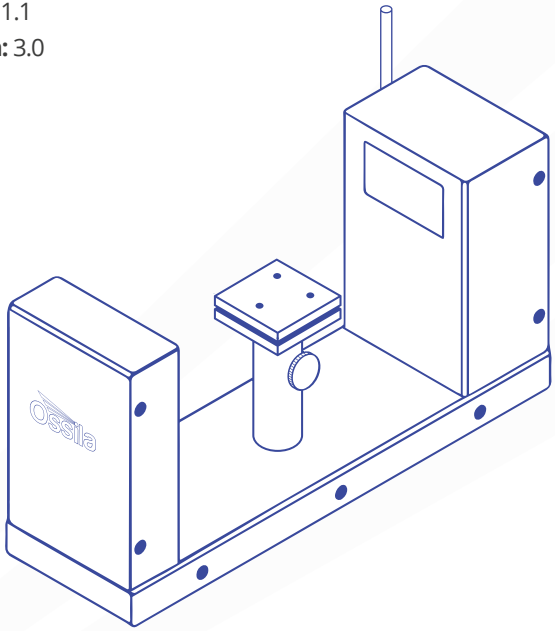
Ossila

CONTACT ANGLE GONIOMETER

USER MANUAL

Manual Version: 1.1.D
Product Code: L2004A1
Product Version: 1.1
Software Version: 3.0



Ossila.com

Contents

1. Overview

The Ossila Contact Angle Goniometer, part of the Institute of Physics award-winning Solar Cell Prototyping Platform*, provides a fast, reliable, and easy method to measure the contact angle or surface tension of a droplet. The system comes complete with PC software that provides a simple and intuitive interface for contact angle measurements.

*The Ossila Solar Cell Prototyping Platform is a complementary collection of substrates, materials, and equipment as part of a high-performance standard photovoltaic reference architecture. This platform enables researchers to produce high-quality, fully-functional solar cells which can be used as a reliable baseline.

For more information: **ossila.com/pages/solar-cell-prototyping-platform**

2. EU Declaration of Conformity (DoC)

We

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declare that the DoC is issued under our sole responsibility and belongs to the following product:

Product: L2004A1 Contact Angle Goniometer
Serial number: L2004A-0105-1000-3000- xxxx
Object of declaration:
L2004A1 / Contact Angle Goniometer

The object of declaration described above is in conformity with the relevant Union harmonisation legislation:

EMC Directive 2014/30/EU
RoHS Directive 2011/65/EU

Signed:

Name: Dr James Kingsley
Place: Sheffield
Date: 01/02/2018

[Декларация] за съответствие на ЕС
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3. Safety

3.1 Warning

To avoid safety hazards, obey the following:

- Do not look directly into the backlight.
- Turn the backlight off when the system is not in use.

3.2 Caution

- Only use the device for the purposes intended (described in this document).
- Take care when handling syringes to avoid touching the needle.
- If using within a shared workspace, position the backlight to point away from others.
- Take care to avoid trapping fingers while adjusting the tilt stage position.

4. Requirements

Table 4.1 details the power requirements for the system, and the minimum computer specifications for the Ossila Contact Angle software.

Table 4.1. Contact Angle Goniometer and Contact Angle software requirements

Power	12 V / 1 A DC (supplied with the system)
Operating Systems	Windows Vista, 7, 8, or 10
CPU	Dual Core 2 GHz
RAM	2 GB
Available Hard Drive Space	250 MB
Monitor Resolution	1920 x 1080 pixels
Connectivity	USB 2.0 or newer. A USB-A to USB-B cable is supplied with system. NOTE: USB connection does not supply power to the backlight.

5. Unpacking

5.1 Packing list

The standard items included with the Ossila Contact Angle Goniometer are:

- The Ossila Contact Angle Goniometer.
- Tilt Stage Assembly
- 12V / 1 A power adapter with a cord set specifically for country of operation.
- USB-A to USB-B cable.
- USB memory stick pre-loaded with the user manual and software installer.
- Printed copy of the user manual.
- 25µl syringe with blunt needle
- Syringe clamping mechanism

5.2 Damage Inspection

Examine the components for evidence of shipping damage. If damage has occurred, please contact Ossila directly for further action. The shipping packaging will come with a shock indicator to show if there has been any mishandling of the package during transportation.

6. Specifications

The Contact Angle Goniometer measurement specifications are shown in **Table 6.1**, and the physical specifications are shown in **Table 6.2.**

Table 6.1. Contact Angle Goniometer measurement specifications.

Angle Range	5° to 180°
Max measurement speed	33 ms (30 fps)

Table 6.2. Contact Angle Goniometer physical specifications.

