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</table>
1 GENERAL INFORMATION

1.1 Contact Data and Legal Information

1.1.1 Contact Data

Support

If you cannot find information you need in this guide, or if you have questions or problems, contact Brainlab support:

<table>
<thead>
<tr>
<th>Region</th>
<th>Telephone and Fax</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States, Canada, Central and South America</td>
<td>Tel: +1 800 597 5911 Fax: +1 708 409 1619</td>
<td><a href="mailto:us.support@brainlab.com">us.support@brainlab.com</a></td>
</tr>
<tr>
<td>Brazil</td>
<td>Tel: (0800) 892 1217</td>
<td><a href="mailto:brazil.support@brainlab.com">brazil.support@brainlab.com</a></td>
</tr>
<tr>
<td>UK</td>
<td>Tel: +44 1223 755 333</td>
<td><a href="mailto:support@brainlab.com">support@brainlab.com</a></td>
</tr>
<tr>
<td>Spain</td>
<td>Tel: +34 900 649 115</td>
<td></td>
</tr>
<tr>
<td>France and French-speaking regions</td>
<td>Tel: +33 800 676 030</td>
<td></td>
</tr>
<tr>
<td>Africa, Asia, Australia, Europe</td>
<td>Tel: +49 89 991568 44 Fax: +49 89 991568 5811</td>
<td><a href="mailto:support@brainlab.com">support@brainlab.com</a></td>
</tr>
<tr>
<td>Japan</td>
<td>Tel: +81 3 3769 6900 Fax: +81 3 3769 6901</td>
<td></td>
</tr>
</tbody>
</table>

Expected Service Life

Brainlab provides five years of service for software. During this period of time, software updates as well as field support are offered.

Feedback

Despite careful review, this manual may contain errors. Please contact us at igs.manuals@brainlab.com if you have suggestions as to how we can improve this manual.

Manufacturer

Brainlab AG
Kapellenstr. 12
85622 Feldkirchen
Germany
1.1.2 Legal Information

Copyright

This guide contains proprietary information protected by copyright. No part of this guide may be reproduced or translated without express written permission of Brainlab.

Non-Brainlab Trademarks

Microsoft® and Windows® are registered trademarks of Microsoft Corporation in the United States and other countries.

Integrated 3rd-Party Software

This software is based in part on the work of the Independent JPEG Group.
This software is based in part on OpenJPEG. The full license and copyright notice can be found here: https://github.com/uclouvain/openjpeg/blob/master/LICENSE.
This software is based in part on libjpeg-turbo. The full license and copyright notice can be found here: https://github.com/libjpeg-turbo/libjpeg-turbo/blob/master/LICENSE.md.
This product includes libtiff 4.0.4 beta, copyright © 1988 - 1997 Sam Leffler and copyright © 1991 - 1997 Silicon Graphics. For a full description of copyrights and license see: www.remotesensing.org/libtiff.
This software is based in part on Xerces-C++ made available under the Apache Software License: https://xerces.apache.org/xerces-c/.

CE Label

• The CE label indicates that the Brainlab product complies with the essential requirements of European Council Directive 93/42/EEC, the Medical Device Directive ("MDD").
• According to the rules established by the MDD, Image Fusion is a Class IIb product.

NOTE: The validity of the CE label can only be confirmed for products manufactured by Brainlab.

Disposal Instructions

Only dispose of electrical and electronic equipment in accordance with statutory regulations. For information regarding the WEEE (Waste Electrical and Electronic Equipment) directive, visit:

Sales in the US

US federal law restricts this device to sale by or on the order of a physician.
1.2 Symbols

Warnings

Warnings are indicated by triangular warning symbols. They contain safety-critical information regarding possible injury, death or other serious consequences associated with equipment misuse.

Cautions

Cautions are indicated by circular caution symbols. They contain safety-critical information regarding possible problems with the device. Such problems include device malfunctions, device failure, damage to device or damage to property.

Notes

NOTE: Notes are formatted in italic type and indicate additional useful hints.
1.3 Intended Use

Indications for Use

The Image Fusion Element can be used in clinical workflows that benefit from the co-registration of image data. For example, this applies to navigation systems or medical data information terminals for image processing or image guided surgery in general as well as for treatment planning software for radiosurgery and radiotherapy. The device itself does not have specific clinical indications.

Intended Use for Image Fusion

The Image Fusion Element is an application for the co-registration of image data within medical procedures by using rigid and deformable registration methods. It is intended to align anatomical structures between data sets.

Intended User

Image Fusion is intended to be used by medical professionals and their assistants working in the field of neurosurgery, traumatology or radiotherapy planning.

Place of Use

The Image Fusion Element is designed to be used in:

• A hospital office environment or at any other location offering a computer.
• An operating room/suite or in rooms appropriate for surgical interventions.

Plausibility Review

⚠️ Before patient treatment, review the plausibility of all information input to and output from the system.

Careful Hardware Handling

⚠️ Only trained medical personnel may operate system components and accessory instrumentation.
1.4 Compatibility with Medical Devices

1.4.1 Brainlab Medical Software

Compatible Brainlab Medical Software

Image Fusion is compatible with:
- DICOM Viewer 3.1
- Content Manager 2.3
- Patient Selection 4.2
- Spine & Trauma 3D 2.6
- DICOM Proxy 3.4

Brainlab Software Updates

Other compatible Brainlab software may become available after the release of this user guide. If you have questions regarding compatibility of the software contact Brainlab support.
If you are currently running software versions other than those specified above, contact Brainlab support for clarification regarding compatibility.
1.4.2 Non-Brainlab Devices

Authorization

Only authorized Brainlab employees may install software on the Brainlab system. Do not install or remove any software applications.

