4 Automatic Registration

Overview

The Automatic Registration application can align series of differing modalities, including PET, CT, MR, and SPECT. The software provides three different image registration methods: Automatic, Match Points, and Interactive image registration.

The application's Automatic registration method offers three algorithms for auto-registration: Normalized mutual information, cross correlation, and or local correlation.

The registration process consists of the Setup, Registration and Review worksteps. You can register a movable floating series to a fixed reference series.

General Registration Workflow

The following section provides a general workflow for the main steps in the registration process.

Launching Automatic Registration

You can load up to four studies from one patient into Automatic Registration. Open the application from the IntelliSpace Portal Directory window.

Loading Gated Data

By default Automatic Registration registers all intervals of gated data together using a summed data set and then applies the same registration to the individual gated frames. If you want to register each interval of gated data individually, load each interval separately.

Opening Automatic Registration from the Directory Window

1. From the Directory window, select two or more studies from a single patient.

2. Click **Analysis** > **Automatic Registration**

   The selected series display in the Automatic Registration application with floating and reference viewers. The **Workstep Navigator** displays with **Setup** selected.

Setting Up a Registration

In the Setup workstep, use the Timeline to drag and drop a study or series into place to replace the designated reference or floating image. Refer to section "Timeline" on page 169 for more information about using the Timeline.

The viewer tabs identify the reference and floating images.

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NOTICE

To return to the Setup workstep after proceeding to Registration or Review, you must either save your registration or reset it to its original state before returning to Setup.

Registering an Image

1. Select **Registration** from the **Workstep Navigator**.
2. From the Application panel, choose Automatic, Match Points, or Interactive image registration.

   The application defaults to the Automatic registration method. You can set the program preferences to perform Automatic registration immediately when you move to the Registration workstep. See section “PET” on page 344 for information about Automatic Registration preferences.

   You can also select **Help** to display instructions specific to the application workstep.
3. Use the tools provided with the registration method you selected to help register the images.

Reviewing Registration

1. Select **Review** from the **Workstep Navigator**.
2. Select an image layout.
3. Visually confirm that the images are properly registered.

NOTICE

Inspect registration thoroughly before continuing. If necessary, use the manual registration tools to refine the registration. The accuracy of the registration could affect image interpretation.

Saving Registered Images

If the registration is acceptable save the registered image in one or both of two ways:

- Save the image registration result by saving the registered floating image as a new series.
- Save the registration matrix in a DICOM object (special registration IOD) containing information on both the reference and floating series.

Registering Multiple Series

Use this workflow to register patient studies acquired at different times or to register images from more than two modalities.

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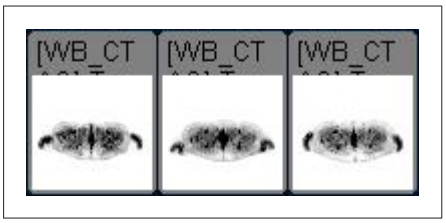
1. Set up your registration as described in section “Setting Up a Registration” on page 165.
2. Select the Registration workstep. Only one floating series displays.
3. Click **View Status Bar** to view the application status. The Status Bar shows a list of all registrations.
4. To view multiple series after registering sequentially, select the Interactive Registration method.

   The Interactive Registration control panel displays thumbnail images of all floating series.



5. Move your cursor over a thumbnail to identify a series.
6. To view a series, click the thumbnail and drag and drop the image into a viewer displaying the floating series.

Automatic Registration Display

The Automatic Registration application interface consists of the Control Panel, Image Area, Timeline (for the Setup workstep only, as shown in the illustration that follows) and Status Bar.