Stage Dimensions	50 mm x 50 mm
Maximum Droplet Width	20 mm
Overall Product Dimensions	Width: 95 mm Height: 170 mm Depth: 320 mm
Maximum Sample Thickness	20 mm
Maximum Camera Resolution	1920 x 1080 pixels

7. Installation

1. Connect the system to your computer using the USB cable provided. Next, plug in the power supply for the system and check that the backlight turns on.
2. Run the file 'Ossila-Contact-Angle-Installer-2-0-x-x.exe' on the USB drive provided and follow the on-screen instructions to install the Contact Angle Software.
    I. Alternatively, the software can be downloaded from: **ossila.com/pages/software-drivers**

8. Operation

8.1 Recording a Video

Video recording is performed in the 'Capture' Tab located in the top left of the software.

Figure 8.1. Software Tabs (Capture and Analyse)

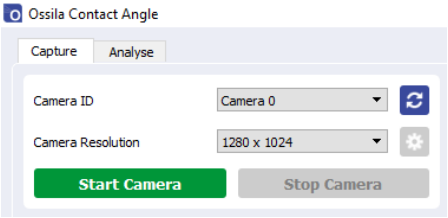
To record a video or an image, follow the instructions below. More detailed information on individual settings will be explained later in this section.

1. Open the Ossila Contact Angle software.
2. Click 'Start Camera'.
    I. The image should appear on the right of the screen.
3. Place your sample in the centre of the vertical tilt stage.
4. Adjust the stage height until the sample can be seen in the bottom half of the image.
5. Twist the camera lens until the sample is in focus on the display.
6. Select 'Image' or 'Video'
7. Set a video length and frame rate.
    I. Make sure that your video length takes into account the time it will take to dispense the droplet and any spreading time that you wish to observe.
8. Choose a save directory and file name.
9. Prepare to dispense a droplet.
10. Click 'Record' in the controls.
11. Dispense the droplet.
12. When you are finished taking recordings, press 'Stop Camera' to turn the camera off.

8.2 Software Settings

8.2.1 Camera Settings

Figure 8.2. Camera settings.



(I) Camera ID

- Select the camera you are using from the camera ID list.
    I. The program will choose 0 (zero) by default, as it assumes that no other USB camera is connected to your computer.

(II) Camera Resolution

- Sets the resolution of the camera.
    I. Higher resolution videos will result in larger video files.

(III) Camera Settings

- Opens a settings dialogue box for the camera.

(IV) Start Camera

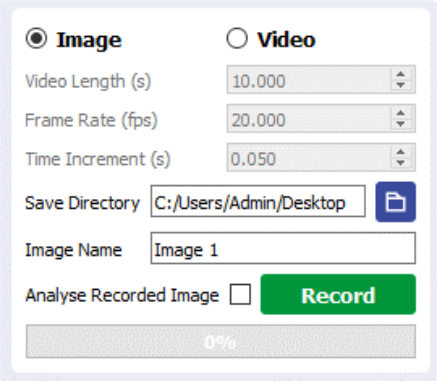
- Connects to the camera and displays the image in the main viewer.

(V) Stop Camera

- Stops the video and disconnects from the camera.

8.2.2 Recording Settings

Figure 8.3. Recording Settings



(I) Video Length

- Sets the total length of time to record for in seconds.
    I. Choose a number between 0.1 and 3600 (1 hour).
    II. The default is 10 seconds.

(II) Frame Rate

- Sets the frame rate in frames per second.
    I. This will update the increment to match the chosen frame rate.
    II. Default is 20 frames per second.

(III) Time Increment

- Sets the time increment in seconds.
    I. This will update the frame rate to match the chosen increment.
    II. Default is 0.05 seconds.

(IV) Save Directory

- Sets the directory in which videos are saved.
    I. Directory can be input manually or selected using the button with a folder icon.

(V) Image/Video Name

- Sets the name of the image/video file.
    I. If a file with the same name is saved, a number will be included in the file name so that the original file is not overwritten.
    II. Video files are saved as .avi files. Image files are saved as .png files.

(VI) Analyse Recorded Image/Video

- If this box is checked, the software will load the recorded file into the analysis tab after it has finished recording.

(VII) Record Button

- Starts video recording.
    I. This will save a set number of frames determined by the chosen video length and the frame rate.

8.3 Performing Measurements

Both contact angle and surface tension measurements are performed in the 'Analyse' tab located in the top left of the software.

