Automated Cell Identification Device (ACID)

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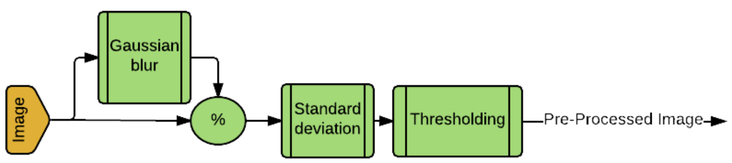
Abstract

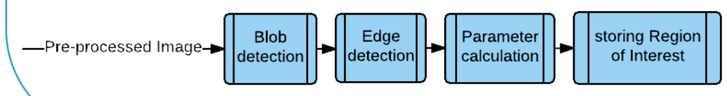
We present a cell detection and identification software that communicates with the Biostinger (a single cell nano-manipulation platform) to detect, identify, and inject cells autonomously. The underlying computer vision software acquires and processes images of the cell culture and stores an image of each cell, then communicates with the injection software through the Transmission Control Protocol. In each iteration of the time-lapse, it compares the images of each cell with the images that were captured in the previous iterations, using the Speeded-Up Robust Features Algorithm. Finally, it runs an analysis on the growth rate of each cell.

Cell Detection



To detect the cells, we preprocess the image by subtracting the Gaussian blur from the original image (reduce image blur) and superimpose the standard deviation of the image to increase the definition of the edges.

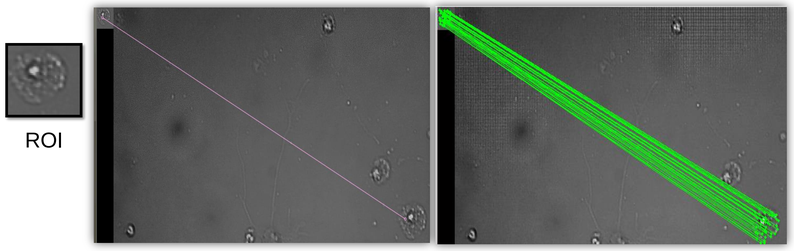
By thresholding and edge detection, regions of interest (ROI) around the cells are selected and the cell's physical parameters (area and perimeter) are computed are stored in the computer.



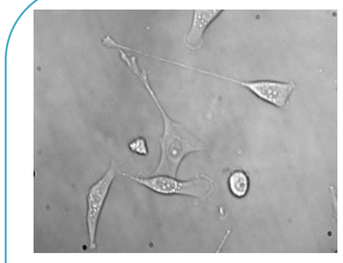
Cell Identification

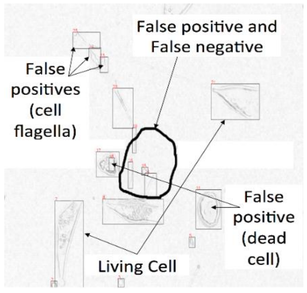
In a time-lapse, images are taken from cell cultures and after cell detection the ROI's are compared to identify each cell. We are utilizing the Speeded Up Robust Features (SURF) computer vision algorithm to perform the comparison. If SURF fails to find enough matches in the time-lapse images, the program re-runs the images under the Scale-Invariant Feature Transform (SIFT) algorithm which results in a higher chance of finding matches at the price of false positives and slower performance

In each iteration of the time-lapse the parameters are compared and the cell growth rate is determined.



Detection of ROI using SURF Detection of ROI using SIFT





Challenges

It is possible that the feature detection algorithms: (top) Computer vision detection and indexing of cancer cells. Original image (filter: Ocra Flash 2.8), (Bottom) Contour detection (canny edge detection). The custom built algorithms identify the cells, classify them (sorts out the cells from false positives and false negatives) and store the images for future processing.

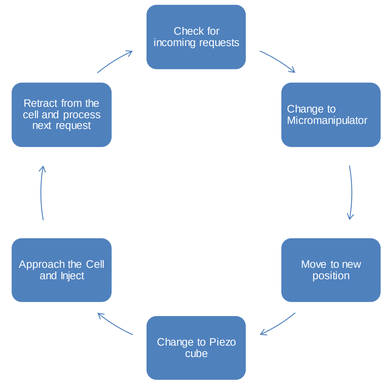
Acknowledgements

We would like to thank Adam Seger for Biostinger technical support.

Automated injection

Single Cell Nano-injection is automated by emulating the mechanical process using a Hierarchical State Machine (HSM). The nano-injection method is broken into 5 unique states.

When cells are detected, we calculated the center of the imaginary bounding rectangle enclosing the cell. These center points are passed through Transfer Control Protocol (TCP) to the injection software.



Future Work

- Automate a closed system to study single cells over time
  - Incubate, relocate, identify and interrogate cells by nano-injection
    - Incorporate robust cell identification software to interrogate the same cell over time
    - Maintain cells at incubator environment during interrogation
    - Relocate cells from incubator to interrogation stage
- Increase throughput of cells interrogated
- Study the progression of disease models such as Alzheimer's and Breast cancer

References

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