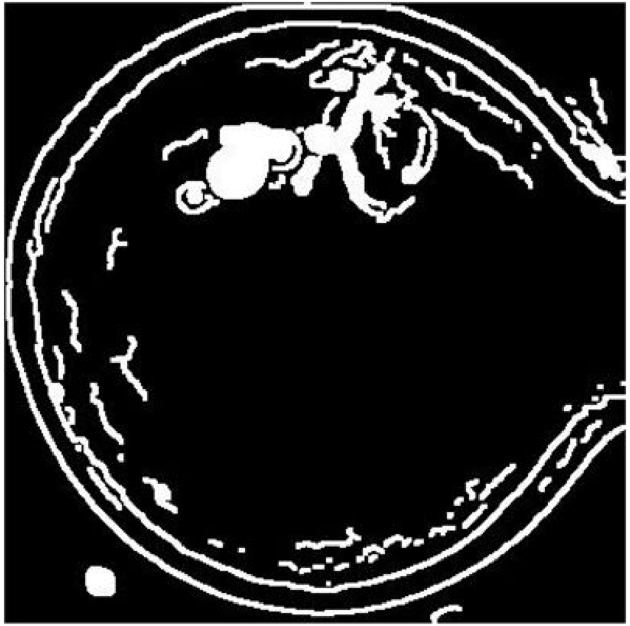
Turn the Image to Binary Image

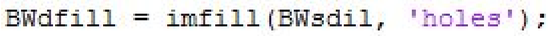




```
[~, threshold] = edge(X2, 'canny');
fudgeFactor = 0.8;
BWs = edge(X2,'canny',threshold*fudgeFactor);
```

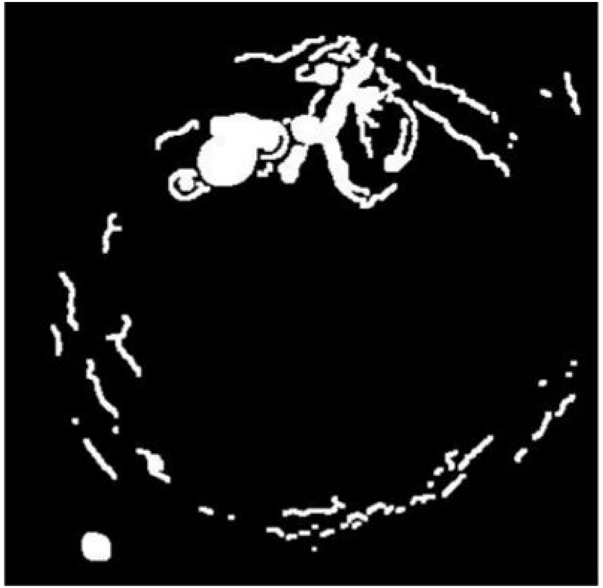
Fill up the Cells

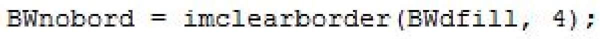




```
BWdfill = imfill(BWsdil, 'holes');
```

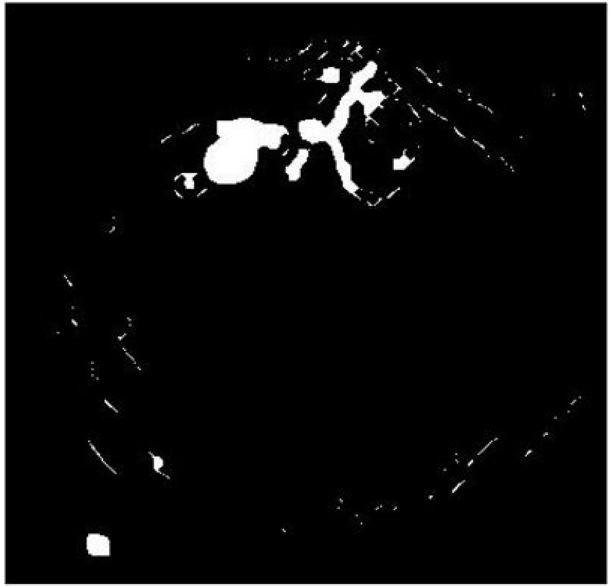
Remove the edge

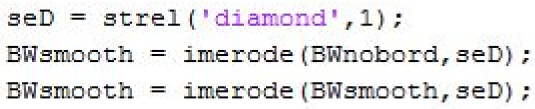




```
BWnobord = imclearborder(BWdfill, 4);
```

