OpenDrop

Apr 21, 2022

Contents

CHAPTER 1

Release builds

Stand-alone builds for Windows are provided for certain major releases and do not require the installation of additional software: https://github.com/jdber1/opendrop/releases/.

Releases for Linux and macOS don't exist yet and OpenDrop should instead be installed as a Python package. See next section.

CHAPTER 2

Building package from source

OpenDrop requires Python 3.6 or higher, the GTK 3 library, OpenCV Python bindings, and the following build dependencies:

- Boost.Math
- SUNDIALS ARKODE

Other required Python packages will be automatically installed by pip.

Platform specific build instructions follow.

2.1 Ubuntu

1. Install OpenCV.

    - If on Ubuntu 17.10 (or later):

    ```
    sudo apt install python3-opencv
    ```

    - Alternatively there is an unofficial opencv-python package that can be installed using pip:

    ```
    pip3 install opencv-python
    ```

2. Install SUNDIALS. Unfortunately `libsundials-dev` from the Ubuntu repositories are too old, we require at least version 4.0.0 and above. Here are brief instructions for installing SUNDIALS from source.

    1. Download the latest version from the releases page. (Note: the latest version requires a CMake version newer than available in Ubuntu < 20.04. If this affects you, try an older version of SUNDIALS like 4.0.0 instead.)

    2. Extract and change into the source directory, e.g.:

    ```
    tar -xvf sundials-5.7.0.tar.gz
    cd sundials-5.7.0/
    ```

3. Create a build directory:

```
mkdir build
cd build/
```

4. Configure, build, and install (make sure `cmake` and `build-essential` are installed from the Ubuntu repos):

```
cmake \
  -DEXAMPLES_INSTALL=OFF \
  -DBUILD_ARKODE=ON \
  -DBUILD_CVODE=OFF \
  -DBUILD_CVODES=OFF \
  -DBUILD_IDA=OFF \
  -DBUILD_IDAS=OFF \
  -DBUILD_KINSOL=OFF \
  -DBUILD_STATIC_LIBS=OFF \
  -DCMAKE_BUILD_TYPE=Release \
  ..
make
sudo make install
```

3. Install Boost.Math. If on Ubuntu 20.04 or newer, run:

```
sudo apt install libboost-dev
```

The `libboost-dev` package on older versions of Ubuntu is not recent enough and Boost will need to be installed from source. We need at least Boost 1.71.0.

4. Follow the installation instructions here for installing PyGObject and GTK.

5. Use pip to install OpenDrop from the repo:

```
pip3 install git+https://github.com/jdber1/opendrop.git
```

Run `pip3 uninstall opendrop` to uninstall.

6. Run `python3 -m opendrop` to launch the app.

2.2 Fedora

Tested on Fedora 35.

1. Install Python, pip, and OpenCV:

```
sudo dnf install python3-devel python3-opencv python3-pip
```

2. Install glib:

```
sudo dnf install glib2-devel
```

3. Install SUNDIALS:

```
sudo dnf install sundials-devel
```

4. Install Boost:

```
sudo dnf install boost-devel
```

5. Use pip to install OpenDrop from the repo:

```
pip install git+https://github.com/jdber1/opendrop.git
```

   Run `pip uninstall opendrop` to uninstall.

6. Run `python -m opendrop` to launch the app.

2.3 macOS

1. Install the latest version of Python 3 and pip. You can do so using a third-party package manager like MacPorts or Homebrew.
2. • Install the unofficial opencv-python package by running:

   ```
   pip install opencv-python
   ```

   (Make sure `pip` refers to your Python 3's pip installation.)

   • Alternatively, OpenCV and its python bindings can also be installed using the opencv Homebrew formula or opencv MacPorts port.
3. • If Homebrew was used to install Python 3, PyGObject and GTK can also be installed by running:

   ```
   brew install pygobject3 gtk+3
   ```

   • or if MacPorts was used, run:

   ```
   sudo port install py36-gobject3 gtk3
   ```

   (Instead of the `py36-` prefix, use `py37-` or `py38-` if Python 3.7/3.8 is the version installed.)
4. Install Boost.Math and SUNDIALS. (todo: Add MacPorts and Homebrew example).
4. Use pip to install OpenDrop from the repo:

```
pip install git+https://github.com/jdber1/opendrop.git
```

   Run `pip uninstall opendrop` to uninstall.

5. Run `python3 -m opendrop` to launch the app.

2.4 Windows

Installing OpenDrop as a Python package is possible on Windows using platforms like MSYS2 or Anaconda. The process is not very straightforward so your mileage may vary.

(todo: This page is out of date and should be updated.)

CHAPTER 3

Usage

When OpenDrop is launched, the Main Menu window will first appear.

Click on either of the 'Interfacial Tension' or 'Contact Angle' buttons to begin a new analysis of the respective type.

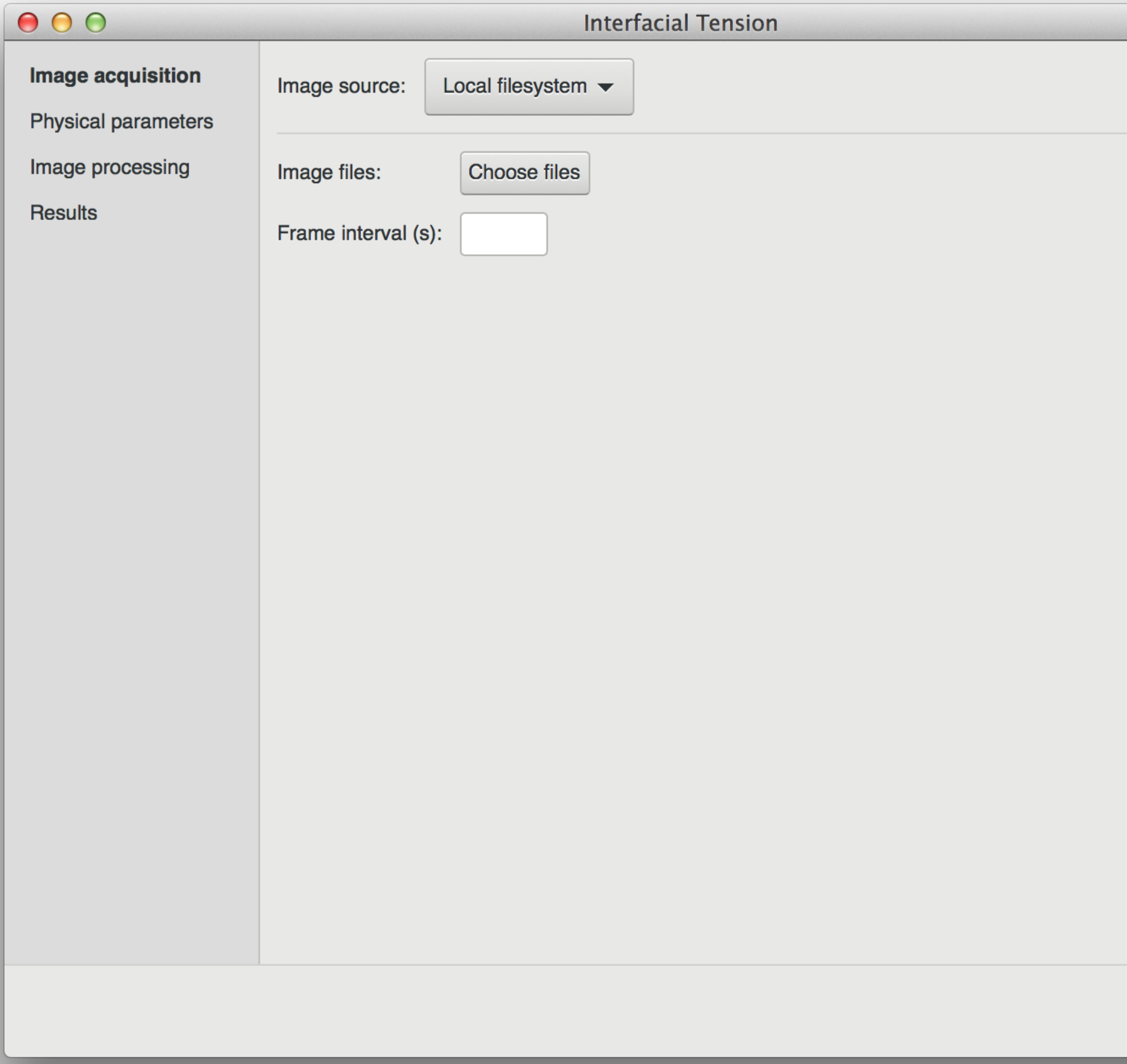
3.1 Interfacial Tension

A wizard-style window will guide you through the process of performing an interfacial tension analysis.