Compatible Non-Brainlab Software

Image Fusion is compatible with:

- Microsoft Windows 7
- Microsoft Windows 8.1
- Microsoft Windows 10
- Microsoft Windows Server 2008
- Microsoft Windows Server 2012 R2

For information regarding compatible service packs, please contact Brainlab support.

Only critical Microsoft Windows operating system updates are allowed. It is not recommended to download or install updates during patient treatment.

It is recommended to protect the system with a state-of-the-art antivirus software. Be aware that this can negatively affect the system performance e.g., real time scans (also known as on-access scanning, background guard, resident shield, auto-protect) can slow downloading and saving patient data.

Other Non-Brainlab Software

Only software specified by Brainlab may be installed and used with Image Fusion.
1.5 Training and Documentation

1.5.1 Training

Brainlab Training

To ensure safe and appropriate use, before using the system all users should participate in a training program held by a Brainlab representative.

Supervised Support

Before using the system for surgical procedures where computer-aided navigation is considered critical, perform a sufficient number of complete procedures with a Brainlab representative present to provide guidance where necessary.

Responsibility

This system solely provides assistance to the surgeon and does not substitute or replace the surgeon’s experience and/or responsibility during its use.
1.5.2 Documentation

Reading User Guides

The user guides describe complex medical devices and software that must be used with care. It is important that all users of systems, instruments and software:

• Read the user guides carefully before handling the equipment
• Have access to the user guides at all times

Available User Guides

<table>
<thead>
<tr>
<th>User Guide</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software User Guides</td>
<td>• Overview of treatment planning and image-guided navigation</td>
</tr>
<tr>
<td></td>
<td>• Description of OR system setup</td>
</tr>
<tr>
<td></td>
<td>• Detailed software instructions</td>
</tr>
<tr>
<td>Instrument User Guides</td>
<td>Detailed instructions on instrument handling</td>
</tr>
<tr>
<td>Cleaning, Disinfection and</td>
<td>Details on cleaning, disinfecting and sterilizing instruments</td>
</tr>
<tr>
<td>Sterilization Guide</td>
<td></td>
</tr>
<tr>
<td>System User Guides</td>
<td>Comprehensive information on system setup</td>
</tr>
<tr>
<td>Technical User Guide</td>
<td>Detailed technical information on the system, including specifica-</td>
</tr>
<tr>
<td></td>
<td>tions and compliances</td>
</tr>
</tbody>
</table>
2 USING IMAGE FUSION

2.1 Introduction

General Information

Image Fusion allows you to register a minimum of two image sets together. You can fuse the same or different modalities (CT, MR, PET, SPECT). You can apply Image Fusion within different workflows (e.g., when using Cranial or Spine software).

Once two image sets are fused, they can be viewed simultaneously. All planned content (e.g., objects and trajectories) defined in one image set is visible in any other fused image set.

Image Fusion proposes a fusion network based on pre-defined pairing rules. For further information contact Brainlab.

Image Fusion uses an algorithm to fuse the selected image sets. The algorithm matches two image sets together with common anatomical structures for optimal fusion results. The two image sets must share the same common anatomical area.

Automatic image fusion is suitable for most image modality combinations with some exceptions (e.g., ultrasound image sets). In the case of unsupported modalities, the original scanner position (frame of reference) is available by default. Manual adjustments are possible.

NOTE: Depending on the type of fusion applied, different imaging modalities are supported. Scan protocol recommendations are given in the following chapters or can be found in the Brainlab Scan Protocols.

Rigid Fusion and Correction

Rigid fusion inaccuracies can be caused by distortion within one of the image sets or by different patient positions in several image sets. You can correct distortion using Cranial Distortion Correction within cranial workflows and correct different patient positions using Spine Curvature Correction for spine workflows. By doing so, a new image set is generated using a deformable registration algorithm (elastic deformation).

An elastic deformation by definition is not uniform throughout the whole volume. This can potentially mean accurate deformation in your area of interest but inaccurate deformation in another part of the brain or spine.

You should carefully verify the new image set generated, considering its entire image volume. The verification tools available in the application are described in the following sections.

Deformation Availability

Deformation is optional and dependent on licensing and system configuration. For more information, contact Brainlab support.

Reviewing Image Sets

Always review the image sets selected for fusion. The better the image quality and resolution, the better the fusion result.
2.2 Starting Image Fusion

Select and Start your Workflow

Steps

1. Select your workflow: E.g., Cranial > Planning.

2. Choose Image Fusion from within the workflow on the main screen of Content Manager.

Before You Begin

Use Patient Selection to select the patient and desired data. Refer to the Software User Guide, Content Manager Patient Selection for more information.

Adding or removing data influences how the algorithm creates the fusion network.