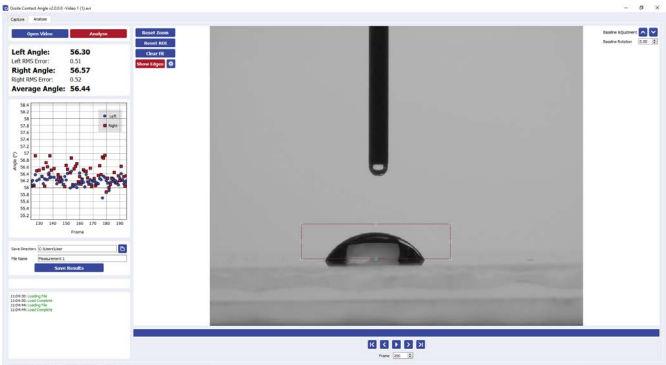
Figure 8.4. Analyse Tab

To take a contact angle or surface tension measurements, follow the instructions below in sections 8.3.1 or 8.3.2 respectively. For more detailed information on individual settings, please see later in this section.

8.3.1 Contact Angle Measurements

1. Open the 'Analyse' tab.
2. Select 'Open Video' and use the file dialogue to select a video for analysis.
3. The image will appear in the centre of the screen.
4. Select 'Contact Angle' as the measurement choice.
5. Use the video controls at the bottom of the image to navigate to a frame that has a droplet.
6. Adjust the region of interest (ROI) box until the entire droplet is within the box.
    I. The baseline of the measurement is the bottom of the box.
    II. Make sure that the bottom line is level with the base of the droplet.
    III. If the image is slanted, or the stage was not completely level, you can adjust the baseline angle using the 'Baseline Rotation' control in the top right corner.
    IV. You can also make fine adjustments to the baseline height using the up and down arrows in the top right corner.
7. Click 'Analyse'.
    I. The software will detect the edges of the droplet within the ROI.
    II. A fitting technique is applied to the droplet, depending on its estimated angle:
        - < 10° Circle Fit
        - > 10° Polynomial Fit
    III. The gradient of the fit at the baseline is used to calculate the contact angle.
8. Click the play button (optional).
    I. The program will cycle through the frames in the video and fit a contact angle to the droplet in each frame.
    II. The calculated angles are shown on the left of the screen as a contact angle vs frame plot.
9. Choose a directory and save the results.
    I. The results are saved in a .csv file, which can easily be opened in any data analysis program.

Figure 8.5. Region of interest



8.3.2 Surface Tension Measurements

Note: Before a surface tension measurement can be performed, the system should first be calibrated. For calibration instructions, please see section 9.

1. Open the 'Analyse' tab.
2. Select 'Open Video' and use the file dialogue to select a video for analysis.
3. The image will appear in the centre of the screen.
4. Select a drop density. If the liquid is not in the drop-down list, select 'Add New' to add a new liquid to the settings.
5. Use the video controls at the bottom of the image to navigate to a frame that has a droplet.
    I. The droplet should be pushed out of the needle tip until it is close to falling.
6. Adjust the region of interest (ROI) box until the entire droplet and the tip of the needle is within the box (as shown in **Figure 8.6**).
    I. If the image is slanted, you can adjust the image angle using the 'Baseline Rotation' box in the top right corner.
7. Click 'Analyse'.
    I. The software will detect the edges of the droplet within the ROI.
    II. A fitting technique is applied to the droplet. The parameters of the fit (radius, B number, X0, Y0) are shown in the controls to the top right of the viewing window.
    III. The calculated surface tension is displayed in the left corner of the screen.
8. If the droplet fit looks poor, the fit parameters can be adjusted manually to achieve a better fit.
9. Choose a directory and save the results.
    I. The results are saved in a .csv file, which can easily be opened in any data analysis program.

Figure 8.6. Surface tension droplet fitting.

8.3.3 Video Controls

Figure 8.7 Video Controls

(I) Open Video

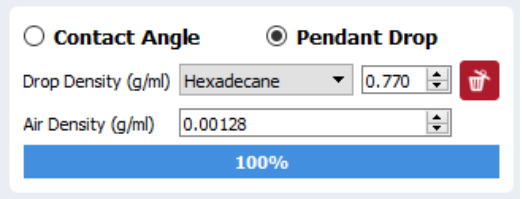
- Opens a dialogue box where you can select a video for analysis. The name of the selected video is then displayed in the window title at the top of the software.

(II) Analyse

- Performs analysis of the image within the region of interest box.
- The resultant fits are shown on the image and the calculated contact angles are displayed in the results display.

8.3.4 Measurement Type Selection

Figure 8.8 Measurement type selection



(I) Contact Angle, Pendant Drop

- Choose between the two possible measurement types. This will affect which measurement is performed when the 'Analysis' button is pressed.