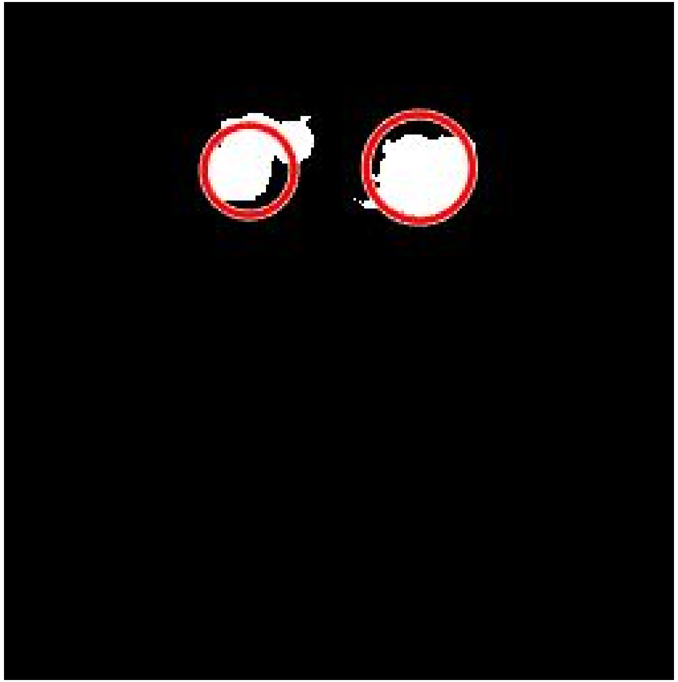
Smooth the image

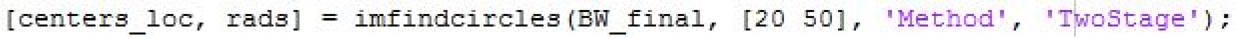




```
seD = strel('diamond',1);
BWsmooth = imerode(BWnobord,seD);
BWsmooth = imerode(BWsmooth,seD);
```

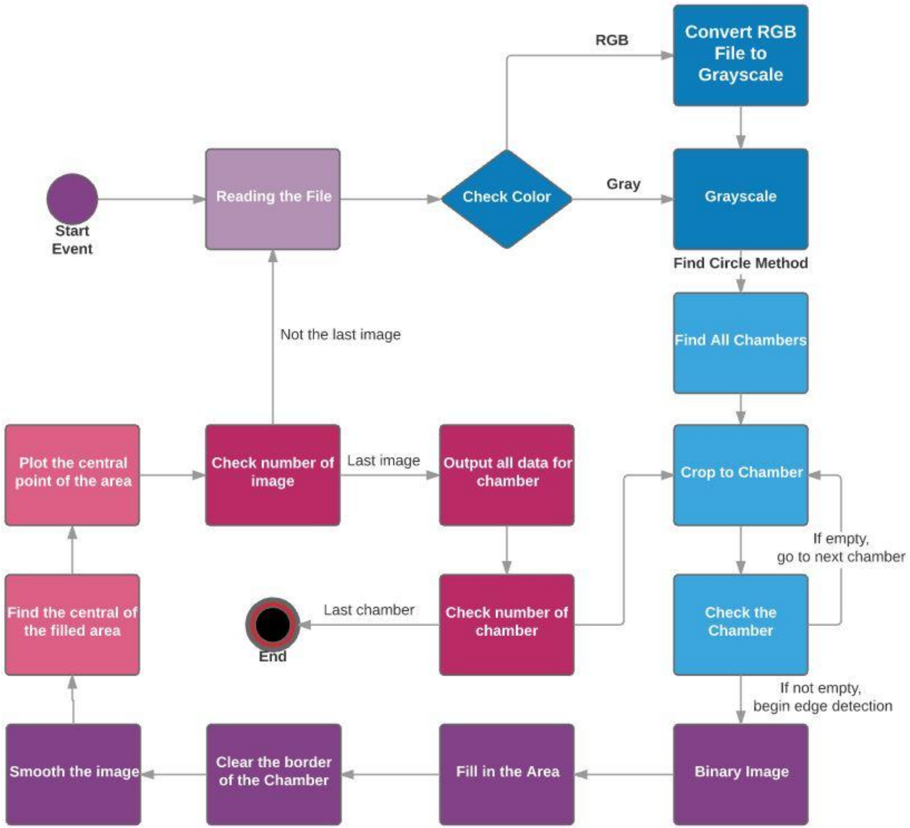
Find The Cells with the Find Circle Method





```
[centers_loc, rads] = imfindcircles(BW_final, [20 50], 'Method', 'TwoStage');
```