Image Modification

NOTE: Modifying image sets outside Image Fusion when already in use can lead to corruptions or inaccuracies.
General Navigation Functions

Options

<table>
<thead>
<tr>
<th>Button</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Home" /></td>
<td>Displays the main screen of <strong>Content Manager</strong>.</td>
</tr>
</tbody>
</table>
| ![Back](image) | Returns to the previous step.  
You are prompted to save or discard the current fusion results. |
| ![Done](image) | Confirms the fusion status and continues to the next step.  
Current results are saved for further processing. |
| ![Data](image) | Displays the list of fusion pairs and the data selection page. |
| ![MORE](image) | Data can be added or deleted from the data selection process. |
| ![Alerts](image) | Displays available alerts connected to the data. |

Image Navigation Functions

<table>
<thead>
<tr>
<th>Button</th>
<th>Function</th>
</tr>
</thead>
</table>
| ![Zoom](image) | **Zoom**: Drag the mouse pointer:  
• Down to zoom in  
• Up to zoom out  
**NOTE**: You can use CTRL on the keyboard and the mouse wheel as a shortcut. |
| ![Scroll](image) | **Scroll**: Drag the mouse pointer through image slices.  
**NOTE**: You can use the mouse wheel as a shortcut. |
| ![Pan](image) | **Pan**: Display vertical and horizontal planes indicated by yellow lines on the images.  
**NOTE**: When **Pan** is selected in one view, the other views update accordingly.  
**NOTE**: You can use CTRL on the keyboard and the left mouse button as a shortcut. The position of the click/touch defines the view center. |
## Fusion Options

<table>
<thead>
<tr>
<th>Options</th>
<th>Description</th>
</tr>
</thead>
</table>
| ![Fusion](fusion) | Performs a fusion on the current selection.  
*NOTE: Once a fusion is reviewed and approved, you are prompted to approve the other fusion pairs in your image set.* |
| ![Reset](reset)  | Resets the existing fusion into its two separate image sets.                 |
| ![Pair 1 (of 4)] | Displays the previous/next fusion pair.                                     |
2.3 Image Fusion for Cranial Procedures

2.3.1 Introduction

General Information

When starting a cranial workflow, you can choose between:

- **Image Fusion**
- **Cranial Distortion Correction**

The images are fused based on common anatomical structures visible in both image sets.

The aim is to review the quality of the fusion results, and, if satisfactory, approve the fusion. The fusion is saved by selecting **Done**.

Always verify the results on the whole image set before approving and saving them.

**NOTE:** The fusion is based on common anatomical structures and is affected by brightness variations within the image slices.

Cranial Screen Layout

![Image ofcranial screen layout]

<table>
<thead>
<tr>
<th>No.</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>①</td>
<td>Axial, coronal and sagittal reconstructions as a preview of the current result.</td>
</tr>
<tr>
<td>②</td>
<td>Axial, coronal and sagittal view selector.</td>
</tr>
<tr>
<td>③</td>
<td>Region of interest (ROI) used for rigid fusion is displayed as a dotted line in the main view and the ACS reconstructions ①, see page 50 for more information.</td>
</tr>
<tr>
<td>④</td>
<td>The current fused pair is displayed as an overlay, which can also be previewed within the ACS reconstructions ①.</td>
</tr>
</tbody>
</table>
How to Use Image Fusion for Cranial Procedures

Figure 3

Steps

1. Select and switch between fusion pairs for review. Rigid fusion starts automatically.

2. By default, Spy Glass is activated. Review the fusion by using Blending/Spy Glass.
   
   NOTE: For more information on review and verification tools, see page 38.

3. Select between Axial, Coronal and Sagittal view orientations.

4. Select Scroll and scroll through the image slices using the arrow buttons.
   
   NOTE: You can also use the mouse wheel to scroll.

5. Review and accept the fusion result when satisfied.

6. On accepting the fusion result, its status is displayed.
Steps

| 7. | Select **Done** when complete.  
|    | The fusion results are saved for further processing. |
2.3.2 Cranial Distortion Correction

General Information

Certain imaging modalities are susceptible to geometric distortions arising from e.g., system imperfections and gradient nonlinearities of the imaging system. Consequently, inaccuracies within rigid fusion results may exist after automatic fusion, manual adjustment or applying ROI fusion.

You can choose Cranial Distortion Correction to obtain a better match between images. Cranial Distortion Correction creates a corrected image set by deforming it to better match the defined reference image set. The aim is then to review the corrected image set and potential contents that were present in the image set, and if satisfactory, approve the result.

NOTE: The fusion is based on common anatomical structures and is affected by brightness variations in the image slices and scan quality.

NOTE: Image sets corrected by Cranial Distortion Correction are not recommended for patient registration.

Recommendations

Image data for Cranial Distortion Correction should follow these recommendations to ensure the best results:

• Image pairs should cover an intersecting volume of the patient.
• A minimum of 10 slices
• A slice distance lower than 4 mm (slice thickness lower than 4mm and an acquisition without gaps are recommended)
• Full DICOM information (i.e., complete DICOM header, indicating e.g., acquisition parameters)
• Good raw image quality (e.g., high resolution, high contrast, minimal artifacts)

Supported Image Modalities

The following imaging modalities are supported for distortion correction, if paired as follows:

• CT-MR
• MR-MR
• MR-DTI

Unsupported Image Modalities

The following special modalities and sequence types are not supported:

• Previously deformed image sets
• RGB images
• FA and ADC maps
• Phase and velocity maps
• Perfusion maps
• Spectroscopy images
• Gradient calibration scans

Figure 4
• FLAWS scans (fluid and white matter suppression)
• Subtraction images and projections (Minimum/Maximum Intensity Projections)
• Image sets containing burned-in objects

**Supported Content**

The following content is supported and corrected based on the deformation of an image set:

- Voxel objects
- Labeled points
- Trajectories
- Fiber bundles (e.g., DTI fiber tracts)

**How to Start Cranial Distortion Correction**

| Step | Choose Cranial Distortion Correction from the main screen of Content Manager. |

