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Software development for the visualization of brain fiber tract by using 24-bit color coding in diffusion tensor image

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Purpose : The purpose of paper is to implement software to visualize brain fiber tract using a 24-bit color coding scheme and to test its feasibility.

Materials and Methods : MR imaging was performed on GE 1.5 T Signa scanner. For diffusion tensor image, we used a single shot spin-echo EPI sequence with 7 non-colinear pulsed-field gradient directions: (x, y, z)=(1,1,0),(-1,1,0),(1,0,1),(-1,0,1),(0,1,1),(0,1,-1) and without diffusion gradient. B-factor was 500 sec/㎟. Acquisition parameters are as follows: TR/TE=10000ms/99ms, FOV=240㎜, matrix=128x128, slice thickness/gap=6㎜/0㎜, total slice number=30. Subjects consisted of 10 normal young volunteers (age:21～26 yrs, 5 men, 5 women). All DTI images were smoothed with Gaussian kernel with the FWHM of 2 pixels.

Color coding schemes for visualization of directional information was as follows. HSV(Hue, Saturation, Value) color system is appropriate for assigning RGB(Red, Green, and Blue) value for every different directions because of its volumetric directional expression. Each of HSV are assigned due to (r,θ,ϕ) in spherical coordinate. HSV calculated by this way can be transformed into RGB color system by general HSV to RGB conversion formula. Symmetry schemes: It is natural to code the antipodal direction to be same color(antipodal symmetry). So even with no symmetry scheme, the antipodal symmetry must be included. With no symmetry scheme, we can assign every different colors for every different orientation.($H=\phi, S=2\theta/\pi, V=\lambda_w$, where λ_w is anisotropy). But that may assign very discontinuous color even between adjacent voxels. On the other hand, Full symmetry or absolute value scheme includes symmetry for 180° rotation about xy-plane of color coordinate (rotational symmetry) and for both hemisphere (mirror symmetry). In absolute value scheme, each of RGB value can be expressed as follows. $R=\lambda_w|v_x|$, $G=\lambda_w|v_y|$, $B=\lambda_w|v_z|$, where (v_x,v_y,v_z) is eigenvector corresponding to the largest eigenvalue of diffusion tensor. With applying full symmetry or absolute value scheme, we can get more continuous color coding at the expense of coding same color for symmetric direction. For better visualization of fiber tract directions, Gamma and brightness correction had done. All of these implementations were done on the IDL 5.4 platform.

Results : In no symmetry scheme, the discontinuity artifact was shown in directional map images, but not in the absolute value scheme. With the absolute scheme, it was possible to compare each hemisphere's information on fiber directions. And we found that our implementation visualized major fiber tracts like corpus callosum, internal capsule and pyramidal tract very well.

Conclusions : In this study we are to implement the software of visualizing the orientations of fiber tracts by using various 24-bit color schemes. With applying various symmetry schemes, we can make a good directional map for white matter structure.