3.1.1 Image acquisition

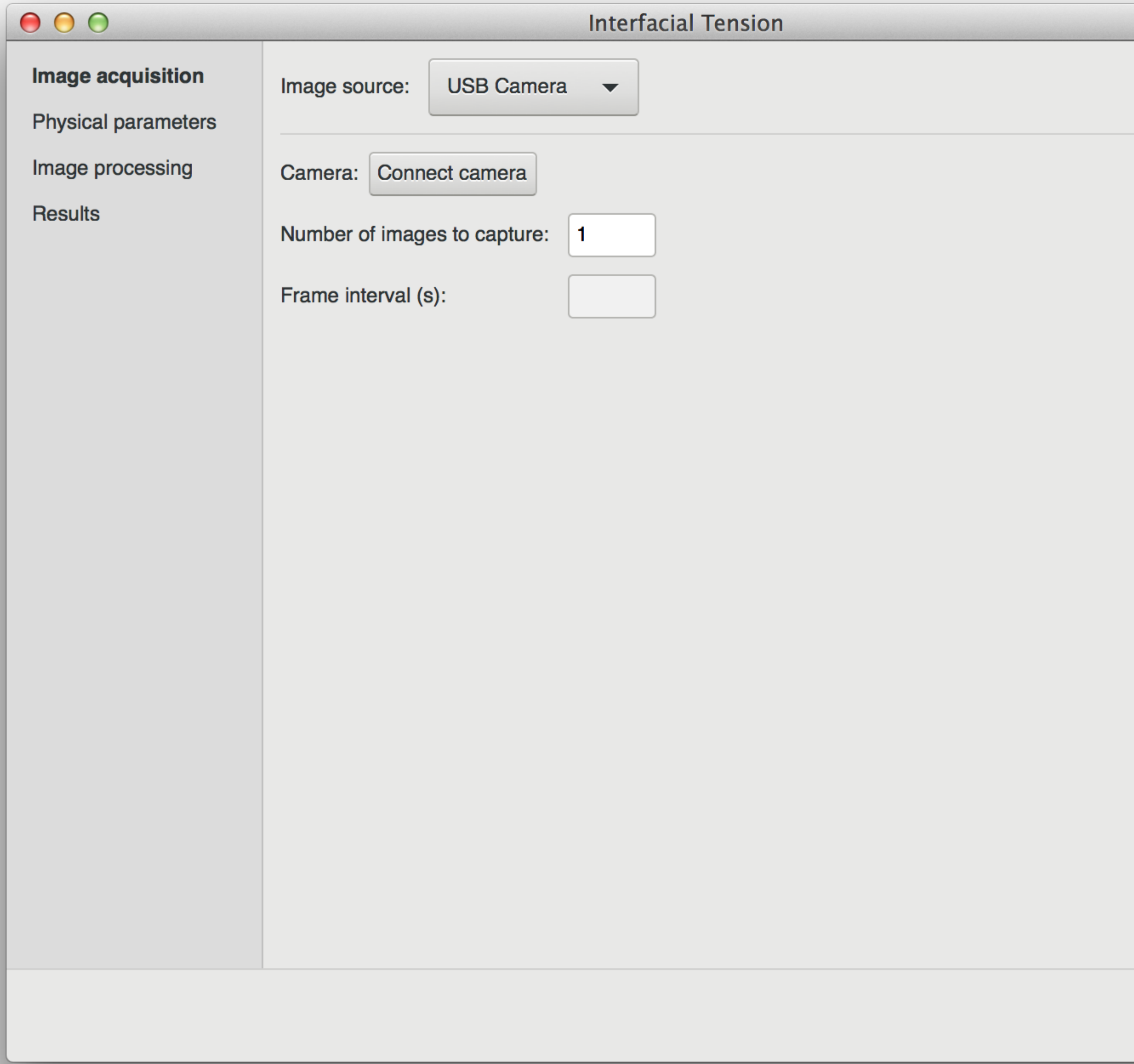
First, choose an image input method. OpenDrop currently supports opening images from the local filesystem or capturing images with a USB camera.

Local filesystem

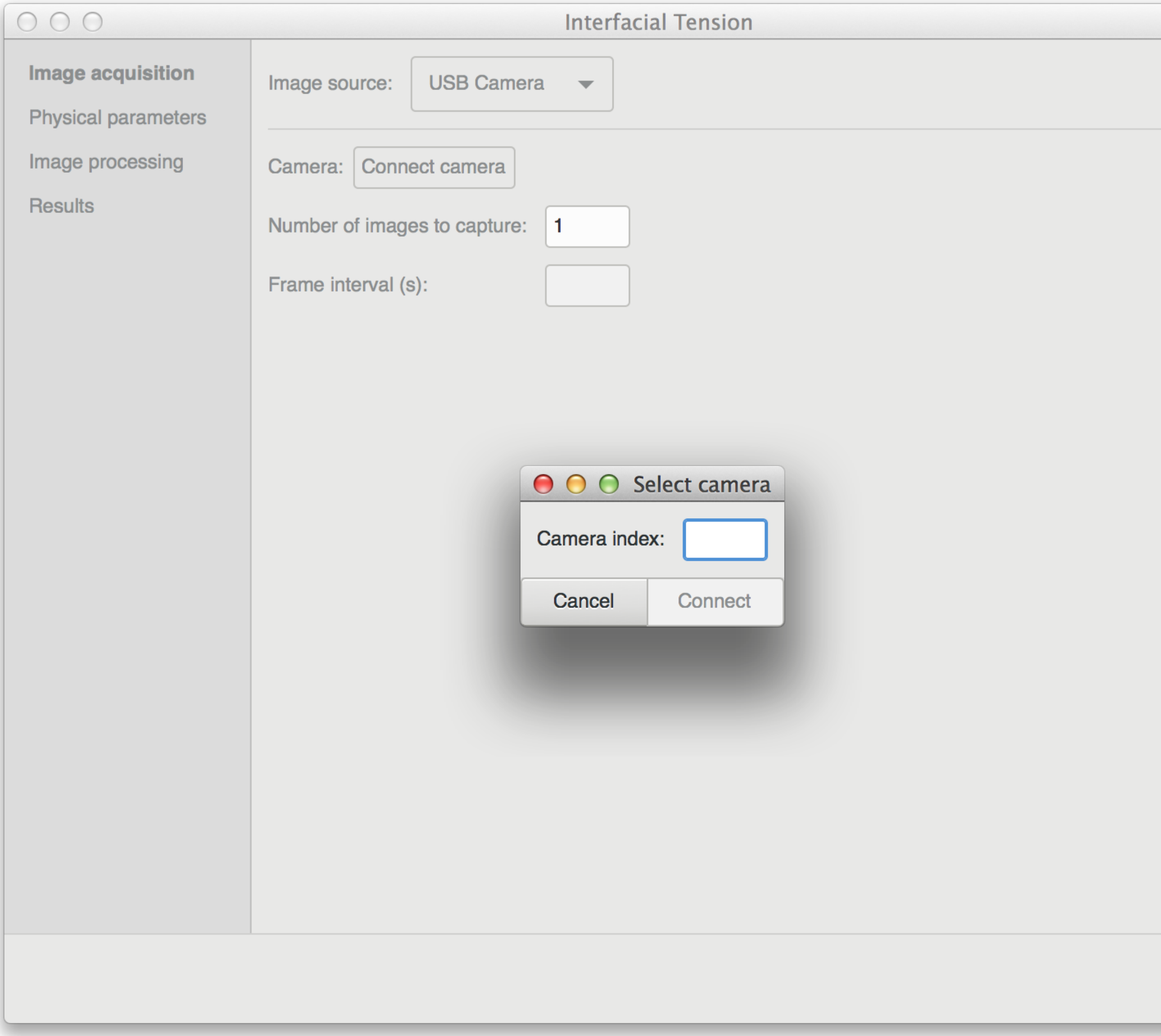


Click on 'Choose files' to open the file chooser dialog and select an individual image or a sequence of images. When analysing a sequence of images, 'Frame interval' refers to the time interval (in seconds) between each image. Sequences of images are ordered in lexicographic order.

USB camera



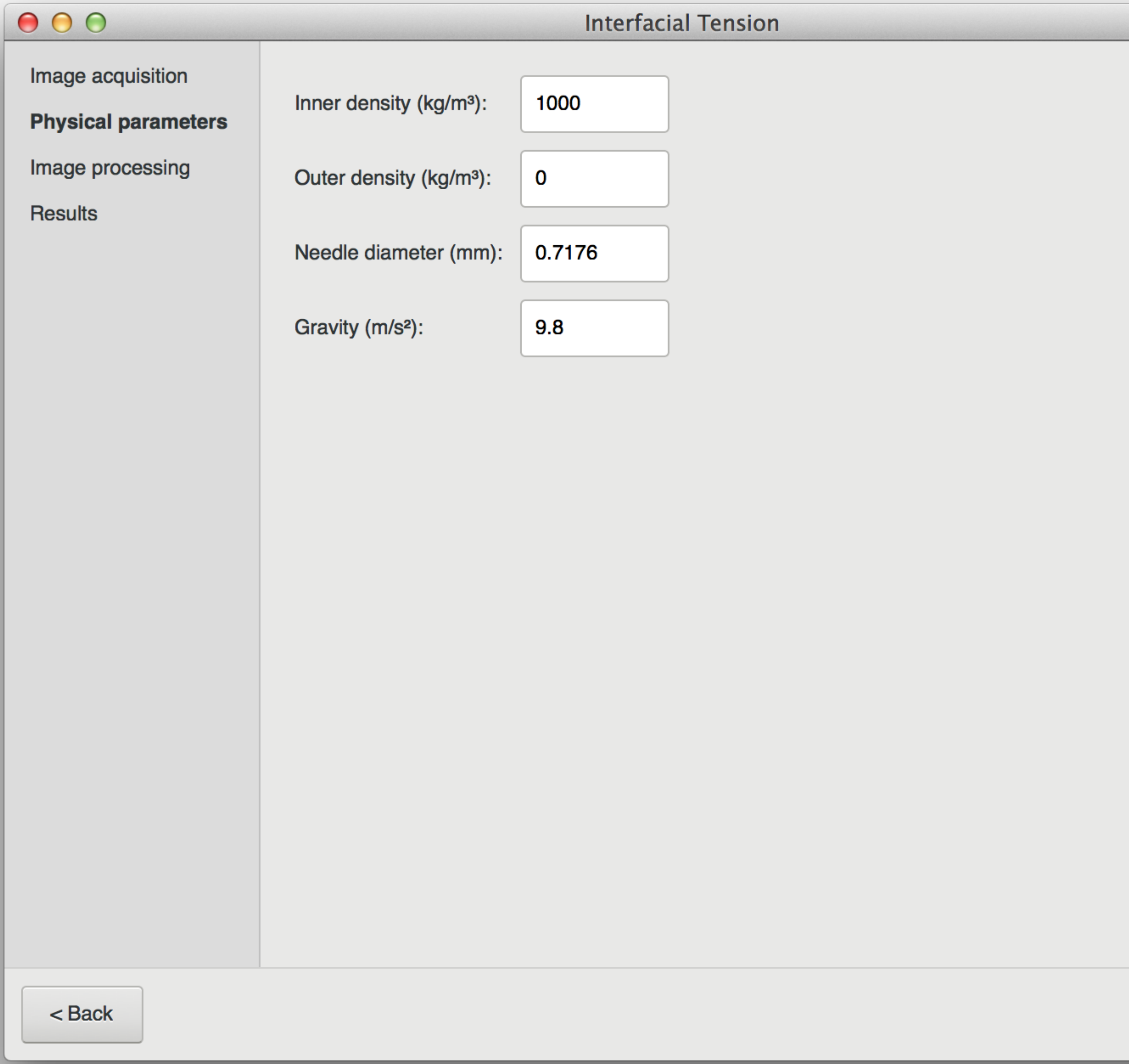
Click on 'Connect camera' to open the camera chooser dialog.