**How to Use Cranial Distortion Correction**

**Steps**

1. Select the fusion pair ③ for review or calculation.
## Steps

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>By default, <strong>Spy Glass</strong> is activated. Review your data by using <strong>Blending/Spy Glass</strong> and if necessary use <strong>Adjust</strong>. <strong>NOTE:</strong> For more information on review and verification tools, see page 38.</td>
</tr>
</tbody>
</table>
| 3 | Select **Calculate** to start the fusion. Depending on the input images, you may be prompted to:  
  • Select the image set to be corrected, see page 23  
  • Transfer the correction calculated for one image set to a network of further image sets, see page 28. |
| 4 | Select between Axial, Coronal and Sagittal view orientations. |
| 5 | Select **Scroll** and scroll through the image slices using the arrow buttons. **NOTE:** You can also use the mouse wheel to scroll. |
| 6 | Review and verify the distortion correction by toggling between **Blending/Spy Glass**.  
  Toggle **Original** to compare the distortion correction with the original image. |
| 7 | Review and accept the fusion result when satisfied. |
| 8 | On accepting the fusion result, its status is displayed. |
| 9 | Select **Done** when complete. The corrected image set is saved for further processing. |

**NOTE:** **Cranial Distortion Correction** results are saved as a new DICOM image set, containing the prefix **[Corrected]**. The original image sets are replaced by the corrected data and stored locally.  

Consider the impact of making modifications within Cranial Distortion Correction to pre-existing objects and other planning contents (e.g., points, trajectories or fiber bundles). Always verify the shape and position of planning content within DICOM Viewer or the Element used to create the content.
Selecting Image Sets to be Corrected

If Cranial Distortion Correction cannot automatically determine which image set needs to be corrected, you need to select this image set manually. In this case Brainlab recommends selecting the image set showing greater distortion.

<table>
<thead>
<tr>
<th>Button</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Cancel" /></td>
<td>Close the dialog and return to the original source data.</td>
</tr>
<tr>
<td><img src="image" alt="Proceed" /></td>
<td>Start the Cranial Distortion Correction algorithm.</td>
</tr>
</tbody>
</table>

Do not use Cranial Distortion Correction during surgery or with image sets containing strong local deformations (e.g., an open skull showing brainshift).
How to Select Images to be Corrected

![Figure 7](image_url)

**Steps**

1. Highlight the image set.
2. Press **Proceed**. The calculation starts.

Cranial Distortion Correction Example

![Figure 8](image_url)

When the Cranial Distortion Correction algorithm is complete, the resultant image set is marked **FUSED** and the new image set is labeled as **Corrected**. DTI data is always treated as a bundle.
2.3.3 TRAM (Treatment Response Assessment Map)

General Information

Treatment Response Assessment Maps (TRAMs)* visualize the accumulation of a contrast agent against its rate of clearance. This approach can support the decision making/differentiation of tumor progression from treatment effects in most cranial tumor cases (see publications**). The method works by acquiring two MRI series – one at 5 minutes and another at approx. 75 minutes after injection of a standard dose of contrast agent – and subtracting the first series from the second, resulting in the TRAM. Use Image Fusion to fuse and compare the two MRI image sets.

* Developed at Sheba Medical Center with technology provided by Brainlab.

Example

![TRAM Example Image]

<table>
<thead>
<tr>
<th>Color</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Accumulation of the contrast agent (slow clearance)</td>
</tr>
<tr>
<td>Blue</td>
<td>Clearance of the contrast agent (fast clearance)</td>
</tr>
</tbody>
</table>

TRAM Requirements

The TRAM calculation requires the following:

- Two 3D MRI volumes need to be acquired
- Both sequences must be acquired using the equivalent scan protocol
- The first sequence must be taken approx. 5 minutes after contrast agent injection (using e.g., Gd/Gadolinium)
- The second sequence must be taken 60-105 minutes after contrast agent injection.
How to Use TRAMs

Steps

1. Select the first and second MRI volumes (i.e. early and late image acquisitions after the contrast agent injection).

2. Select **Calculate** to start the TRAM calculation. A rigid fusion of both MR sequences is performed automatically prior to the TRAM calculation.

3. Select between Axial, Coronal and Sagittal view orientations ①.

4. Select **Scroll** and scroll through the image slices using the arrow buttons ②. NOTE: You can also use the mouse wheel to scroll.

5. Review the accumulation/clearance of the contrast agent, see page 25 for more information.

6. By default, **Spy Glass** ③ is activated. Review the fusion by using **Blending/Spy Glass**. NOTE: For more information on review and verification tools, see page 38.

7. Review and accept the fusion result ② when satisfied.

Figure 10
Steps

8. Select **Done** when complete. The fusion results are saved for further processing.

NOTE: TRAM image sets are saved as a new DICOM RGB image set, fused to the first MR image set (early, after contrast agent injection). The second (later) MR image set is removed from your current data selection automatically after calculation.
2.3.4 Cluster Deformation

General Information

Cluster Deformation gives you the option to transfer the correction calculated for one image set to a network of further image sets, rigidly fused to this set.

NOTE: Distances, volumes and angles are modified accordingly if data is corrected together with its parent image set.

Example Dialog

<table>
<thead>
<tr>
<th>Options</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculate correction for the left image set and transfer correction to all image sets in the above group.</td>
<td></td>
</tr>
<tr>
<td>Correct left image set only and break existing fusions to image sets on the right.</td>
<td></td>
</tr>
</tbody>
</table>

Cluster-based corrections are only valid if distortions are equivalent in all image sets. This scenario is most likely given if rigidly fused image sets were acquired within a single MRI session.

