Intelligent Microfluidic Cell Sorter

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The Problem

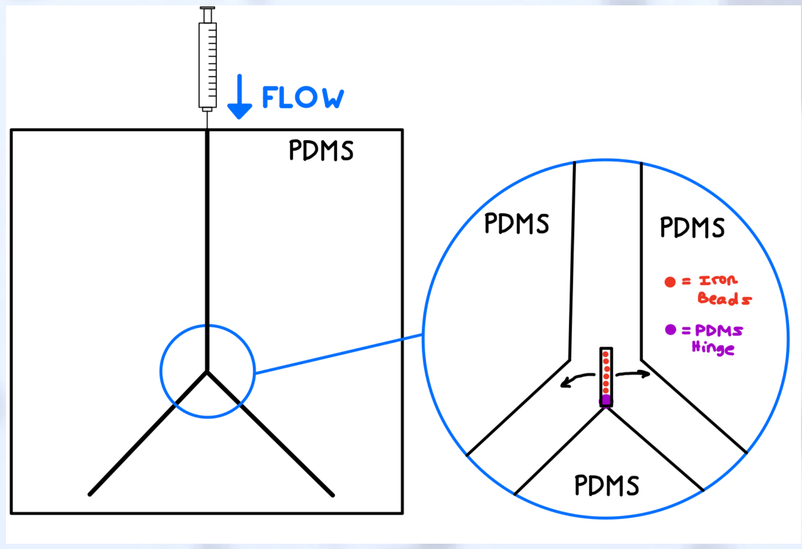
Our goal is to develop an intelligent microfluidic cell sorter that will sort cells suspended in biological fluids.

The Concept

The cell sorter uses an iron infused hydrogel hinged at the bifurcation in the channel and is controlled using electromagnets. The microchannel and hinge are made of PDMS shaped using a mold then stuck onto a PDMS coated slide. The gate is a hydrogel beam infused with iron particles and actuated with an external electromagnet. A camera is positioned upstream of the bifurcation for our machine learning system. The trained Machine Learning model determines which branch the particles should be directed and then activates the proper electromagnet to move the gate. The gate blocks off one channel and allows the particle to go through the other.

Inject fluid with particles → Taking picture of particle upstream of bifurcation → CNN[1] recognizes particle in image → Computer provides feedback to circuit → Move hydrogel gate with electro-magnet

[1]Convolutional Neural Network



Manufacturing Process

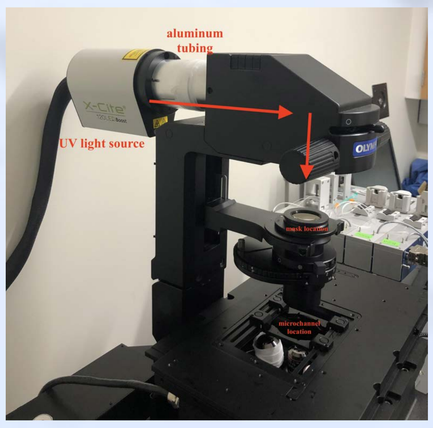
Fabricate of microchannel mold & PDMS microchannel

Fill microchannel with Photoresist and iron particles

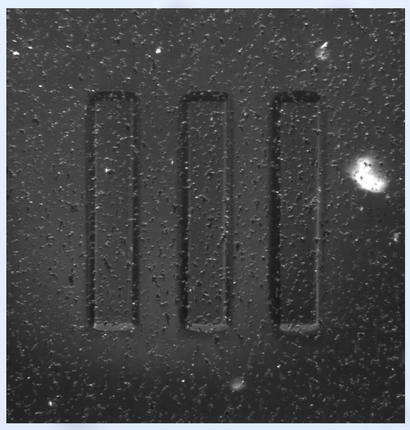
Crosslink iron-infused hydrogel gate with UV light using microscope

Create circuit with two nail electromagnets

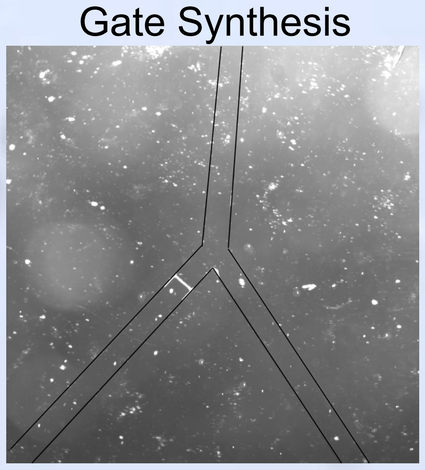
3D print holder for electromagnet and microchannel