OpenDrop uses OpenCV to capture images from a connected camera. 'Camera index' refers to the device index argument passed to the OpenCV function `cv2.VideoCapture()`. An index of 0 refers to the first connected camera (usually a laptop's in-built webcam if present), an index of 1 refers to the second camera, and so on. Currently, there does not appear to be a way in OpenCV to query a list of valid device indices and associated device names, so in a multi-camera setup, some trial-and-error is required.

'Frame interval' refers to the time interval (in seconds) between capturing images.

3.1.2 Physical parameters



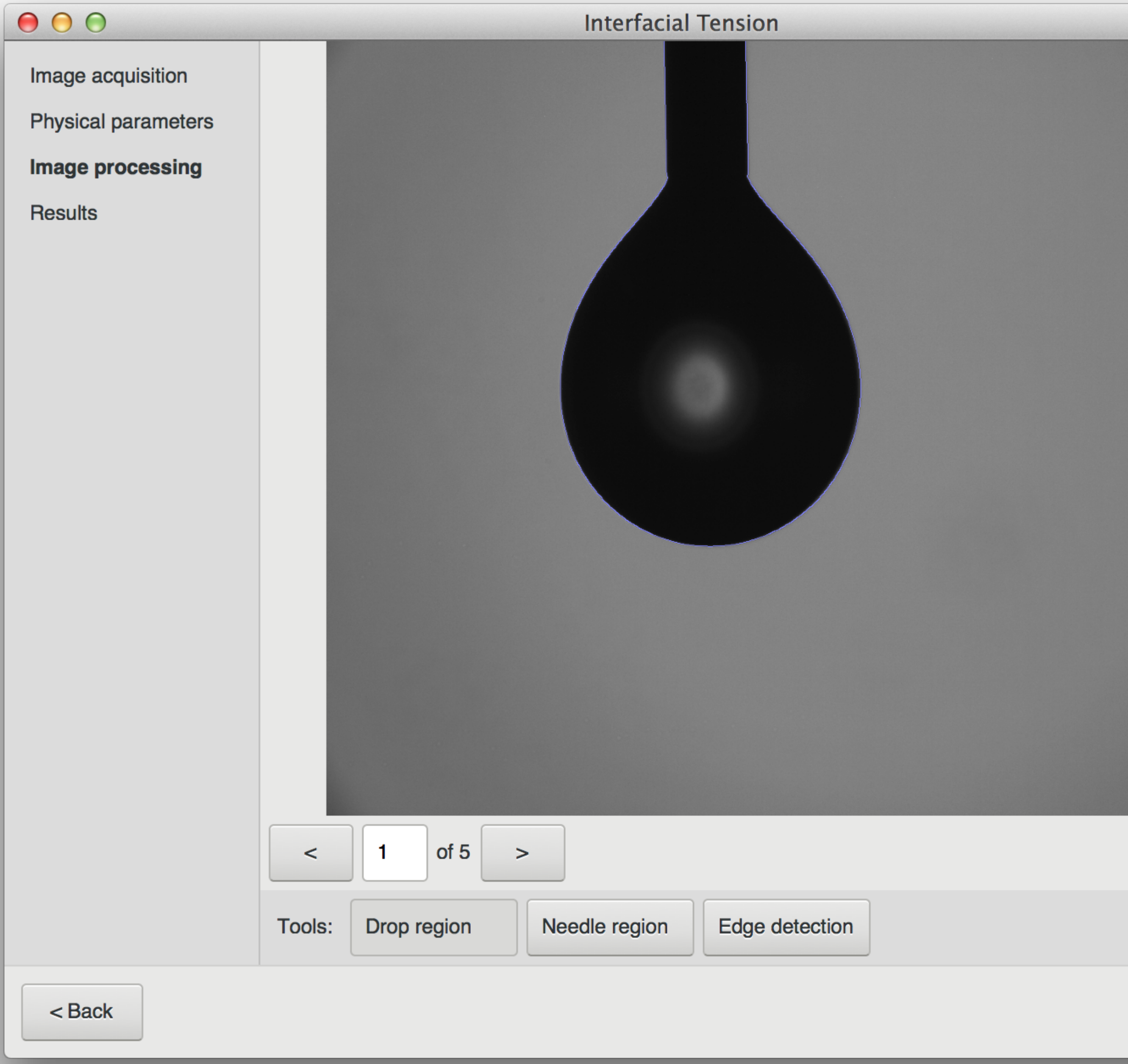
'Inner density' refers to the density of the drop.

'Outer density' refers to the density of the surrounding medium.

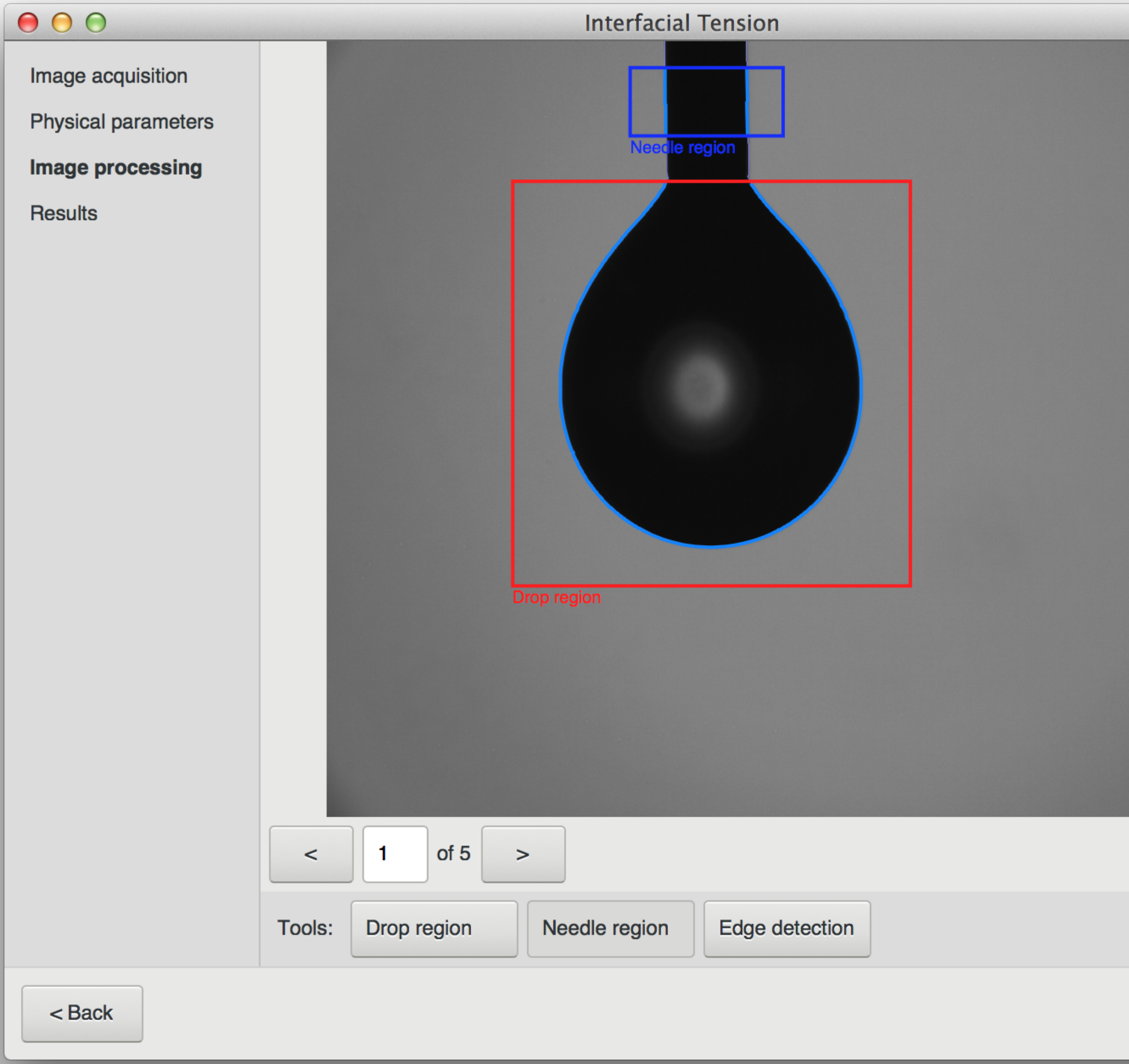
'Needle diameter' refers to the diameter of the needle the drop is suspended from.

'Gravity' refers to the gravitational acceleration.

3.1.3 Image processing



The image processing window requires you to define the 'drop region' and 'needle region' of the image. Click on the 'Drop region' or 'Needle region' buttons in the 'Tools' panel, then drag over the image preview to define the associated region.



