



## USER GUIDE

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# TABLE OF CONTENTS

OVERVIEW .....	3
FILE COMPATIBILITY .....	4
ALGORITHM SETTINGS .....	5
Void Filter .....	5
Expected SWE Variations .....	5
IMPORT AND DEFINE SWE RATE .....	7
Importing Methods .....	7
Manually Define SWE Frames .....	8
FILE PROPERTIES.....	9
VIDEO FILES EXTRA SETTINGS .....	10
Ultrasound and Color Map Layouts .....	10
Image Scaling.....	11
DRAW FORMS IN FRAMES.....	12
PROCESS DATA .....	14
REVIEW AND EXPORT RESULTS .....	15
Zoom Window .....	15
Chart View .....	16
Exporting .....	16
Live Mode .....	17
Compatibility .....	17
Connect and Control an Ultrasound .....	17
Recording Frames.....	18
Data Process or Auto-Process .....	18

# OVERVIEW

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The ElastoGUI application is a graphical user interface dedicated to analyzing shear wave imaging data in images or clips recorded with specialized ultrasounds. The ElastoGUI application assists in drawing dimensional areas of interest of different shapes (i.e., polygons, rectangles, or circles) in the desired ultrasound frame. The application also facilitates a batch processing for the delimited color map region(s) in all frames, corresponding to the shear wave imaging (SWE) rate in all imported files. From the delimited color map region(s) in frames, the ElastoGUI application processes young modulus (maximal value, mean, and standard deviation), shear modulus (mean and standard deviation), shear wave velocity (mean and standard deviation), and surface area.

Drawing tools facilitate editing form shape and sizing across frames and files. It also helps to keep forms in the exact same between files.

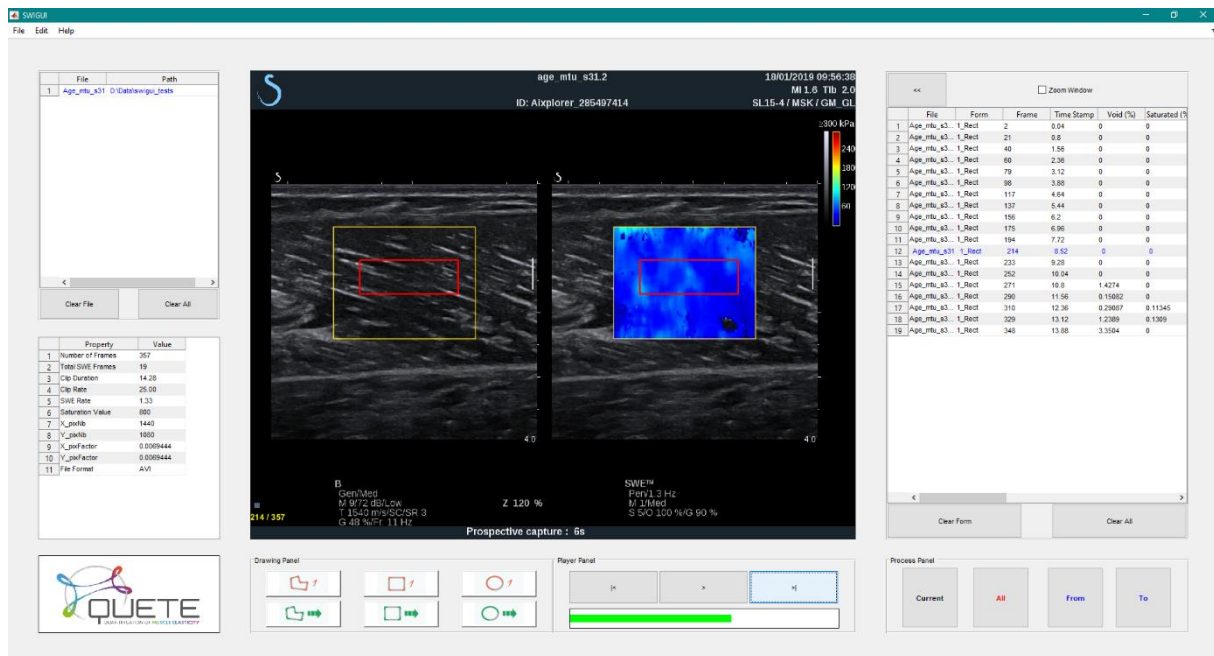


Figure 1. ElastoGUI main window

## FILE COMPATIBILITY

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By default, the ElastoGUI application can import both video (i.e., AVI and MP4) and DICOM files, directly from specialized ultrasounds. Functional tools to import these file formats are in a user folder labeled “userFcn”, downloaded with the ElastoGUI application. The user folder can be located anywhere in a user’s computer; however, its path must be defined at first application opening (or every time the user changes its location) in the “Edit > User Settings > Set Importing Path” menu.

Either DICOM images or clips can be imported from the ElastoGUI application. Since the DICOM file format already includes most file properties required to make the application function properly, this file format will not require additional user interventions (e.g., layout tracking, image scaling). However, video files require the ultrasound and color map layouts to be checked and the image to be calibrated at importing time (refer to “Video Files Extra Settings” section).

**Warning:** Since methods to extract frames from video files vary between operating systems and Matlab® versions (e.g., mmreader / VideoReader Matlab classes, ffmpeg codec), a user can edit the “avi.m” and “mp4.m” functions in the user folder to import frame from video files easily.

*N.B. It is recommended to save the original “avi.m” and “mp4.m” files in another location before editing to reuse them a later time.*

**Warning:** Since DICOM file tree varies between different hardware sources, a user can edit the “dcm.m” function in the user folder for predefined DICOM fields to match the user ones.