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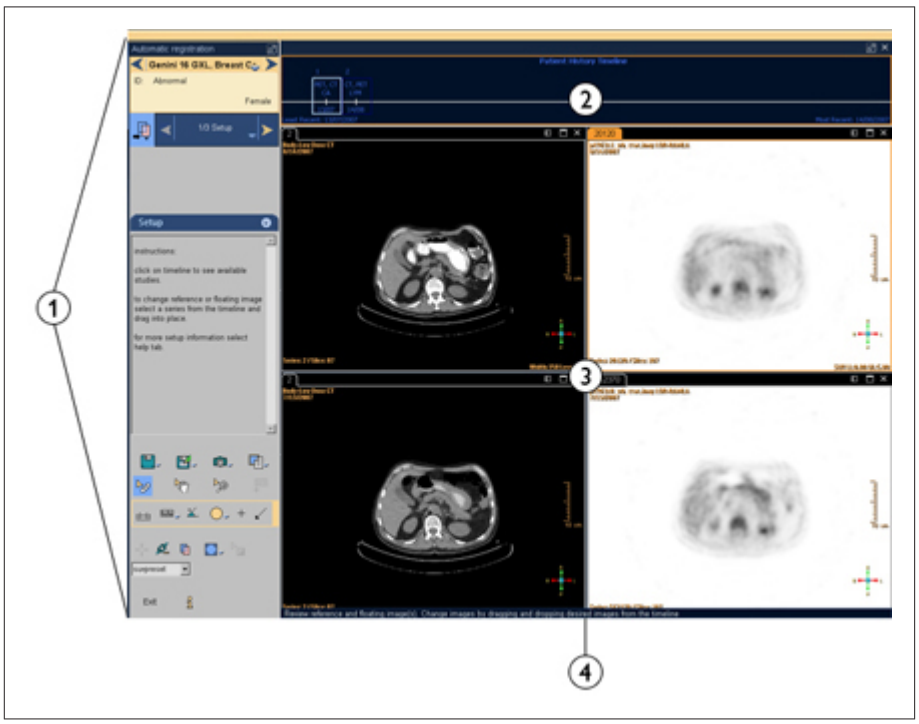

1	Control Panel
2	Timeline
3	Image Area
4	Status Bar

Control Panel

The Control Panel displays patient demographics, the Workstep Navigator, application tools, general tools and the application Exit button.

Click **Auto-Hide** to hide the Control Panel and allow more room for image display.

Click **Auto-Hide** again to turn off auto-hide. If the **Auto-Hide** pin points down, the Control Panel remains visible. If the Auto-Hide pin points left, the application hides the Control Panel.

Demographics

Use the plus and minus controls in the patient demographics area to display or hide the patient name and ID.

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Workstep Navigator

Use the Workstep Navigator arrows or drop-down menu to switch between steps in registration.

Application Tools

The tools that display in the Application Tools area are determined by the current step in the workflow process and/or the type of registration selected.

General Tools

The General Tools available in the Automatic Registration application conform to the Toolbox tools available in the NM Viewer. Refer to section “Utilities” on page 141 for more information on the tools available to review and save your images.

Timeline

The Timeline displays the available studies sequentially. The application displays each study as a graphic including modality information and acquisition date.

Click on a study in the Timeline to view the series that make up the study. The series view includes a thumbnail image of the series and detailed information about the series such as study date and series description. Click on a thumbnail and drag and drop a study or series into place if you want to replace the designated reference or floating image.

Use the Viewing preferences in the PET preferences to specify the study order. Select or deselect **Display Timeline Newest To Oldest** to display the most recent or oldest study first.

Image Area

During the Setup workstep, the Image Area displays layouts containing the reference image in the axial orientation and between one and five floating images displayed in the native orientation in setup. For example, if a short axis is loaded, it displays as short axis in setup, but then is converted to TSC for registration.

The Image Area displays default layouts tailored to the selected registration type during the Registration workstep. The active layout determines the orientation of the series display. You can also select alternate layouts from the list of layout icons provided in the control panel.

During the Review workstep, use the default layout or select a layout to review your registration.

Status Bar

Displays information about the current operation or application workstep. From the Control Panel, click **View Status Bar** to display or hide the Status Bar.

Registration Tools

Common Registration Tools

The following tools are available for multiple registration styles:

- Select a layout (for automatic or match points registration) from the list of available layouts.
-  Click **Registration Save** to open a Save registrations window.