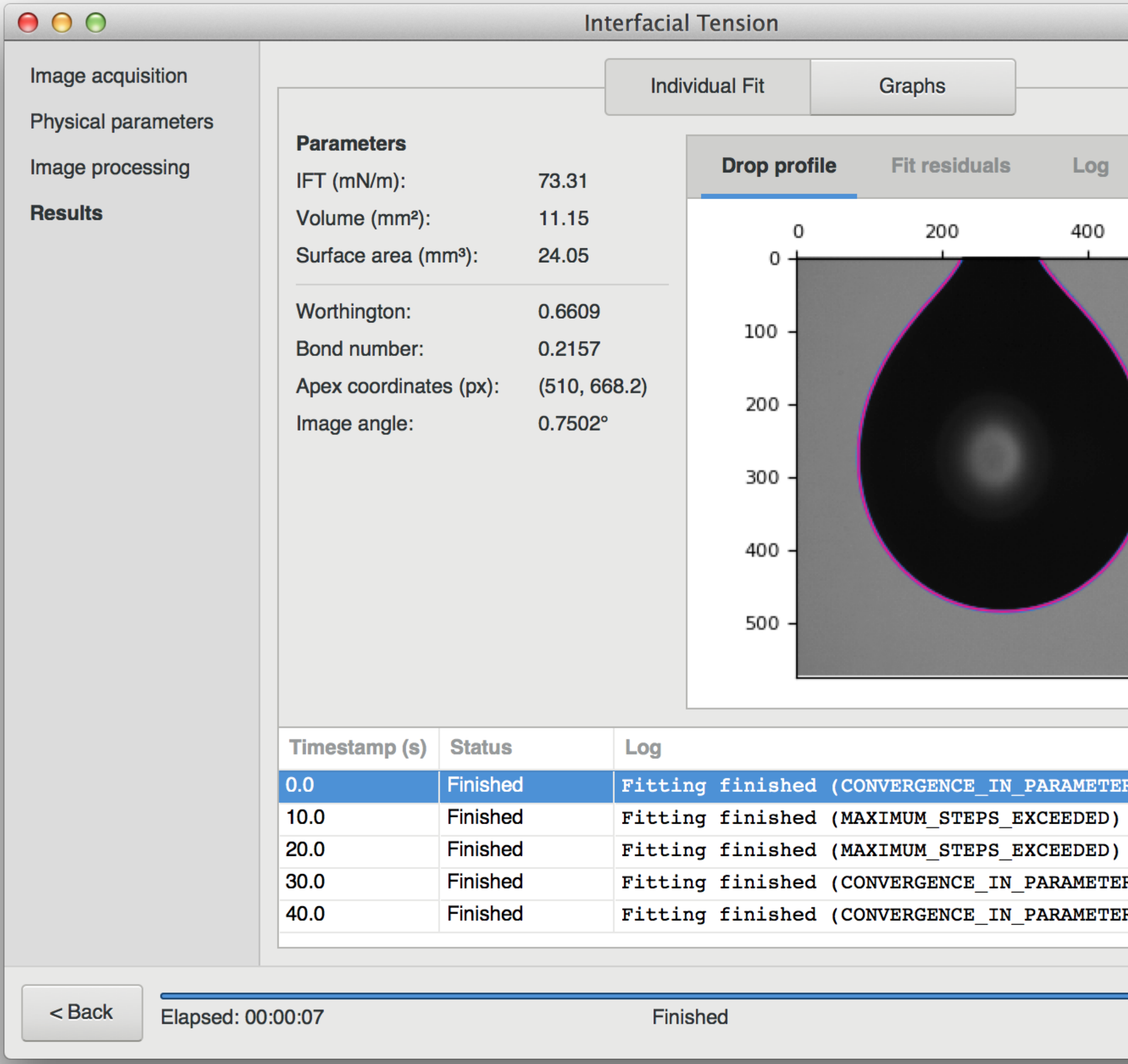
Once each region is defined, a blue outline will be drawn over the preview showing the drop or needle profile that has been extracted.

OpenDrop uses OpenCV's Canny edge detector to detect edges in the image, click on the 'Edge detection' button in the 'Tools' panel to open a dialog bubble which will allow you to adjust the lower and upper threshold parameters of the Canny edge detector. Thin blue lines are drawn over the preview to show detected edges.

The extracted needle profile is used to determine the diameter in pixels of the needle in the image. Along with the needle diameter in millimetres given in the 'Physical parameters' page, a metres-per-pixel scale can be determined, which is then used to derive other physical properties of the drop after the image is analysed.

Click on 'Start analysis' to begin analysing the input images, or begin capturing and analysing images if using a camera.

3.1.4 Results



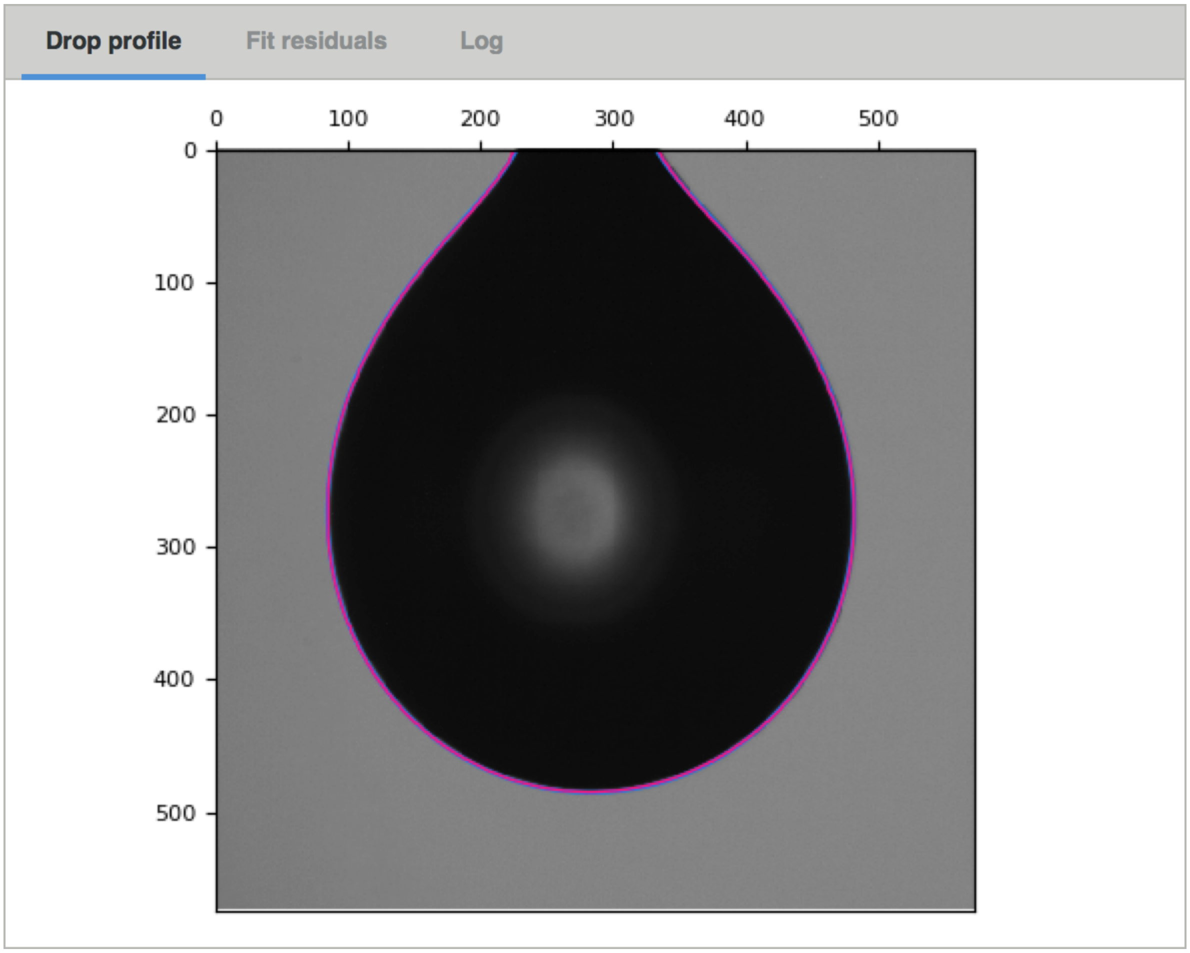
The results page shows the current status of the analysis. Data shown in the window is updated as the analysis progresses.

There are two main views, the 'Individual Fit' view and the 'Graphs' view. The 'Graphs' view is not available when analysing a single image.

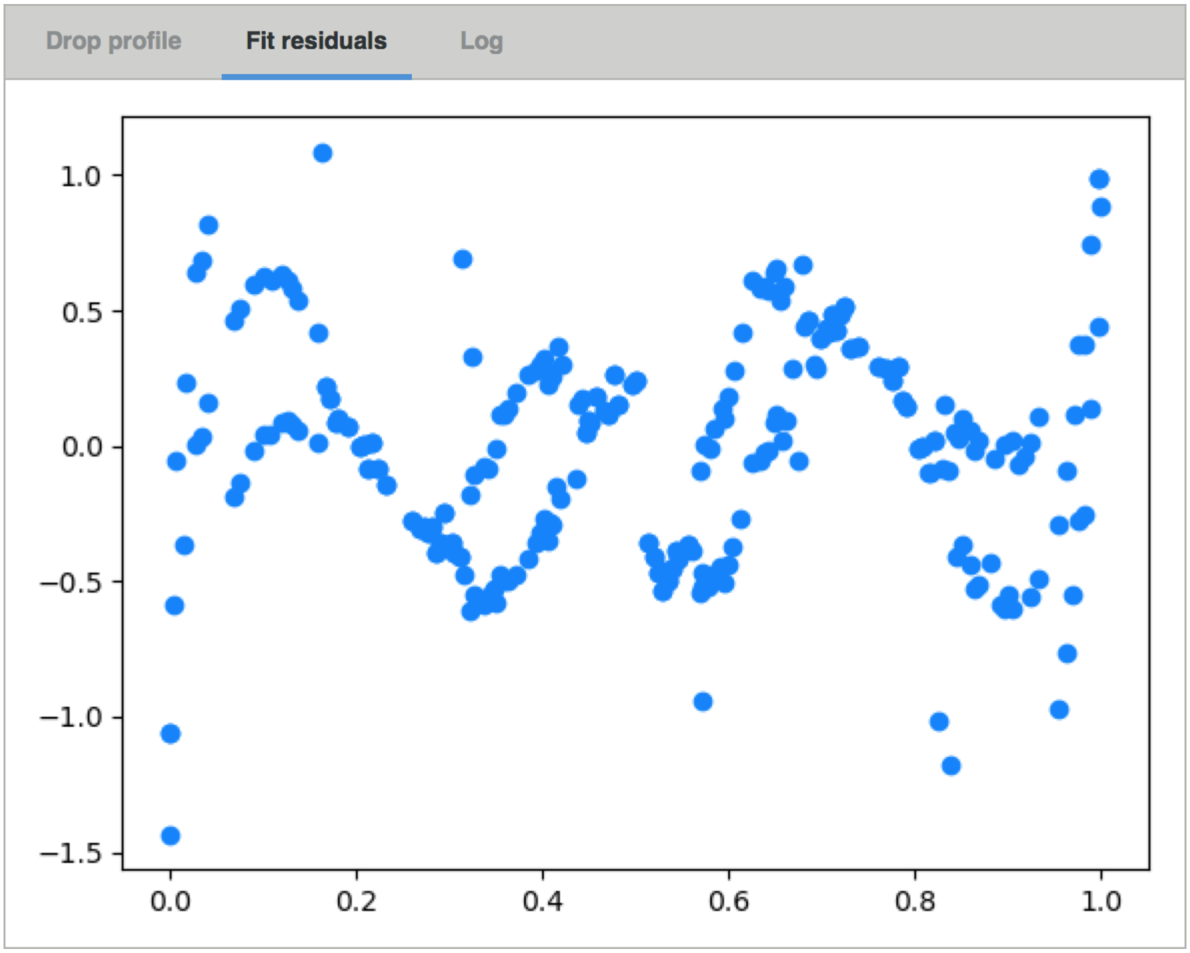
Individual Fit

The 'Individual Fit' view shows analysis details for an individual image. Pick an analysis in the lower panel to preview its details in the upper panel.

