

# Image Fusion Systems Research

<http://www.imgfsr.com>

## Customized Semi-Automatic Nonrigid Image Registration for Use with Arcturus Veritas Mirodissection Software

### User's Guide

#### Overview

This document describes the functions and operations of the Semi-Automatic Multi-Sensor Image Registration Software developed by Image Fusion Systems Research and customized for use with the Arcturus Veritas Microdissection software. When the program starts, it first looks for file *ifsrs.ini* in the same directory. If the file is found, it will read from it the names of the reference, the target, and an optional alternate target image filenames. If file *ifsrs.ini* is not found, the program will ask the user the names of the reference, the target, and an optional alternate target image files.

File *ifsrs.ini* should have the following structure and saved in ascii format:

```
Reference image = "#7StaticImageforSlide#114.png"  
Target image 1 = "#8StaticImageforSlide#114.png"  
Target image 2 = "#9StaticImageforSlide#114.png"
```

The text between the quotes represents a filename. If an alternate target image is not available, the third line should be replaced with:

```
Target image 2 = ""
```

Two different similarity measures are provided to allow registration of single modality as well as multimodality images. They are cross-correlation coefficient and mutual information. When the images are in the same modality cross-correlation coefficient is preferred but if the images are obtained by different sensors or under different lighting or environmental conditions, mutual information is the preferred similarity measure. The default similarity measure is cross-correlation coefficient, but this can be changed as needed.

Rather than using a single warping model to register all image types, different warping models have been developed to provide the highest registration accuracy possible. For images with only translational differences, a transformation function with two parameters describing the relative shift of the target image with respect to the reference image along the *x* and *y* axes is used. The user needs to use only one pair of corresponding control points in

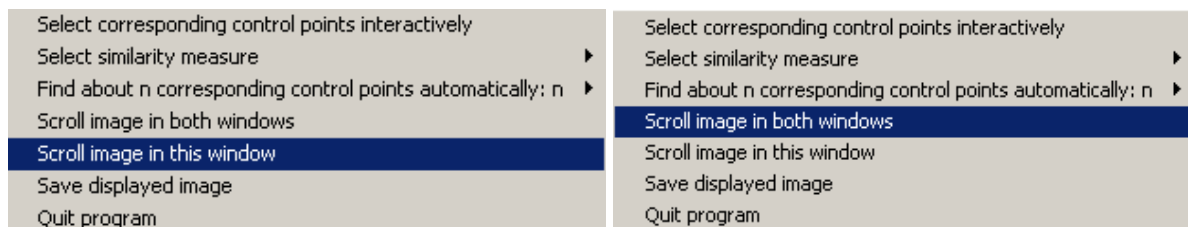
the images. For images that have translational, rotational, and scaling differences, a similarity transformation is used to register the images. For that, the user should select two corresponding control points in the images. If the images are related by an affine or a linear transformation, three corresponding control points should be selected. If the images are related by a projective transformation, the user should select four corresponding control points in the images. If the images have local geometric differences, the user should select five or more corresponding control points in the images. Thin-plate spline is used to register such images. Care should be taken not to select three or more control points that are collinear.

For very large images with nonlinear geometric differences, registration may be achieved in steps. First select one, two, or three corresponding control points in the images to approximately register the images. Then select a larger number of corresponding control points in the images automatically or interactively to more accurately register the images. Once the images are registered, review the registration result. If further refinement is needed, choose a larger number of control point correspondences either automatically or interactively and repeat the process. If control point correspondences are selected automatically, verify the correctness of the correspondences and remove the inaccurate ones.

### **Viewing**

If the images to be registered are larger than 1024×768 pixels, only the center 1024×768 pixels are shown. To show parts of the images not shown, translate the images within their respective windows to bring into view the hidden parts. To achieve that, press ‘1’ on the keyboard while the cursor is within the reference or the target window. To scroll the image within a window, left-click somewhere inside the window and while holding down the mouse, drag the image to the left, to the right, up, or down within the window. Key ‘1’ may be pressed as many times as needed to repeat the scrolling process. Alternatively, while holding down key ‘1’ the user may keep scrolling an image in its window until the desired image area comes into view. Pressing ‘2’ on the keyboard will translate images in both windows.

