Proceedings of the International Workshop on the Scientific approach to the Acheiropoietos Images, ENEA Frascati, Italy, 4-6 May 2010

ShroudScope, a web tool to analyze high-resolution photographs of the Shroud of Turin

Mario Latendresse

SRI International (Room AE215)
333 Ravenswood Ave, Menlo Park, CA 94025, USA
latendre@iro.umontreal.ca

Abstract
ShroudScope is a freely accessible Web tool to display very high-resolution photographs of the Shroud of Turin through a zoom-in and –out mechanism. ShroudScope, available at sindonology.org (aka dshroud.com), can also be used to do high-precision length measurements of various images and objects seen on these photographs. Predefined overlays that display various data over the photographs can be activated and deactivated at will. These capabilities can be done on two photographs: Enrie (1931) and Durante (2002). As far as we know, the ShroudScope has the highest resolution photographs of the Shroud of Turin, on the Web, worldwide.

Keyword: ShroudScope**,** Web tool, high-resolution photograph, length measurement

1. INTRODUCTION

ShroudScope is a Web tool to display high-resolution photographs of the Shroud of Turin, via a zoom-in and –out mechanism, activate diagram overlays and do length measurements over them.

By a "Web tool" we mean that the ShroudScope can be used via any popular browsers (e.g., Firefox) without any special "plug-in" or the need to install any computer software. The ShroudScope has been tested on Safari 4.0 and 5.0, Firefox 3.6, IE 7 and 8, and Chrome 6. The only constraint is that JavaScript must be turned on in the browser used; this is the default of popular browsers. Depending on the network speed connection of the user, the ShroudScope might take a few seconds before responding.

ShroudScope is accessible at the Sindonology Web site [1]. More specically, the ShroudScope is at [2]. It replaces a previous tool to do length measurements over Shroud photographs (also available at [1]).

We invite the reader to access the ShroudScope while reading this paper and try out some of the tools presented (see Figure 1 for the ShroudScope in its initial state).

The ShroudScope was motivated by the need to make accessible to a large audience, in an economical way, high-resolution photographs of the Shroud of Turin. We also believe that there is a need to provide a simple and easily accessible tool to do precise and reproducible length measurements on high-resolution Shroud photographs.

The ShroudScope can also be used to describe specific parts of the Shroud with text, graphics, diagrams, and small photographs overlaid on the high-resolution Shroud photographs. It offers permanent links that can record its current state (i.e., position, zoom level, active overlays, selected photograph) so that users can easily link what they exactly see from their own Web pages, documents, emails, or the bookmark toolbars of their own browsers.

The ShroudScope can currently display two different photographs: the 1931 Enrie photograph (shown in negative) and the 2002 Durante photograph (shown in positive).

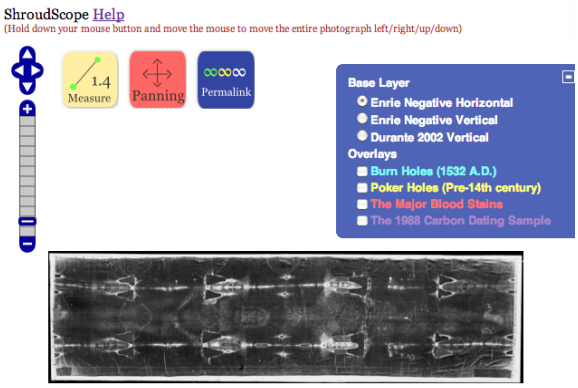

Figure 1. The initial ShroudScope Web page with the base layer selected as the Enrie Negative Horizontal photograph. The zoom level is on the second step of the ladder. The panning tool has a redish color: the photograph can be panned, that is the interface is in panning mode. At this point, the user can also click any overlay title to activate it, zoom-in or –out the Shroud photograph using the left ladder, start a measurement by clicking the measure icon, or ask for a permanent link to the current state of ShroudScope by clicking the permanent icon.

