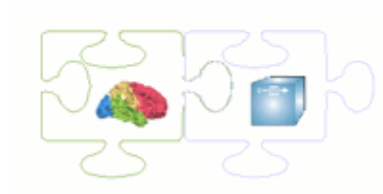


transformationsheet
addendum for
nifti converter plugin manual



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Geometrical transformations sheet

Introduction

This transformationsheet is an addendum for the NIfTI converter manual. It describes possible image transformations that can be entered as transformation matrix on the transformations tab of the NIfTI converter plugin (see figure 1). These transformations can be applied to currently opened BrainVoyager [2] images.

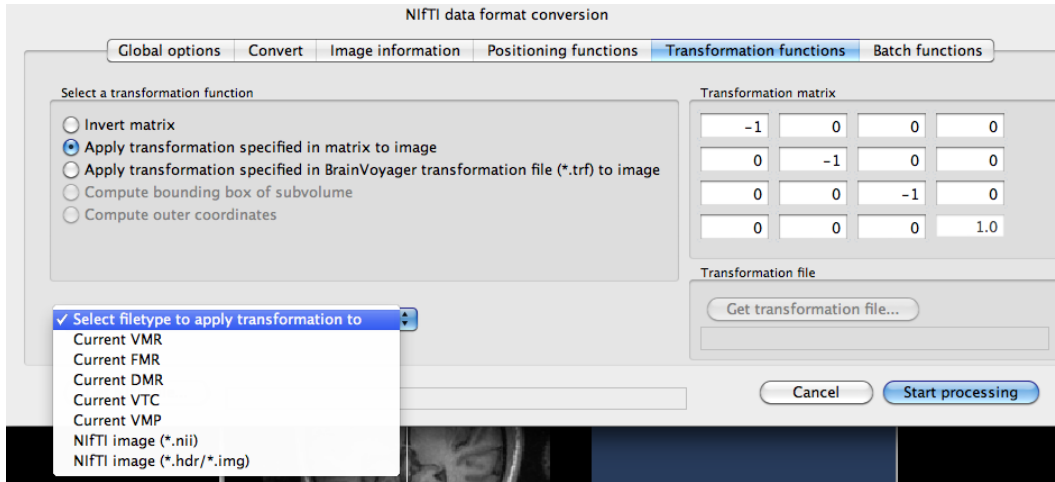


Figure 1: Transformation tab of NIfTI converter 1.08

One possible application is applying the transformation to an image to adapt it to another coordinate system (see figure 5), if the default transformations can not be used. The image transformations module is powered by prof. Thevenaz' code [3].

Thanks to Pim Pullens. Version: 1. In version 1 of this sheet just VMR images and just rotations are described; for information about how to place translations (shifts) in transformation matrices, see the NIfTI converter plugin manual.

Numbers

angle (radians: degrees)	0	0.5π : 90°	π : 180°	1.5π : 270°
sin	0	1	0	-1
cos	1	0	-1	0

Table 1: Rotations over right angles

Transformation matrices

To make a rotation matrix fit for 3D voxels, just add a column at the right ($[0\ 0\ 0\ 1]'$) and a row at the bottom of $[0\ 0\ 0\ 1]$, so that it becomes a 4×4 matrix.

axis	0	$0.5\pi: 90^\circ$	$\pi: 180^\circ$	$1.5\pi: 270^\circ$
x	$\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$	$\begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & -1 \\ 0 & 1 & 0 \end{pmatrix}$	$\begin{pmatrix} 1 & 0 & 0 \\ 0 & -1 & -0 \\ 0 & 0 & -1 \end{pmatrix}$	$\begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & -1 & 0 \end{pmatrix}$
y	$\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$	$\begin{pmatrix} 0 & 0 & -1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{pmatrix}$	$\begin{pmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{pmatrix}$	$\begin{pmatrix} 0 & 0 & 1 \\ 0 & 1 & 0 \\ -1 & 0 & 0 \end{pmatrix}$
z	$\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$	$\begin{pmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{pmatrix}$	$\begin{pmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$	$\begin{pmatrix} 0 & 1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 1 \end{pmatrix}$

Table 2: Rotation matrices for voxels

For more information, see chapter 5 of the book "Computer Graphics" by Foley et al [1].

Resulting transformations for VMR

In the paragraphs below, the effects of rotating over axes of a standard coordinate system (Talairach, NIfTI) on the images in BrainVoyager are shown.

