

DUKE UNIVERSITY

AnnotateVessels V1.0 Manual

Manual version: 1.0

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9/21/2016

Contents

Introduction	2
Interface	2
Importing Data	4
Exporting Results	5
Exporting Images.....	5
Annotation Controls.....	5
Analysis	8

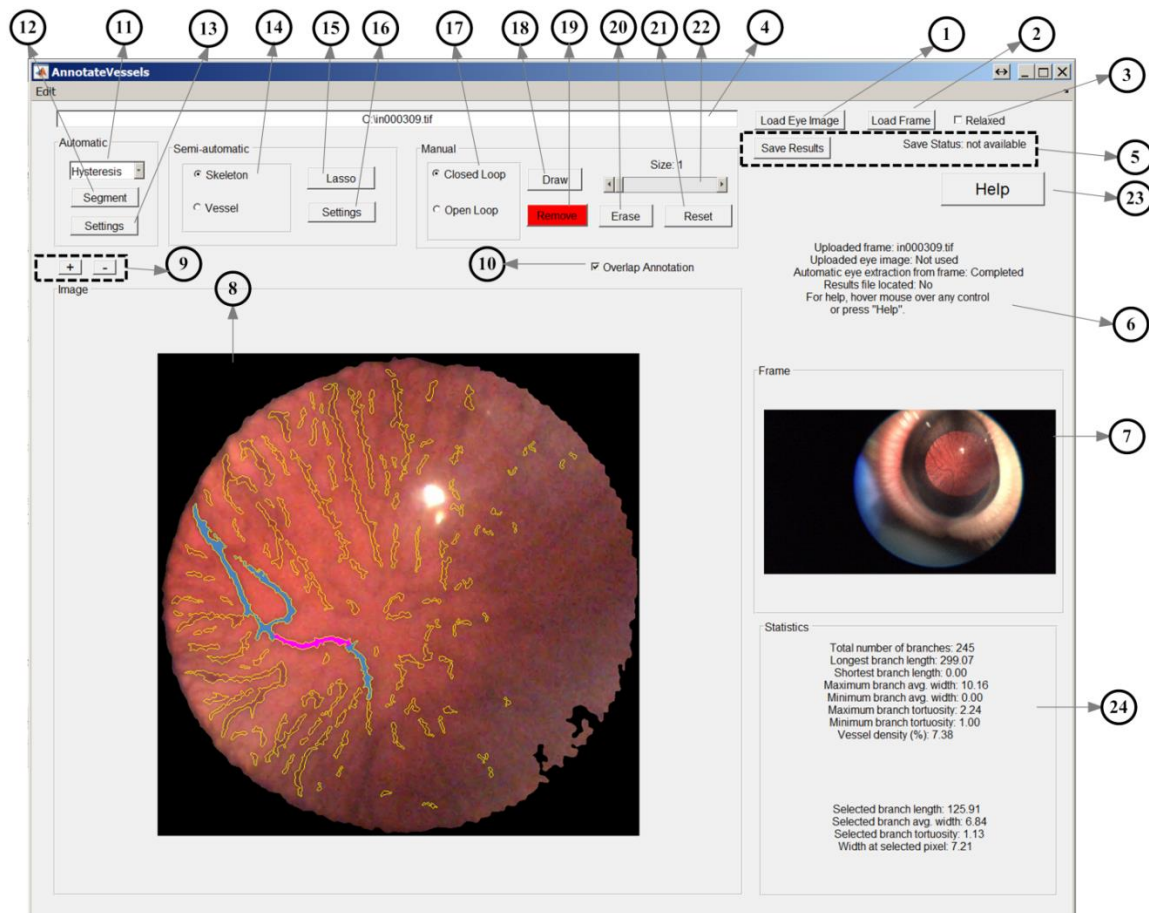
Introduction

AnnotateVessels is a software for annotating vasculature on eye images captured using an iPhone, and save the annotation as a groundtruth data. The software has the option to upload eye images (containing only eye regions) or images containing eye as well as other facial/non-facial regions. In the latter case, eye region is automatically extracted. Provision for manual extraction of eye region is also present.

The software provides options to annotate vasculature automatically, semi-automatically or manually. Currently, it has four automatic segmentation algorithm and a magnetic lasso tool to guide semi-automatic annotation. Freehand draw/erase options are available as part of manual annotation. An approximate statistics of vasculature (length, width, density etc.) is also computed and displayed in real-time. Finally, saved annotation (in .mat format) can be automatically pulled up if exists, and modified as desired.