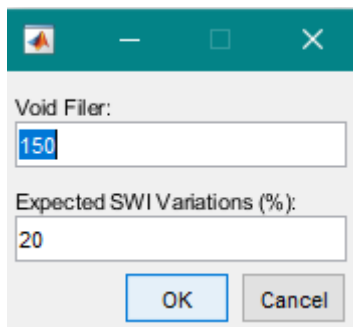
*N.B. It is recommended to save the original “dcm.m” file in another location before editing to reuse it a later time.*

## ALGORITHM SETTINGS

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The ElastoGUI application uses algorithms for image inspection. Some algorithm settings might be adapted according to user's file characteristics (e.g., low color map variations across clip frames). Customizable settings can be edited through the "Edit > Algorithm Settings" menu.

*N.B. Editing settings remain between application openings; thus, it is a good practice to check the settings when reopening the application.*

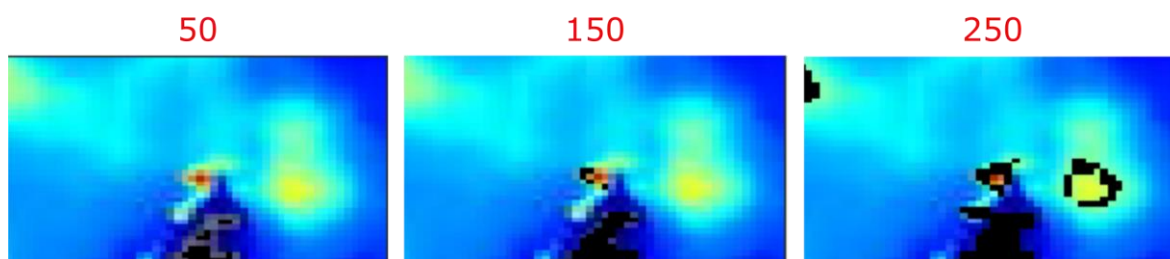


**Figure 2.** Algorithm settings window

### Void Filter

This setting defines the threshold at which the algorithms consider a pixel with color or without color (void pixel). The lower the void filter, the less sensitive the color requirement (refer to Figure 3 for more examples). This setting is important to determine the void pixel ratio in the results and to exclude void pixels from the analysis of other result variables.

## Void Filters Examples

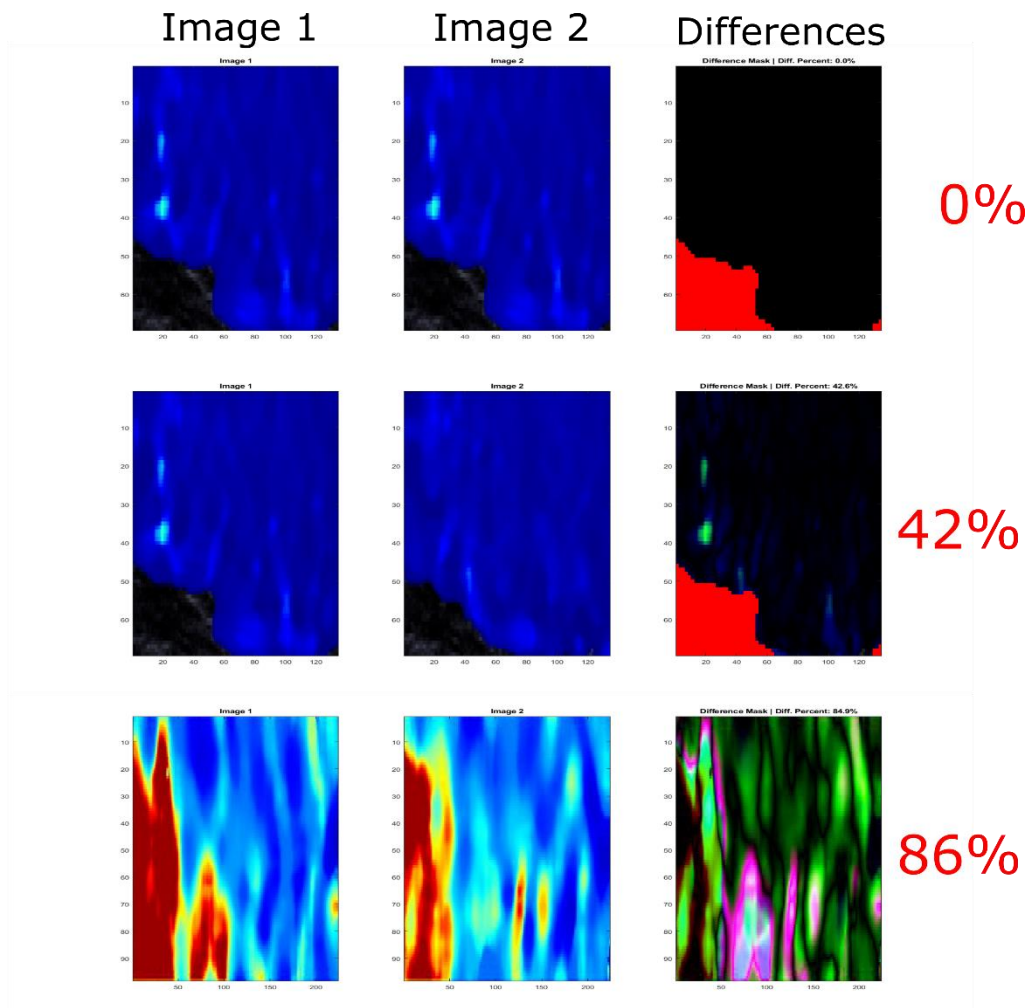


**Figure 3.** Examples of a color map with different void filters (i.e., 50, 150, and 250). Void pixels are in black on the color map.