The Enrie photograph is in negative and has two versions: vertical and horizontal.

At the highest zoom-in level, the Durante photograph offers a resolution of 0.17 mm per pixel (a pixel is a dot on a computer screen).

As far as we know, this is the highest resolution photograph of the Turin Shroud publicly available on the Web.

The initial ShroudScope Web page contains several widgets, panels, and icons as shown in Figure 1. In the following paragraphs we give brief descriptions of them and more details are available in the following sections.

The *Switch Panel* is the blue rectangle panel that appears on the right side, near the top, of the Web page as seen in Figure 1. The panel can be minimized by clicking the minus icon and maximized by clicking the plus icon. The switch panel displays two lists: *Base Layer* and *Overlays*. The list of base layers is above the list of overlays. Each base layer is a photograph of the Shroud of Turin. Only one base layer is active at a time whereas several overlays can be active at the same time. Select the desired base layer and overlays by clicking their title or their radio button in the Switch Panel. Figure 2 shows one active overlay.

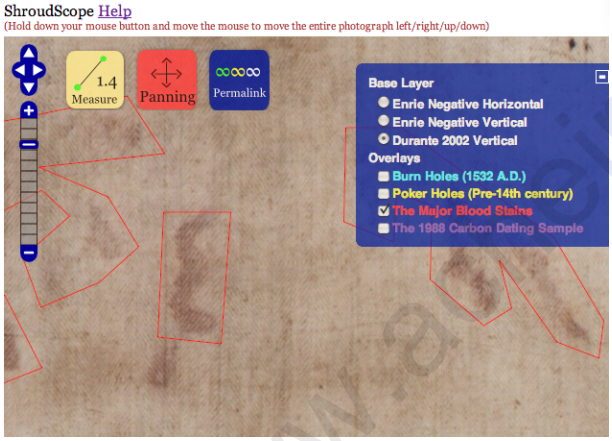

Figure 2. The ShroudScope with the Durante 2002 photograph selected. The Major Blood Stains overlay is also selected and traces the red polygons encircling the major bloodstains visible in the face, in particular the inverted "3" bloodstain. Mousing over these polygons would show tooltips.

The *ladder widget* is a blue widget in the form of a ladder with over 10 steps displayed on the left of the Web page as seen in Figure 1. It is used for zooming-in and -out the current active photograph (aka base layer). You can click on any ladder step to go directly to a specific zoom level. You can also use the plus icon to zoom-in or the minus icon to zoom-out.

The colorful rounded-square icons (see Figure 3) near the ladder and top of the Web page can be used to activate different tools. The tools are: measure, panning, and permalink. These tools are described in the following sections. To activate a tool icon, simply click it. An icon that has a reddish hue means that it is active and that the state of the ShroudScope is in the state given by the icon.

Figure 3. The three tool icons. The yellow measure icon is to enable/disable the length measurement mode. The panning icon, shown as active, enables the panning mode to easily move the entire photograph in all directions using a click-and-hold mouse gesture. The blue permalink icon opens up a popup window displaying a URI link based on the current state of the ShroudScope; the user can save the link by drag-and-drop in an email, a browser toolbar, a document, etc.

The permalink tool does not change the state of the ShroudScope. Currently, there are two states: measure or panning state. For example, when the panning tool is active no measurement can be done, and vice versa. A tool icon remains active until you click another tool icon. When you first visit the ShroudScope Web page, the panning icon is active. The panning icon enables you to move (or pan) the entire photograph on the Web page.

2. HIGH-RESOLUTION SHROUD PHOTOGRAPHS

A base layer is essentially the main Shroud photograph shown on the Web page. Currently, three base layers are provided: Enrie Negative Horizontal, Enrie Negative Vertical, and Durante 2002 Vertical. The first two base layers used the same photograph, but one is displayed vertically whereas the other is displayed horizontally. More base layers are planned for the future. The Durante 2002 photograph has the highest resolution. As far as we know, this is the highest resolution Shroud photograph available on the Web, worldwide.

