BRAIN SURFACE RECONSTRUCTION FROM SLICE CONTOURS

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Abstract

Although surface-based analysis has become a standard tool in neuroimaging, existing surface reconstruction software is not fully general. For example, reconstruction of only a portion of the brain surface is not possible with existing tools, which make many restrictive problem-domain assumptions. Applications in which hand-tracing is the only reliable way of identifying tissue boundaries require new methods for surface reconstruction.

Here, we present a set of software tools for creating surface representations from arbitrary image data. These tools provide a user interface designed to ease the process of hand-tracing brain structures of interest. A novel algorithm for surface reconstruction was developed to convert the hand-traced slice contour representation into a triangular mesh surface representation.

Since hand identification of brain structures is laborious, we provided a user interface that addresses a range of editing requirements typical of this process. The intersection of the object surface with each slice image is traced, yielding a set of slice contours comprised of vertices with real-valued coordinates. The contour vertices need not be uniformly spaced, and can therefore sample the tissue of interest adaptively with its curvature. Since sub-surfaces are valid input, contours can be open or closed. Contour tracing is preferred over voxel labeling since tracing requires fewer locations on the object surface to be identified by the user. Tracing speed is increased by automatically timed contour vertex placement, allowing the user to quickly trace a feature while matching the density of contour vertices to curvature.

Tracings of convoluted surfaces such as the brain can exhibit multiple contours in each slice, even when the surface is simply connected in three-dimensions. Thus, each slice may contain an arbitrary number of open or closed contours. Our algorithm for surface reconstruction establishes correspondence between contours on adjacent slices via a heuristic that matches location and shape to identify locations where the object branches between slices. The minimal area surface is fit between each pair of corresponding contours using a graph search technique on the space of potential surface edges to find the optimal set. Finally, the surface between each pair of contours is concatenated to form an entire surface representation.

Other algorithms for surface reconstruction from slice contours, such as Delaunay-based methods [1], are unable to reconstruct brain sub-surfaces. Reconstruction of partial brain surfaces is important when imaging data of the entire brain is unavailable, as in many histological section datasets, or when automatic segmentation is not possible and manual methods are required. In this case, the amount of hand-tracing can be minimized by reconstructing only the structures of interest.

The software developed for hand identification and surface reconstruction of brain structures is available at http://eslab.bu.edu/software. Examples of cortical reconstructions from MR data and histological sections in human and other species will be presented.

References

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