(II) Drop Density (Pendant Drop Only)

- Select the drop density of the liquid under investigation. This density is used along with the droplet fitting to determine the surface tension.
- If a suitable density is not in the list, select 'Add New'. The new density will be saved to file.

(III) Air Density (Pendant Drop Only)

- This is the density of the air surrounding the droplet. This can be left as the default value in most circumstances.

8.3.5 Calibration Controls

(I) Calibration Diameter

- Select the diameter of the calibration sample under test. The calibration sample provided with the system has a diameter of 10 mm, which is the default value of this field.

(II) Calibrate

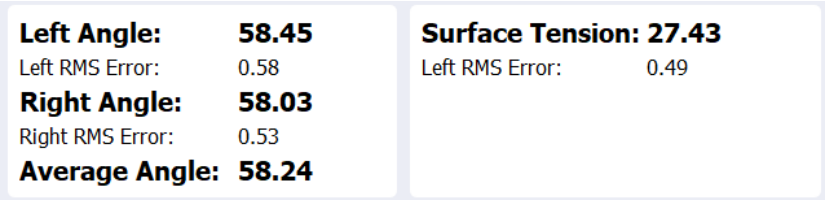
- Performs the calibration procedure on the calibration sample within the region of interest. For more information on calibration, see section 9.

(III) Millimetres per Pixel

- Shows the millimetres per pixel determined by the calibration procedure.

8.3.6 Results Display

Figure 8.9. Contact angles and surface tension results display.



This display changes based on the type of measurement currently selected.

(I) Left Angle, Right Angle

- Shows the measured contact angle in the current frame for the left and right sides of the droplet.

(II) Left RMS Error, Right RMS Error

- Shows the root-mean-square error of the polynomial fit to the detected edge data.
    I. This should be as low as possible.
    II. A fit with an RMS error value of 1 or more is considered to be poor, and the resulting data is discarded for the corresponding frame.

(III) Average Angle

- Shows mean average of the left and right angles.

(IV) Surface Tension

- Shows the measured surface tension.

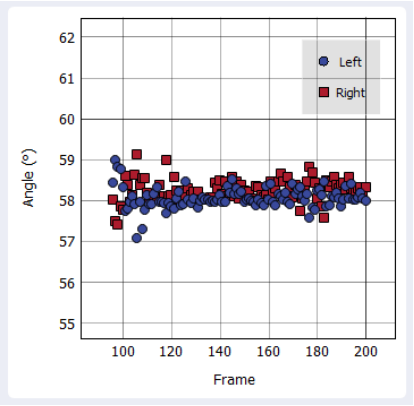
(V) Left RMS Error, Right RMS Error

- Shows the root-mean-square error of the fitted droplet to the detected edge data.
- A fit with an RMS error value of 1 or more is considered to be poor.

8.3.3 Results Plot

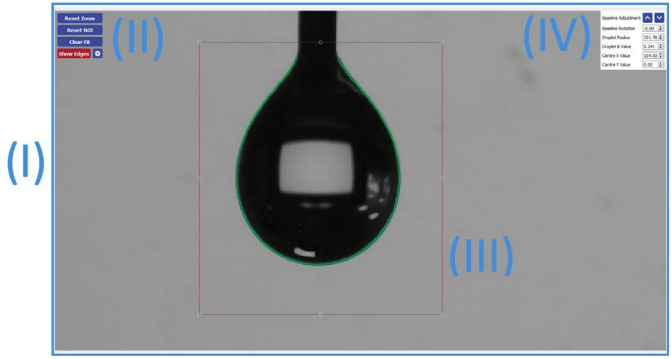
Plots the contact angles or surface tensions measured vs frame for the currently selected video or image.

Figure 8.10. Results plot of the left and right contact angles vs frame number.



8.3.4 Video Display

Figure 8.11. The main viewing section of the Contact Angle software.



(I) Main Viewer

- Displays the selected video for analysis.

(II) Display Controls

Controls how the image appears in the main viewer.

- **Reset Zoom** restores the window to its default zoom.
- **Reset ROI** restores the ROI box to the centre of the screen.
- **Clear Fit** removes the contact angle fit from the viewer.
- **Show Edges** displays the edge detection used in the contact angle measurement. For more information on the edge detection, see section 10.3.

(III) Region of Interest (ROI) Box

- Defines the region of interest for the contact angle and surface tension measurements.
- Only the part of the image inside the box will be used in the analysis.
- The baseline of the measurement is defined by the bottom of the box.

(IV) Baseline and Pedant Drop Controls

For more information on the pendant drop controls, see section 10.4.