Interface

The interface is simple and intuitive as shown in Fig. 1. The functionality of each interface element is listed in Table 1.



Interface Element ID	Name	Type	Functionality
1	Load Eye Image	Button	Upload eye image (not a frame)
2	Load Frame	Button	Upload a frame containing an eye image
3	Relaxed	Check Box	Check to relax eye detection constrains
4	Image Address	Text Box	Shows the path to the uploaded image
5	Save Results	Button/Label	Saves annotation and shows save status
6	Status Label	Label	Shows the status of uploads and extraction
7	Frame	Image	Shows the uploaded frame (if any)
8	Main Window	Image	Displays the uploaded eye image (or frame)
9	Zoom In/Out	Buttons	Zoom in and out of the Main Window image
10	Overlap Annotation	Check Box	Show/hide overlap of annotation/segmentation
11	Auto-Seg Type	Popup	Select the type of automatic segmentation
12	Segment	Button	Apply the selected automatic segmentation
13	Auto-Seg Settings	Button	Show/Change auto-seg parameters
14	Semi-auto-seg Type	Radio Button	Annotate vessel skeleton / draw vessels
15	Magnetic Lasso	Button	Use magnetic lasso for annotation
16	Semi-auto-seg Settings	Button	Show/Change magnetic lasso parameters
17	Manual Seg Type	Radio Button	Close the drawn annotation automatically / keep it open
18	Draw	Button	Annotation freehand drawing
19	Remove	Button	Remove annotation by selection
20	Erase	Button	Annotation freehand erasing
21	Reset	Button	Reset annotation to the condition of uploading
22	Eraser Size	Slider	Change the eraser size
23	Help	Button	Open the user manual
24	Statistics	Label	Shows the vasculature statistics

For the rest of this document, row X in the table will be referred to as Table 1:X. Similarly, rows X,Y and X – Y will be referred to as Table 1:X,Y and Table 1:X-Y respectively.

The data importing options are located on the top-right corner (the buttons defined in Table 1:1,2). If a complete frame containing an eye (specifically, pupil) is loaded, the eye is automatically extracted and displayed on the main window (Table 1:8) while the frame is displayed on the frame window (Table 1:7). If only an eye is loaded, the frame window will be vacant.

The annotation can be done automatically (Table 1:11-13), semi-automatically (Table 1:14-16) or manually (Table 1:17-22). The semi-automatic and manual options are also available for eye extraction from frame, if for any reason the automatic eye extraction returns wrong or no results or the results are not up to the standards determined by the user.

At any time, annotation can be toggled on and off to determine the accuracy (Table 1:10). Zooming in and out of the image can be done for minute annotations (Table 1:9).

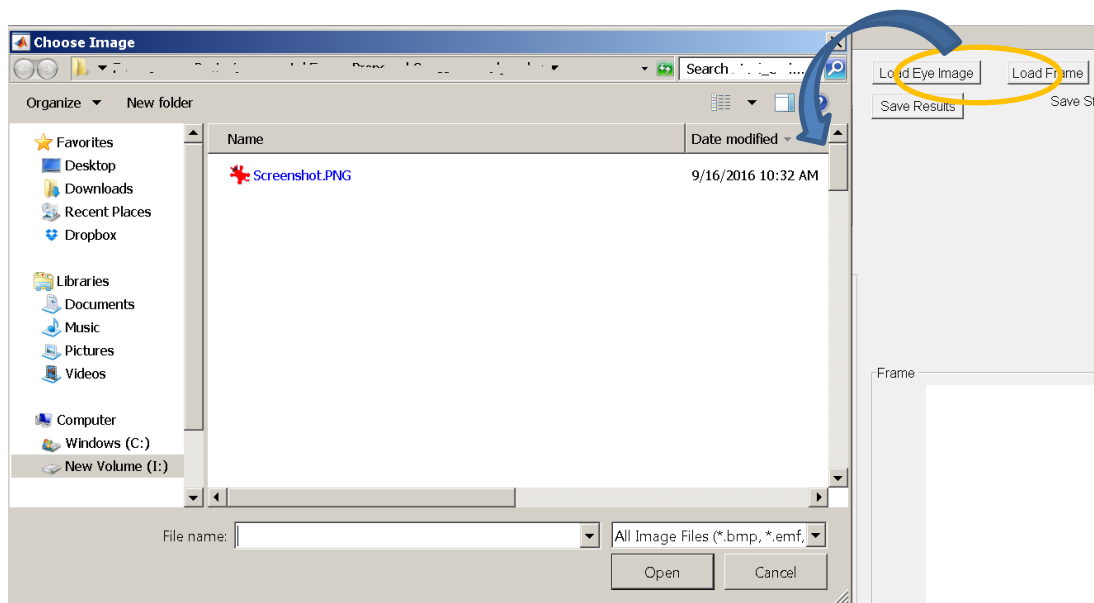
At any time, approximate annotation statistics will be displayed (Table 1:24).