Instead of pressing ‘1’ or ‘2’ on the keyboard, the user may choose *Scroll image in this window* or *Scroll image in both windows* from the menu and proceed in the same manner to reposition the image within a window or reposition the images in both windows for better viewing. To get the menu, press the right mouse button.



## Operations

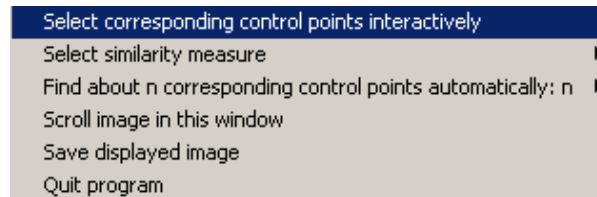
To register two images, first select a number of corresponding control points in the images. Then, geometrically transform (warp) the target image to the geometry of the reference image. Finally, examine the registration result and refine it, as needed.

### Starting the program

To start the program, double click at *IFSRS.exe*. If file *ifsrs.ini* does not exist, a file selector window will appear on the screen. After selecting the reference image filename, another file selector window will appear allowing the selection of the target image filename. The images may be in pgm, ppm, jpg, gif, tif, png, bmp, and other popular formats. The reference image will be displayed in the reference window and the target image will be displayed in the target window. The user will be asked whether or not to load an optional target image at this point. The user may choose an optional target image, if needed.

### Selecting corresponding control points in the images

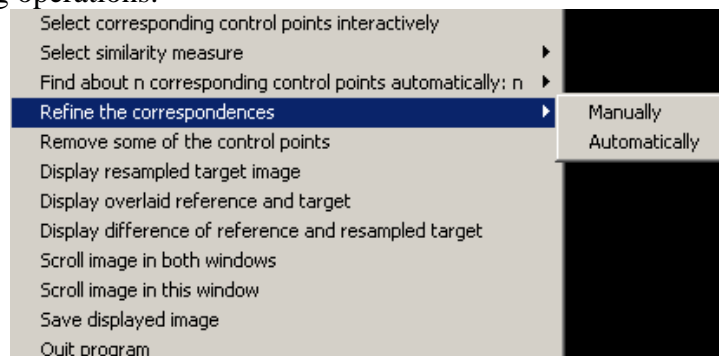
The first step in image registration is to select a number of corresponding control points in the images. To achieve this, right-click the mouse and choose *Select corresponding control points interactively* from the menu:



Left-click at a point in the reference window and then, at the same point in the target window. A selected control point will be marked with a '+'. A bright or dark circular region centered at the control points will also appear in the image. Repeat the control-point selection process as needed to choose the desired number of corresponding control points in the images.

### Refining the selected correspondences manually

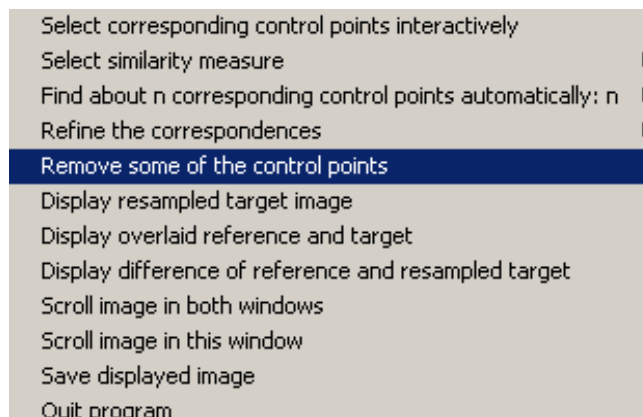
The selected control point correspondences may contain positional errors. To refine the correspondence accuracy, if the images have about the same scale, choose *Refine the correspondences* and then *Automatically* from the menu. If the images have different scales, first approximately register the images to bring the images into the same scale using one, two, or three correspondences. Then refine the correspondences automatically using more correspondences. Note that the menu entries change as registration progresses to avoid selection of wrong operations.