The Durante photograph was done after the 2002 summer restoration. The patches that were stiched in 1534 were removed during that restoration. Some of the burned areas were also scrapped to remove the burned linen.

Note that the Durante photograph is in positive whereas the Enrie photograph is a true negative. In particular, the left side of the Enrie photograph is on the right side on the Durante photograph. For example, the right arm on the Durante photograph is on the left on the Enrie photograph.

To select a different base layer, click the title or the circle preceeding the title of the desired base layer. If the selection is different than the current displayed base layer, the current displayed photograph will be replaced with the new selected photograph at the same zoom level and at the same centered location as the current displayed one.

3. PANNING

Panning is required at some zoom levels since zooming-in will increase the level of the details and the entire

photograph will become taller or wider than the size of the computer monitor.

Panning is the operation of moving the entire photograph left/up/down/right as if you were grabbing a piece of paper. When the ShroudScope is first displayed, panning can be done by holding the left mouse button and moving the mouse in the desired directions. The entire photograph will move. Therefore, the scrolling bars are not used to move the photograph. Likewise, if your mouse has a wheel, it no longer can be used to move the photograph. The wheel can actually be used for the zoom-in and -out operations (see next section).

Note that once the measurement tool is active, via the measure icon, panning is deactivated. You either need to reactivate panning by clicking the panning icon or you can use the arrow icons above the ladder to slowly pan the photograph.

4. ZOOMING-IN AND –OUT

One of the main functionality of the ShroudScope is the possibility to zoom-in or -out the Shroud photographs. This can be done in several ways: by clicking the ladder widget shown on the left of the Web page, by double-clicking on the photograph, or by using the mouse wheel. Essentially, this works in a similar manner as the well-known Google Maps.

Double-clicking always zoom-in and center the photograph at the double-clicking location. This is handy to zoom-in to a particular location on the Shroud photograph.

Clicking on any step of the ladder widget, which is on the left of the Web page, brings the Shroud photograph to the clicked level. A higher step on the ladder is a higher zoom-in. Depending on the speed of your network connection, your location (e.g., Europe vs USA), and the speed of the server, zoom-in might take sometime to display the photographs; typically it should take a few seconds (i.e., 2 to 8 seconds). Note also that caching (i.e., storing Web content locally on your computer) is typically done by a browser, so that a first visit to the ShroudScope takes longer to display the photographs than a repeated visit.

5. OVERLAYS

An overlay is a set of geometric figures drawn on a Shroud photograph that can be used to show data, text and small photographs. The geometric figures, drawn as polygons, circumscribe regions of the photograph. Each geometric figure has associated data, text, or photograph. These are shown in a small popup window, called a tooltip, when the user mouse-over the region of the geometric figure.

Each overlay can be made visible or invisible by simply clicking its title in the Panel Switcher. Figure 2 shows one active overlay on the Durante photograph.

When invisible, all geometric figures become invisible but the overlay itself is not removed from the Switch Panel. The overlay can be reactivated by clicking its title to make the geometric figures visible again. Four overlays are currently provided:

- Burn holes of 1532.
- Poker holes.
- The major blood stains.
- The 1988 radiocarbon dating sample location.

When mousing over a geometric figure a small popup window opens up to display the data, text, or small photographs associated with this geometric figure. For example, if the Major Blood Stain overlay is active and that the mouse is moved over the inverted “3” bloodstain, a small popup window opens up describing that bloodstain. Another example is the radiocarbon dating overlay. Mousing over the geometric figure showing the location of the sample of the radiocarbon dating, a popup window opens up describing that sample with a small photograph further describing the four segments of the sample, which dating laboratory received which segment, and so on.

6. LENGTH MEASUREMENTS

The icon with the label *Measure* enables you to do length measurements on any of the Shroud photographs at any zoom level. Figure 4 shows a length measurement that was done along the nose.