Automatic Registration

You can use a bounding box control to define a three-dimensional region to use for the image search area when performing Automatic registration.

Algorithms

The Automatic registration method allows you to choose one of three algorithms for your registration.

To display the current algorithm, hover your mouse over the Algorithm icon and view the tooltip. To change the algorithm click on the algorithm icon and select another method from the menu.

Normalized Mutual Information

- Best used to perform multi-modality registration in cases where there is limited anatomical data or large misalignments.
- Uses a histogram-based method.
- Calculates the probability distribution of gray values in each data set and uses this in the mutual information equation.
- Does not rely on a functional relationship between the gray values in the data sets.

Cross Correlation

- Best used for single modality registration.
- Assumes a linear relationship between distributions of the two data sets.
- Based on simple squared difference equation between gray values.

Local Correlation

- Best used for multi-modality registration in cases where there is significant anatomical detail and only small misalignment.
- Similar to Cross Correlation, but applies a similarity equation in many small neighborhoods of the data sets.

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Automatic Registration Controls

The following tools are available when you select Automatic Registration.

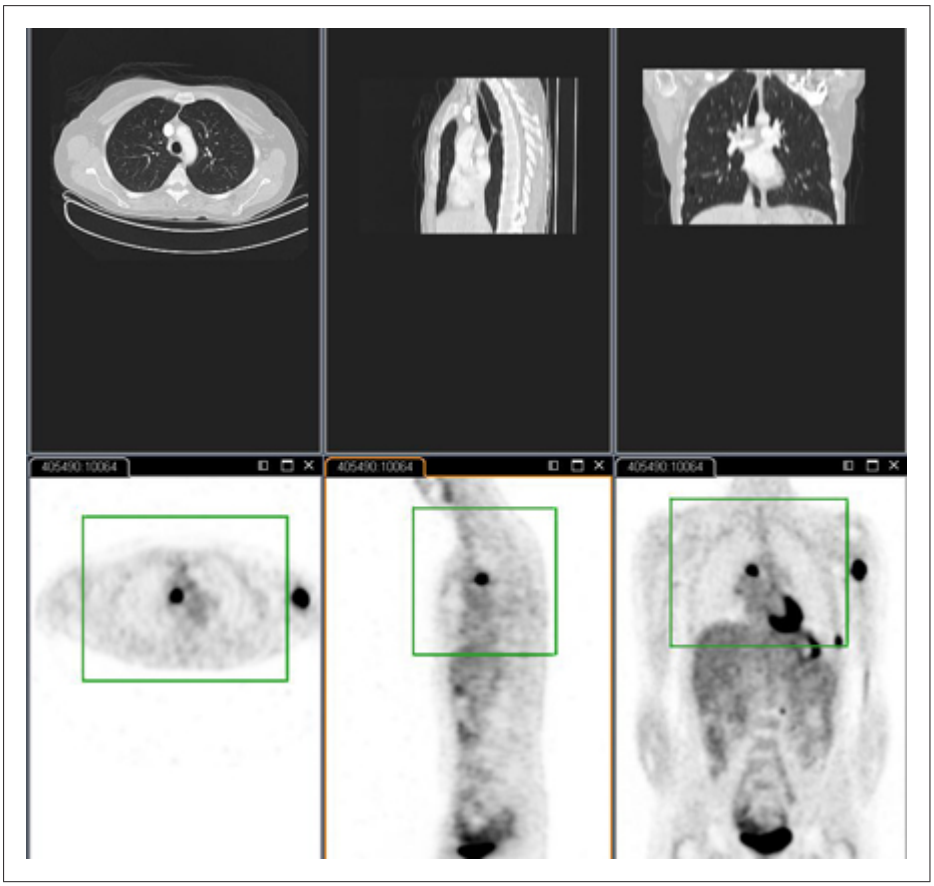
Click **Algorithm** to open the interface for selecting auto algorithm options Local Correlation, Cross Correlation, and Normalized Mutual Information.