### Expected SWE Variations

To determine the SWE rate in the clip, algorithms inspect variations in SWE color map across frames of the entire clip. The 'expected SWE variations' setting defines the expectation of variable color pixels across frames. The user should adjust the expected SWE variations setting low enough to detect actual variations in the color map and high enough to avoid being misled by noisy variations.

Expected SWE variations value must be numerically ranging between 0 and 100; the lower the value, the lesser the variation of the SWE color map (refer to Figure 4 for more examples).



**Figure 4.** Examples of color map comparison between images. The right image of each row represents the differences between the images on the left and in the middle of the same row. Percent of differing value, indicated in red on the right, is the percent of the pixel that differs between images. To define two images as different, the expected SWE variations' setting must be higher than the actual percentage of the difference. Void pixels, represented in red on a different image, are excluded from the calculations.

*Tips: If the user encounters troubles with its files (e.g., wrong automated SWE rate detection), editing these settings might fix them.*

# IMPORT AND DEFINE SWE RATE

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## Importing Methods

Since SWE data are not sampled at the same rate with the clip rate, not all frames should be considered in the analysis (results of the application returns based on SWE rate and not on clip rate). Therefore, the ElastoGUI application offers different methods to import frames and to define SWE rate in files. A user can import files with the three following methods, which can be selected through the “Edit > User Settings > Set Importing Method” menu:

### 1) All Frames

All clip frames are imported, and the application automatically defines SWE rate based on color map variations (refer to “SWE Color Variations” method below). If the user is unhappy with the automated SWE rate detection, frames of interest can manually be defined through the “Edit > Define SWE Rate” menu (refer to “Manually Define SWE Frames” below).

### 2) Fixed Rate

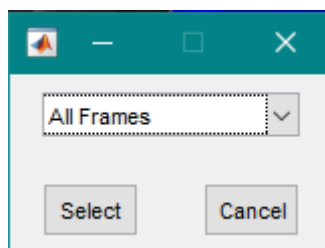
The application requests the user to manually enter the SWE rate at importing time; then, frames are imported using the following constant step from the first to the last clip frame:  $\text{Step} = \text{Total Frame Number} / (\text{Clip Duration} * \text{SWE Rate})$ .

### 3) SWE Color Variations

Based on a customizable “Expected SWE Variations” setting (refer to “Settings” section below), the application uses an algorithm to automatically detect color map variations among all clip frames and imports only frame that detects a significant variation in the color map.

*N.B.1 Not all frames are imported using “Fixed Rate” and “SWE Color Variations” importing methods. It is recommended to use “All Frames” method, then, manually define the frames to work with (refer to “Manually Define SWE Frames” below for a customized SWE rate).*

*N.B.2 For time efficiency, it is recommended to first try editing “Expected SWE Variations” setting before using a different importing method. Algorithms for SWE pixel variation tracking might be successful with the proper setting value.*



**Figure 5.** Importing method settings window

*Tips: To import file(s), you can either navigate "File > Import File(s)" or drag and drop file(s) from the file explorer to the ElastoGUI window.*

*Tips: The application helps to import multiple files. In this case, the user can navigate between files by selecting a file from the file lists in the top left panel of the ElastoGUI main window.*