Depending on the number of selected control points, it may take a few to several minutes to find the correspondences when mutual information is used as the similarity measure. The refinement step will reposition the control points in the target image, if needed.

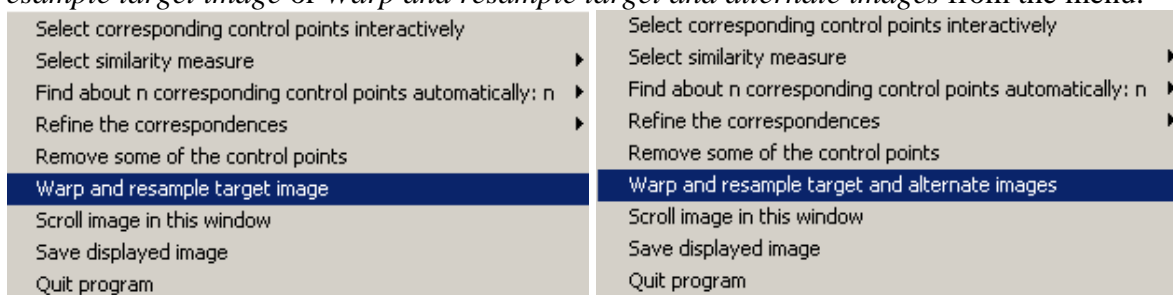
### Removing the bad correspondences

For some low quality images, the refinement process may not reposition some of the correspondences accurately. At this point the user can refine the correspondences manually. To do that, choose *Refine the correspondences* and then *Manually* from the menu by right-clicking the mouse. Then, left click at the control point in the reference or the target window and drag it to the desired position. Alternatively, the user may remove the bad correspondences. To do that, choose *Remove some of the control points* from the menu with right mouse and then left click at or near the control points to be removed in either of the windows.



### Warping the target image and the alternate target image

Once one or more corresponding control points in the images are selected, the target image may be warped to take the geometry of the reference image. To do that, choose *Warp and resample target image* or *Warp and resample target and alternate images* from the menu.

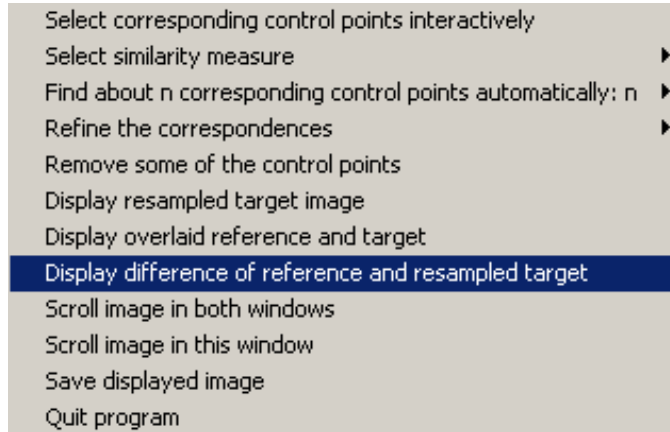


This will geometrically transform (warp) the target image and the alternate target image, if available, so that corresponding control points in the images perfectly align. Therefore, when the images are overlaid after this warping, corresponding control points in the image fall exactly on top of each other.

