



# Bend it like bacteria: Tracking bacteria propelled microbeads

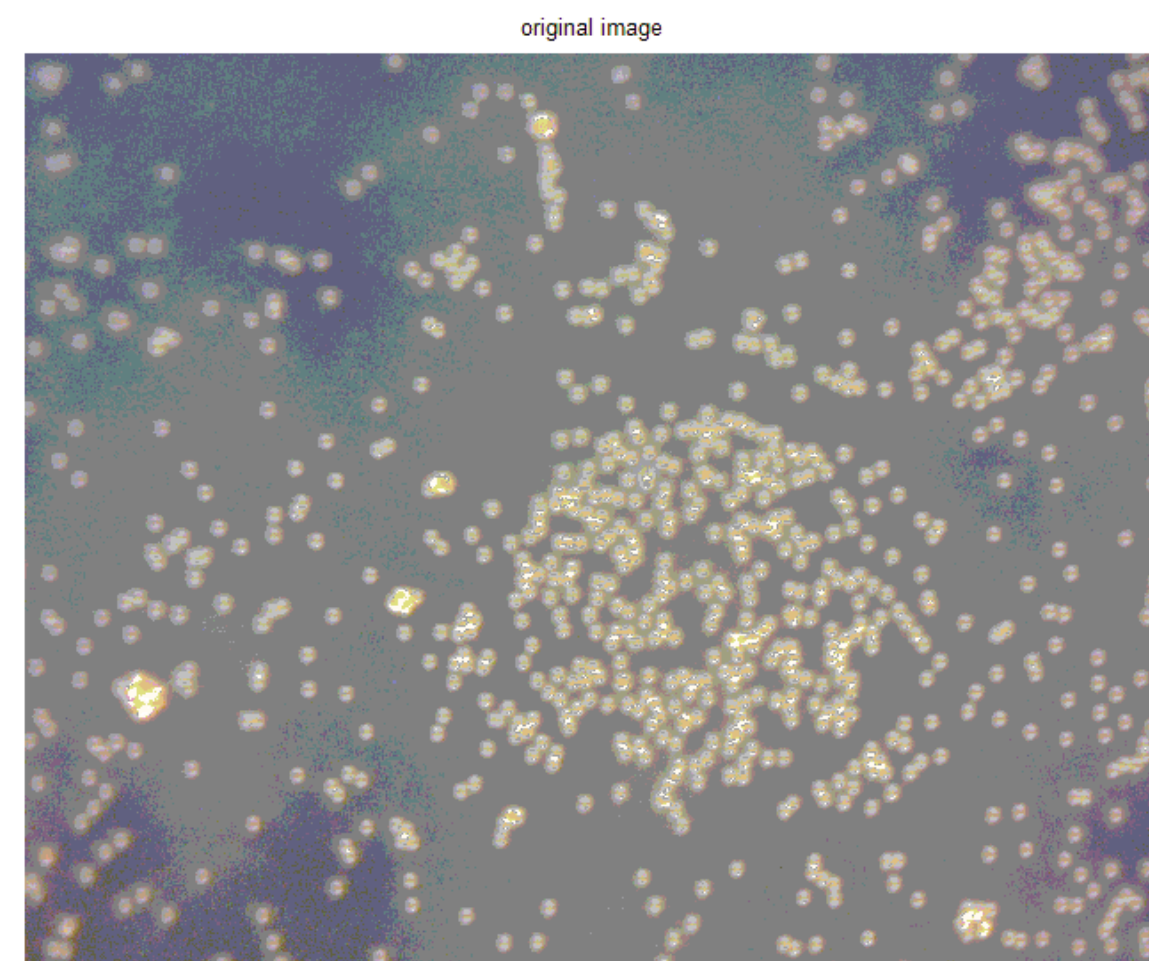
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## Introduction

The goal of this research was to develop automated methods for tracking polystyrene spheres (microbeads) that are propelled by attached bacteria. The bacteria are attached to one hemisphere so that net motion is in one direction.