NOTE: Correction is only calculated for one image set and transferred to connected sets. No individual correction is calculated for each image set.
2.4 Image Fusion for Spinal Procedures

2.4.1 Introduction

General Information

When starting a spine workflow, you can choose between:

- **Image Fusion**
- **Spine Curvature Correction**

The images are fused together based on anatomical structures common to both image sets. The aim is to review the quality of the fusion results, and, if satisfactory, approve the fusion. The fusion is saved by selecting **Done**.

Always verify fusion results on the whole image set before approving and saving them.

**NOTE:** Fusion is not triggered automatically within a spine workflow. You must start a fusion manually.

**NOTE:** The fusion is based on common anatomical structures and is affected by brightness variations within the image slices.

Spine Screen Layout

![Spine Screen Layout](image)

**Figure 12**

<table>
<thead>
<tr>
<th>No.</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>①</td>
<td>Axial, coronal and sagittal reconstructions as a preview of the current result.</td>
</tr>
<tr>
<td>②</td>
<td>Axial, coronal and sagittal view selector.</td>
</tr>
<tr>
<td>③</td>
<td>Region of interest (ROI) is displayed as a dotted line in the main view and the ACS reconstructions ①, see page 50 for more information.</td>
</tr>
</tbody>
</table>
No. | Explanation
--- | ---
④ | Currently fused pair is displayed as an overlay, which can also be previewed within the ACS reconstructions ①.

### How to Use Image Fusion for Spinal Procedures

![Image of Spinal Procedure]

**Figure 13**

### Steps

1. Select and switch between fusion pairs ⑤ for review.

2. ![ROI Icon] Select **ROI** (region of interest).

3. Re-size ⑥ or re-position ③ to the desired area and shape by dragging the corners of the window.

4. Select between Axial, Coronal and Sagittal view orientations ①.
<table>
<thead>
<tr>
<th>Steps</th>
<th>Description</th>
</tr>
</thead>
</table>
| 5. | **Adjust** Manually align the images using the move and rotate tools prior to calculation.  
**NOTE:** Consider a central vertebra within the intersection of both image volumes when adjusting to obtain a rough match. |
| 6. | **Fusion** Select **Fusion** to fuse the image sets together. |
| 7. | **Spy Glass** By default, **Spy Glass** is activated. Review the fusion by using **Blending/Spy Glass**.  
**NOTE:** For more information on review and verification tools, see page 38. |
| 8. | **Scroll** Select **Scroll** and scroll through the image slices using the arrow buttons.  
**NOTE:** You can also use the mouse wheel to scroll. |
| 9. | Review and accept the fusion result when satisfied. |
| 10. | On accepting the fusion result, its status is displayed. |
| 11. | **Done** Select **Done** when complete. The fusion result is saved for further processing. |
2.4.2 Spine Curvature Correction

General Information

The position of a patient might change between different image acquisitions. Consequently, inaccuracies within rigid fusion results may exist after automatic fusion, manual adjustment or applying a ROI fusion. You can choose Spine Curvature Correction to obtain a better match between images.

Spine Curvature Correction creates a deformed image set that better matches the original image set.

The aim is then to review the corrected image set and potential contents that were present in the image set, and if satisfactory, approve the result.

NOTE: The fusion is based on common anatomical structures and is affected by brightness variations in the image slices and scan quality.

NOTE: Image sets corrected by Spine Curvature Correction are not recommended for patient registration.

Recommendations

Image data for Spine Curvature Correction should follow these requirements to ensure the best results:

• A minimum of 10 slices
• A slice distance lower than 3 mm (slice thickness lower than 3 mm and an acquisition without gaps are recommended)
• Full DICOM information (i.e., complete DICOM header, indicating e.g., acquisition parameters)
• If MRI data needs correcting, it should be acquired as a 3D or 2D-axial sequence with a T1-weighting (a T2-weighting or fat suppressed acquisition is also recommended).
• Good raw image quality (e.g., high resolution, high contrast, minimal artifacts)

Supported Content

The following content is supported and is corrected together with an image set:

• Voxel objects
• Labeled points
• Trajectories
• Fiber bundles (i.e., DTI fiber tracts)

Image Modalities

Common imaging modalities like CT and MRI with several submodalities are supported for deformation.

The following special modalities and sequence types are not supported:

• Previously deformed image sets
• RGB images
• FA and ADC maps
• Phase and velocity maps
• Perfusion maps
• Spectroscopy images
• Gradient calibration scans
• FLAWS scans (fluid and white matter suppression)
• Subtraction images and projections (Minimum/Maximum Intensity Projections)
• Image sets containing burned-in objects

How to Start Spine Curvature Correction

Step

Choose **Spine Curvature Correction** from the main screen of **Content Manager**.

How to Use Spine Curvature Correction

Steps

1. Select and switch between fusion pairs ③ for review or calculation.
   
   By default, **Adjust** is activated.

2. Manually align the images using the move ① and rotate ② tools prior to calculation.
   
   **NOTE**: Consider a central vertebra within the intersection of both image volumes when adjusting to obtain a rough match.
### Steps

3. **Select Calculate** to start the fusion. Depending on the input images, you may be prompted to:
   - Select the image set to be corrected, see page 35.
   - Transfer the correction calculated for one image set to a network of further image sets, see page 37.