Finally, the data can be saved at any time using the “Save Results” button (Table 1:5).

Importing Data

There are two types of data import:

- 1) Import eye images: import image containing only the eye (specifically, pupil) using the “Load Eye Image” button (Table 1:1). The software does not run the algorithm to extract the eye from this image, and readily puts the image on the main window (Table 1:8).



- 2) Import frame: a frame containing the eye image can be loaded using the “Load Frame” button (Table 1:2). Upon loading, the software automatically tries to find eye candidates from the image, and loads the best candidate in the main window (Table 1:8) while the frame itself is loaded in the frame window (Table 1:7).

If by any reason, the eye extraction algorithm fails to find an acceptable eye candidate, the user can semi-automatically or manually extract one. To do this, simply left-clicking on the frame window (Table 1:7) will show the frame image on the main window (Table 1:8). Afterwards, using the semi-automatic or manual annotation option, the eye region can be annotated. Upon completion of annotation, left-clicking on the frame window (Table 1:7) again will remove the frame from the main window (Table 1:8) and put the newly annotated eye image on it. If a previous eye image exists, the software will prompt the user to confirm the changes, when unloading the frame from the main window, since this operation is irreversible.

Exporting Results

If an eye image is successfully extracted (by the software or the user), the results can be saved at any time using the “Save Results” button (Table 1:5). The result is always saved with the same name as the uploaded image, and in the same folder. It takes an extension of .mat, readable through Matlab. The saving status is displayed in the corresponding label at any time (Table 1:5).

Re-uploading the image will automatically upload the result, if it exists. Hence, any annotation along with the image will also be uploaded and displayed in its exact saved form.

Note: any changes to annotation will only reflect in the results, if it is saved.

Exporting Images

Exporting annotation as images (.tif format) is easier. On the top-left corner of the software, the “Get Image” menu contains two menu items.

“Annotated Image” (shortcut key: Ctrl + L) saves the annotated vasculature (with an extension of “_SEG” after uploaded image name), the annotation overlapped on the uploaded/extracted eye (extension of “_OVERLAP” after uploaded image name). It also saves the eye image (extension of “_IMG” after uploaded image name) ONLY when the eye image is extracted, and not uploaded by itself.

“Annotated Frame” (shortcut key: Ctrl + K) saves the annotated vasculature (in yellow/blue) and eye image (in pink) overlaid on the frame image with an extension of “_OVERLAP_FRAME” after the uploaded frame name.

Annotation Controls

The software has several options for annotation, in three distinct categories.

- 1) Automatic: automatic annotation (Table 1:11-13) contains four algorithms for vasculature segmentation from eye images. Since these algorithms only apply to vasculature segmentation, the automatic annotation options are not displayed while annotating the frame image to extract an eye.
Since each type of segmentation has different algorithm to treat noises and illuminations differently, the results may vary from one to another. Hence, the user may keep the one mostly likely to be a vessel.
To perform an automatic annotation, the user needs to choose the type (Table 1:11) and click on the “Segment” button (Table 1:12). If there are existing annotations, the software will prompt the user to confirm whether to add the new annotation to the previous ones, or replace them with the new one.

At any point of time, the annotation can be undone/redone using Ctrl + Z/Ctrl + Y respectively.

There are several options for each of the algorithm. They can be found using the “Settings” button (Table 1:13). Changing a value and saving the changes may improve the segmentation in some cases. For details on the parameter values, please contact the developer team.