The **Auto Registration Progress Status/Score** indicator displays information on level of registration that has occurred and closeness of registration.

Click **Automatic Registration** to start the automatic registration process. If you need to stop the registration while it is in process, click **Automatic Registration** again.

Click **Limit Area for Registration** to place a bounding box that determines the extent of the image to use for Automatic Registration.

1. Turn off fusion in the layout.
2. Click **Limit Area for Registration**.
3. Click an image. The bounding box appears:



4. Position and/or resize the bounding box in all orientations in the same series.
5. Repeat steps 1-4 for the corresponding images, if needed.
6. Click **Register** to register your images.

Match Points Registration

1. Select **Match Points** registration.

   Turn off fusion in your layout, if necessary, to allow the addition of point pairs. To do so, right-click in a fusion-enabled viewer and select Fusion from the menu.

2.  Click **Add Point Pair** and place the point pair.
3. Place a landmark control point by clicking on a landmark point on either the floating or reference image.

NOTICE

Triangulating on a point pair in a MIP positions the point at the surface on 2D images. This is due to the way in which each MIP projection is created.

4. Select the corresponding landmark point(s) on the other image series and modify as necessary.

   The location of the point should match in each image.
5. Add point pairs from the control panel or delete point pairs as needed using the tools available in the control panel.

   To run Match Points you must define at least three point pairs.

   If you define only one or two pairs the application displays a warning that only translation and not rotation will occur.
6. Modify defined landmarks, if necessary, by selecting any of the defined points and dragging them to a new location.

    Click **Show/Hide All Point Pairs** to display or hide all existing point pairs. You may have to scroll through the series to observe all points, which may not appear on the same slices or plane.

7.  Click **Register** to activate the landmark matching point alignment processing.

   The application aligns the images based on the selected landmarks.

Residual Error

The **Residual Error** area populates automatically when you perform registration. Use the plus tool to triangulate the series on the associated point pair.

Additional Tools

When you select Match Points registration, you can access the following tools by right-clicking on a landmark point.

- Click **Color** to select a color for the current point pair.

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- Select **Delete** to delete the current point pair.
- Select **Delete All** to delete all existing point pairs.

Review Tools

The **Select Layout** area contains thumbnail images of the default layouts available in the registration application. Click a thumbnail to display that layout.

Click **Help** to display instructions specific to the application workstep.

Interactive Registration

When you select the Interactive registration method, the Control panel displays a set of tools you can use to interactively register images.

Interactively registering fusion images

The controls provided as part of the Registration and Review worksteps in the Registration Tools section of the Control panel allow you to interactively fine tune fusion views. The controls allow you to adjust the position of the floating image in relation to the reference image in the selected viewer.

-  Click **Translate** to drag the floating image up, down, left, or right in the selected viewer. You can also use the arrow keys to move the floating image in 0.5 mm increments.
-  Click **Rotate** to rotate the image clockwise or counterclockwise in the selected viewer. You can also use the left and right arrow keys to rotate the floating image in 0.25 degree increments.

-OR -

If you know the exact amount to move the image:

1. Select **Interactive** from the drop-down menu.
2. Change the x, y, and z values in the **Translation Offset (mm)** field to move the image up, down, left, or right by the specified number of millimeters.
3. Change the x, y, and z values in the **Rotation Angle (degrees)** field to rotate the image clockwise or counterclockwise by the specified number of degrees.
4. Click **Apply** to make the specified changes.

NOTICE

If you apply your changes all at once after changing both the Rotation Angle and Translation Offset, all changes are made from the same (current) registration position.
If you apply your changes after making changes to the Rotation Angle then again after making changes to the Translation Offset, the second set of changes are made from the new Translation offset.

To undo your most recent change, click **Undo**.

Interactive Registration Tools

Click **Translate** to drag the floating image up, down, left, or right.

Click **Rotate** to rotate the image clockwise or counterclockwise

Click **Undo** to revert the registration in the selected viewer to the previous change.