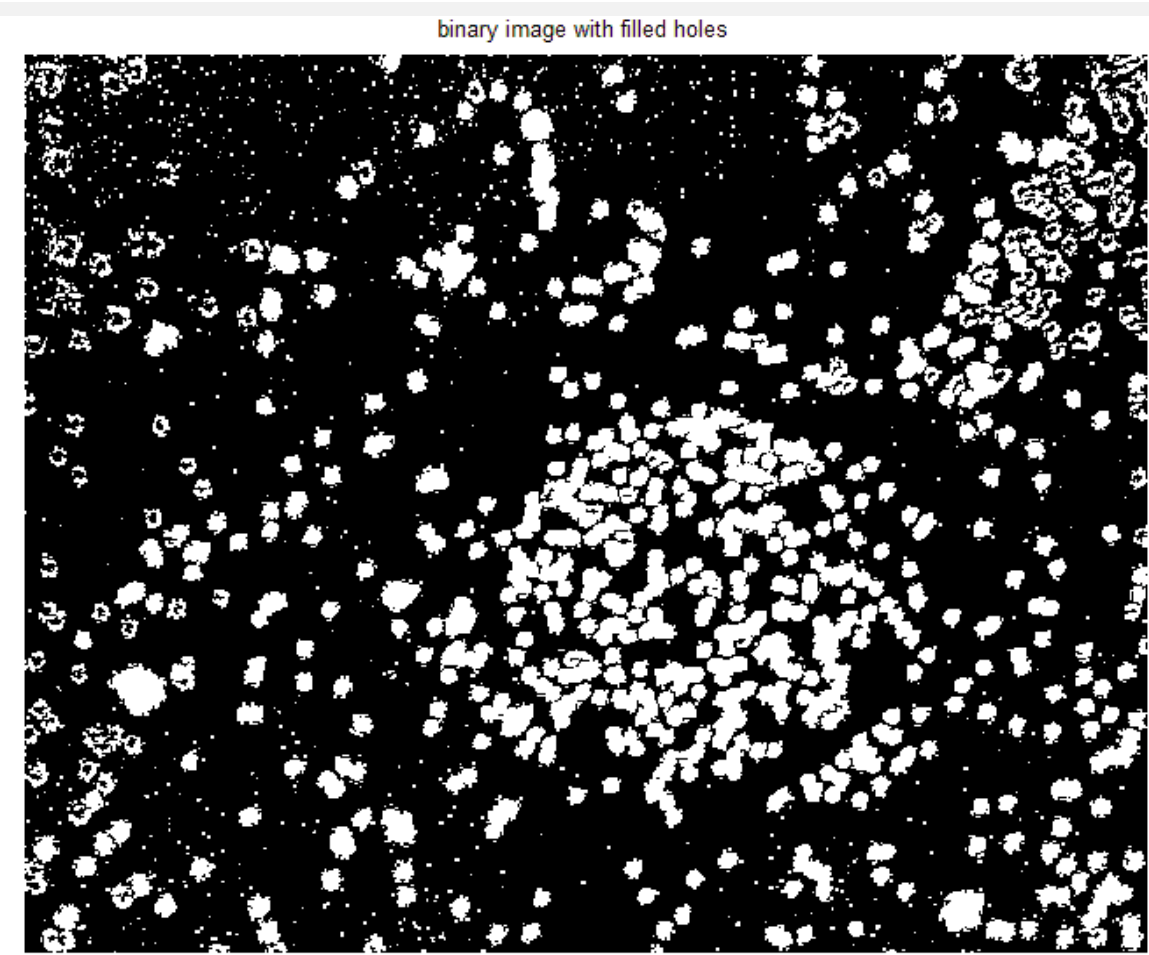
An automated method of tracking will let us work on controlling the movements of the bacteria and microbeads with better precision.