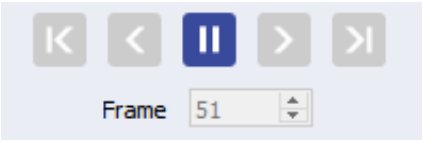
- **Baseline Adjustment** moves the bottom of the region of interest up and down by a single pixel.
- **Baseline Rotation** rotates the image.
    I. This is used to align the bottom of the droplet with the region of interest.
- Allows manual editing of the pendant drop fitting parameters.
- **Droplet Radius** changes the radius of the fitted droplet.
- **Droplet B Value** changes the fitting constant B of the fitted droplet.
- **Centre X Value** changes the x coordinate of the fitted droplet origin.
- **Centre Y Value** changes the y coordinate of the fitted droplet origin.

8.3.5 Video Controls

(I) Frame Controls

Figure 8.12. Frame Controls while video is paused.

Figure 8.13. Frame Controls while video is playing.



1. **First**
    I. Displays the first frame in the video.
2. **Previous**
    I. Displays the previous frame in the video.
3. **Play (visible while paused)**
    I. Cycles through every frame in the video.
    II. If 'Analyse' button is checked, the contact angle will be measured for each frame.
4. **Pause (visible while playing)**
    I. If pressed after 'Play', the video will stop at the current frame.
5. **Next**
    I. Displays the next frame in the video.
6. **Last**
    I. Displays the last frame in the video.

(II) Frame

- Displays the index number of the frame being displayed.
- The first frame in the video has an index of 0.

8.3.10 Data Saving

Results files are saved in a tabular format as .csv files, which can be opened with most spreadsheet programs. The file contains seven columns of measurement results, which are described in the **Table 8.1.** The save directory and file name can be selected using the controls shown in **Figure 8.14.**

Table 8.1. Column names and descriptions for contact angle data saved in the results .csv file.

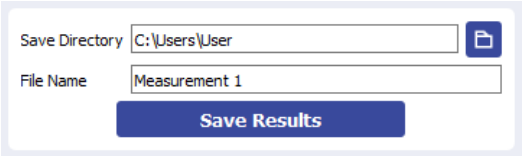
Column Name	Description
Frame Number	The frame number in the video file
Time (s)	The time at the frame number
Left Angle (°)	Left fitted contact angle
Right Angle (°)	Right fitted contact angle
Average Angle (°)	Mean average of the right and left angles
Left Contact Point	The x coordinate (in pixels) at the point where the left edge of the droplet intercepts the baseline

Right Contact Point	The x coordinate (in pixels) at the point where the right edge of the droplet intercepts the baseline
Droplet Width (Pixels)	The difference in pixels between the left and right contact points

Table 8.2. Column names and descriptions for surface tension data saved in the results .csv file.

Column Name	Description
Frame Number	The frame number in the video file
Time (s)	The time at the frame number
Surface Tension (mN/m)	Surface Tension in millinewtons per metre
RMSE	Root mean squared fit of the simulated pendant drop to the detected droplet edge
Drop Volume (µL)	Calculated droplet volume of the simulated pendant drop.

Figure 8.14. Save directory and file name controls.



(I) Save Directory

- Sets the directory in which videos are saved.
- Directory can be input manually or selected using the button to the right of the input box.

(II) File Name

- Sets the name of the results .csv file.

(III) Save Results

- Saves the results to file.

9. Calibration

9.1 Calibration Recording

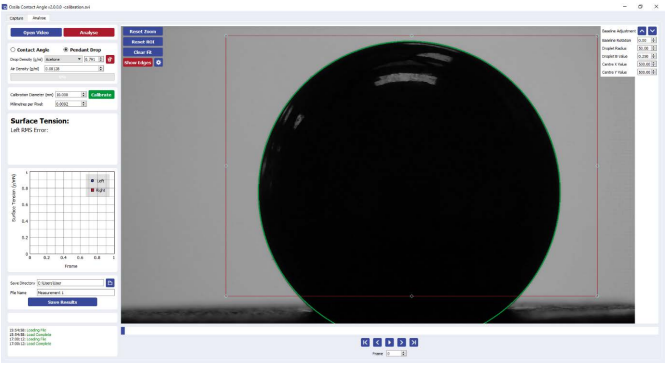
The system is calibrated by focusing on a sphere with a known width. The software detects the edges of the sphere and determines the number of pixels that correspond to the known diameter. The first step in calibration is to record an image or video of the calibration sphere.

