A Simple Algorithm for Curvilinear Reformatting of 3D MRI Data.

J. P. Wansapura[1], O. L. Williams[1], J. M. Williams[1], G. Mandybur[1]
[1]University of Mississippi, Jackson, Mississippi, United States

Abstract
A simple algorithm for curvilinear multiplanar reformatting (CMPR) of 3D MR imaging data is presented. The contour of the cortical surface was delineated interactively on several user-selected slices of the 3D data set. The contour data is then used to form a surface grid to which the 3D MRI data is mapped. Curved surfaces at different depth levels are generated automatically. The method written in MATLAB, was used to visualize the position of subdural strip electrodes on epilepsy patients (n=3), who were undergoing invasive electroencephalography.

Introduction
To interpret EEG recordings of seizure-onset zones, the positions of the subdural multicontact electrodes relative to the cortical surface are necessary. 3D MRI has been used to estimate the electrode position by multiplanar reformatting[1] but is limited due to the inherent complexity of the brain's convolution patterns. Recently CMPR using commercially available software has been introduced as a more efficient method of visualization[2, 3]. In step by step, a simple but robust method to perform CMPR is presented.

Method
All imaging was done on a 0.5T GE Signa SP (General Electric Medical Systems, Milwaukee, WI). A fast gradient echo sequence with parameters TR/TE = 18ms/9ms, slice thickness = 1mm, flip angle=30°, NEX=3 was used. Isotropic voxel resolution of $1mm^3$ was achieved. Imaging time was 10-12 minutes depending on the number of slices acquired. Data were transferred to a PC workstation in DICOM format and processed using software written in MATLAB (MathWorks, Natick, MA). One normal volunteer and three Epilepsy patients with implanted subdural strip electrodes were studied. Following is a description of the algorithm used. The processing took approximately 8 minutes to construct multiple curvilinear surfaces of the entire brain

Step 1: Contours of the cortical surface on a user-selected rectilinear slices (axial or coronal) were drawn. A polar coordinate system was used, where the slice axis was chosen as the Z direction.

Step 2: Spline fit for $\rho=f(\theta)$ was done for θ ranging from 0 to 2π at intervals of 0.01 radians for a smooth contour.

Step 3: Taking z as the selected slice locations, fitted a surface of the form $\rho=f(\theta,z)$ to the data in the non uniformly spaced vectors and linearly interpolated this surface at points specified by the desired resolution in $\rho,\theta,$ and z directions, forming a grid surface.

Step 4: Converted the grid surface in step 3 in to Cartesian coordinates (x',y',z'). Interpolated 3D MRI data $IM=f(x,y,z)$ to find the pixel values of the function IM at points x',y',z' on the curved surface.

Step 5: To find inner layers of the cortex, changed ρ found in step 3 by a specified length and repeated step 4.

Results

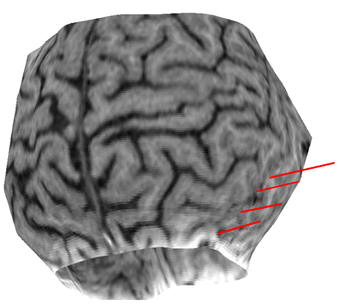
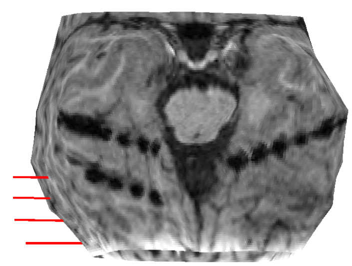


Figure 1. Lateral curvilinear reformatting shows the cortical surface with a subdural strip electrode with contacts (solid lines). Susceptibility artifacts on a surface 4mm above the current surface were used to determine the electrode positions.

Figure 2. Posterior view of the same surface as in Figure 1, shows clearly the susceptibility artifacts created by three overlaying strip electrodes.



Conclusion
CPMR of 3D MR data is useful in visualizing the underlying cortical surface of subdurally placed electrodes. The method, described here can be easily implemented on a standard PC, and was shown to be efficient.

References: (1) Barkovich AJ, et al. AJNR 1995;16:339-343. (2) Bastos AC., et al. Ann Neurol 1999;46:88-94. (3) Schulze-Bonhage A, et al. AJNR 2002,23:400-403.