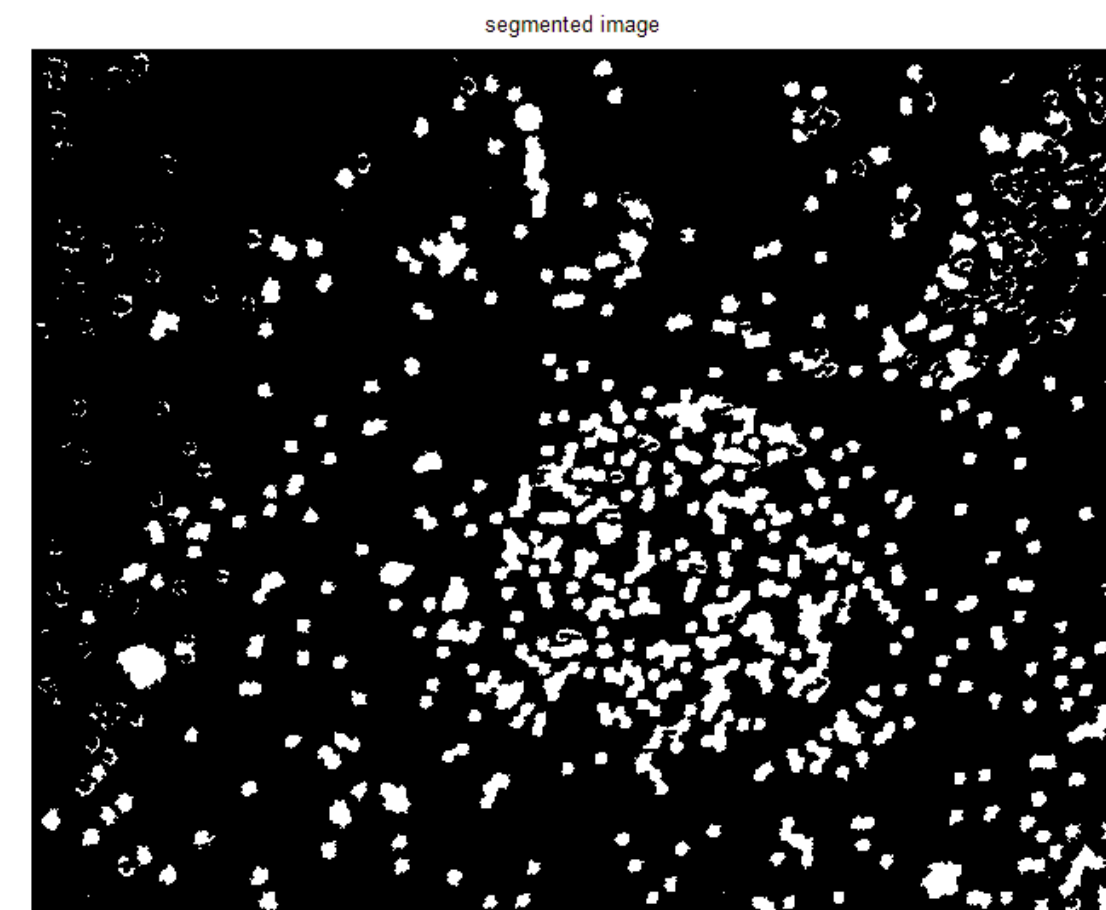