A length measurement is typically done using the following steps:

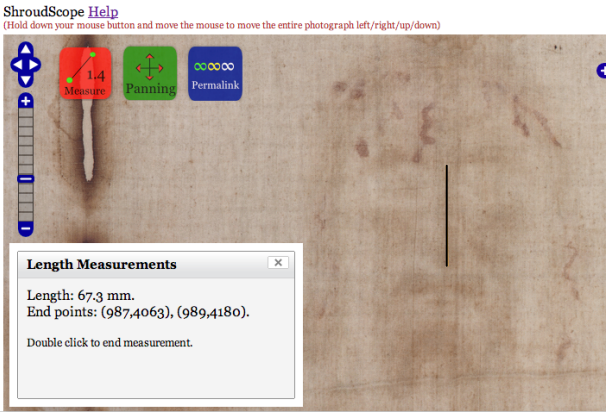

Figure 4. A length measurement was done along the nose on the Durante photograph. The measure icon has a redish hue: the ShroudScope is in measurement mode and no longer in panning mode. The black line shows the location of the measurement and the small popup window on the left shows the length as 67.3 mm (millimeter) and the two end-points of the yellow line as coordinates (987,4063) and (989,4180).

1. Select and center the photograph at the location where the measurement will be done.
2. Click the *Measure* icon; it will become redish.
3. Click on the photograph at one end of the object to measure; a small window will open showing the current length (0 mm).
4. Click, or double-click, on the other end of the object to measure; the small window will display the length in millimeters. The end-points of the measurement, in pixel locations, are also shown.
5. If on the previous step, you double-clicked, the length-measuring tool is ready for a new measurement. But if you clicked, you can continue measuring multiple segments: the measuring tool keeps adding the lengths.
6. To turn off the measuring tool, click the panning icon. You will also return to the panning mode.

To dismiss the small popup window showing the measurement results, click the small x icon in the top-right corner of the small popup window.

The end-points are given so that a measurement can be reproduced. Note that the end-points depend on the zoom level and the base layer. Therefore, not only the end-points but also the zoom level and base layer should be provided to anybody who would attempt to reproduce the measurements.

7. PERMANENT LINK (PERMALINK)

One of the useful ability of the Web is to reference any Web page with a unique address. Such an address is refered to as a URI (or URL in the specific case of the http protocol). A tool such as the ShroudScope has a URL, but this refers to the initial state of the ShroudScope. This is one of the difficulties of a Web tool such as the ShroudScope to be able to refer to a specific state of the Web page, once a series of operations have been done, such as activating some overlays, zoom-in to a specific location and/or selecting a specific base layer.

The permanent link solves this problem. When the permalink icon is clicked a small window opens up to display a Web link in blue (see Figure 5). This link was created based on the selected base layer, the overlays that are active, the zoom level, and the position of the center of the base layer.

Most importantly you can save the link by dragging and dropping it to any of the following:

- Your bookmarks folder
- The toolbar of your browser
- The desktop of your computer
- An email
- Any document (e.g., Word) that accepts the drag-and-drop operation

If you are familiar with HTML you can also embed such permanent links in your own Web pages. A Web page can describe various aspects of the Shroud and have a permalink centering and zooming on the location described.

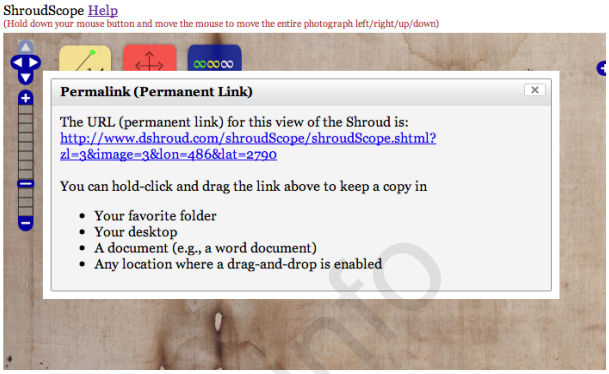

Figure 5. The permalink icon was clicked. A popup window opened displaying a URI link in blue. This link corresponds to the current state of the shroudScope. We can see that the image selected is noted "3" which is the Durante 2002 photograph; the zoom level is 3, and the central location of the image is at location (486, 2790). The link can be saved in many ways in particular by dragging it to the bookmark bar of the browser.