Rotating over x-axis of an image

In a VMR, the x-axis is the anterior-posterior (sagittal) axis. So the effect of rotating over the x-axis on TAL-VMR is that the head rotates leftward (counter-clockwise as seen from the back of the head) over the anterior-posterior (sagittal) axis (see COR window in figure 2).

rotation over x-axis	$0\pi: 0^\circ$	$0.5\pi: 90^\circ$	$\pi: 180^\circ$	$1.5\pi: 270^\circ$
$\begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos(\theta) & -\sin(\theta) \\ 0 & \sin(\theta) & \cos(\theta) \end{pmatrix}$	$\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$	$\begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & -1 \\ 0 & 1 & 0 \end{pmatrix}$	$\begin{pmatrix} 1 & 0 & 0 \\ 0 & -1 & -0 \\ 0 & 0 & -1 \end{pmatrix}$	$\begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & -1 & 0 \end{pmatrix}$

Table 3: Rotation matrices for rotation over x-axis

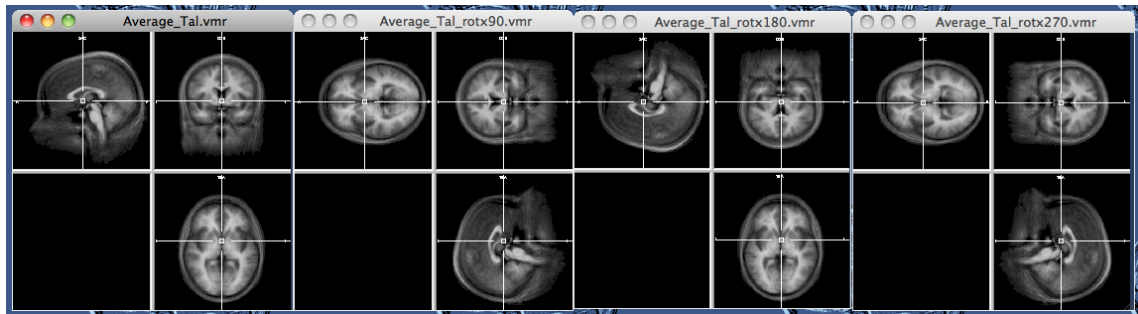


Figure 2: Effect of rotation matrices on x-axis of coordinate system on VMR image

Rotating over y-axis of an image

In a VMR, the y-axis is the inferior-superior (axial) axis. So the effect of rotating over the y-axis on TAL-VMR is that the head rotates leftward (counter-clockwise as seen from the top of the head) over superior-inferior (axial) axis (see TRA window in figure 3).

$$\begin{array}{ccccc}
 \text{rotation over y-axis} & 0\pi: 0^\circ & 0.5\pi: 90^\circ & \pi: 180^\circ & 1.5\pi: 270^\circ \\
 \begin{pmatrix} \cos(\theta) & 0 & -\sin(\theta) \\ 0 & 1 & 0 \\ \sin(\theta) & 0 & \cos(\theta) \end{pmatrix} & \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} & \begin{pmatrix} 0 & 0 & -1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{pmatrix} & \begin{pmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{pmatrix} & \begin{pmatrix} 0 & 0 & 1 \\ 0 & 1 & 0 \\ -1 & 0 & 0 \end{pmatrix}
 \end{array}$$

Table 4: Rotation matrices for rotation over y-axis

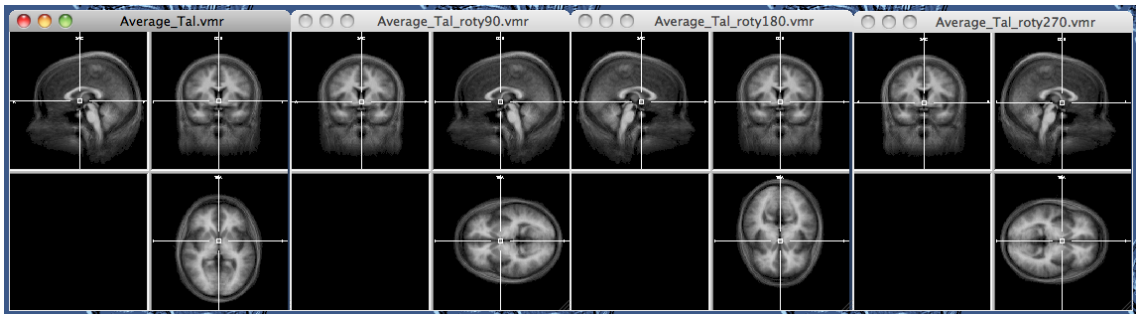


Figure 3: Effect of rotation matrices on y-axis of coordinate system on VMR image

Note: some use the following matrix for rotations over the y-axis [1]:

$$\begin{pmatrix} \cos(\theta) & 0 & \sin(\theta) \\ 0 & 1 & 0 \\ -\sin(\theta) & 0 & \cos(\theta) \end{pmatrix}$$