4. By default, **Spy Glass** is activated. Review the fusion by using **Blending/Spy Glass**.
   *NOTE: For more information on review and verification tools, see page 38.*

5. **Select Scroll** and scroll through the image slices using the arrow buttons ④.
   *NOTE: You can also use the mouse wheel to scroll.*

6. Review and verify the distortion correction by toggling between **Blending/Spy Glass**.
   Toggle **Original** to compare the curvature correction with the original image.

7. Review and accept the fusion result when satisfied.

8. On accepting the fusion result, its status is displayed.

9. **Select Done** when complete.
   The corrected image set is saved for further processing.

*NOTE: Spine Curvature Correction results are saved as a new DICOM image set, containing the prefix [Corrected]. The original image sets are replaced by the corrected data and stored locally.*

---

Consider the impact of making modifications within Spine Curvature Correction to pre-existing objects and other planning contents (e.g., points, trajectories or fiber bundles). Always verify the shape and position of planning content within DICOM Viewer or the Element used to create the content.
Selecting Image Sets to be Corrected

![Image](image.png)

**Figure 16**

<table>
<thead>
<tr>
<th>Button</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="cancel.png" alt="Cancel" /></td>
<td>Close the dialog and return to the original source data.</td>
</tr>
<tr>
<td><img src="proceed.png" alt="Proceed" /></td>
<td>Start the <strong>Spine Curvature Correction</strong> algorithm.</td>
</tr>
</tbody>
</table>
Curvature Correction Example

When the Spine Curvature Correction algorithm is complete, the resultant image set is marked FUSED ① and the new image set is labeled as [Corrected].

Figure 17
2.4.3 Cluster Deformation

**General Information**

Cluster Deformation gives you the option to transfer the correction calculated for one image set to a network of further image sets, rigidly fused to this set.

*NOTE: Distances, volumes and angles are modified accordingly if data is corrected together with its parent image set.*

---

**Cluster Deformation for Spine**

![Figure 18](image)

**Options**

- Calculate correction for the left image set and transfer correction to all image sets in the above group.
- Correct left image set only and break existing fusions to image sets on the right.

*Cluster-based correction is only valid if the patient position is the same in all image sets.*

*NOTE: Correction is only calculated for one image set and transferred to connected sets. No individual correction is calculated for each image set.*
2.5 Reviewing and Verifying Fusion Results

2.5.1 Introduction

General Information

Verification features available within Image Fusion are:

- Spy Glass
- Blending
- Toggling between both Original and corrected image sets
- Windowing
2.5.2 Spy Glass

General Information

Use Spy Glass to visually verify the accuracy of the image fusion for the whole image set by moving it to the position of interest on the image slice. This allows you to view structures in two image sets at the same time (e.g., the shape or size of a tumor).

How to Use Spy Glass for Rigid Fusions

![Image of Spy Glass interface](image)

Figure 19

<table>
<thead>
<tr>
<th>Steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Select <strong>Spy Glass</strong> from the tool bar.</td>
</tr>
<tr>
<td>2. <strong>Spy Glass</strong> superimposes the second image set in a frame over the first image set. Position the window anywhere over the underlying image.</td>
</tr>
<tr>
<td>3. Re-size or re-position to the desired area and shape by dragging the corners of the window.</td>
</tr>
<tr>
<td>4. Scroll through the image slices using the arrow buttons. <strong>NOTE</strong>: Scroll using the mouse wheel or by dragging up and down in the view if <strong>Scroll</strong> is active.</td>
</tr>
<tr>
<td>5. Use <strong>Zoom</strong> to zoom in or out. <strong>NOTE</strong>: You can also use CTRL and the mouse wheel to zoom.</td>
</tr>
<tr>
<td>6. Review and accept the fusion result when satisfied.</td>
</tr>
</tbody>
</table>
### Steps

7. **Done**

Select **Done** when complete.  
The fusion result is saved for further processing.
2.5.3 Spy Glass in Correction Mode

General Information

Use Spy Glass to visually verify the accuracy of the deformation, by moving it to the area of interest on the image slice. This allows you to view structures in two image sets at the same time (e.g., the shape or size of a tumor).

Color Coded Deformation Grid

When Spy Glass is selected within Cranial Distortion Correction or Spine Curvature Correction, a color coded deformation grid is displayed by default. Grid lines indicate the direction of correction while colored cells mark the areas of image modification. The color coding is defined by the degree of non-rigid transformation of a particular voxel.

NOTE: You can toggle the color coded grid on/off by moving the Spy Glass or holding down the Shift key.

Example Deformation

As displayed in the example above, distortions of DTI images (EPI sequences) are corrected along the A-P direction in the outermost parts of the brain (left image). Spine Curvature Correction results in deformation (compression or extension) of the intervertebral discs (right image).

The red areas indicate the areas of image modification from the original source data. Unshaded areas are not deformed but may have shifted as indicated by the grid lines.
How to Use Spy Glass in Correction Mode

**Steps**

1. Select **Spy Glass** from the tool bar.

2. **Spy Glass** superimposes the second image set in a frame over the first image set. The window ① can be positioned anywhere over the underlying image.

3. Re-size or re-position to the desired area and shape by dragging the corners of the window.

4. Scroll through the image slices using the arrow buttons ③. **NOTE:** Scroll using the mouse wheel or by dragging up and down in the view if Scroll is active.

5. Use **Zoom** to zoom in or out. **NOTE:** You can also use CTRL and the mouse wheel to zoom.

6. Analyze the deformation area by toggling and comparing the **Original** ② image set with the corrected one. **NOTE:** The original image remains visible as long as the button is pressed and the corrected image is displayed when the button is released.