Program Process



3D Methods

- Confocal Point Method
- 3D Microscope in Iowa State
- New 3D Microscope in the Lab

Confocal Point Method

By finding the confocal point of each cell we might come up with a method to track cell’s movement in 3D. There is a rubber band where the cells sit on within this machine, however it is very unstable. The confocal point therefore will be inaccurate.

3D Microscope

It is an ideal way to get the data - except the fact that it costs too much.

Over $60/hour for simply using the machine goes far beyond our budget.

New 3D Microscope in the lab

A new 3D machine was just introduced in our lab, but it might take some time to get the data before we can start to work on the code for 3D plotting.

Focus on 2D Plotting

Did not get a chance to work on 3D plotting, but our project is still beneficial.

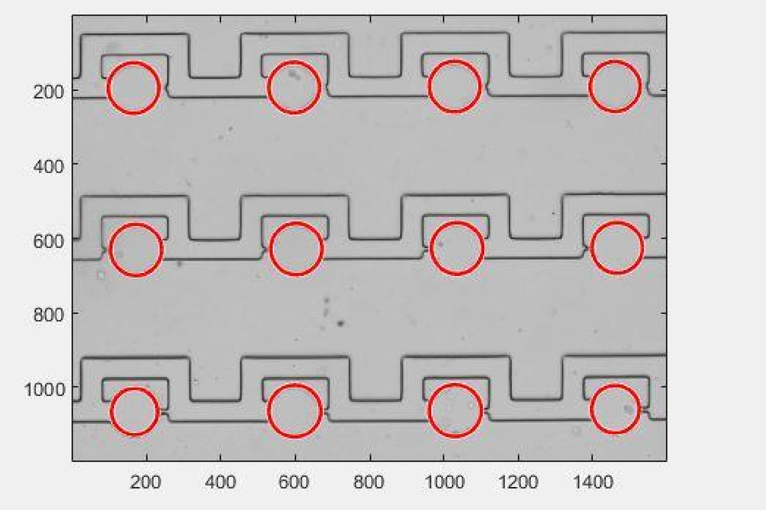
- Analysis of the behavior of the cells
- It is the starting point for 3D plotting

Issues & Challenges

Sorting the data

Solve:

Before: Sorting by the best circle method of the provided Matlab function.
Now: Sorting by the x-y position.



