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Contact Angle Measurement

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Measuring Contact Angles

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Introduction

The contact angle, where a liquid/vapor interface meets a solid surface, has been widely used to measure the wettability of a surface in physics and chemistry. Scientists place a drop on a surface of interest, take an image of the drop in profile, and measure the angle the drop makes with the surface. We have developed a Contact Angle Measurement plugin for the ImageJ image analysis framework, which provides researchers a easier way to access experiment data. The goal of our algorithm is to automatically detect drops and surfaces via image analysis, so that the contact angle can be measured.

Challenges

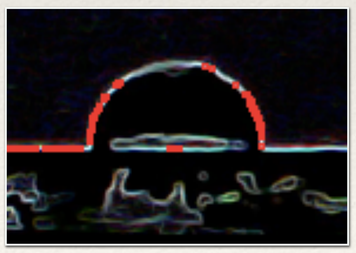
- All shapes (e.g., lines and circles) we see on an image is in fact a set of discrete points.
- Detecting those shapes actually is solving discrete problems.
- No efficient solution method is known for discrete problems. Potentially, it might be necessary to test each possibility sequentially in order to determine if it is the best fit for the pattern of interest.
- The number of possibilities could grow exponentially due to the size of images.
- We need to narrow down the search space (i.e., avoiding exhaustive search), so that computers are able to produce results within the limited runtime.

Algorithm visualization

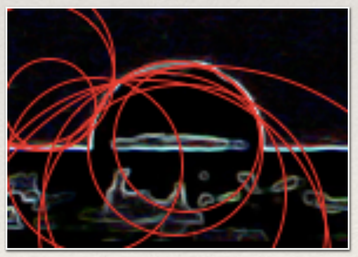
The raw image of a drop.

We apply Edge Detection to the image to collect a set of points of interest.

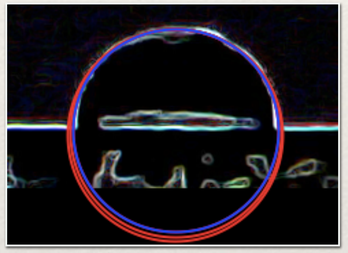
Then we randomly sample nearly- or pure-white pixels which could potentially be points on the circle (i.e., the drop).



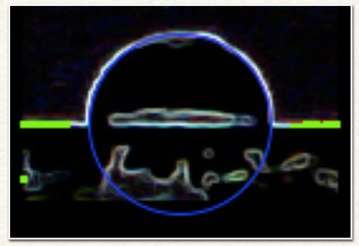
We generate candidate circles from randomly selected sets of 3 white pixels (given that 3 points defines a circle). Of these, we select the candidate circle that overlaps with the largest number of white pixels.



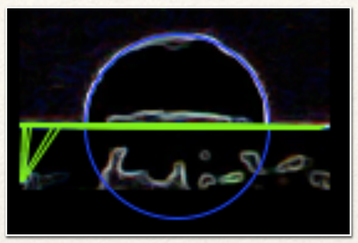
And we adjust the radius and center further by using various methods.



To locate the surface on which the drop rests, we collect the light pixels outside the circle.



Then we apply Theil-Sen estimator, an advanced linear regression method, to analyze all surface candidates. We pick a line "in median" to be our actual surface.



The geometry of the detected circle and surface is analyzed to determine the angle of contact between the two.

Future Work

For now, our algorithm to calculate contact angles relies on a manually selected region. Potentially, a relatively big input region could lead to a bad fit. In the future, we plan to make the plugin entirely automatic to analyze the images without manually choosing any region.

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