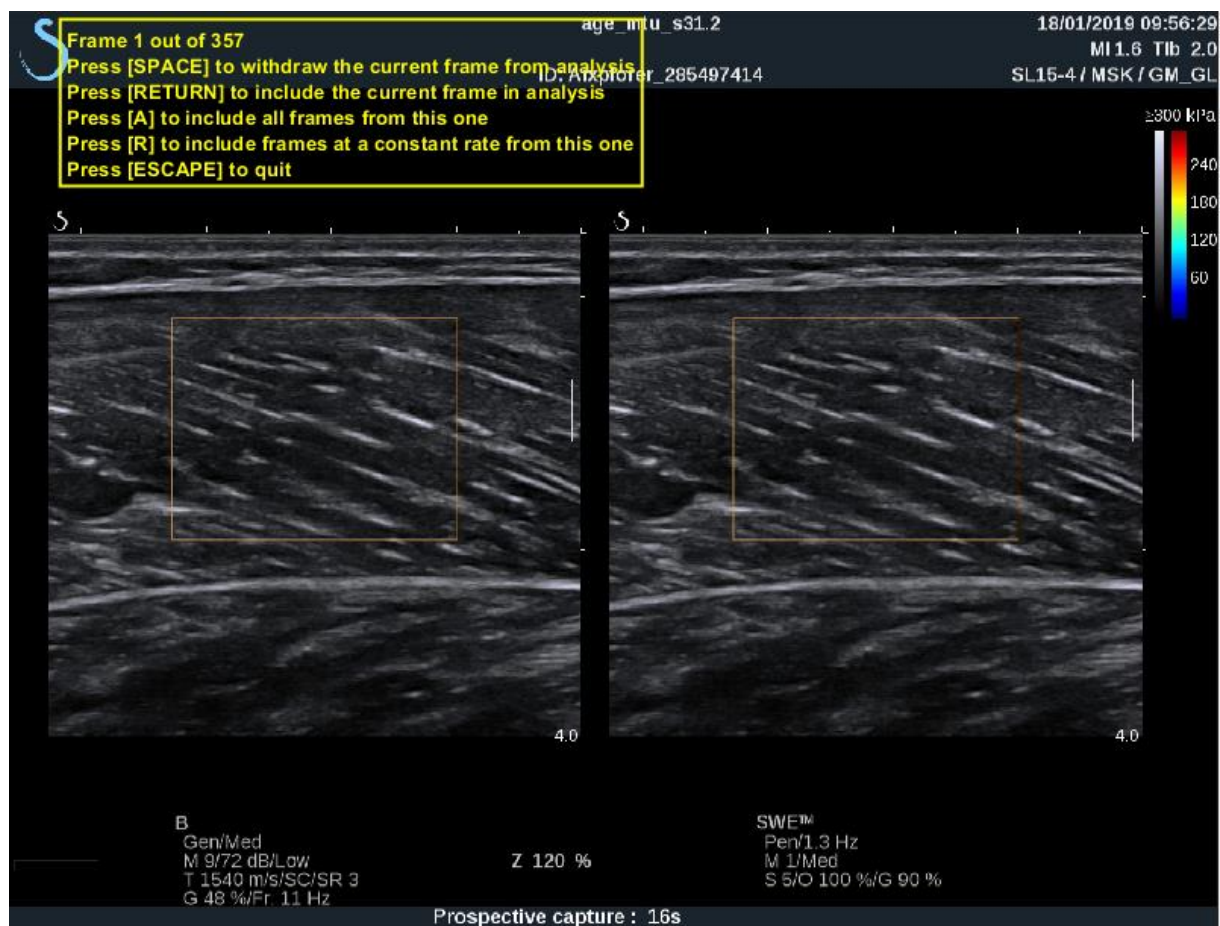


## Manually Define SWE Frames

The user can manually define frames for the analysis of the current file through the “Edit > Define SWE Frames” menu. This menu allows the user to include or withdraw frames from all imported clip frames.

Use the following keyboard commands to define SWE frames:

- [SPACE] Withdraw current frame from the analysis
- [RETURN] Include the current frame in the analysis
- [A] Include all remaining frames in the analysis (i.e., after the current frame)  
*N.B. This command is an alternative way to import all frames; however, it facilitates skipping the first few frames if necessary (i.e., using successively SPACE and A commands).*
- [R] Include frames at a constant rate in the analysis from the current one  
*N.B. This command is an alternative way to import frames at a fixed rate; however, it enables skipping first few frames if necessary (i.e., using successively SPACE and R commands).*
- [ESCAPE] Quit the menu



**Figure 6.** View of “Define SWE Rate” settings window



## FILE PROPERTIES

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In the ElastoGUI application main window, the <Properties panel> displays some properties in the current file. These properties can either be defined in user importing functions (refer to “dcm.m” or “avi.m” files for examples) or require the user to define them manually (e.g., an SWE saturation value).

The user must manually enter the SWE saturation value for each imported file; this value is readable above the color scale on the image. Saturation value can also be entered at processing time; however, it is recommended to enter a saturation value before processing to avoid slowing down the processing time.

If using “All Frames” or “SWE Color Variations” importing methods, the user must confirm that algorithms detect the SWE Rate property correctly (this inspection can fail for some reasons owing to the clip quality or SWE color map layout detection).

# VIDEO FILES EXTRA SETTINGS

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Unlike the DICOM file format, video clips do not have the essential properties that can make the application function properly. To help the user configuring missing settings, the application automatically pops up successive windows when the user imports video file formats.

## Ultrasound and Color Map Layouts

### Step #1

The first window that pops up after the user selects a video file helps to verify the automated tracking of ultrasound layouts (i.e., ultrasound scanned fields). Owing to a bad image quality (e.g., too dark contrast, lack of gel, absence of contact between skin and probe), the user may edit automated tracking using the following commands:

- [F1]            Edit ultrasound layout edges
- (1)    Hold left-click on box corners and drag to resize the first layout edges  
        Hold left-click on the box center and drag to move the first layout  
        Right-click to end box editing
  - (2)    Hold left-click on the box center and drag to move the second layout  
        Right-click to end box editing  
        *N.B.: The second layout is non-resizable, and it is automatically aligned with the first layout according to their respective positions (superimposed or side-by-side).*
- [F9]            Edit the threshold value used for automated detection of layout edges. Use a low threshold value for dark contrast
- [SPACE]        Validate editing and quit preview (**DO NOT CLOSE THE FIGURE**)

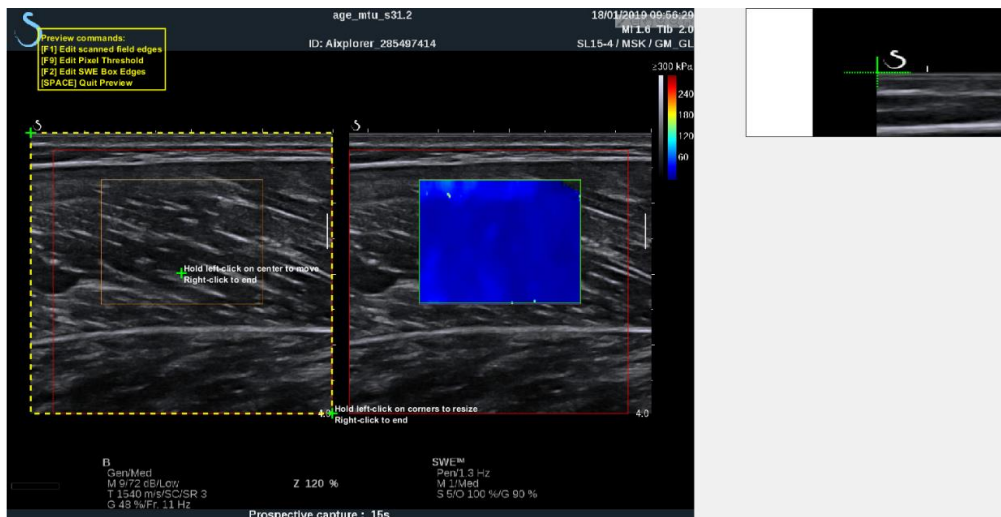
### Step #2

After confirming ultrasound layouts, a second window pops up to define which of the two ultrasound layouts includes a SWE color map. The user must left-click the desired layout.