### Evaluating the registration quality by image differencing

Once the images are registered, the registration quality can be visually examined. If the images are in the same modality, subtracting the registered images and displaying the

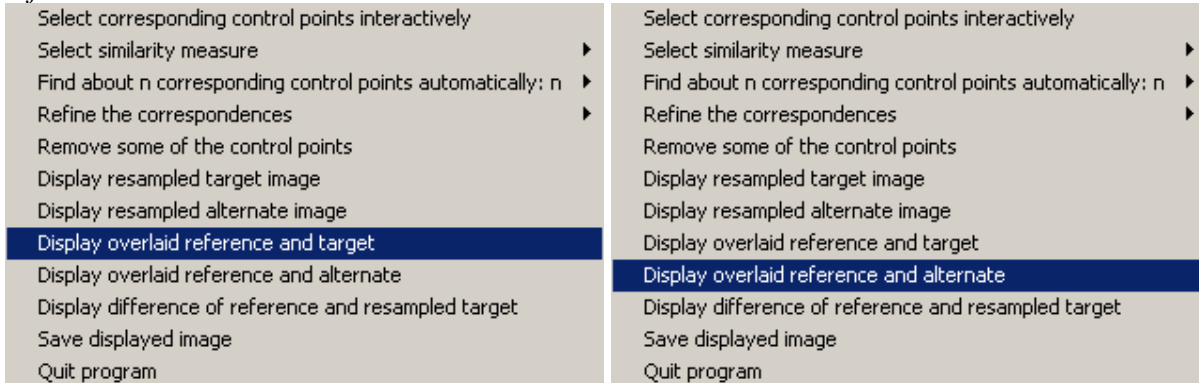
absolute intensity differences will show the quality of registration. To find the absolute difference between registered images, choose *Display difference of reference and resampled target* from the menu.



When two images in the same modality are accurately registered, their difference image will be dark everywhere. If the difference image is mostly dark except for a few of bright spots, this is an indication that the images are registered well but some changes have occurred in the scene between the times the images were obtained. If the difference image shows bright elongated regions, this is an indication that the images are not registered well. To refine the registration, do one of the following: 1) Select more correspondences. 2) Refine the existing correspondences. 3) Remove some of the inaccurate correspondences. 4) Do a combination of the above.

Evaluating registration quality by image overlaying

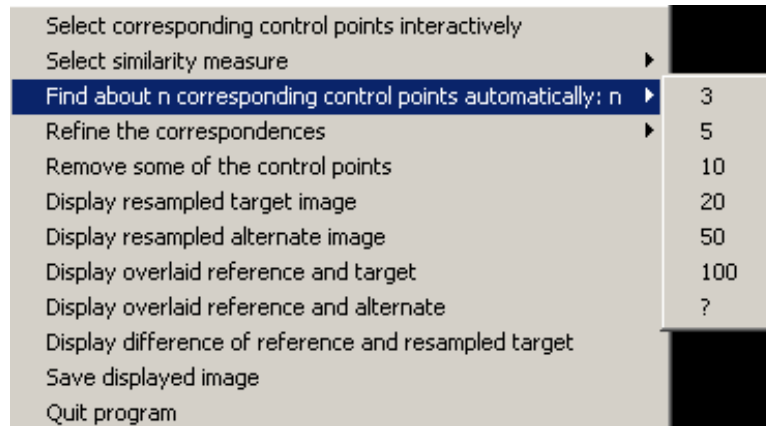
Alternatively, to evaluate the registration quality, the images may be overlaid and viewed. When the images are from different modalities or when intensity differences exist between the images, image overlaying is preferred over image differencing. Overlaid images containing double boundaries indicate that the images are not registered well. To overlay registered images, choose *Display overlaid reference and target* or *Display overlaid reference and alternate* from the menu.



By clicking at the extreme left in the target window, the reference image will be shown. By clicking at the extreme right in the target window, the resampled target image will be shown. By clicking somewhere between the left and right borders in the target window, a weighted sum of the reference and the resampled target images will be shown. The weights will be proportional to the distances of the clicked point to the left and right window borders.

### Selecting the control points automatically

If the images are already approximately registered, or after approximately registering the image using a small number of correspondences, refine the registration by selecting more corresponding control points in the images. Choose *Find about  $n$  corresponding control points automatically* and then the desired number from the menu. If the desired number is not in the provided list, choose '?'. The program will allow you to enter the desired number of control points from the command window. The provided number should be between 1 and 200.