Click **Redo** to reapply changes that have been removed.

Click **Apply** to make the changes if you entered values in the Translation or Rotation areas. (Only available when you select Interactive registration.)

Click **Reset** to revert the registration to the state of registration the last time **Apply** was clicked or to its original state if changes have not been applied. Click **Redo** to reinstate changes.

Batch

Select **Batch** from the drop-down menu in the Tools area of the Control panel to open the Batch panel. The Batch panel contains controls for creating image batches that you can save as new image series from a scan series.

NOTICE

If you close the viewer, change the layout, or change the **Generate batch to enable tiling** settings after defining your batch settings, all of your batch settings will be changed.

If you change slab thickness after defining your batch settings, the images will be saved with the new slab thickness.

1. Click in the viewer you want to use to generate your batch. The selected viewer type determines which options in the Batch panel are available to you.
2. Right-click in the viewer and use the tools in the menu to set the slice thickness and slice angle.

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NOTICE

Slice thickness and slice angle are not available for Basic2D layouts. Slice angle is not available for SlabMPR viewers.

3. Select the area to use for the batch.
   - **Viewer** uses the viewer you currently have selected. Select this option if you want to save data, such as the coronal views, to a new series.
   - **Display** uses the entire viewing area. Select this option for secondary captures.
4. Select the batch type. The batch type determines the format of the batch you want to save.
   - **Data** - saves the images as a new series that you can use for further display or analysis.
   - **Secondary Capture (SF)** - secondary capture (single frame)
   - **Secondary Capture (MF)** - secondary capture (multi frame)
   - **Monochrome Secondary Capture (SF)** - secondary capture (single frame) in grayscale
   - **Monochrome Secondary Capture (MF)** - secondary capture (multi frame) in grayscale
   - **AVI**
   - **JPEG**

NOTICE

The Data option is only available for Slab, SlabMPR, Basic2D, and Cardiac viewers. Volume viewers can only be saved as secondary captures. Also, if you select the Data option, you will not be able to specify time bins. If you select the Display option, the Data option is disabled.

5. If you selected the Data batch type, select a batch option.
   - **Activity** - stores the data as activity concentration. (This option is only available if the data can be converted to activity concentration.)
   - **Share** - adds the saved batch to the Series list.
   - **Square** - creates the batch as square images for viewing on those systems that require the X,Y pixel spacing to be the same.

6. Click the **Select Batch Viewer** icon.

7. Set the range of images you want to use in the batch.

   Scroll in the selected batch viewer (or alternately triangulate using any other related viewer) until the first image you want to use appears in the selected batch viewer. Then click the **First Slice in Batch** icon. The position of the selected image is shown next to the icon.

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NOTICE

For volume viewers, the image range is labeled "Oblique" and you do not need to define the range of images. For other oblique viewers, you must define the range of images.

8. Scroll in the selected batch viewer (or alternately triangulate using any other related viewer) until the last image you want to use appears in the selected batch viewer. Then click the **Last Slice in Batch** icon. The position of the selected image is shown next to the icon.

9. If you are using gated or dynamic data, set the range of time bins you want to use in the batch. The time bin is defined by the viewer movie control. The first time bin is displayed by default.

   If you are not using gated or dynamic data, continue to step 13.

10. To change the displayed time bin, select the movie control from the viewer context menu.
11. Move the slider to the time bin you want to use as the first bin in the batch, and click the first time bin icon in the Batch panel. The number of the bin you selected is shown next to the icon in the panel.

12. Move the slider to the time bin you want to use as the last bin in the batch, and click the last time bin icon in the Batch panel. The number of the bin you selected is shown next to the icon in the panel.

13. From the Save As drop-down menu, select **Save Batch As**. The Saving dialog opens.

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14. Choose the saving options, as necessary, and click **OK** to save the batch. Image parameters, such as slab thickness, are applied when you save the batch. Pan and zoom settings are saved when you save secondary capture images or reoriented images such as short axis, vertical long axis , and horizontal long axis.