7. Review and accept the result when satisfied.
## Steps

| 8. | Select **Done** when complete. The corrected image set is saved for further processing. |
2.5.4 Blending for Rigid Fusions

**General Information**

**Blending** distinguishes between image sets by displaying one in blue and the other in amber, highlighting critical areas of interest. Blue and amber are complementary colors. If the two image sets display the same information, the overlay is displayed as a grayscale image. Where it differs, the result is blue or amber.

**How to Use Blending**

1. **Move the slider** ① left or right across the viewing area with the mouse (or finger for touchscreens) to adjust the blended image with Blending selected.

2. **Scroll through the image slices using the arrow buttons** ②.
   
   *NOTE: Scroll using the mouse wheel or by dragging up and down in the view if Scroll is active.*

3. Use **Zoom** to zoom in or out.
   
   *NOTE: You can also use CTRL and the mouse wheel to zoom.*

4. **Review and accept the fusion result when satisfied.**

5. **Select Done** when complete.
   
   The fusion result is saved for further processing.

---

**Figure 22**
Blending Example

The images that are displayed furthest left and right show a grayscaled image and blending is established in the middle by simultaneously weighting the intensity of either one or both images according to the slider position.

![Blending Example](image)

Figure 23

<table>
<thead>
<tr>
<th>No.</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>①</td>
<td>MR image (displayed as grayscale)</td>
</tr>
<tr>
<td>②</td>
<td>MR image (displayed in blue)</td>
</tr>
<tr>
<td>③</td>
<td>Blended composite image</td>
</tr>
<tr>
<td>④</td>
<td>CT image (displayed in amber)</td>
</tr>
<tr>
<td>⑤</td>
<td>CT image (displayed as grayscale)</td>
</tr>
</tbody>
</table>
2.5.5 Blending in Correction Mode

General Information

Blending within Cranial Distortion Correction or Spine Curvature Correction follows the same principle as with an Original fusion, see page 44, with the two image sets displayed using blue and amber.

When Blending is selected within Cranial Distortion Correction or Spine Curvature Correction, a deformation grid is displayed by default. Grid lines indicate the direction of correction while colored lines mark the areas of image modification.

NOTE: You can toggle the deformation grid on/off by moving the blending slider or holding down the Shift key.

How to Use Blending with Correction

Steps

1. Move the slider left or right across the viewing area with the mouse (or finger for touchscreens) to adjust the blended image with Blending selected.

2. Scroll through the image slices using the arrow buttons.

   NOTE: Scroll using the mouse wheel or by dragging up and down in the view if Scroll is active.

3. Analyze the deformation area by toggling and comparing the Original image set with the corrected one.

   NOTE: The original image remains visible as long as the button is pressed and the corrected image is displayed when the button is released.
### Steps

| 4. | Review and accept the result when satisfied. |
| 5. | Select **Done** when complete. The corrected image set is saved for further processing. |

### Windowing

**Figure 25**

Windowing enables you to adjust brightness and contrast for each set of your current fusion pair.

<table>
<thead>
<tr>
<th>Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select Windowing ②, then choose your image set ①.</td>
</tr>
</tbody>
</table>

### Windowing Adjustment Functions

<table>
<thead>
<tr>
<th>Function</th>
<th>How to Adjust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brightness</td>
<td>Drag mouse (or finger for touchscreens) up or down across the screen.</td>
</tr>
<tr>
<td>Contrast</td>
<td>Drag mouse (or finger for touchscreens) left or right across the screen.</td>
</tr>
</tbody>
</table>
2.6 Manually Adjusting Fusion Results

2.6.1 Adjusting Images

General Information

If automatic fusion results are unsatisfactory, you can make manual adjustments. Aligning the image set manually sets a starting point to aid the registration algorithm and to improve fusion results.

How to Adjust for Automatic Fusions

Steps

1. Select **Adjust** from the tool bar.

2. Move the image by dragging the arrow symbol until the amber image is appropriately positioned.

3. Rotate the image by dragging the curved handle until the amber image is appropriately positioned.

4. Scroll through the image slices using the arrow buttons. *NOTE: You can also use the mouse wheel to scroll.*

5. Use CTRL and the mouse wheel to zoom in or out. The position of the click defines the zoom center.
### How to Perform a Manual Fusion

<table>
<thead>
<tr>
<th>Steps</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Select <strong>Adjust</strong> from the tool bar.</td>
</tr>
<tr>
<td>2.</td>
<td>Move the image by dragging the arrow symbol ① until the amber image ④ is appropriately positioned.</td>
</tr>
<tr>
<td>3.</td>
<td>Rotate the image by dragging the curved handle ② until the amber image ④ is appropriately positioned.</td>
</tr>
</tbody>
</table>
| 4. | Scroll through the image slices using the arrow buttons ③.  
**NOTE:** You can also use the mouse wheel to scroll.  |
| 5. | Review and accept the fusion result when satisfied. The manually adjusted result could be saved as a fusion for the current pair.  |
| 6. | Select **Done** when complete. |
2.6.2 Adjusting the ROI (Region of Interest)

General Information

Use the adjustment functions to adjust the fusion area to include all relevant structures for treatment.

Performing image fusion on a manually defined ROI (Region of Interest) restricts the fusion algorithm to the ROI area. It enables higher fusion accuracy in a limited spatial area.

NOTE: The ROI process displays one image set at a time.