Rotating over z-axis of an image

In a VMR, the z-axis is the left-right (coronal) axis. So the effect of rotating over the z-axis on TAL-VMR is that the rotates backward (clockwise as seen from the left side of the head) over left-right axis (see SAG window in figure 4).

rotation over z-axis	$0\pi: 0^\circ$	$0.5\pi: 90^\circ$	$\pi: 180^\circ$	$1.5\pi: 270^\circ$
$\begin{pmatrix} \cos(\theta) & -\sin(\theta) & 0 \\ \sin(\theta) & \cos(\theta) & 0 \\ 0 & 0 & 1 \end{pmatrix}$	$\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$	$\begin{pmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{pmatrix}$	$\begin{pmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$	$\begin{pmatrix} 0 & 1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 1 \end{pmatrix}$

Table 5: Rotation matrices for rotation over z-axis

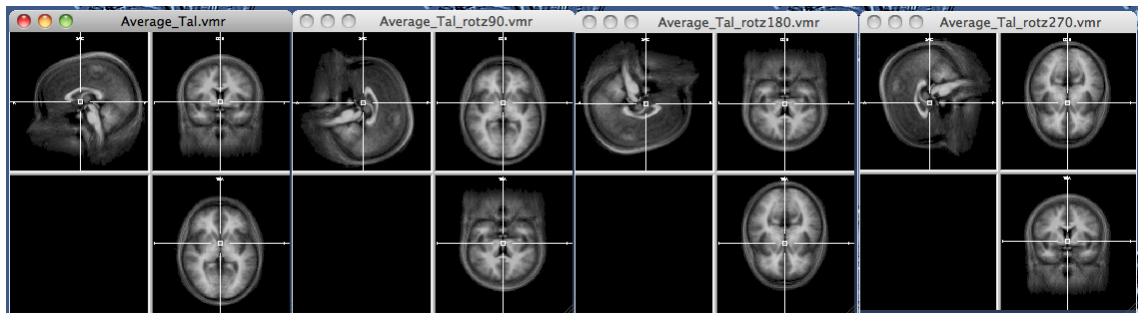


Figure 4: Effect of rotation matrices on z-axis of coordinate system on VMR image

Axes of coordinate systems

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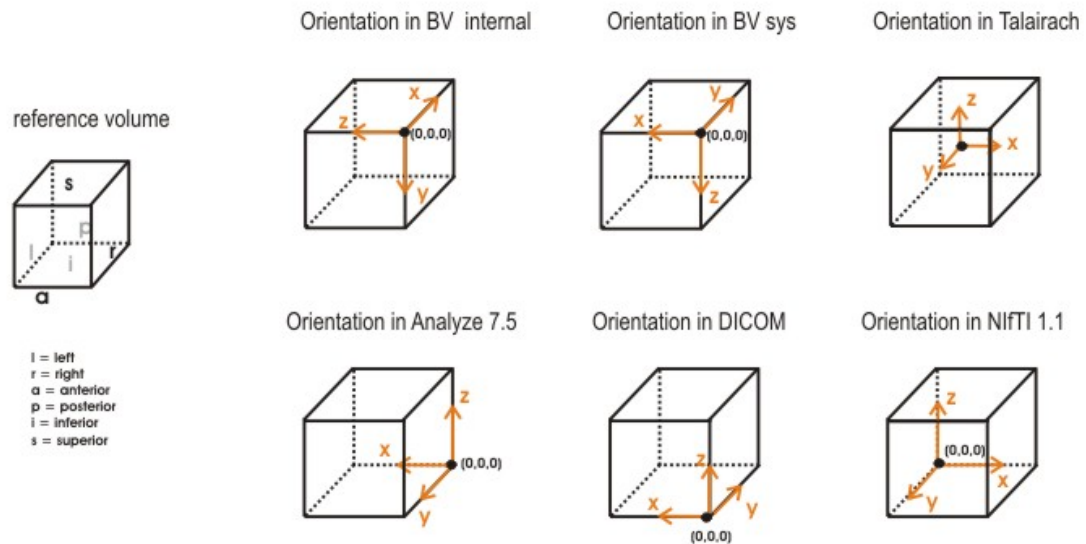


Figure 5: Coordinate systems in MRI

References

- [1] J.D. Foley, A. van Dam, S.K. Feiner, and J.F. Hughes. *Computer Graphics; principles and practice*. Addison-Wesley Publishing Company, Inc., 1996.
- [2] R. Goebel, F. Esposito, and E. Formisano. Analysis of fiac data with brainvoyager qx: From single-subject to cortically aligned group glm analysis and self-organizing group ica. *Human Brain Mapping*, 27(5):392–401, 2006.
- [3] P. Thevenaz, T. Blu, and M. Unser. Interpolation revisited. *IEEE Transactions on Medical Imaging*, 19(7):739–758, 2000.