9.2 Calibration Analysis

Once an image or video has been recorded, open it in the 'Analysis' tab of the software. Click the 'Pendant Drop' option in the top left of the window. Choose the calibration diameter (the calibration sphere provided with the system is 10 mm). Drag the region of interest box so that is surrounds most of the sphere, as shown in **Figure 9.1.** Click 'Calibrate', and the software will fit a circle to the edge of the sphere. This is seen as a green line. The 'Millimetres per Pixel' field will update with the new value.

The software will save the new calibration value and it will remain even when the software is closed and reopened. If the camera focal distance is changed, the system will need to be re-calibrated.

Figure 9.1. Calibrating the software using a calibration sphere.

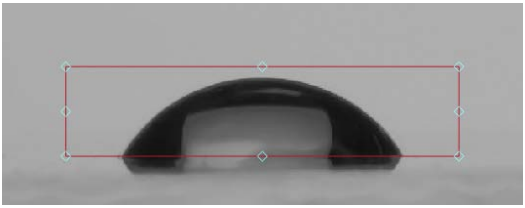


10. Advanced Measurement Guide

10.1 Region of Interest (ROI)

The region of interest (ROI) is set using the ROI box in the main viewer. **Figure 10.1.** shows the ROI box as is appears on a droplet image. The box has handles on the sides and corners that can be dragged to resize it. The baseline can be moved pixel-by-pixel using the 'Baseline Adjustment' control in the top right corner of the main viewer.

Figure 10.1. Region of interest box.



10.1.1 ROI Box Bottom Line (Baseline)

The most important line is the bottom, as this defines the baseline of the measurement. A useful method for determining baseline position is to use the point of reflection of a droplet on a surface. **Figure 10.1** shows a droplet reflecting on its substrate. The pointed edges of this droplet are used to position the baseline. Only the part of the image above the baseline will be used in the fitting and resultant contact angle calculations.

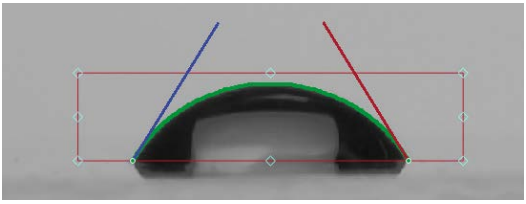
10.1.2 ROI Box Top, Left and Right Lines

The top, left and right sides of the ROI box are used to exclude any unwanted features from the image. If there is a second droplet in the same image, this should be excluded from the region of interest.

10.2 Polynomial Fitting

If the contact angle is above 10° then the software will fit a polynomial to the edge of the droplet. The polynomial fit is overlaid on the image as a green line. The detected edge is displayed as green dots, which are more visible when zoomed in to the image. The blue and red straight lines show the left and right contact angles respectively.

Figure 10.2. Polynomial fitting to a droplet edge.

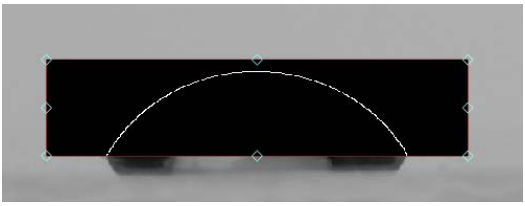


If the angle is below 10° then the software uses a circle fit to determine the contact angles, and this is not displayed on the image.

10.3 Canny Edge Detection

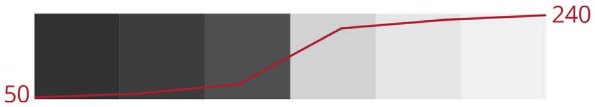
Canny edge detection is the process by which the software determines the edge pixels of a droplet. **Figure 10.3** shows the same droplet as **Figure 10.1**, however the 'Show Edges' option has been toggled in the main viewer, and so the edge detection is now visible.

Figure 10.3. Edge detection of a droplet. The edge can be displayed using the 'Show Edges' button in the main viewer.



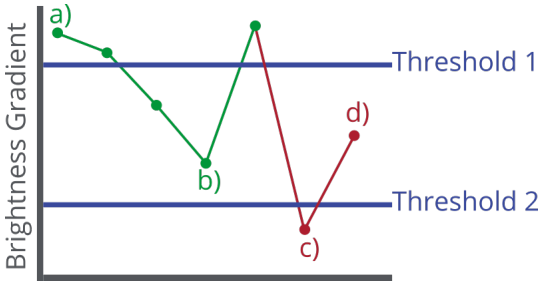
The edge detection algorithm looks for large changes in pixel lightness that would signify the edge of a region of darkness (a droplet). When an area of the image changes from light to dark over a small number of pixels, there is likely to be an edge. **Figure 10.4** shows a change in lightness between pixels in a straight line. The pixel on the left has a lightness value of 50, which increases to 240 over the 6 pixels in the line. The change in lightness between the two central pixels is the highest, shown by the steep gradient of the line between these points.