Saving Options

Select saving options from the choices that appear under the Saving Options heading.

- Select **Save Registration IOD** to create a DICOM Spatial Registration IOD object.

  A DICOM spatial registration object specifies the spatial relationship between the registered reference and floating series and provides the ability to spatially relate the series to each other.

  You can transfer this file – along with the original reference and floating data – to another workstation. The receiving workstation uses the spatial transformation to display or process the referenced image data in a common-coordinate system.

- Select **Save Registered Floating as Data** to save the registered floating series as a new series. This saves a series in the directory with the modality REG.

- Select **Save All Registrations** to save multiple registrations as a DICOM Spatial Registration IOD object or as new series. This creates a new series which you can view and analyze with other applications. This new series is also registered to (has the same frame of reference as) the reference series. The settings selected in the save registration option determine exactly what portion of the image is saved.

If you do not select a saving format, either Registration IOD or data, the application does not save anything when you click **OK**.

Voxel Size/Slice Thickness

Select the thickness of images saved in your new series from the choices that appear under the **Voxel Size/Slice Thickness heading**.

- Select **Match Reference** to match the voxel size/slice thickness in the saved image set to the voxel size/slice thickness in the reference image set.
- Select **Match Floating** to match the voxel size and slice thickness in the saved image set to the voxel size/slice thickness in the original floating image set.
- Select **Match Floating XY, Reference Z** to match the in-plane pixel size of the derived image set to the in-plane pixel size of the floating image and to match the number of images and image positions of the derived image set to those of the reference image set (slice thickness of the derived image set matches that of the reference image set).

NOTICE

If you select both Match Reference extent and Match XY, Reference Z, image positions will match between the saved registered series and the original reference series but may be in reverse order.

For Match Floating extent and Match XY, Reference Z, the application always maintains the floating extent. Image positions in the saved registered series will not match the original reference image due to different starting/offset positions.

- Select **Custom** to set the voxel size for the new series by adjusting the values in the **X/Y (mm)** and **Z (mm)** fields.

NOTICE

If the reference series contains overlapping images and you select *Match Reference* for slice thickness, the new series that you save will have a slice thickness equal to the image spacing of the reference series and will not have overlapping images.

If the reference series contains uneven slice spacing, the new series that you save will have a slice thickness that is equal to the slice spacing of the first image in the reference series.

Volume Extent

Limit the images that you save to match the extent of the floating image or of the reference series.

- Select **Match Reference** to base the boundary of the saved images on the extent of the reference images.
- Select **Match Floating** to base the boundary of the saved images on the extent of the floating images.

NOTICE

Saving studies such as CTA, where the reference image has a very small image thickness, can create series with too many images to view. Philips recommends that you do not save this data type using the combinations of Match Floating extent plus Match Reference voxel size or Match Floating extent plus Match Floating XY, Reference Z for voxel size.

Local Devices

Choose to save to any local device that has been configured for your system.

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Remote Devices

Choose to save to any remote device that has been configured for your system.

Automatic Registration Preferences

Access the Automatic Registration preferences from the Preferences window.

1. Click **PET** and then click **Automatic Registration**.

   The following preferences are available for Automatic Registration:

   - **Registration/Review Workstep Layout**: Specify the default layouts for the registration and review worksteps.
   - **Floating/Reference Image Point Color**: Specify the default colors for floating and reference image points in Match Points registration.
   - **Auto Start**: Select the check box to automatically register images when you launch the registration workstep.
   - **Save NM As Next Matrix Size**: Select the check box to save registered NM data at a standard matrix size. The application increases the matrix to the next standard size, for example, 64×64, 128×128, and so forth. If you do not select this preference, then the registered NM data saves at a minimum matrix size that is determined from voxel size and resampled image field of view.

2. When you have completed your changes:
   - Click **Default** to reset the current properties to their factory settings.
   - Click **OK** to accept changes to the current properties.
   - Click **Cancel** to cancel changes to the current properties.

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