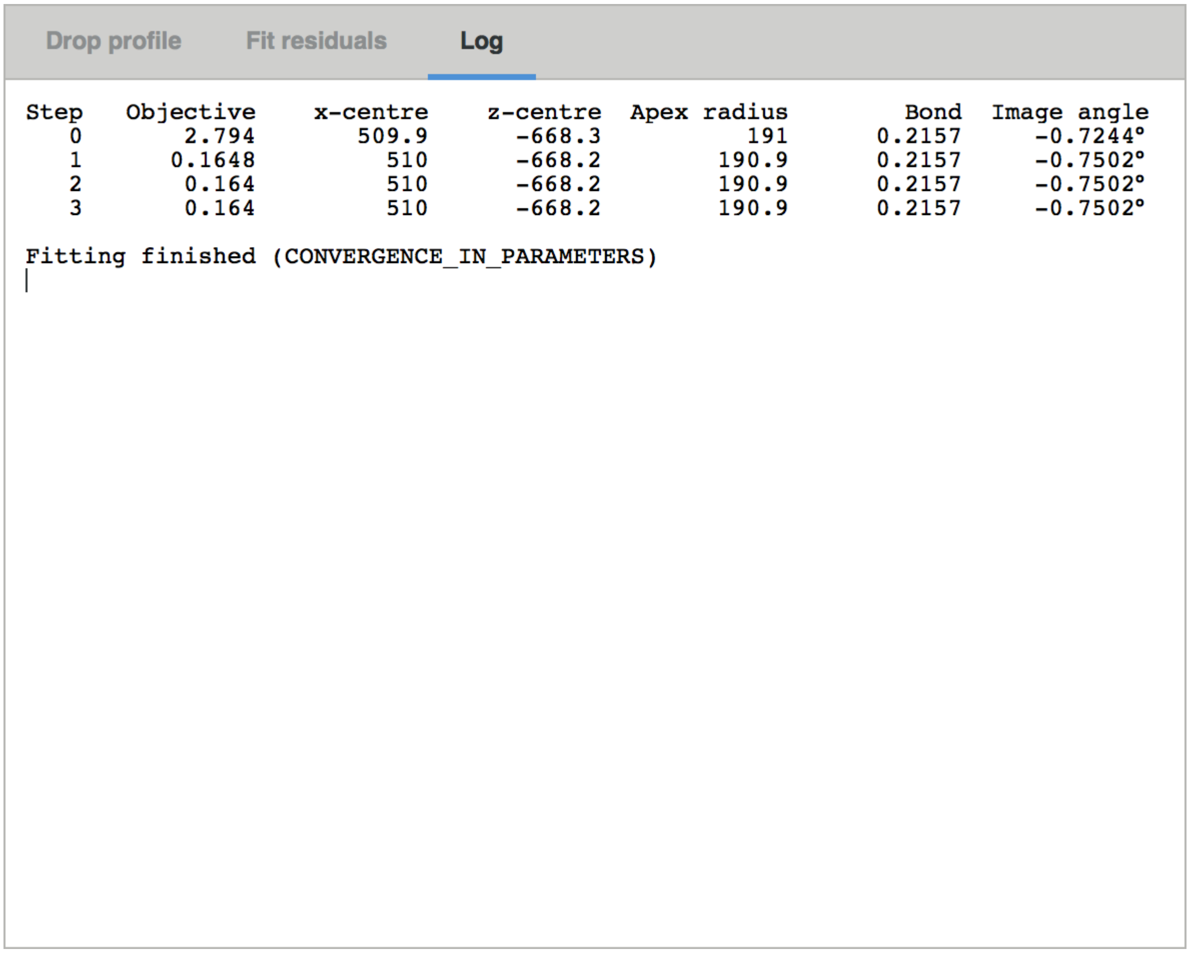
The 'Drop profile' tab on the right of the upper panel shows the fitted drop profile (drawn in magenta) over the extracted drop profile (drawn in blue).



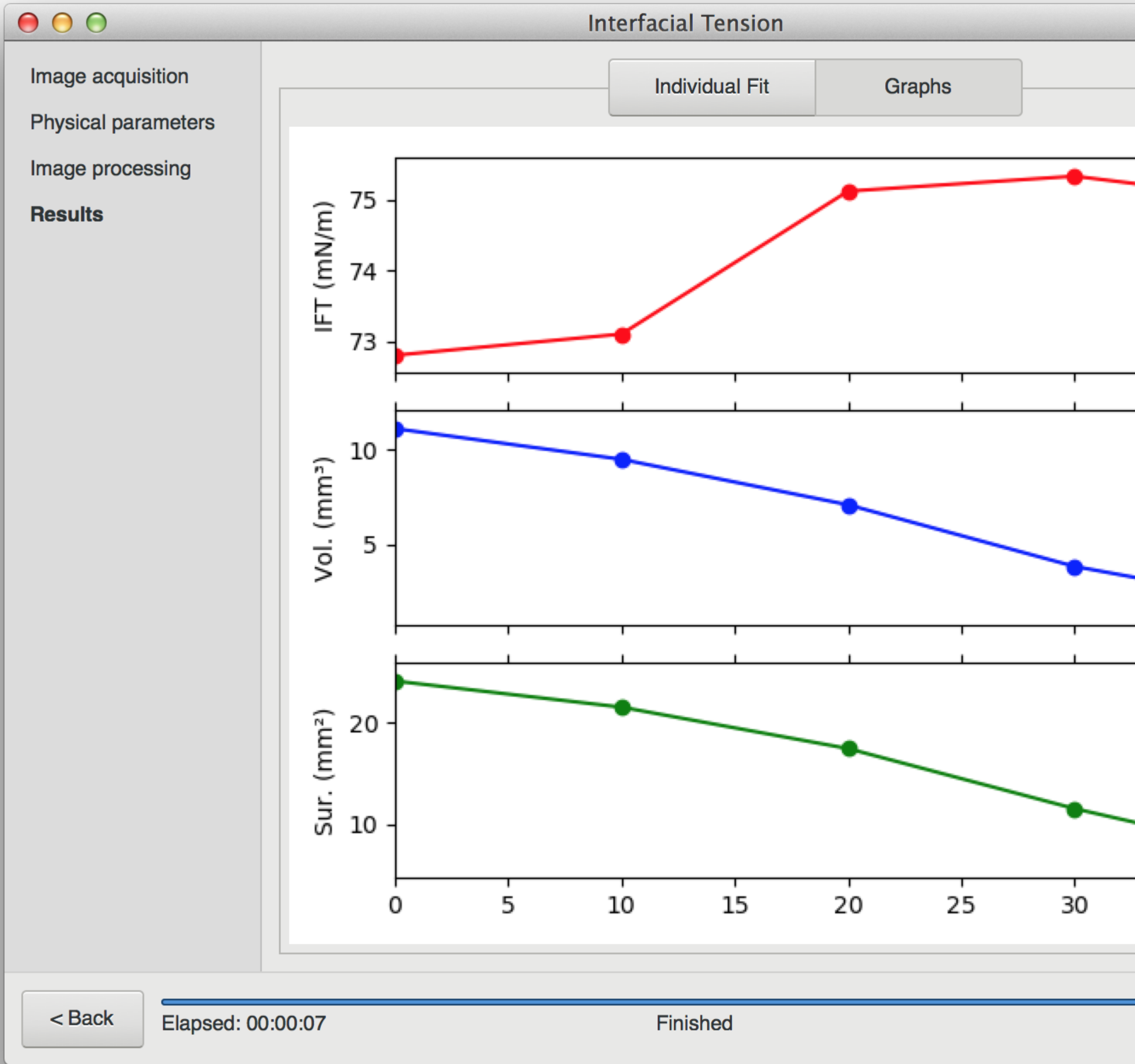
The 'Fit residuals' tab shows a plot of the fit residuals. The horizontal axis is the 'drop profile parameter', ranging from 0 to 1, with 0 corresponding to one end of the drop edge outline, and 1 corresponding to the other end. The vertical axis is some dimensionless quantity indicating the deviation of the extracted profile from the fitted profile.



The ‘Log’ tab shows the history of any messages logged by the fitting routine.