Figure 10.4. Lightness value change from 50 to 240, with a steep gradient between the central two pixels.



There are two gradient thresholds involved with the edge detection, and they are shown in **Figure 10.5.** Threshold 1 determines the minimum change in lightness required for an edge to be detected. To detect and edge in **Figure 10.4**, threshold 1 would need to be lower than the difference between the central two pixels. This corresponds to point a) in **Figure 10.5.**

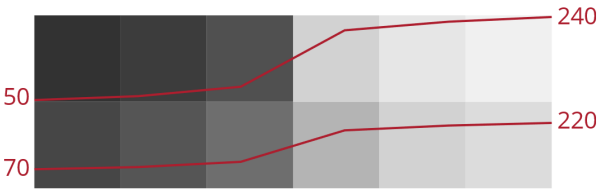
Figure 10.5. Visualisation of the Canny edge detection algorithm. Points in green are accepted as edges, and points in red are rejected.



Sometimes a line of pixels does contain an edge, but it can't be detected as the lightness gradients within it all fall below threshold 1. Threshold 2 is set lower than threshold 1 to catch lines of pixels where this occurs. If the line has a lightness gradient that passes threshold 2 and is adjacent to a line which passes threshold 1, it will also be counted as an edge.

This is demonstrated in **Figure 10.6**, where the gradient change in the bottom row of pixels does not pass threshold 1 but does pass threshold 2. As it is adjacent to the top row which does pass threshold 1, it is still counted as an edge. Rows adjacent to this row that pass threshold 2 will also be counted as edges (point b in **Figure 10.5**).

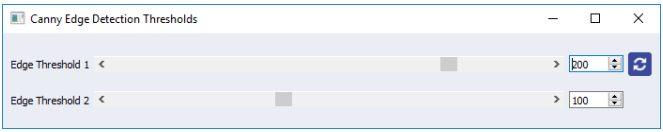
Figure 10.6. Lightness value changes along two lines of adjacent pixels from 50 to 240 and from 70 to 220.



If a row falls below threshold 2, it is never counted as an edge (point c). Point d) also fails, as it is not connected to a row that has passed threshold 1.

Threshold 1 and 2 can be adjusted using sliders within the software. To access the threshold sliders, click the settings button next to the 'Show Edges' button. This will open a new window, as shown in **Figure 10.7.**

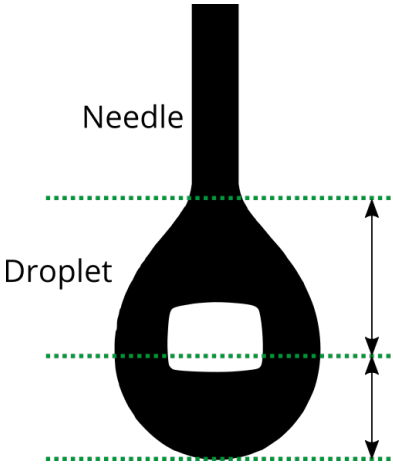
Figure 10.7. Canny edge detection threshold controls. Defaults thresholds are set to 200 and 100.



10.4 Pendant Drop Fitting

An optical tensiometer is a tool for measuring the surface tension of a liquid. The surface tension of a liquid determines how it changes shape under gravity, and thus the shape of a droplet as it hangs off a needle tip. **Figure 10.8.** shows a droplet attached to the end of a micropipette needle. The top of the droplet is elongated, as the droplet deforms under its own weight. If we know the density and volume of the droplet, then we can use its shape to determine its surface tension.

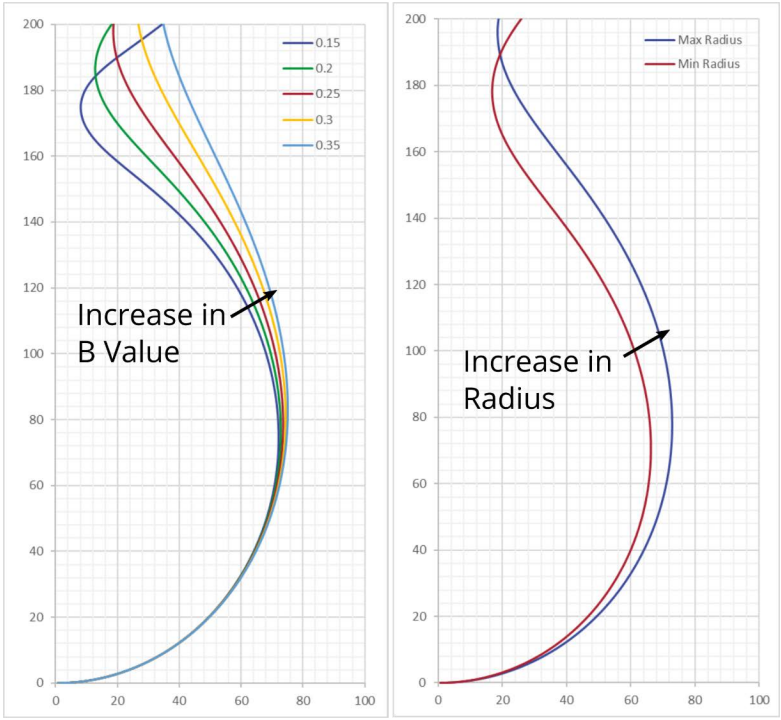
Figure 10.8. A Pendant drop deforming under gravity.