### Step #3

Finally, the last window that pops up helps the user to check the automated tracking of the color map. If the color map is badly filled on the image, the user might edit the color map layouts using the following commands:

- [F2]            Edit SWE layout edges
- (1)    Hold left-click on box corners and drag to resize the SWE layout edges  
        Hold left-click on box center and drag to move the SWE layout  
        Right-click to end box editing
- [SPACE]        Validate editing and quit preview (**DO NOT CLOSE THE FIGURE**)



**Figure 7.** View of ultrasound and color map layouts. Ultrasound layouts and SWE color map layouts are represented by red and green rectangles, respectively. The top right window helps the user to edit layout edges.

### Image Scaling

After the entire frames have been imported, the user must finally perform an image scaling, using the following instructions. This helps parameters (i.e., form area), calculated at the ElastoGUI application, to be calibrated in the metric unit:

- Adjust the red segment (with green markers) to match the actual image scale in either X or Y dimension
- Double left-click to change segment orientation (i.e., scale dimension to inspect)
- Hold left-click on markers and drag to move segment
- Right-click to end image scaling
- Enter the metric value that matches the pixel size given by the segment dimension in the displayed pop-up window. Or click "Cancel" button to redo the image scaling or skip the file



**Figure 8.** Examples of Image scaling window. The left panel shows an example of image scaling using image depth scale, and the right panel shows an example of image scaling using image width scale.

*N.B.1 Note that if multiple files are imported at the same time, the same image scaling can be used for all imported files. This option automatically prompts to the user after a first image scaling has been performed.*

*N.B.2 Conversely, if the user already knows the calibration values in both pixel and the metric units, they can right-click the image directly and enter these values in the window prompting.*

# DRAW FORMS IN FRAMES

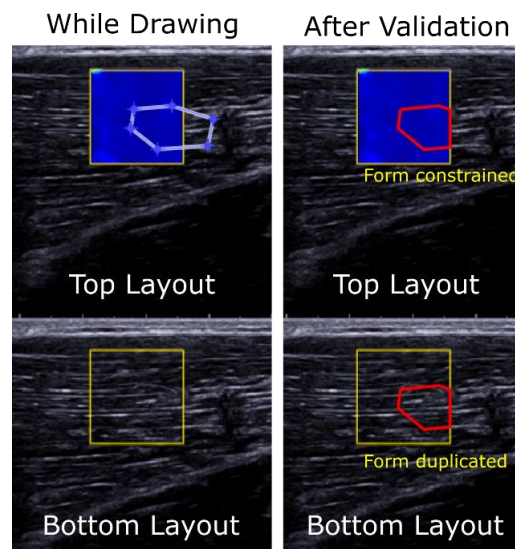
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To draw forms in the current file, click one of the buttons in the <Drawing Panel>.



**Figure 9.** Drawing panel

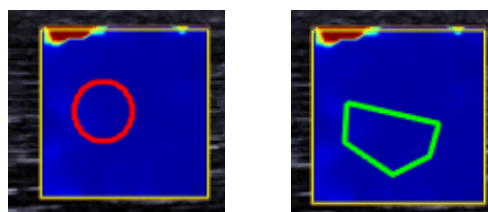
Polygons, rectangles, and circles can be drawn inside SWE color map edges (in both layouts). Each element drawn in one layout is automatically duplicated. Note: any form that exceeds the SWE color map edges is automatically constrained inside the SWE color map edges after creation (refer to Figure 10).



**Figure 10.** An example of polygon drawing in the top layout. The drawn polygon is automatically duplicated in the bottom layout (it is possible to perform the opposite) and it is constrained inside SWE color map edges since some form portions exceed edges.

Forms can either be of 'single' (i.e., red forms) or 'persistent' (i.e., green forms) type. **Single** forms apply to all frames of the current imported file, whereas **persistent** forms apply to all frames of all imported files.

*N.B. Single and persistent forms appear in colored at the ElastoGUI main window when the current frame is included in the analysis; however, both appear in gray if the current frame is excluded from the analysis.*



**Figure 11.** Examples of single and persistent forms

## Creation

Choose the form shape (polygon, rectangle, or circle) and type (**single** or **persistent**) to draw

- Polygon:
  - (1) Left-click and release to draw a point of the polygon
  - (2) Left-click on the first point drawn to close the polygon
  - (3) Hold left-click on the form and drag to move it (optional)
  - (4) Double left-click to end the polygon creation
- Rectangle:
  - (1) Hold left-click and drag to draw the rectangle
  - (2) Release to end the rectangle creation
- Circle:
  - (1) Hold left-click and drag to draw the circle
  - (2) Release to end the circle creation

*Tips: The user can zoom in one of the two-color map layouts by pressing [F5] and [F6] keyboard commands or reset the full window view by pressing [F4] keyboard command.*

## Editing

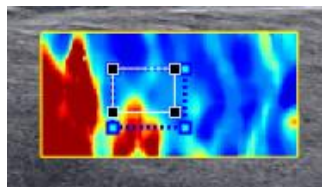
A user can edit some drawn forms properties by right-clicking an existent form on the image. The menu pops lists the following options:

Enable/Disable Persistence: This option changes the form type from single to persistent or inversely. Note that changing the form type from persistent to single will convert the form single to the current file.

