PFUS Image Registration and Fusion

Image Registration

It is routine that multiple functional and anatomical images are acquired in the process of a thorough disease investigation. If this is not achieved in a single hybrid scanning session, the images will show the organs in different orientations due to variable subject positioning. The visual or numerical comparison of such heterogeneous images can be approximate at best. A much better approach is to bring all images into a common frame of reference and then start the actual assessment with matched images.

PFUS features a rich set of automatic methods for the registration of multi-modal images.

Stereotactic Normalization of Brain Images

Research has demonstrated that brain anatomy is comparable between the subjects of a species, and approaches were developed to derive representative brain images. Such template images establish a standard stereotactic space, into which the individual subject images must be mapped by a spatial normalization procedure. This kind of normalization requires not only proportional scaling of the dimensions, but also an elastic component for anatomical fine-adjustment.

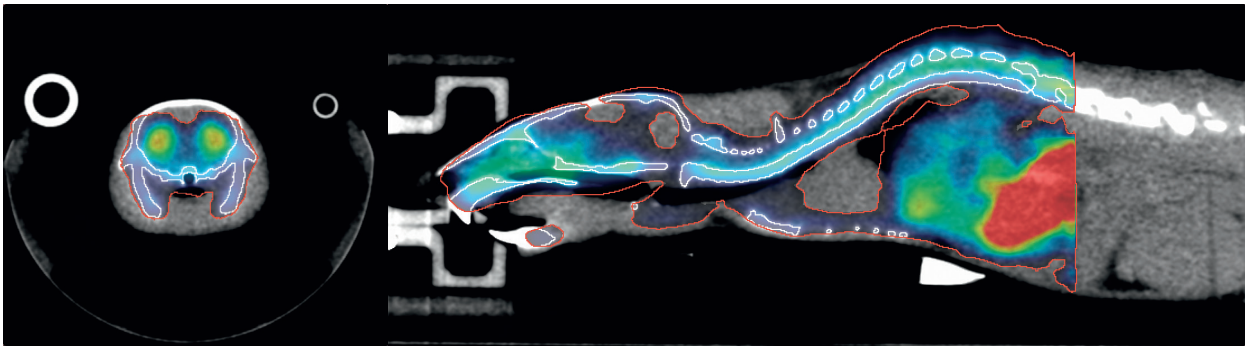
Image Registration and Fusion with PFUS

PMOD's PFUS tool provides a comprehensive environment for all kinds of research tasks related to image registration and brain image normalization. It supports convenient workflows so that a user can extract optimal results from multi-modal images even in the most challenging situations met in human or preclinical research.

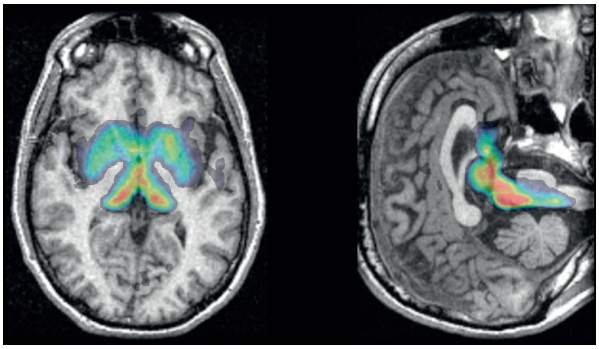
PFUS features a rich set of automatic methods for the registration of multi-modal images, and facilitates interactive precision adjustment of the alignment. Brain images of humans, primates, rats and mice can readily be normalized using templates for different imaging modalities and species. A unique functionality of PFUS is the mathematical combination of spatial transformations, and the calculation of inverse transformations. This allows, for instance, calculation of the spatial normalization with an MR image and using it to indirectly normalize a functional PET image.

Brain images of humans, rats and mice can readily be normalized using templates for different imaging modalities.

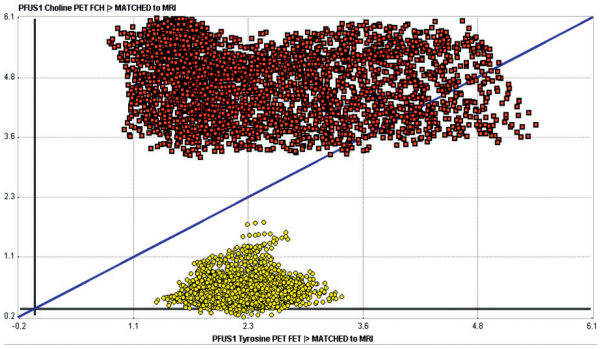
Once the images are registered, PFUS offers powerful tools for their joint analysis. The methods range from various types of fusion renderings, region outlining in the fused images, automatic delineation of standard brain regions, arithmetic operations between images, to the easy generation of scatter plots.



PET-derived dopamine D2/D3 map matched to CT (20 g mouse images).



PET-derived serotonin transporter map automatically matched to subject's MRI.



Scatter plot of corresponding Choline and Tyrosine pixel values in tumor (red) and contralateral tissue (yellow).

Rigid Image Registration
Techniques for rigidly aligning multimodal images:
– Automatic rigid matching using 6 metrics and various fine-tuning parameters
– Interactive manual rigid matching
– Landmark matching
– Motion correction of dynamic series

Deformable Image Registration
Three deformable registration approaches are available:
– Template based normalization (SPM5 compatible)
– Normalization based on 3 tissue probability maps (unified segmentation approach, SPM8 compatible)
– Normalization based on 6 tissue probability maps (SPM12 compatible)
– SyN methodology of ANTS (Advanced Normalization Tools)
Corresponding template information and parameter presets are available to bring human and animal brain images into standard anatomy spaces:
– Human (PET, T_1-MR, T_2-MR, probability maps) in the MNI space
– Mouse (FDG-PET, T_2-MR, CT)
– Rat (FDG-PET, T_2-MR) in the Paxinos space
– Pig (FDG-PET, HMPAO-SPECT, T_1-MR)
– Cynomolgus monkey (T_1-MR, FDOPA, DTBZ)
– Rhesus monkey (T_2-MR)
Standard VOI sets of brain areas are available in the above spaces. Users can easily add and apply their own VOI atlases.

Use of Transformations
Image registrations and normalizations are represented by mathematical transformations or deformation fields. The following operations are supported:
– Visualization of the deformation field
– Calculation of the inverse transformation
– Combination of transformations
– Application of a transformation to map VOIs from one image space to another

Image Interpolation
Control over the image interpolation process after registration is important for the subsequent visual or quantitative analyses. Supported interpolations:
– Nearest neighbor (for atlas applications)
– Trilinear
– Sinc (kernel with 5 or 7 voxels)
– Cubic spline

Image Fusion
Once the images are registered to a common space, they can be evaluated on a pixel-by-pixel basis. Available fusion options:
– Alpha blending
– Exchange of iso-contours
– Overlay of image parts above threshold
– Moving spyglass
– MIP rendering of up to three fused images and production of rotation cines
– Visualization of up to four fused and synchronized images in parallel
– VOI definition directly in fused images
– Saving fused images as DICOM SC objects for later research

Pixelwise Operations
– Handheld calculator-like algebra operations between images
– 2D and 3D scatter plots of the corresponding image values (including restriction to user-defined VOIs)