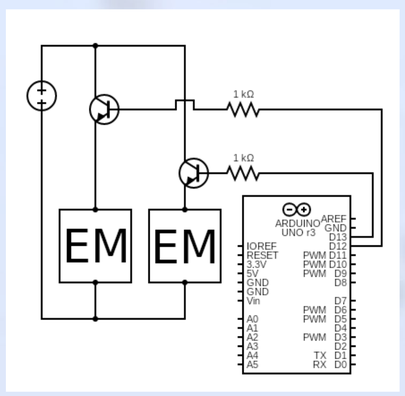
Custom Microscope Setup for Gate Synthesis



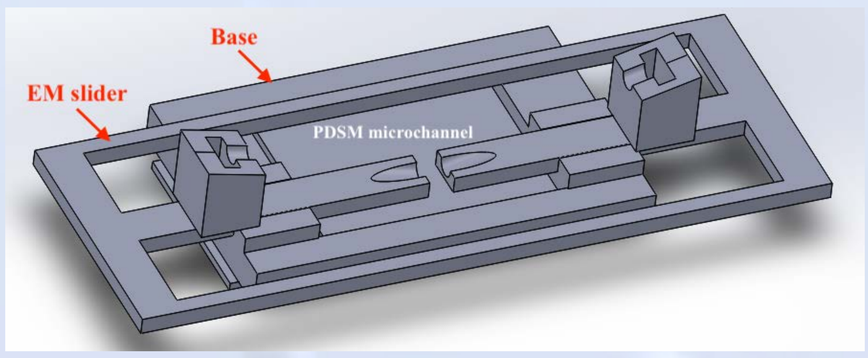
Iron infused prototypes for gate



Channel Bifurcation



Circuit Diagram



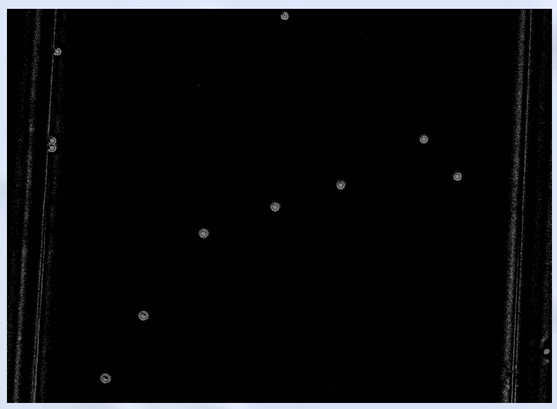
Microchannel & Electromagnet Holder

Machine Learning Program

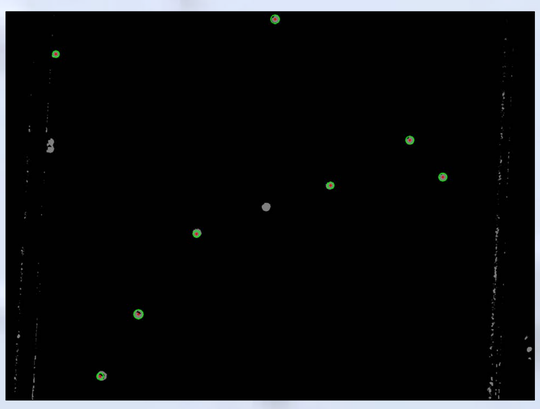
We preprocessed the images with Python and OpenCV library by implementing Frame Differencing and Hough Circle Transform algorithms. We then built a Convolutional Neural Network with TensorFlow and fed these images to train the network to distinguish between different microbead sizes so that our device could intelligently sort cells and help address problems with different biological fluids.

COLLECT: Sequential Images with pymba → FILTER: Applying Frame Differencing → IDENTIFY: Using Hough Circle algorithm → LABEL: Beads with Neural Network[2]

[2]Configuration shown at shorturl.at/CGLU7



After Applying Frame Differencing



Microbeads Detected by Hough Circle Algorithm

References: C. Duprat, H. Berthet, J. S. Wexler, O. Du Roure, and A. Lindner, “Microfluidic in situ mechanical testing of photopolymerized gels,” Lab on a Chip, vol. 15, no. 1, pp. 244–252, 2015.

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