Edit Once/From Here: This option enables the editing of the form shape. Editing depends on the form type.

- Polygon:
  - (1) Hold left-click polygon's markers and drag to change its shape and size
  - (2) Hold left-click the middle of the polygon and drag to move the polygon without modifying its shape and size

*N.B.: it is impossible to add/delete markers in the form.*
- Rectangle:
  - (1) Hold left-click rectangle's corners and drag to resize the rectangle
  - (2) Hold left-click the middle of the rectangle and drag to move the rectangle without modifying its size
- Circle:
  - (1) Hold left-click the circle's edge and drag to resize the circle
  - (2) Hold left-click the middle of the circle and drag to move the circle without modifying its size



**Figure 11.** Example of rectangle size editing

Rename: This option enables the editing of the name associated to a form. Note that renaming the form after processing will not rename the form in the results panel.

Clear: This option clears the form of the current file (if the form is of a single type), or clears all files (if the form is a persistent type).

## PROCESS DATA

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After verifying file(s) properties and drawing at least one form, the user is ready to launch file processing. To process SWE data inside the drawn form(s) through the file(s), click one of the buttons in the process panel:

<u>C</u> urrent:	This option processes forms associated to the current file.
<u>A</u> ll:	This option processes all forms associated to all imported files.
<u>F</u> rom:	This option processes forms associated to the current file and to the following files in the imported file list.
<u>T</u> o:	This option processes forms associated to the current file and to the previous files in the imported file list.

*N.B.1 If key settings (e.g., saturation value) are missing from the processed file, a pop-up window is displayed notifying the user to enter the missing setting.*

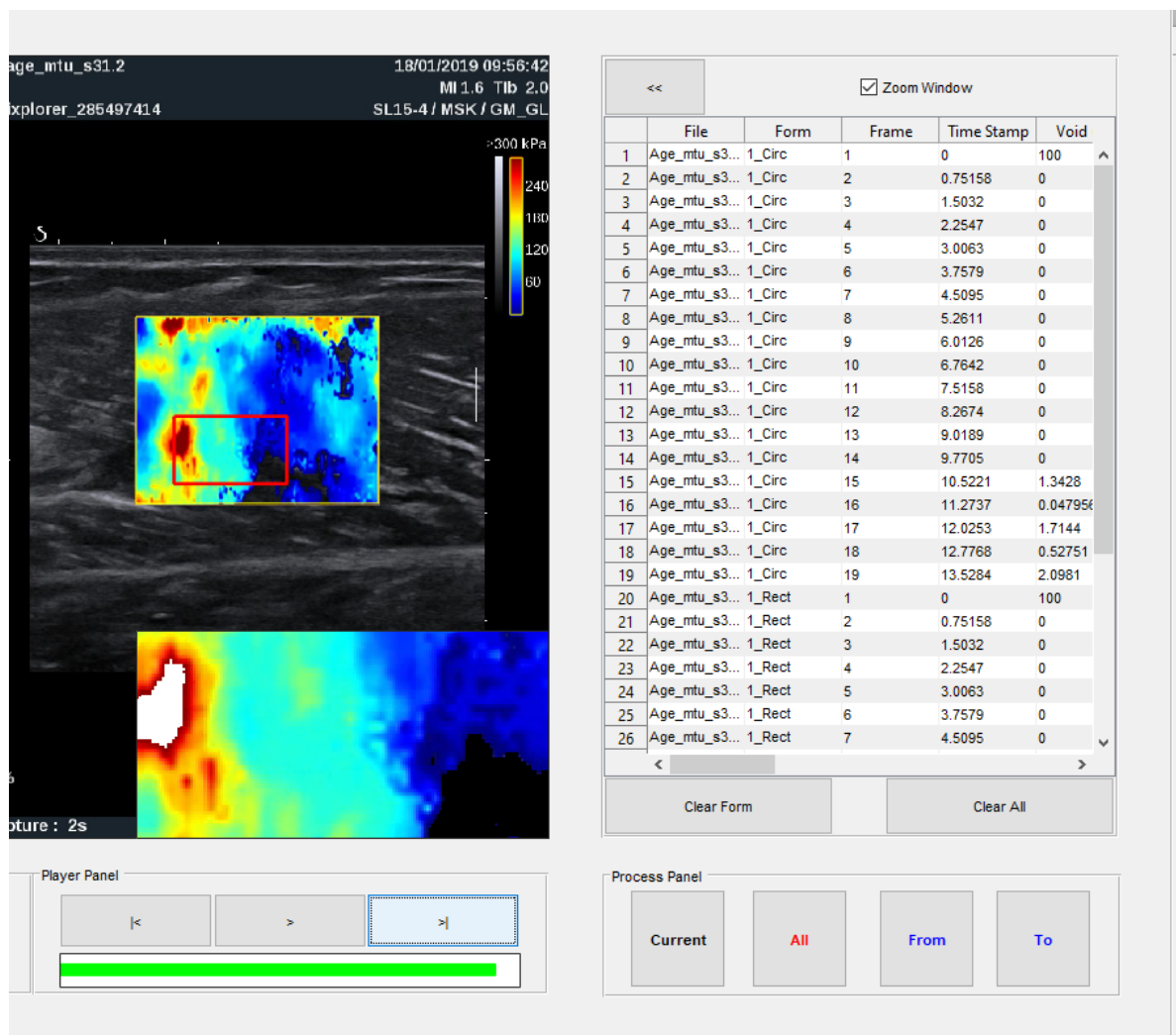
*N.B.2 Results of the processed files are stacked in the results panel. Results are erased when a form already exists in results of the processed file.*