Figure 1: Auto Segmentation Setting

	Name	Value
1	CosFire Threshold:	37
2	Dijkstra Filter Threshold:	0.6000
3	Dijkstra Percentage Value:	0.7000
4	Dijkstra Raw Filtered Value:	0.6000
5	Hysteresis High Threshold:	0.0500
6	Hysteresis Low Threshold:	0.0200
7	Trace High Threshold:	0.5000
8	Trace Low Threshold:	0.0500

Save

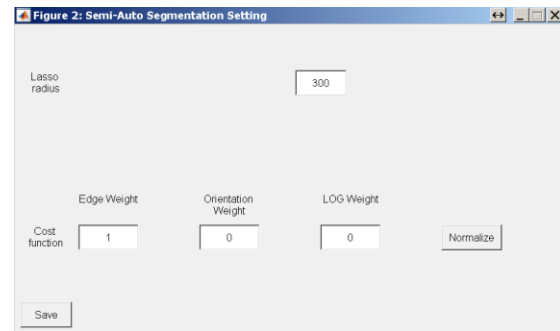
- 2) Semi-automatic: Semi-automatic annotation option consists of the magnetic lasso tool (Table 1:14-16) that turns red when turned ON. Magnetic lasso works by left clicking on the image to define anchor points. After defining an anchor point, moving the mouse over the image moves the lasso while sticking it close to the edges of the image. In this way, the user can choose the best path to the next anchor point to place. The next anchor point can be placed by left clicking again. Upon completing part of an annotation or to break the lasso, the user needs to right-click while moving the lasso by moving the mouse. The user can create as many lasso paths as require while the lasso tool is turned ON (red). While it is ON (red), clicking on the button (Table 1:15) again will turn it OFF. For an image with good contrast and well-defined edges, the annotation can be complete by placing only a few anchor points. However, for not-so-well defined edges, the user may need to put more anchor points close by.

Depending on the type of lasso (type is set from options – Table 1:14), the software processes the lasso after user breaks the lasso operation. If Skeleton is selected, the software assumes the lasso to represent the middle skeleton of a vessel, and tries to expand it on both sides to cover the complete vessel. If “Vessel” is selected, the lasso simply draws a vessel, and the software does not expand it.

Lasso is also available to extract an eye image from the frame image. In this case, the lasso is always “closed”. This means, if the user breaks the lasso at any point, the first and last anchor points are connected and the annotation is filled in.

The lasso tool has a few options. The lasso radius determines how far the lasso will be computed from an anchor point. If the radius is small, the lasso is computed for a smaller region (hence the user cannot hover to larger distances from the anchor point) but is faster to compute. Hence, depending on the configuration of the computer, the user should choose this carefully.

The cost function determines how the lasso should follow pixels in an image. By default, the cost function is edge based (with a weight of 1.0). However, provision for using edge orientation (Orientation Weight) and Laplacian of Gaussian (LOG Weight) is provided. If any cost function is given a weight greater than 0, it will be used while computing the cost of pixel traversal. However, since the total cost is a weighted cost function, the weights require to be normalized by pressing the “Normalize” button (turned red when any weight is changed). Any changes can be saved by pressing the “Save” button. For changes in cost weights, the cost matrices will be recalculated when “Save” is pressed.



At any point of time when the lasso is broken, the annotation can be undo/redo using Ctrl + Z/Ctrl + Y respectively.

- 3) Manual: Manual annotation (Table 1:17-22) is the most intuitive among the annotation options. The user can draw and erase on the image as required. The drawing will be filled in if the “Closed Loop” option is selected (Table 1:17) and will remain open otherwise. The eraser size can be changed at any time using the slider (Table 1:22). While using a tool from manual annotation, no other tool can be used i.e. user can only draw while “Draw” (Table 1:18) button is ON (turns red), and similar for the “Erase” button (Table 1:20).

The “Remove” button (Table 1:19) is provided to fast remove unwanted annotations. Clicking on it turns this option ON (turns red). While turned ON, clicking on any annotation will select it. Upon selecting all undesirable annotations, clicking again on the button will remove the selected ones. This button also has a quick option: clicking on any annotation on the image while not in drawing/erasing/lasso mode, will turn ON (red) the “Remove” button (Table 1:19), while deselecting (by clicking on any part of the image without annotation) will turn it OFF. If manually turned OFF, it will remove the selected annotation as well.

Finally, the “Reset” button (Table 1:21) will undo all annotation up to the current time and bring back the annotation (if loaded from results) or remove all. This option prompts the user so that the annotations are not accidentally removed.

At any point of time, the annotations can be undone/redone using Ctrl + Z/Ctrl + Y respectively.

Analysis

The statistics panel (Table 1:24) shows the approximate statistics of the vasculature at any point of operation. To understand this option, junction and branch need to be defined. A branch is a vasculature with no side-branches connected. A junction is a connection between three or more branches. Hence, the length and number of branches may provide different results from a manual measure of a complete vessel.

Clicking on any annotation selects the annotation with a blue color, while selecting the current branch with a pink color. The statistics for the current branch at the current point is also displayed (Table 1:24).