# 3-D Manipulation of Brain Atlas

○백 철 화, 김 원 기
임상의공학 연구센터
삼성 생명과학연구소

Chul Hwa Paik, Won Ky Kim
Biomedical Engineering Research Center
Samsung Biomedical Research Institute

**Abstract**

Tri-planar interpolation of the orthogonal digital brain Atlas is proposed to achieve a higher resolution of a volume-metric atlas. With these expanded dataset, the brain mapping will be accomplished with fewer registration errors.

**Introduction**

The brain is characterized by reasonably consistent spatial features. Thus it is possible to relate individual experimental measurements to spatial coordinates which can then be related to other measurements in the same subject or compared to measurements from the same location in other subjects. Constantly, a universal reference system based on a Cartesian coordinate reference system keyed to a common anatomic landmark, the anterior commissure(AC), can provide a framework for a database containing any kind of experimental data for which a spatial relationship to this Co-ordinate system can be determined. This concept was pioneered by Dr. Jean Talairach and it is proposed to build his work.

"The Co-planar Stereotaxic Atlas of the Human Brain" by Jean Talairach and Pierre Tournoux contains artistically rendered images of transaxial, coronal and sagittal sections of the human brain. The initial analogue atlas consists of orthogonal sets of 27 axial slices, 38 coronal slices and 36 sagittal slices cross sections based on over 20 brains analyzed by Dr. Talairach, et.al. Versions of this Atlas have been in use for over 20 years and its accuracy is well documented in practice and in the literature; it has been applied to over 5,000 clinical stereotactic procedures all over the world. There has been limited generalization of individual data using the Atlas coordinate system as a common spatial reference. This requires rescaling of an individual's morphology to match the Atlas in order to pool data for population studies.

**Methods**

All of the figures in the Talairach Atlas has been digitized using camera with red, green, and blue filters for staying in the Johns Hopkins University, Medicine with the help of Dr. N. Bryan. The digitization process produced three 1024x1024-pixel resolution files for each figure of each view. The image files were compressed to 8-bits/pixel and imported into an ISG Allegro 3-D processing image station. The rendering capabilities of the system, normally used for three-dimensional rendering of MR image sets, is used to create a volume dataset of the atlas. This volume dataset is spatially resolved to 1024x1024x1024 over a 20cm FOV which produces square voxels of approximately 0.2 mm per slide. For this resolution of 0.2 mm, it is needed to achieve better interpolation by utilizing three orthogonal atlas. This expanded and corrected image dataset of Talairach is the organizational core of brain mapping. Every voxel location in this dataset has associated with a specific coordinate. It is through these coordinates that locations, names and descriptions of voxels are referenced. Atlas is labeled with 70 anatomical names with different colors. The system of using voxels to reference a database has allowed us to create a database based on location in Talairach space.

The tri-planar interpolation of orthogonal atlas is done as follows :
For each c running from 0 to 70, W values are calculated and the assigned value to pixel at (x,y,z) is determined by selecting c having the biggest value of W(x,y,z,c).

$$\underset{\substack{0<x,i \\ 0<y<j \\ 0<z<k}}{W(x,y,z,c)} = \sum_{\substack{\text{all i,j, and k of} \\ \text{cubic boundaries}}} V(i,j,k,c) \;/\; \left( 2 + 4^{*}d + 2 \sum_{0<m<d} m^{*}4 \right)$$

$$V(i,j,k,c) = 1 \qquad \text{if } V(i,j,k) = c$$
$$= 0 \qquad \text{if } V(i,j,k) \neq c$$

with d denoting a manhattan distance between pixel(x,y,z) and pixel(i,j,k) shown in Fig. 1.

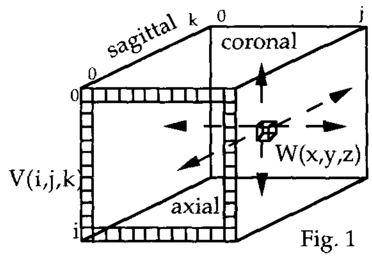

Fig. 1

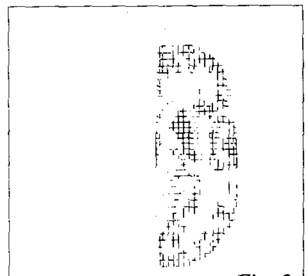
Fig. 2

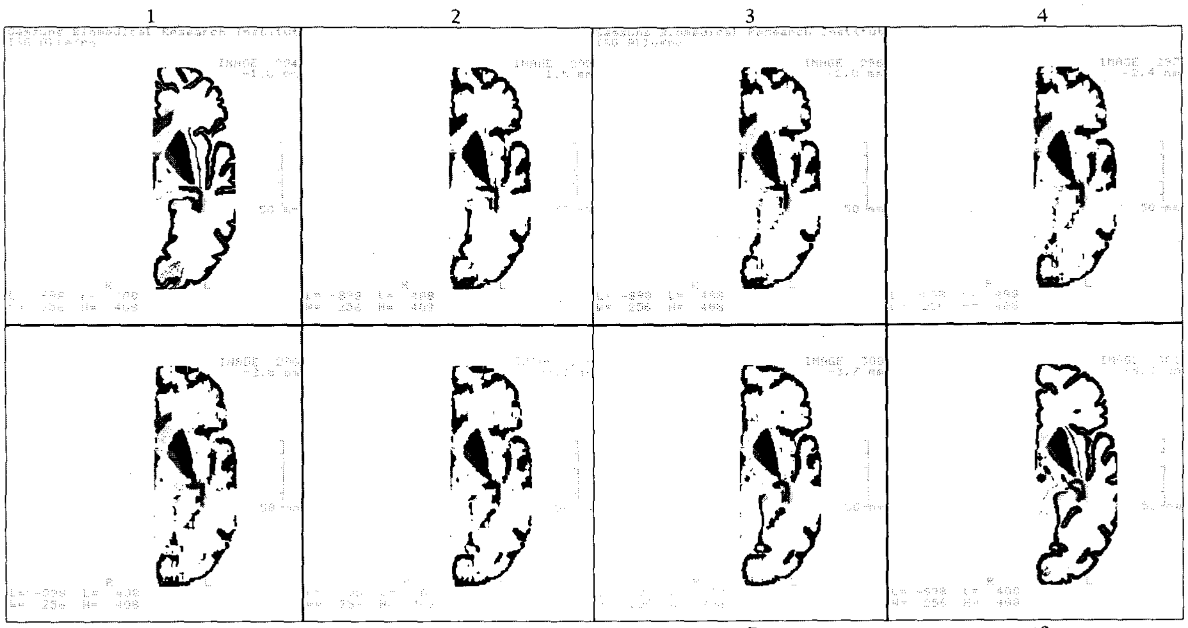

Fig. 3

In Fig.2, informations obtained from coronal and sagittal dataset are depicted in the corresponding slice location as an axial view. This figure is used to generate the interpolated slices in Fig.3's 4th image with Fig.3's 1st and 8th images. Fig. 3 shows the six(2-7) axial interpolated atlas with two original axial atlas(1, 8). The point being mentioned is the anatomical structure of "Claustrum" in interpolated slices. From Fig. 3, the Claustrum of the axial and sagittal atlas couldn't compensate for Claustrum missing in the original coronal atlas.

**Conclusion**

The expanded brain atlas proposed promises a valuable tool for the archiving and statistical investigation of large numbers and types of brain images. Even if this preliminary results were done with the imperfectly registered atlas in 3-D fashion, the neuroradiologist may give a opinion to find and fix the missing anatomical structures originally from three orthogonal dataset.

**Reference**

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