The fit has two main variables: droplet radius and B (a fitting constant). **Figure 10.9.** shows the affect that both the fitting constant and the radius have on a simulated droplet. The B value changes how a droplet shape deviates from a circle. The higher the value of B, the more deformed the droplet becomes due to gravity. Droplets with low surface tension are more deformed by gravity, so increasing B will result in a droplet fit with a lower surface tension.

Changing the radius does not alter shape of the droplet like changing B does, however it changes the scale of the droplet. If a droplet volume is increased by increased its radius, it will deform more under the increased gravity. If two droplets have the same shape but different sizes, the larger droplet must therefore have a higher surface tension to retain the same shape with a higher volume. This means that increasing the simulated droplet radius will increase the surface tension.

Figure 10.9. Plots demonstrating how a change in fitting constant or radius affects the simulated droplet shape.



The software iterates through value of radius and B to create many different simulated droplets. It then compares the simulated droplets with the detected edge of the droplet in the region of interest. The simulated fit that most closely matches the detected edge is chosen as the 'real' droplet. The difference between the simulated edge and the detected edge is the root mean squared error (RMSE). This is displayed when a measurement is performed and can be used as an indicator of how closely the simulated droplet matched the detected edge.

11. Troubleshooting

We run extensive tests on our products to verify that they are stable and in working order. However, sometimes you may have issues connecting to and using them. Most of the issues that may arise are detailed below. If you encounter any issues that are not detailed here, then contact us by email at **info@ossila.com**. We will respond as soon as possible.

Table 11.1. Troubleshooting guidelines for the Ossila Contact Angle Goniometer

Problem	Possible cause	Action
Backlight not turning on.	a. The power supply may not be connected properly. b. The power supply adaptor has a fault.	a. Ensure the system is firmly plugged into the power supply, and that the plug is connected to both the adaptor and a working power socket. b. Contact Ossila for a replacement power supply adaptor.
Software does not start	a. The wrong version of Windows is installed on the computer. b. The software has not installed properly.	a. Install the software on a computer with Windows Vista or newer. b. Try reinstalling the software.
Cannot detect the camera	a. The USB cable may not be connected properly. b. The USB cable may not be connected to a working USB port. c. The USB cable is defective.	a. Ensure the USB cable is firmly plugged in at both ends. b. Try connecting the unit to a different USB port on the computer. d. Use a different USB-B cable (any should work), and contact Ossila if necessary.

12. Related products

12.1 Related Consumables

ITO Coated Substrates

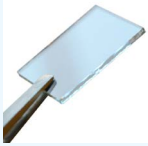
Our range of 15 x 20 mm ITO substrates for OPV, OLED and sensing applications.

Product codes: S111 / S101 / S211 / S281 / S171

Flat Tip Tweezers

Provides a good substrate grip without scratching.

Product codes: C121



Ultra-flat Quartz Coated Substrates

These substrates are coated with a 20nm layer of synthetic quartz.

Product code: S151

Micropipettes

Pre-calibrated and tested micropipettes. Volumes range from 0.5 µl to 10 ml.

Product code: C2001V1

12.2 Related Equipment

Spin Coater

Produce high-quality coatings without any substrate warping. Perfect for busy labs with limited space.

Product code: L2001A3

Slot-Die Coater

Perfect for those wanting to scale-up their processing techniques in a small laboratory.

Product codes: L2005A1

UV Ozone Cleaner

For removing contamination on the surface of samples, providing you with ultraclean surfaces within minutes.

Product code: L2002A2

Dip Coater

Provides high-performance specs and simple to use intergrated software at a reasonable cost.

Product code: L2006A1

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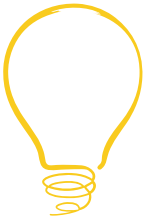

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