## REVIEW AND EXPORT RESULTS

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### Zoom Window

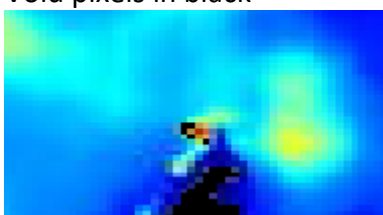
After processing SWE data, results are displayed in the <Results Panel>, ordered by file and form names. By left-clicking a line in the panel, the associated frame is displayed on the graph window. By clicking the 'Zoom Window' checkbox, the color map of the current file/form/frame displays an enlarged window in the bottom right corner of the graph window. In this enlarged color map, void and saturated pixels are shown in black and white, respectively.



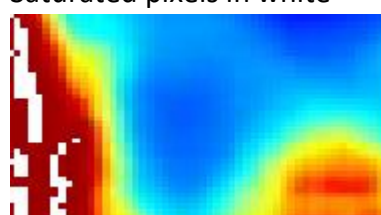
**Figure 12.** Results panel and zoom window

### Zoom window legend:

Void pixels in black



Saturated pixels in white

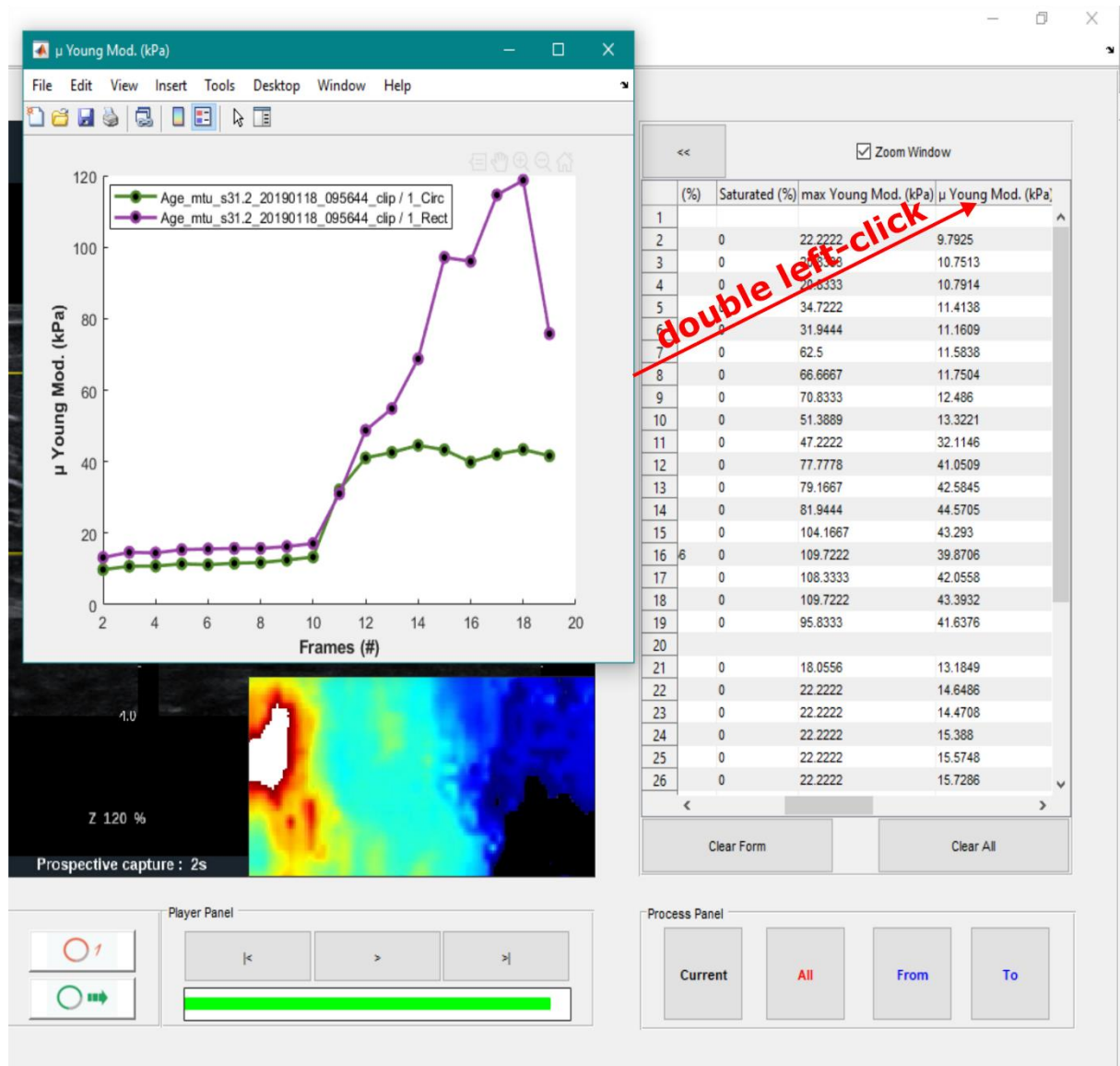




## Chart View

To display a specific variable for all frames, forms, and files in a separate chart view, double left-click on the column name of the desired variable in the results table.