Drop profile
Fit residuals
Log
Step Objective x-centre z-centre Apex radius Bond Image angle
0 2.794 509.9 -668.3 191 0.2157 -0.7244°
1 0.1648 510 -668.2 190.9 0.2157 -0.7502°
2 0.164 510 -668.2 190.9 0.2157 -0.7502°
3 0.164 510 -668.2 190.9 0.2157 -0.7502°
Fitting finished (CONVERGENCE_IN_PARAMETERS)

Graphs

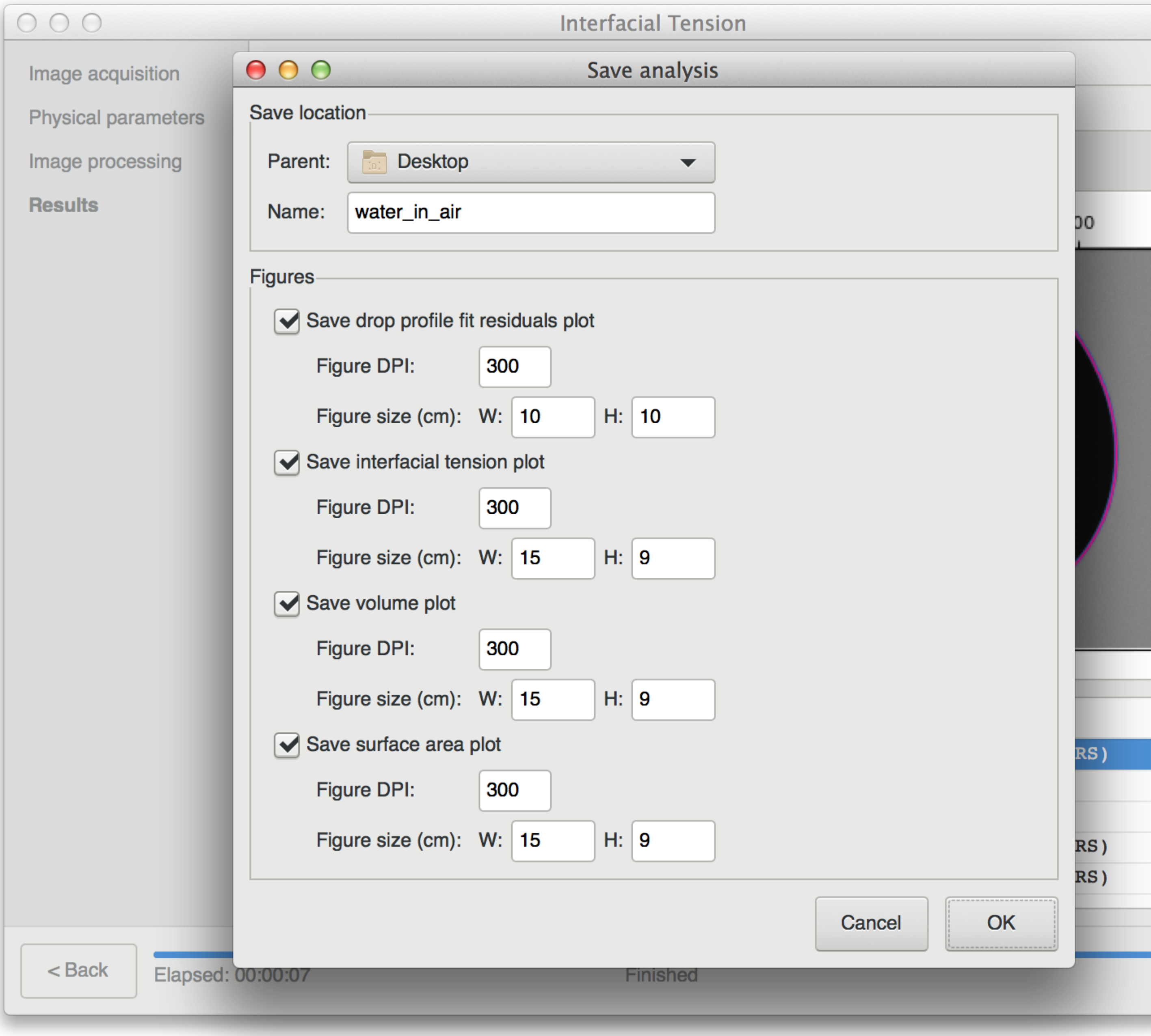


The 'Graphs' view shows plots of interfacial tension, volume, and surface area over time.

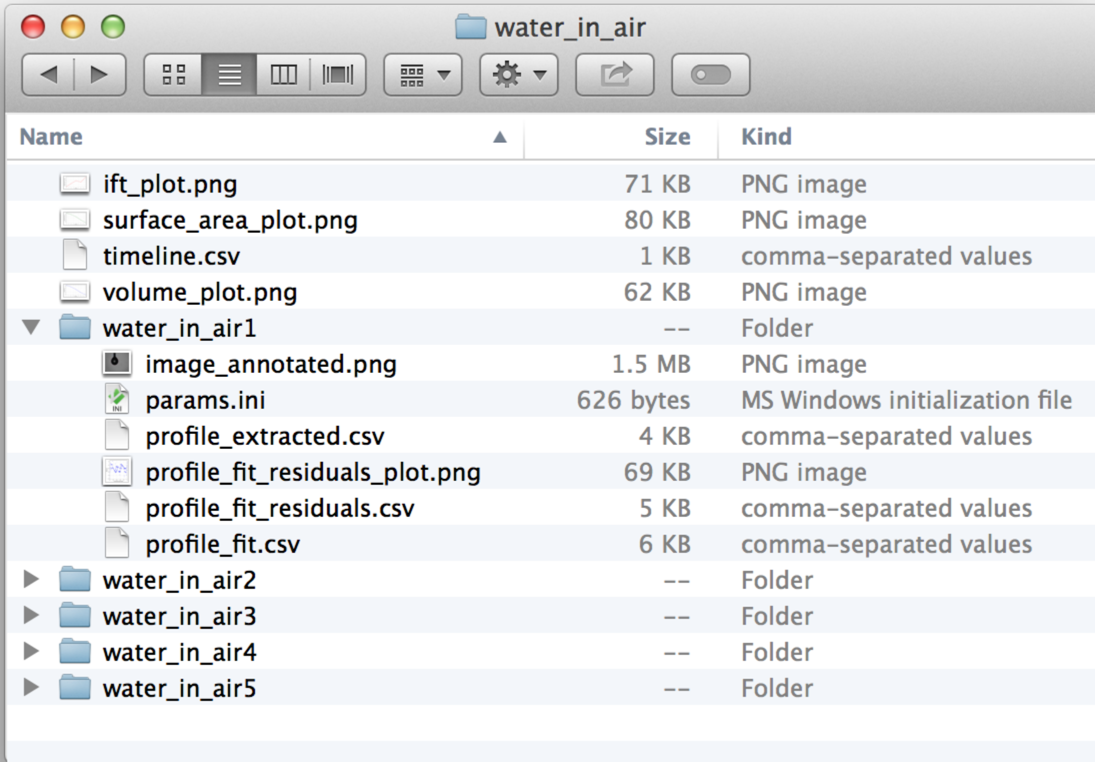
Cancel or discard analysis

You may cancel an in progress analysis by clicking on the ‘Cancel’ button in the footer (not shown in the screenshots above). To discard the results of a finished analysis, click the ‘Back’ button, which will return you to the ‘Image processing’ page, or close the window to return to the Main Menu.

3.1.5 Saving



Once an analysis is finished, click on the ‘Save’ button in the footer to open the save dialog. All data will be saved in a folder with name determined by the 'Name' entry, and in a parent directory determined by the 'Parent' selection. As a convenience, you may choose to save some pre-made plots.



An example save output is shown above, and screenshots of the contents of some files are shown below.

	A	B	C	D	E	F	G	H	
1	Time (s)	IFT (N/m)	Volume (m3)	Surface area (m2)	Apex radius (m)	Worthington	Bond number	Image angle (degrees)	Apex x-co
2	0	0.07314079	1.11E-08	2.40E-05	190.9476255	0.660164878	0.215668351	0.750239186	
3	10	0.07403865	9.59E-09	2.16E-05	183.2378967	0.563250946	0.197145149	0.943330233	
4	20	0.07486292	7.10E-09	1.75E-05	168.7986281	0.412477462	0.164804511	1.438876614	
5	30	0.07447403	3.81E-09	1.14E-05	140.8010106	0.222528336	0.11430311	2.961690995	
6	40	0.07586085	1.64E-09	6.38E-06	108.2299753	0.094101497	0.066661351	8.384363644	

Fig. 1: timeline.csv

3.2 Contact Angle

A wizard-style window will guide you through the process of performing a contact angle analysis.

	A	B
1	449.9	185.5
2	448.7	187.7
3	447.3	189.9
4	446	192.1
5	444.6	194.3
6	443.2	196.4
7	441.7	198.5

Fig. 2: water_in_air1/profile_fit.csv (each row is an (x, y) coordinate pair)

	A	B
1	449	185
2	449	185
3	448	186
4	446	191
5	446	192
6	438	203
7	438	204

Fig. 3: water_in_air1/profile_extracted.csv (each row is an (x, y) coordinate pair)

	A	B
1	0.500615	0.243107
2	0.500615	0.243107
3	0.495907	0.227124
4	0.495907	0.227124
5	0.513201	-0.360234
6	0.513201	-0.360234
7	0.482544	0.154277

Fig. 4: water_in_air1/profile_fit_residuals.csv (first column is 'drop profile parameter', second column is residual)

