AUTOMATIC LINEARIZATION DURING MULTIPLE-MATERIAL SURFACE MESH GENERATION

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Accurate reconstruction of 3D boundary surfaces from 2D medical images is a crucial procedure in many computational biomedical applications. The surface models can be used for studies such as localizing pathological tissues, surgical planning, visualizing anatomical geometries, and serving as boundary input for creating solid volume meshes needed in FEM-based simulations.

The single-material marching cube algorithm (SMMC) was used extensively for medical image reconstruction due to its simplicity and robustness. [1, 2] However, more and more biomedical applications take the tissue heterogeneity into account, which requires identifying multiple materials. The conventional algorithms were insufficient to delineate intact tissue surfaces. Subsequently, the multiple-material marching cube (M3C) algorithm was developed which creates contiguous surface platelets between as many materials as user specified within a single sweep through the images. [3] It is robust, fast, and all adjacent cube faces match with fidelity. However, the M3C models also exhibit the same stair-step characteristics prominent in the SMMC models.

Currently, surface smoothing techniques are intensively employed to achieve more realistic model appearance. Unfortunately, while simple methods, such as Laplacian smoothing, suffers from volume shrinkage and shape deformation, more sophisticated strategies are computationally expensive. In this article, an automatic surface linearization approach is presented. It locates mating loops created in adjacent image slices, generates triangular panels connecting the two, and projects the associated surface nodes of the marching-cube triangles onto each panel. By sweeping through the medical image set, a linearized surface model is obtained, which removes the stair-steps while having controlled volume and shape changes. This linearization increases the accuracy of the marching-cube model by an order of magnitude. It is fully compatible with the M3C, retains all boundary delineations, and operates within the M3C code at the layer level.

References:

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[2] C. Montani, R. Scateni, and R. Scopigno, "Discretized marching cubes", presented at IEEE Visualization '94 Congress, 1994.
[3] Z. Wu and J. M. Sullivan, Jr., "Multiple material marching cubes algorithm", *International Journal for Numerical Methods in Engineering*, in press, 2003.

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