*N.B. line colors are randomly assigned at each chart view opening.*



**Figure 13.** Chart view of a selected variable.

## Exporting

To export results displayed in the <Results Panel>, go to “File > Export Results” menu. Enter path, filename and choose the file extension among '.mat' or '.csv' formats to save the list of results as displayed in the <Results panel>.

# LIVE MODE

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## Compatibility

For the current release, the live mode is only compatible with Aixplorer® ultrasounds, using the SonicLab library. ElastoGUI software does not embed this library; therefore, a user must get a personal SonicLab library and add it to the Matlab® path.

*N.B. For different ultrasound brands controlled by Matlab® (using libraries), please contact the authors.*

## Connect and Control an Ultrasound

To connect an ultrasound, the user must follow these steps:

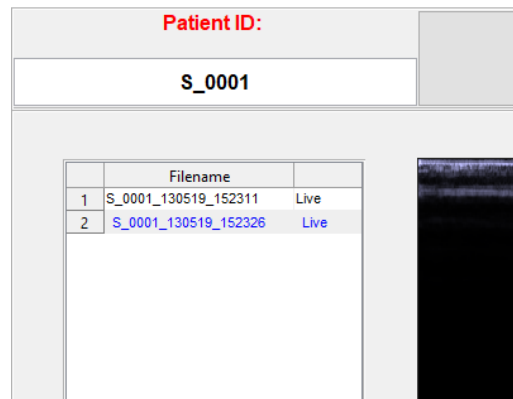
- Connect the ultrasound to the computer running ElastoGUI using a network RJ45 cable;
- Start network access to the ultrasound settings (System Config. > Administration > Network tools > Start access)
- Configure local network IP address of the computer with a different IP address (only the last index must be different; e.g., 192.168.1.1 on the ultrasound and 192.168.1.2 on the computer). Leave the default netmask (255.255.255.0)
- Run ElastoGUI software and go to “Live > Connect an ultrasound” in ElastoGUI software, enter the ultrasound IP address (e.g., 192.168.1.1) and click “Connect” button

After these steps, a live panel will appear on the top of the software main window (refer to figure below), and a successful message appears in the Matlab® command line. Conversely, an error is displayed, and the user must double-check the connecting steps or report the error message to the authors.



**Figure 14.** Live panel with controllers

The live panel consists of controllers that control the connected ultrasound on the software, such as (un)freezing and switching between B-mode and SWE mode. Two additional controllers assist in getting a single frame or in listening to new frames acquired by the ultrasound. The live panel also has an editing area for defining patient ID that is associated with incoming data.



**Figure 15.** Patient ID labeling

## Recording Frames

Two ways to obtain live data from the ultrasound are:

- 1/ Use “Get Single Frame” button to obtain the current ultrasound image and associated SWE data. This controller can be used while ultrasound is either frozen or unfrozen.
- 2/ Use “Listen to ultrasound” toggle button to obtain a series of frames acquired by the ultrasound and stored in a software buffer. From here, different scenarios to manage buffer are:

### Start storing data in the buffer

*If the ultrasound is unfrozen when “Listen to ultrasound”, the button is activated; image and data are stored in the software as soon the button is activated.*

*If the ultrasound is frozen when “Listen to ultrasound”, the button is activated; image and data are stored in the software as soon ultrasound is unfrozen.*

### Stop storing data in the buffer and get data

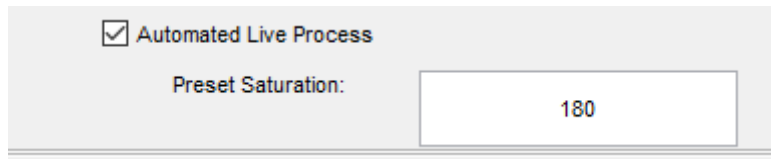
*If the “Stop listening” button is deactivated while ultrasound is unfrozen, the software buffer stops acquiring data, and data are directly thrown in the software as a new file in the file panel.*

*If the “Freeze” button is clicked (from the software or from the ultrasound) before deactivating “Stop listening” button, data ceased to be stored in the buffer; however, data will only be thrown in the software when “Stop listening” button is deactivated. Note that if ultrasound is unfrozen again before deactivation of “Stop listening” button, the software buffer will be empty, and data will start to be stored from that moment.*

## Data Process or Auto-Process

In live mode, incoming SWE data come as raw numerical SWE data. Therefore, the software only handles these raw data rather than RGB pixel recognition for processing. Live images also look different than the offline mode. Indeed, images come directly from the reconstructed ultrasound probe captured in live mode, whereas images look like they appear on the ultrasound screen in offline mode.

Despite these differences, processing tools and procedure are the same in live mode and in analysis mode.



☒ Automated Live Process

Preset Saturation:

**Figure 16.** *Auto-process options section*

In live mode, it is possible to activate the auto-process option to auto-process SWE data as soon as they are retrieved from the software buffer. To enable this option, the user must set the saturation value to associate with incoming files (i.e., saturation set on the ultrasound) and drawn a **persistent** form in a first file to be automatically reused for next incoming files. It is recommended to get a single frame first, then, set saturation value and draw a **persistent** form on this file (you can either decide to analyze this first file) to activate auto-process. Then, the user is ready to acquire frames in auto-process mode. If the user wants to edit either the shape of the drawn form or saturation value, a new single frame should be retrieved and the desired **persistent** form and saturation value should be applied on the new frame before getting new frames.