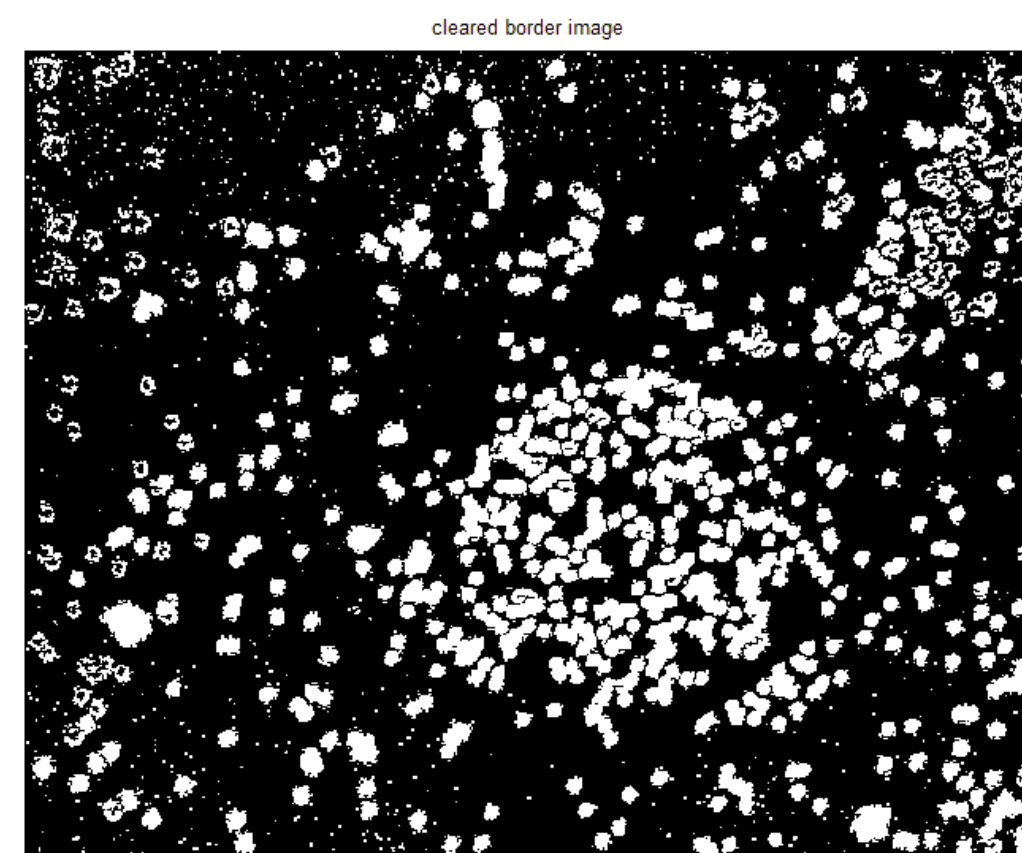
## Tracking process