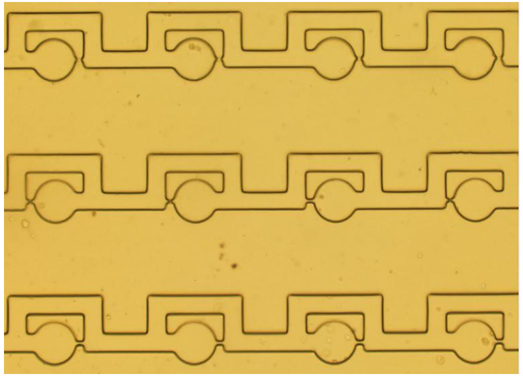
Issues & Challenges

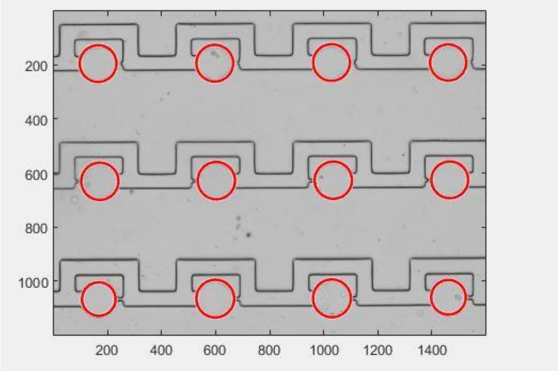
Potentially different types of input data:

Grayscale or RGB tiff image stack files

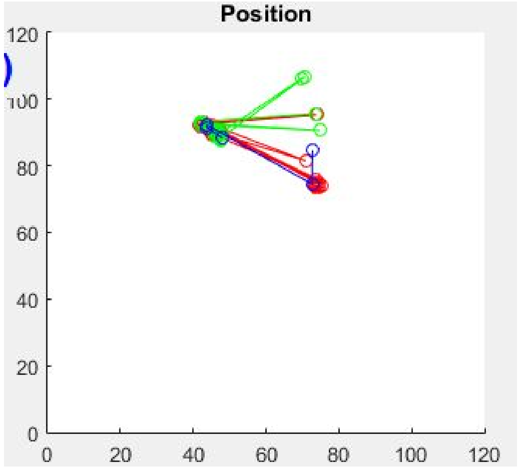
Solutions:

check for bitdepth value, convert RGB tiff to grayscale





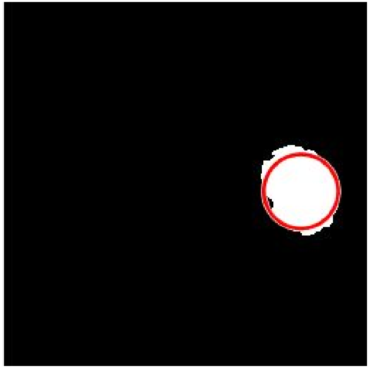
Issues & Challenges

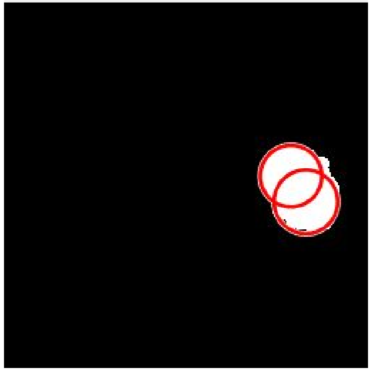


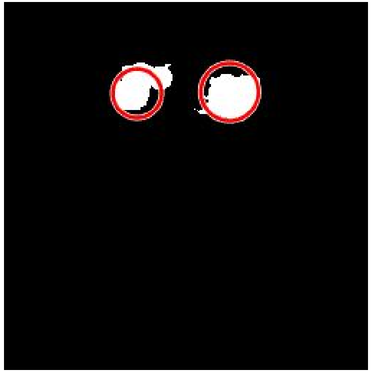
Cell overlapping

Solutions:

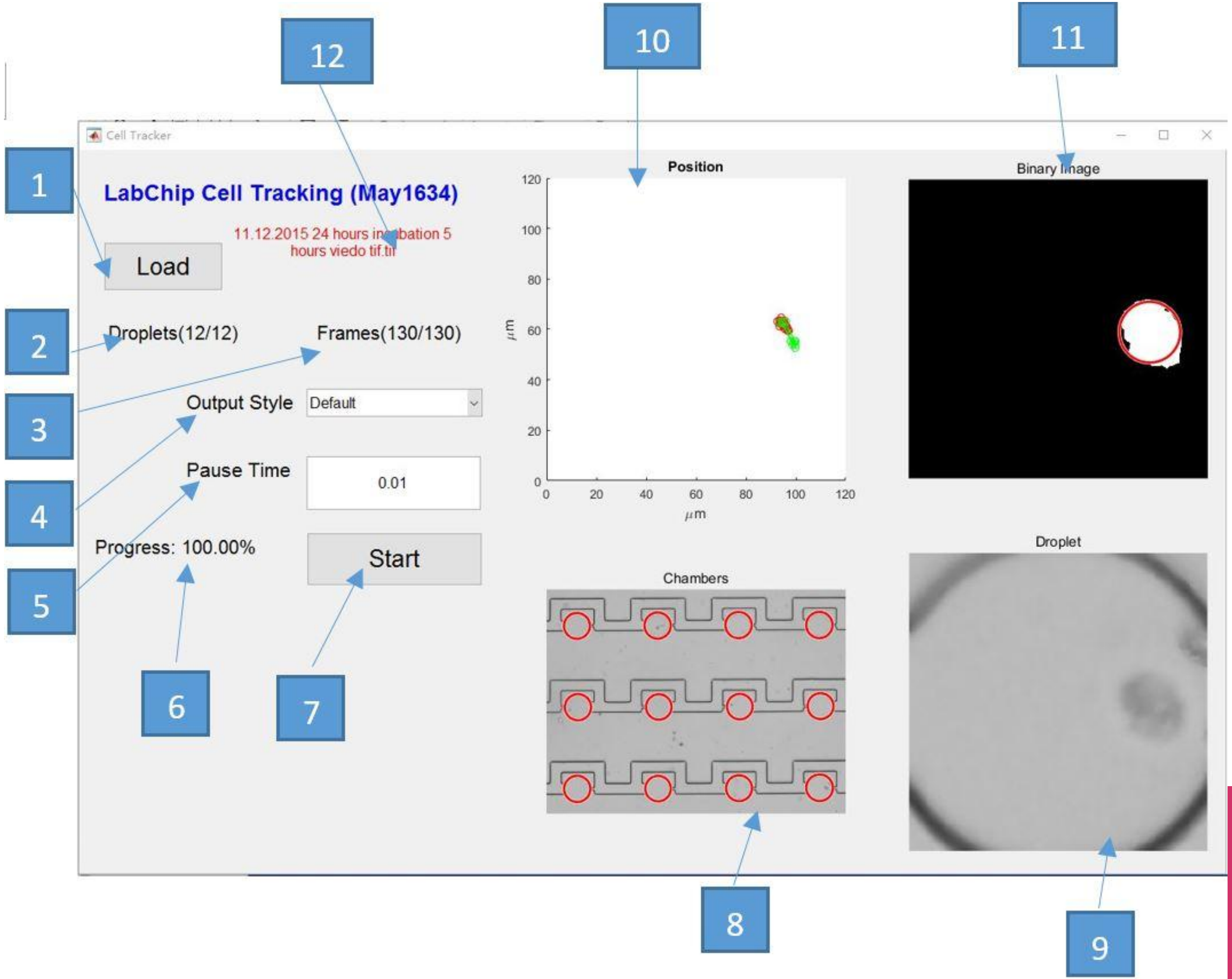
- Method of finding the circles
  - Compare each frames to see the location of the circle.







GUI



Cell Tracker

LabChip Cell Tracking (May1634)

11.12.2015 24 hours incubation 5 hours viedo tif.tif

Droplets(12/12)

Frames(130/130)

Output Style: Default

Pause Time: 0.01

Progress: 100.00%

Work and Accomplishment

Before the Spring break: 1. Trying to find ways to collect 3D data

2. Work on possible skeleton code for analyzing 2D data into 3D position.

After the break: 1. New 3D machine introduced, wait for data.

(Work before the Break in vain)

2. Shift focus back on improving the code for 2D

- GUI improvement
- Better sorting
- Make colored-data input possible

Question?