Direct Painting Software for Tracing on 3D Brain Surfaces with Global Conformal Parameterization

Center for Computational Biology (CCB)

[1]Yalin Wang , [2]Xianfeng Gu, [1]Tony F. Chan, [3]Paul M. Thompson, [4]Shing-Tung Yau

[1]Department of Mathematics, UCLA, Los Angeles, CA, USA.
[2]Computer Science Department, SUNY at Stony Brook, Stony Brook, NY, USA
[3]Laboratory of Neuro Imaging, Brain Mapping Division, Department of Neurology, UCLA School of Medicine, Los Angeles, CA, USA.
[4]Department of Mathematics, Harvard University, Cambridge, MA, USA.

Objective: As well as assisting in computational morphometry projects, convenient tools to visualize and trace on 3D brain surfaces may assist in communicating brain data and results, and in teaching anatomy. Since cortical geometry is convoluted and complex, interactive manipulation of high-resolution models proves difficult, and often requires expensive visualization or animation software. We therefore developed a convenient software toolkit that enables users to draw curves and label surface subregions directly on a given brain surface.

Methods: With surface reconstruction tools such as deformable models, level set techniques, or Marching Cubes, geometric models of brain surfaces are frequently extracted from MRI volumes. In our work, we treat these surfaces as complex manifolds and compute their holomorphic differentials (conformal structures). This essentially induces a parameterization of the surface by conformally mapping it onto a sphere, or, in the non-zero genus case, onto a connected set of rectangular subdomains. This mapping, a conformal equivalence, is one-to-one, onto, and angle-preserving.

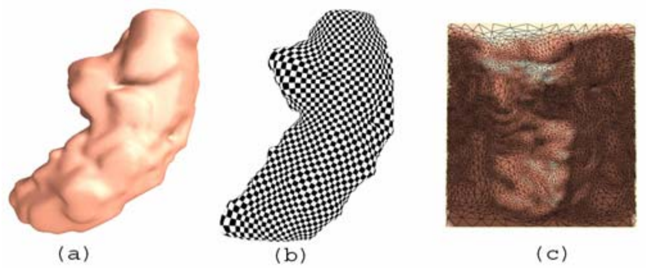

Figure 1 Illustrates a conformal structure of a hippocampal surface. (a) is the original surface; (b) is the conformal structure visualized by mapping a checkerboard from the parameter domain onto the surface; (c) is the rectangle the hippocampal surface is conformally mapped to.

In our tracing software, the global conformal parameterization helps us to convert the mouse position on the screen to a unique position on the brain surface. The software is written with OpenGL in C++, and works on a PC running the Windows XP operating system. The geometry of the traced 3D curves is recorded by saving them as a list of vertices on the surface mesh. A labeled region is stored by recording the set of ordered vertices on its boundary.

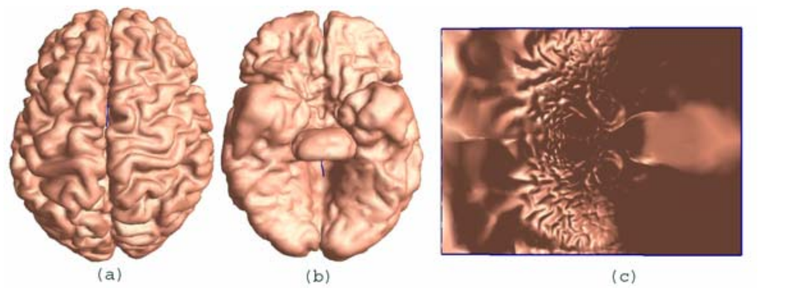

Figure 2 Illustrates the parameterization of a cortical surface. (a), (b) show the two cuts we introduce to change the topology. (c) is the parameter domain.

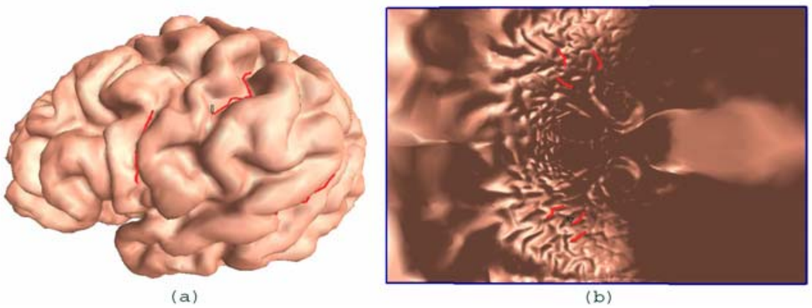

Figure 3 Illustrates how the software converts a 2D position to a 3D surface position. (a) shows the drawing of curves on the 3D surface and (b) shows the curves on the 2D parameter domain.

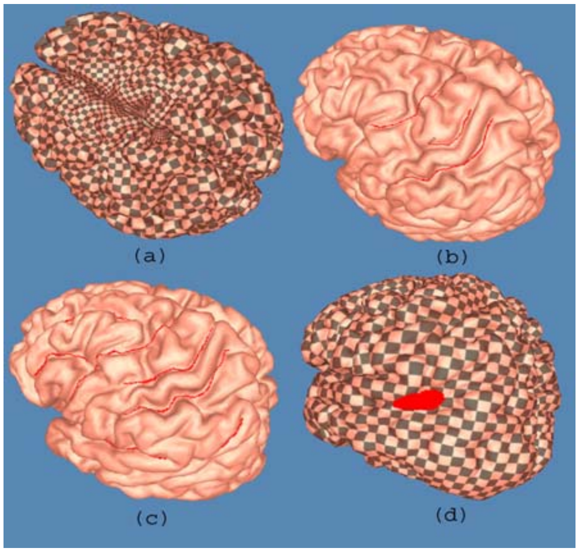

Figure 4 Illustrates tracing on the brain surface with the direct painting software. (a) shows the global conformal parameterization of the surface; (b) shows the curve drawing process; (c) shows a set of sulcal curves drawn on brain surface; (d) shows the region labeling function; a specified region of interest is labeled in red.

Conclusion: Currently, the package can read our internal mesh files. Work is underway on modules to read data formats written by FreeSurfer, BrainVoyager, and BrainVISA.