The tracking uses Matlab's inherent image-processing capabilities. A color image is converted to greyscale and then to a binary image. Our method then uses Matlab's Sobel and Centroid algorithms to find the center of the remaining objects.

When using two images, our method can also determine the most likely change of each center.



We begin with a color image (top left). This image is turned into a greyscale image using Matlab's `rgb2grey`. The greyscale image is turned into a binary mask, which is filled to identify objects (left). The resulting binary image is run through multiple cleanup algorithms (bottom left). The final image (below) is used with the Centroid function, to generate an array of coordinates.



## Applications

Our current methods can be applied to a wide range of microscale photos. The only difficulty is determining how many pixels correspond to a useful metric measurement.

Because we use Matlab, our results are easily testable by many others, without the need for extremely specialized equipment. Matlab is relatively simple and contains all the needed algorithms.

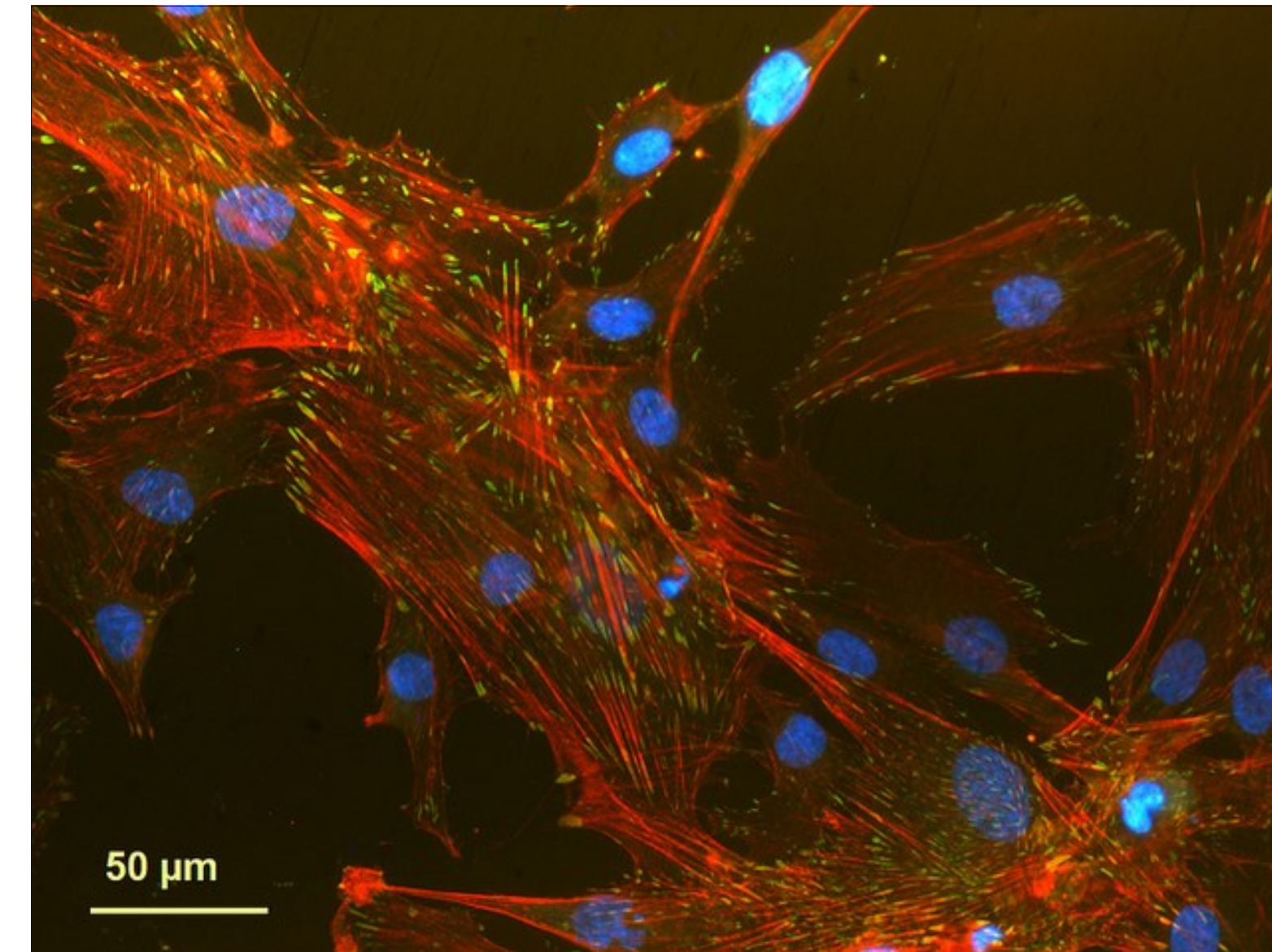


image credits: [Engineering at Cambridge](#), CC-BY-NC-ND

We are improving and adapting our methods to work with many sorts of images, such as the one to the left.

## Noise and Data Loss

There are two main factors that make this process less than ideal. Noise is apparent as something much like television static. This is an artifact of the current process, and requires manual evaluation to determine if a given object is noise.

Data loss occurs when an object in the original image is not present in the final image when it should be. This is also an artifact of our method

## Similar applications

Similar image processing techniques are used by autonomous vehicles for object detection and avoidance. Many of these approaches are integrated systems though, and not easily applicable to lab-bench scale workings.

## References

- Mathworks. Detecting a cell using image segmentation. <http://www.mathworks.com/products/image/demos.html?file=/products/demos/shipping/images/ipexcell.html>
- Attaway, Stormy. MATLAB A Practical Introduction to Programming and Problem Solving. Butterworth-Heinemann Burlington, MA. 2009
- ImageJ. Image processing and analysis in Java. <http://rsbweb.nih.gov/ij/index.html>

## Further Refinements

While functional, our method is not yet a fully automated method of tracking. We hope to automate image selection, and add markers to the original image.

We are working on ways to reduce noise while keeping data from the original image, and to reduce error in calculating the change in positions for large numbers of objects. We will continue testing with a wider variety of images.

## Acknowledgements

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