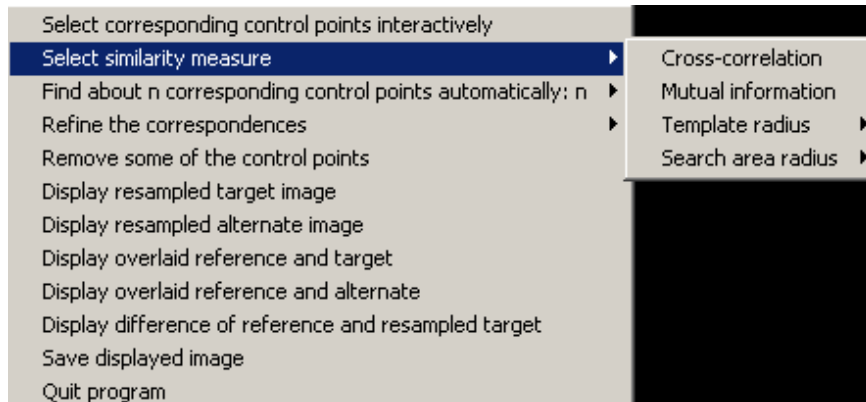


A larger number of control points does not necessarily mean a more accurate registration. As the density of control points increases in a neighborhood, the likelihood of over warping the image in low density areas increases. In addition, as more control points are selected, the registration process becomes slower because the correspondence process requires a larger number of searches for the correspondences and the resampling process requires the solution of a larger system of equations.

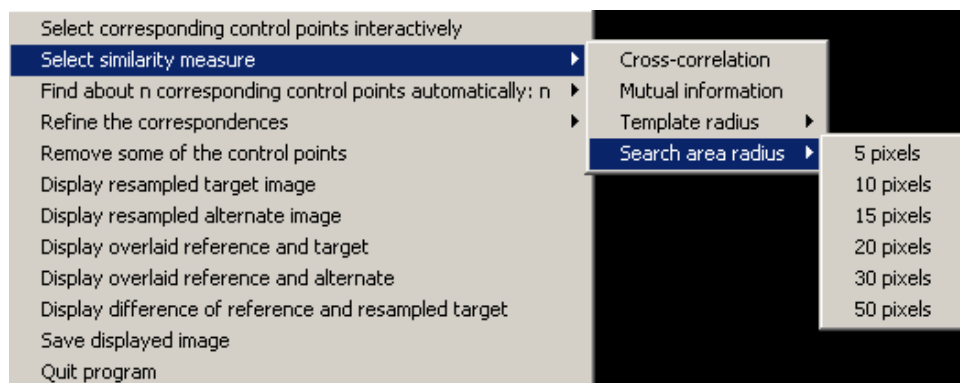
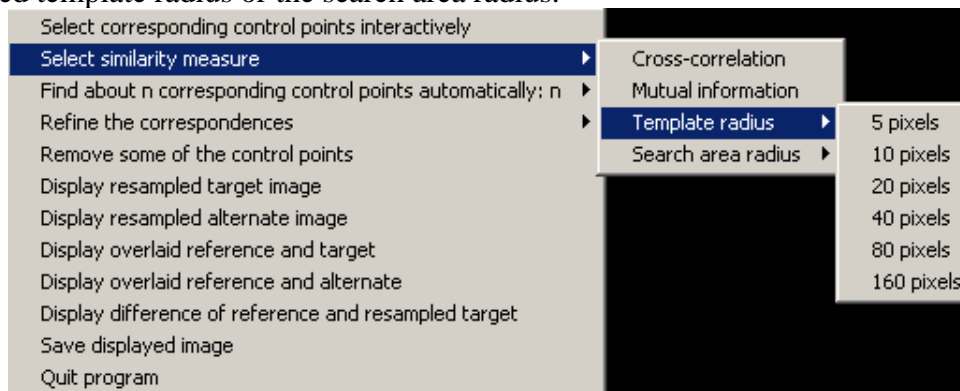
Note that when  $n$  control points are selected in the reference image, some of the control points may not exist in the target image. Therefore, when requiring  $n$  correspondences,  $n$  or fewer correspondences will be found. Correspondence is achieved by template matching and if the similarity measure in a correspondence is not high enough, the correspondence is dropped to avoid inclusion of a possible mismatch among the correspondences. If the desired number of correspondences is not found, choose a larger number of correspondences from the menu and repeat the process.