8. PHOTOGRAPHS RESOLUTION

It would be instructive to do a survey of details visible at the highest zoom level on the Durante photograph; the highest resolution photograph available on the ShroudScope. But this is outside the scope of this paper.

We invite the reader to acces the ShroudScope tool itself to identify various details. Instead we can point out the level of the resolution of that photograph based on two examples. The first example, shown on Figure 6, shows a positive case of a clear identification: the thread used during the 2002 restoration. The second example shows a partial identification of a property often discussed by Shroud researchers: the distinction between real bloodstains and images of bloodstains or wounds. This second example demonstrates that there is a need for even higher resolution photographs available to Shroud researchers.

Figure 6 shows details that are specific to the Durante photograph because of the summer 2002 restoration. We can see the very fine threads used to fasten the Shroud to the back Holland cloth. Naturally, this is possible due to the high quality of the photograph done by Gian Carlo Durante after the restoration was done.

Figure 7 shows a famous bloodstain "image" detail on the arm. According to some researchers, what we actually see is one-half of a bloodstain, that is real blood that came in contact with the Shroud, and the other half is the image of blood or wound that gives us the impression of real blood on the Shroud. We cannot confirm yet this fact from this photograph but we can start seeing the difference between these two possible perceived images.

Photographs we higher resolution would be needed to confirm this important detail.

This detail is important as it would demonstrate the great subtlety of the relation between the image creation process and the more mundane blood tranfer that occurred due to Shroud coming in contact with a real bloodstained body.

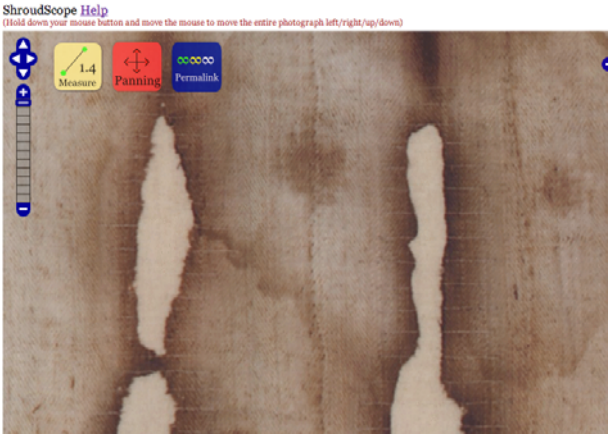

Figure 6. This is a zoom-in on two burned holes on the Durante photograph. This is the highest level of resolution available for this photograph. We can see the threads that were sewed after the 1534 patches were removed during the summer 2002 restoration. The tiny holes done to sew the 1534 patches are also visible. This closeup is from permalink [4].

Figure 7. The lower bloodstain in the form of tilted U is most likely from real blood on the Shroud, but is the segment continuing on the right real blood or an image of blood? We cannot yet confirm this fact with this photograph but this appears possible. This example shows the need for even higher resolution images. This closeup is from permalink [5].

9. IMPLEMENTATION

The ShroudScope uses an open-source JavaScript implementation of a projective mapping library called OpenLayers [3]. This library is typically used to display geographical maps with countries, cities, and roads. But in our case, only photographs are used. It is free of any commercial advertisements.

Since the entire ShroudScope is based on JavaScript and no other "plug-in," there is no need to install any software to use it. The entire ShroudScope works as a standard Web page accessible by most popular Web browsers. The ShroudScope was tested on several browsers: IE (versions 7 and 8), Safari, Firefox, and Chrome.