NOTE: This feature is only available for rigid image fusion. Manual adjustment of the ROI has no influence on the deformation result.

How to Adjust the ROI

1. Select ROI from the toolbar.
2. Adjust the frame by using the re-size, move, and rotate controls so that it surrounds the area to be used as the fusion reference.
3. Ensure that sufficient anatomical information is covered by the region of interest in order to improve the fusion results.

The fusion ROI is only stored for approved fusion pairs when leaving the image fusion task. Approve and save a result in order to avoid misinterpretation of results and to store for later use.
How to Start a Fusion

<table>
<thead>
<tr>
<th>Step</th>
<th>After finishing a manual adjustment of a ROI, select Fusion.</th>
</tr>
</thead>
</table>

*NOTE:* You must select Fusion to apply the fusion algorithm to the newly defined ROI.

How to Reset a Fusion

<table>
<thead>
<tr>
<th>Step</th>
<th>If you have fused images and want to reset the images back to the initial scanner coordinate system, select Reset.</th>
</tr>
</thead>
</table>

*NOTE:* Using Reset allows you to return to the initial alignment of image sets. If a ROI was defined to perform a fusion, the Reset action also deletes the manually defined ROI.
2.7 Changing Fusion Pairs

General Information

*Image Fusion* builds a network of fusion pairs based on image properties e.g., acquisition time, imaging modality, spatial resolution, etc.

Activating the *Data* menu, the *Fusion Pairs* section gives an overview of the current pair under review and the other available pairs.

Two different functionalities are available within the *Fusion Pairs* menu:

- Changing pairing manually using *Edit*
- Changing display orientation of certain image sets using *Align*

How to Select Pairs

![Fusion Pairs Menu](image)

**Figure 28**

**Steps**

1. Select the *Fusion Pair* dialog from the tool bar to change which fusion pair is selected.

2. To select a different pair, highlight your preferred image pair.
Fusion Pairing Example

<table>
<thead>
<tr>
<th>No.</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>①</td>
<td>Selected image pair</td>
</tr>
<tr>
<td>②</td>
<td>Approval status</td>
</tr>
</tbody>
</table>

How to Customize Fusion Pairing

![Figure 30](image_url)

Figure 30
You can change the pairing of the image sets using **Edit**.

### Steps

1. **Select Data and open the Fusion Pairs drop-down.**
2. **Select Edit to access the Manual Pairing functionality and select the images to be fused.**
3. **Select two image sets to be fused.**
4. **Select Use this Pair.**
   - **NOTE:** Select **Cancel** to return to previous menu.
5. **Close the Data menu and return to the main screen.**
6. **Select Calculate/Fusion to fuse the image set.**
   - **NOTE:** The options vary depending on the application mode you are running.
7. **Select Done when complete.**

**NOTE:** Every modification of the image set pairing causes modifications to the initial network/fusion chain. When new data is available, it is added to the existing network/fusion chain and the fusion algorithm runs again. The user needs to verify the results.

For more technical information on default fusion pairs, contact Brainlab support.

If a manually defined fusion pair conflicts with other fusion pairs, or the image set selection is updated, the software automatically resolves the conflict and potentially overwrites or resolves the existing fusion. You must review the fusion again.
How to Define Alignment

You can change the viewing orientation of a fusion pair using Align. This allows you to select the image set that defines the view orientation.

To change the orientation or define the alignment of your selected image set, perform the following:

<table>
<thead>
<tr>
<th>Steps</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Select Align from the menu.</td>
</tr>
<tr>
<td>2.</td>
<td>Choose the image intended to define the alignment.</td>
</tr>
<tr>
<td>3.</td>
<td>Select Confirm. The view aligns automatically.</td>
</tr>
</tbody>
</table>
2.8 Finalizing and Closing Image Fusion

Review Pending

The **Review Pending** dialog opens if you try to proceed without accepting or declining a result.

<table>
<thead>
<tr>
<th>Options</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Review" /></td>
<td>Allows you to go back and approve the pending results.</td>
</tr>
<tr>
<td><img src="image" alt="Discard" /></td>
<td>Allows you to proceed without fusion approval.</td>
</tr>
</tbody>
</table>

**Fusion Approvals**

*NOTE: Fusions must be approved in order to use them in other applications.*
Deformation Results

After fusion approval a corrected image set is saved and the original is then removed from SELECTED DATA. The original can still be selected from the patient repository, if required.

To deform DTI data, always select a complete "DTI Study". If the corrected image set is B0 (as part of a DTI data acquisition), the whole DTI dataset (FA, ADC map) is also deformed.

DTI Data Handling

- Always select a DTI study from the data selection on the left side instead of selecting B0, FA or ADC separately.
- A valid DTI study is treated as a bundle within Image Fusion, named "DTI Bundle".
- All DTI bundles are treated equivalently. For example, if a bundle is corrected, four new image sets are created (B0, FA, colored FA, ADC).

How to Close Image Fusion

<table>
<thead>
<tr>
<th>Steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Finalize your current task by selecting Done. Image Fusion saves your results for later viewing in the DICOM system.</td>
</tr>
<tr>
<td>2. Select Home from the functions menu to minimize the application.</td>
</tr>
<tr>
<td>3. Select Exit from main screen of Content Manager. NOTE: The approved fusion is saved.</td>
</tr>
</tbody>
</table>
Saving Data on Shutdown

Always finalize your current task before closing the software. Always close the software before shutting down the system. Data is not saved automatically if the system is shut down without properly closing the software.
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