### Choosing the right similarity measure

Two similarity measures are provided. They are cross-correlation coefficient and mutual information. The default similarity measure is cross-correlation coefficient. If the images are of the same modality, cross-correlation coefficient is preferred over mutual information because it is much faster and is as good. When the images are in different modalities, mutual information must be used to find the correspondences. To select a similarity measure, choose *Select similarity measure* and then *Cross-correlation* or *Mutual information* from the menu.



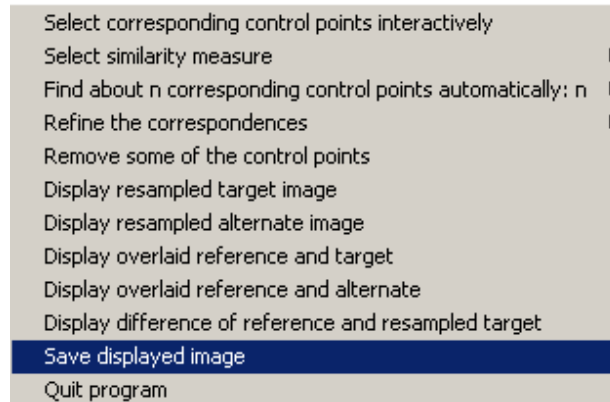
Correspondence is achieved via template matching. A circular window centered at the control point in the reference image is taken and searched for in the target image in a circular search area that is centered at the control point in the reference image. The search area shows pixels in the target image where the center of the template will be positioned when looking for the corresponding control point. There are default values for the template radius and search area radius, but the user may change these values by choosing *Select similarity measure* and then *Template radius* or *Search area radius* from the menu, and then selecting the desired template radius or the search area radius.



### Saving the registration result

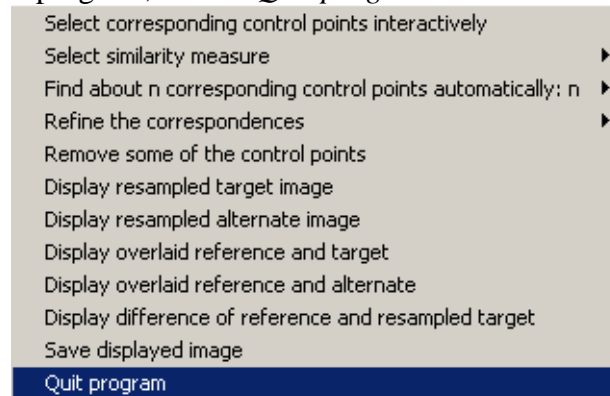
The user may save 1) the warped and resampled target image, 2) the warped and resampled alternate target image, if present, 3) the difference of reference and resampled target, 4) the overlaid reference and resampled target, and 5) the overlaid reference and alternate target, if present. To save any one of these images, first display the desired image and then choose

*Save displayed image* from the menu. Choose a proper file extension when saving an image file. File extensions may be one of pgm, ppm, jpg, gif, png, bmp, tif, and many other popular formats.



### Ending the program

To stop execution of the program, choose *Quit program* from the menu.



### Summary

To register two images:

- 1) Select one or more corresponding control points in the images.
- 2) Refine the correspondences manually or automatically.
- 3) Warp and resample the target image and the alternate target image, if present.
- 4) Evaluate the registration accuracy visually.
- 5) If needed, select more control point correspondences automatically or manually and refine the registration.
- 6) Save the registration result.
- 7) Quit the program.

### Further Information

For further information or questions regarding the functions and operations of this software, please contact: [ag@imgfsr.com](mailto:ag@imgfsr.com)

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