Each base layer and each zoom level is generated by a single photograph that was scaled and rotated appropriately then decomposed and sliced into 400x200px tiles. The appropriate tiles are fetched from the Web server and reassembled by OpenLayers when selecting a base layer and a zoom level. Tiles make it possible to send parts of the photographs at high zoom level. This reduces bandwidth and time to transfer high-resolution images, making the tool more responsive.

The Durante 2002 originial digital photograph used is a 500MB Tiff file. It was transformed into a JPG file then sliced at various scales. Zoom level 0 (the lowest) was generated by a 0.03 rescaling of the original photograph; zoom level 1 was done with a 0.05 rescaling; zoom level 2 uses a 0.1 rescaling and all subsequent zoom levels were done by increasing the rescaling by 0.1. In all, 12 zoom levels are prodvided.

The Enrie photograph was a 40MB Tiff file that went through a similar process. But since it has a smaller resolution compared to the Durante photogtaph, the resulting zoom level photographs appear smaller.

The overlays are generated by the browser running the appropriate JavaScript code in OpenLayers. The descriptions of the overlays are encoded as JavaScript data structures. They were defined using a tool implemented in ShroudScope that is not currently available to users. In particular, the multi-line drawings describing parts of the Shroud images were done by drawing by hand over the Shroud photographs using that tool: the coordinates were generated by the tool and manually copied on the Web server.

A future version of the ShroudScope will let this drawing tool accessible to users so that they can create their own overlays.

The tooltips are actually not generated by OpenLayers but by additional JavaScript code and some Yahoo libraries.

10. FUTURE DEVELOPMENT

The actual ShroudScope (circa 2010) is a first version towards a more advanced tool to analyze Shroud photographs and data that can be overlaid on them. It is hoped that photographs with even greater resolutions will be one day accessible via the ShroudScope. Such photographs do exist, but their access is currently limited

to a small number of people.

The tool is capable of handling photographs of almost any resolution. For example, a photograph with a resolution of less than 1/100 mm per pixel would allow a resolution beyond the thread level. It is possible that such photographs of the Shroud exist but we do not have access to them.

New overlays are currently being created and will be available in a future version of the ShroudScope. It is also planned to add a tool to the ShroudScope such that users can add private as well as public overlays. These user defined overlays could contain graphics, text, and photographs.

More advanced extensions are in the planning stage. For example, the ability to apply graphic transformations on the base photographs. Such transformations could be as simple as color inversion or as complex as Fourier transforms.

11. CONCLUSION

The ShroudScope is the first Web tool of its kind in Shroud research. It requires no special computer software installation and can be used with any popular browser.

The ShroudScope enables the general public, scholars, and researchers free and easy access at any time to very high-resolution photographs of the Shroud of Turin.

Using the ShroudScope, Shroud researchers can do precise and reproducible length measurements directly on the available photographs. They can also use it to pinpoint precise locations on the Shroud using the permalink tool when creating their own Web page, when communicating with other researchers via email, or in research papers.

The use of overlays allows the description of many parts of the Shroud photographs. They can be easily activated and deactivated at will without disturbing the main photograph.

Future developments include more overlays describing various aspects of the Shroud. Users will also be able to create overlays that can be saved for their own personal future reference.

ACKNOWLEDGEMENTS

We thank the Shroud scholars and researchers that provided access to very high-resolution photographs of the Shroud of Turin. The ShroudScope would not have been possible without their help. We also thank the reviewers of this paper for helpful comments.

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3. OpenLayers, *Free Maps for the Web*, openlayers.org, version 2.9.1, July 2010.

4. Permalink, *The threads around two burned holes shown in Figure 6*,

www.dshroud.com/shroudScope/shroudScope.shtml?zl=11&image=3&lon=1742&lat=14962

5. Permalink, *The bloodstains shown in Figure 7*,

www.dshroud.com/shroudScope/shroudScope.shtml?zl=11&image=3&lon=2363&lat=16889