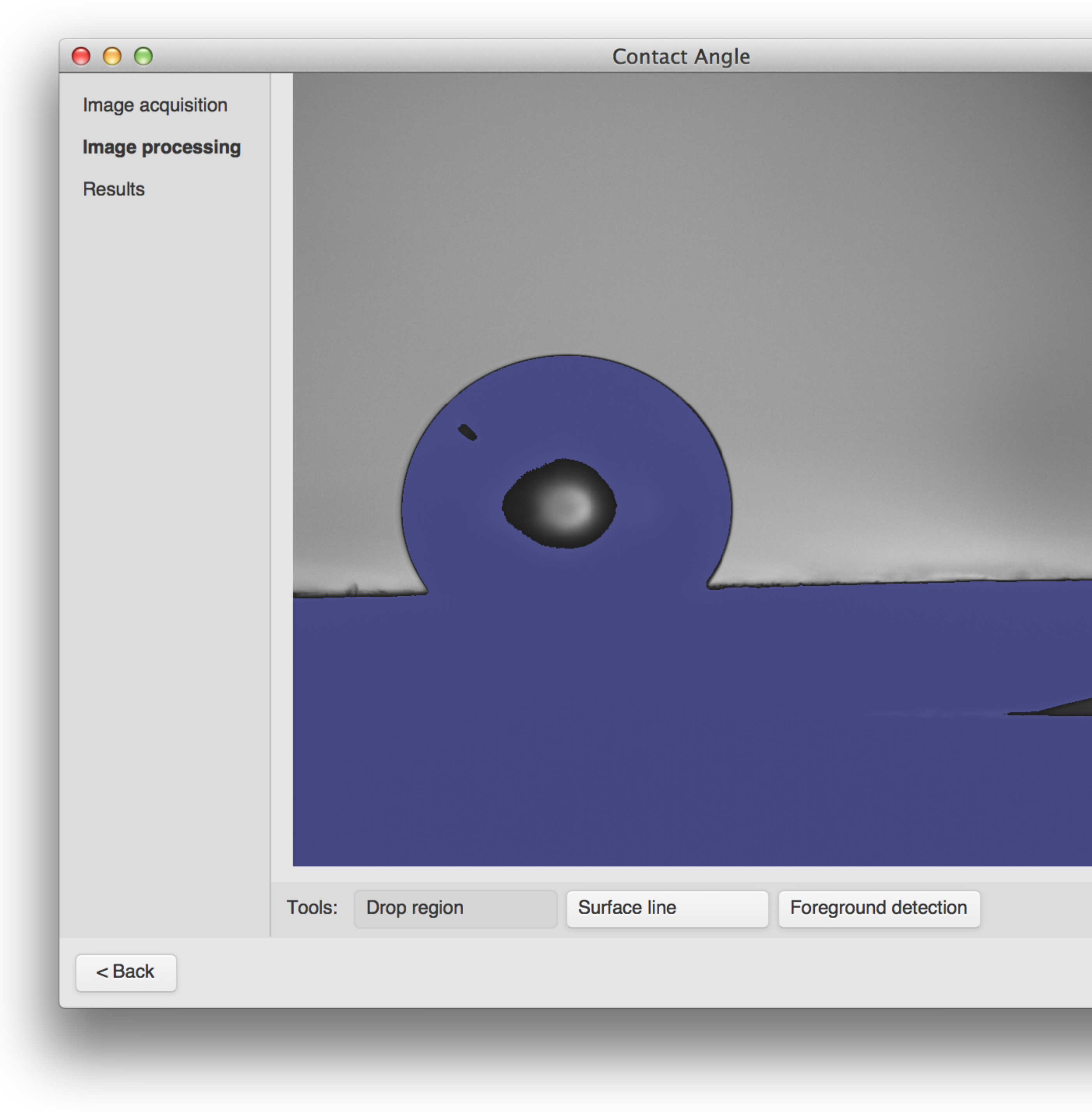
```
[Physical]
; all quantities are in si units
timestamp = 0.0
interfacial_tension = 0.07314079088268234
volume = 1.1107562884936117e-08
surface_area = 2.3996964543219233e-05
apex_radius = 190.94762553531774
worthington = 0.660164878111699
bond_number = 0.21566835099404874

[Image]
; regions are defined by (left, top, right, bottom) tuples
drop_region = (266, 183, 737, 708)
needle_region = (387, 62, 676, 132)
apex_coordinates = (510.0080003164149, 668.2430409901666)
; needle width in pixels
needle_width = 108.00321788135328
; angle is in degrees (positive is counter-clockwise)
image_angle = 0.7502391858826286
```

Fig. 5: water_in_air1/params.ini

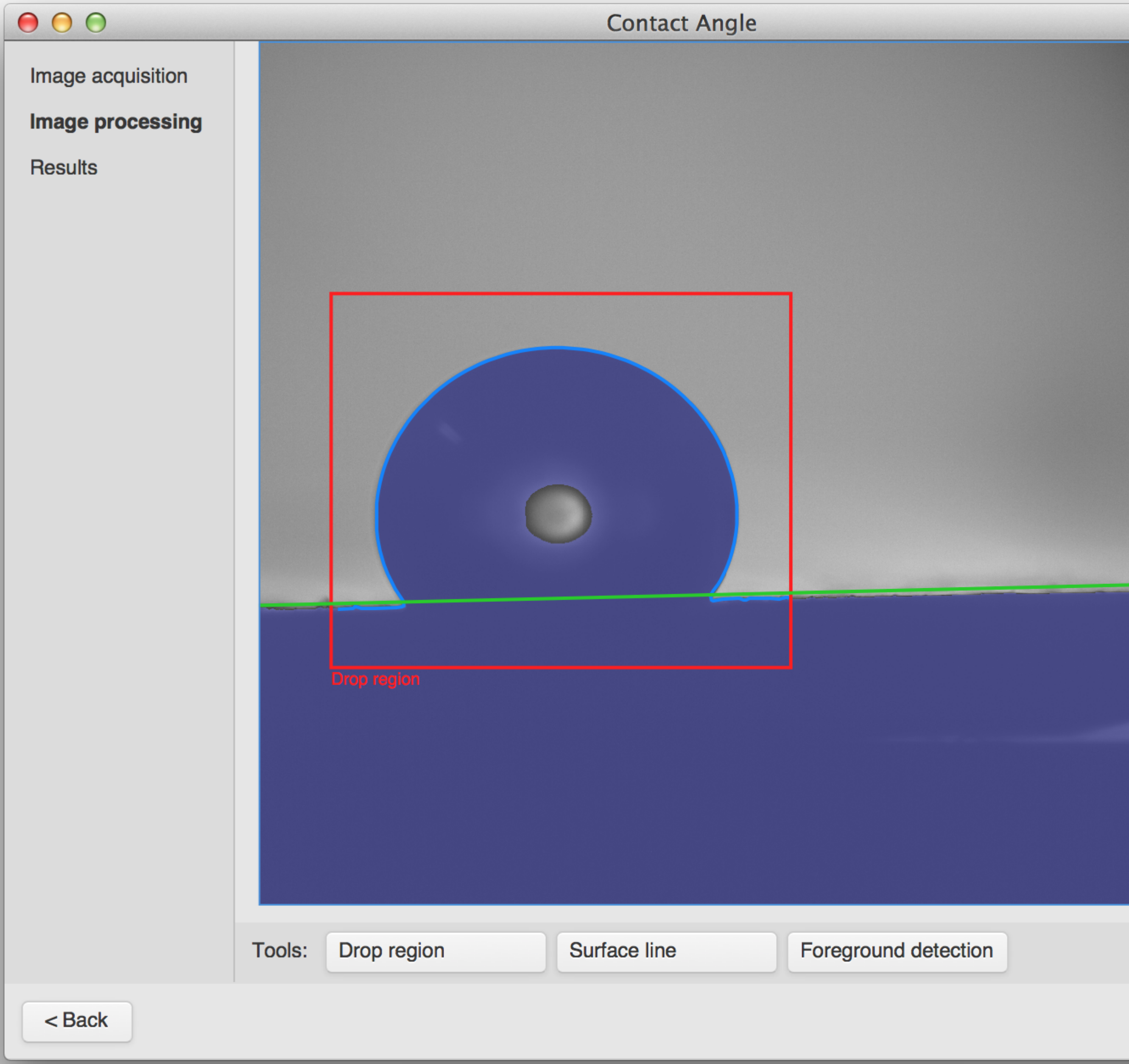
3.2.1 Image acquisition

The contact angle image acquisition page is the same as the one for interfacial tension analyses.

3.2.2 Image processing



The image processing window requires you to define the 'drop region' and 'surface line' of the image. Click on the 'Drop region' button in the 'Tools' panel then drag over the image preview to define the region. Similarly, click on the 'Surface line' button and drag a line to define the surface that the drop is sitting on. With the 'Surface line' button depressed and the preview widget focused, use the arrow keys for finer adjustments of the surface line.



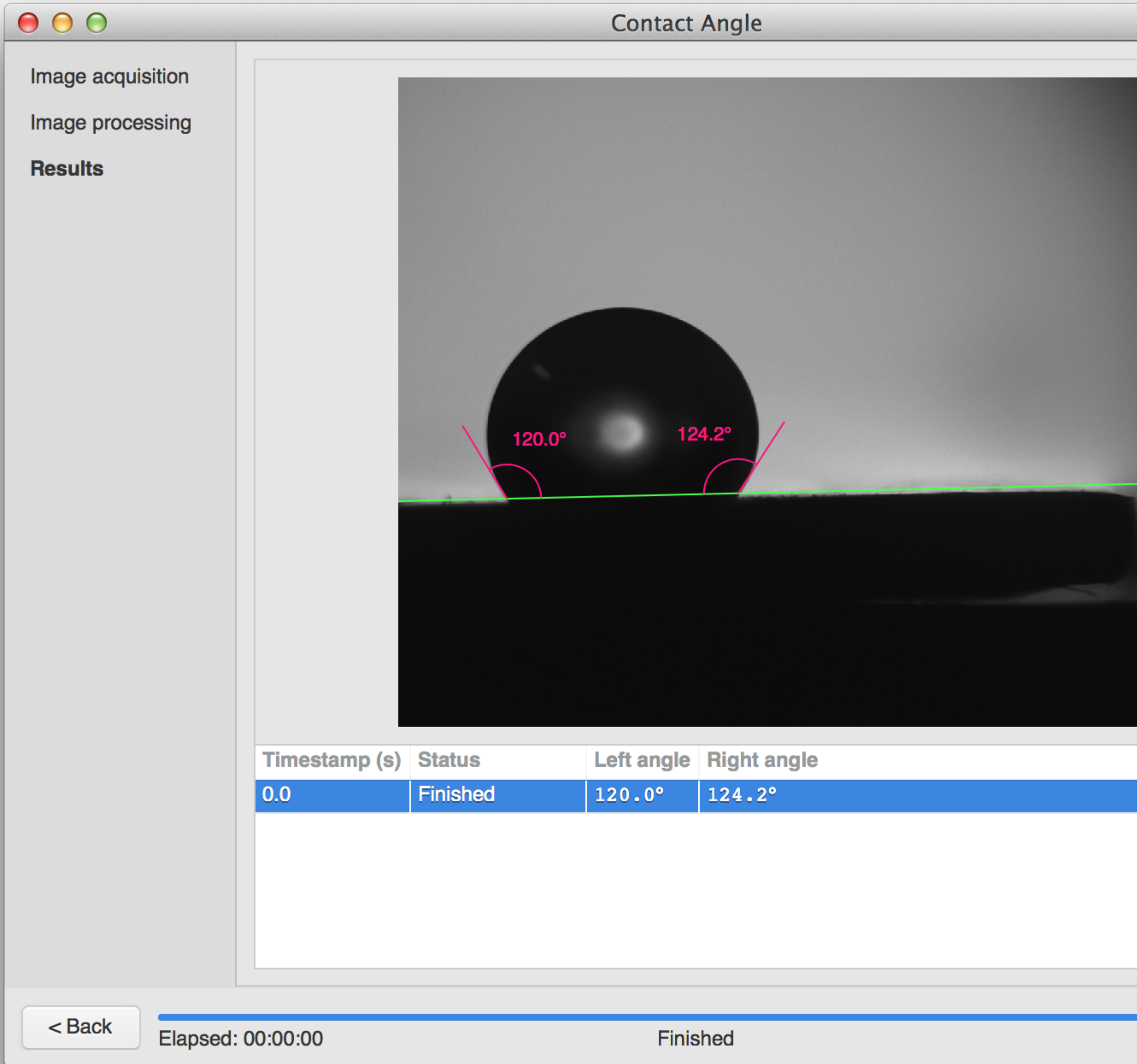
Once the drop region is defined, a blue outline will be drawn over the preview showing the drop profile that has been extracted.

The intersection angle between the drop profile and the surface line will be the contact angle measured.

In a contact angle analysis, OpenDrop uses image thresholding to separate the foreground from the background. Click on the 'Foreground detection' button to open a dialog bubble which will allow you to adjust the threshold value. A blue overlay is painted over parts of the image deemed to be in the foreground.

Click on 'Start analysis' to begin analysing the input images, or begin capturing and analysing images if using a camera.

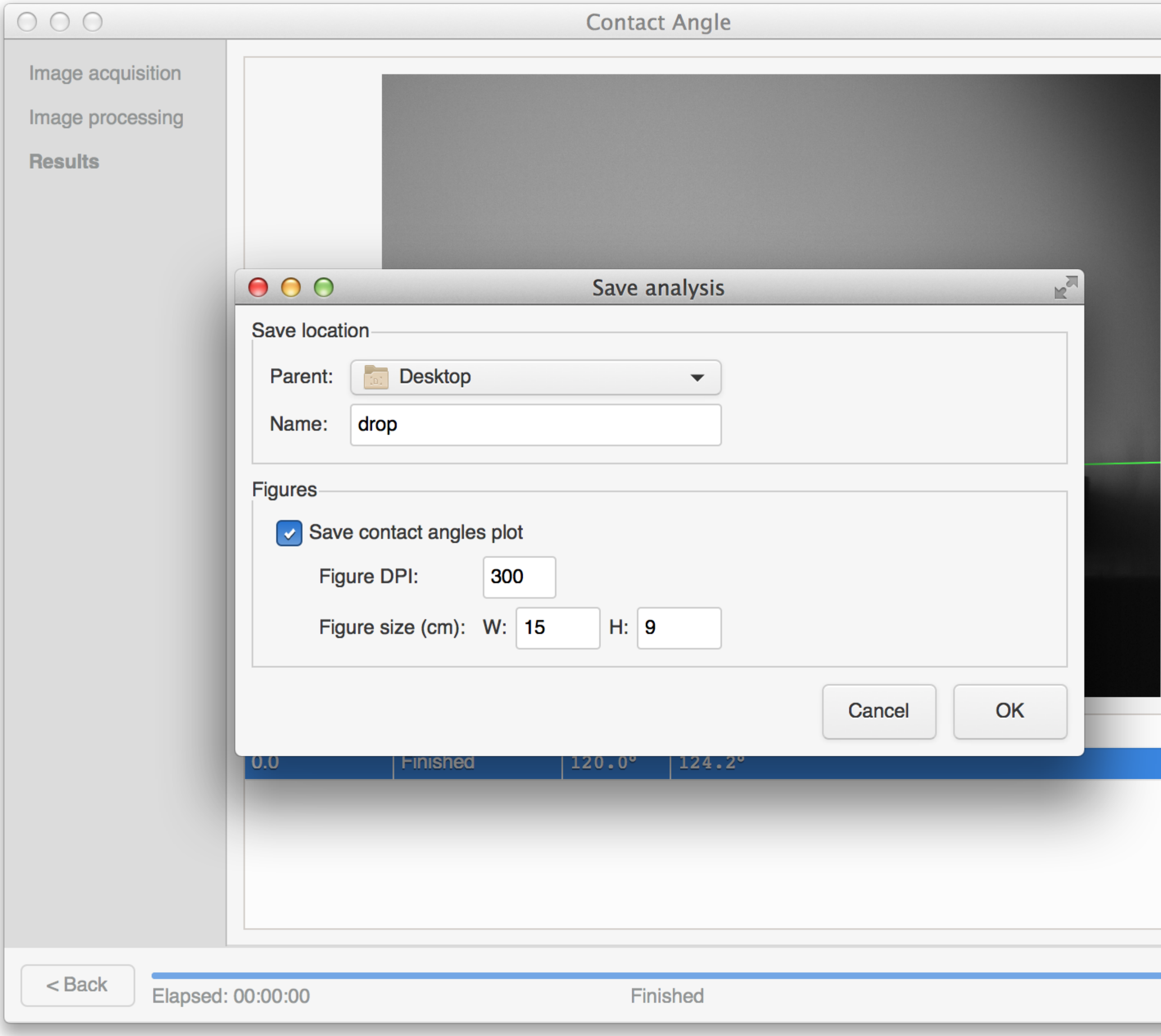
3.2.3 Results



The results page for a contact angle analysis is quite simple.

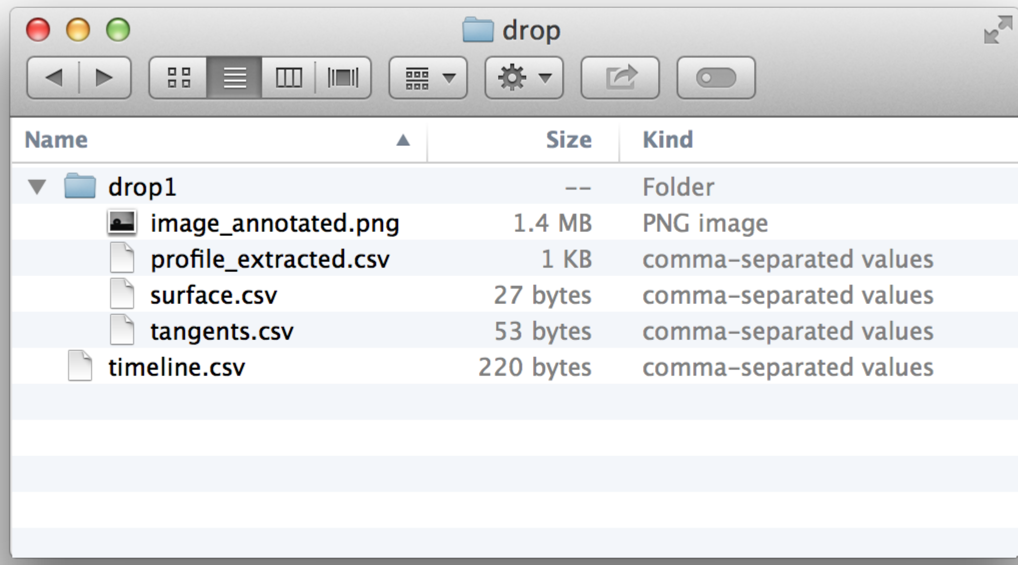
A summary table is shown on the bottom half with a results visualizer on the top half. Graphs of the left and right contact angles are also available if more than one image is analysed.

3.2.4 Saving



Once an analysis is finished, click on the 'Save' button in the footer to open the save dialog. All data will be saved in a folder with name determined by the 'Name' entry, and in a parent directory determined by the 'Parent' selection.

As a convenience, you may choose to save some pre-made plots.



An example save output is shown above, and screenshots of the contents of some files are shown below. (All coordinates are with respect to the origin being on the top-left corner of the image with increasing x and y in the right and down directions respectively.)

	A	B	C	D	E	F
1	Time (s)	Left angle (degrees)	Right angle (degrees)	Left contact x-coordinate (px)	Left contact y-coordinate (px)	Right contact x-coordi
2	0	120	124.2	171.5	664.3	
3						
4						
5						

Fig. 6: timeline.csv

	A	B
1	629	660
2	629	660
3	627	659
4	625	659
5	617	661
6	607	660
7	601	660

Fig. 7: drop1/profile_extracted.csv (each row is an (x, y) coordinate pair)

	A	B
1	-2.36E-02	6.68E+02

Fig. 8: drop1/surface.csv (The coefficients of the surface line; first column is gradient, second column is y-intercept)

	A	B
1	1.64E+00	3.83E+02
2	-1.55E+00	1.49E+03

Fig. 9: drop1/tangents.csv (The coefficients of the tangent lines at the contact point. First row is left tangent, second row is right tangent. First column is gradient, second column is y-intercept)

3.3 GenICam integration

Install a GenTL producer, (e.g. see harvesters README).

OpenDrop checks the environment variable GENICAM_GENTL64_PATH (specified by the GenTL standard) for GenTL producers. To verify that a GenTL producer is installed correctly, you can run:

```
$ echo $GENICAM_GENTL64_PATH
/opt/mvIMPACT_Acquire/lib/x86_64
```

(todo: Add details.)

3.4 Notes

User input validation is not yet implemented, invalid user input may cause OpenDrop to crash or print errors to the console.

CHAPTER 4

Developer notes

Stub.

OpenDrop is a fully-featured image analysis software for performing pendant drop tensiometry and contact angle measurements. Images can be loaded from the file system or acquired directly from USB webcams or GenICam (GigE Vision, USB3 Vision) compliant industrial cameras.

The software is released under the **GNU GPL** open source license, and available for free.

For installation instructions, see "*Installation*".

Git repo:
https://github.com/jdber1/opendrop/

Questions, issues, or feedback:
https://github.com/jdber1/opendrop/issues