Topological Fragmentation of Medical 3D Surface Mesh Models for Multi-Hierarchy Anatomical Classification

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KURZFASSUNG/ABSTRACT:

High resolution 3D models of patient anatomy with appendant functional classification are of high importance in the field of clinical education and therapy planning. In this work a hierarchical mesh data model for multi hierarchy anatomical classification is introduced, allowing labeling of a patient model according to various medical taxonomies. The classification regions are thereby specified utilizing a spline representation to be specified by a medical expert at low effort. Furthermore, application of randomized dilation allows conversion of the specified regions on the surface into fragmented and closed sub-meshes composing the entire anatomical structure. As proof of concept, the semi-automated classification functionality is implemented for VTK library, successfully extracting sub-meshes of the brain lobes and preparing classification regions according to Brodmann area taxonomy.

1 INTRODUCTION

Medical atlases with morphological models are of high importance for clinical education and research and are used for on automated classification. Clinical training applications like *Voxel-Man* [1] and toolkits allow detailed insight into human anatomy with both morphological and a functional aspects, but are restricted to just a few organs. Building customized medical models with specific classifications from pre segmented patient data or 3D meshes, software tools are required to specify the particular regions. Wherever functional classification can be derived from patient morphology, sophisticated automated classification approaches can be utilized for automated processing. Many of these have been presented in the past. Exemplarily, algorithms for fully automated liver lobe classification based on blood vessels [2] and segmentation of gyri and sulci from brain MRI [3] have been developed.

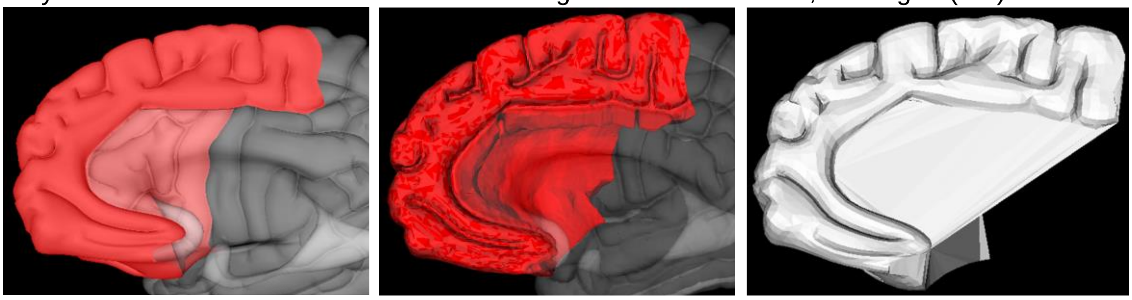
In this work a spline-based contour definition concept is presented, allowing the specification of complex surface shapes needing only a few control points. Topographic changes are thereby precisely handled and the vertex distances from the spline borders allow for visualization beyond the available triangle resolution. To complement the classification regions to enclosed surface mesh representations, randomized dilation is utilized [4].

2 METHODOLOGY

The preparation of multi-hierarchical classifications on a surface mesh comprises several steps. Firstly, all regions of the particular taxonomy must be precisely marked at the surface. In this work 3D B-Splines are utilized as projective walls cutting the regions of interest at the mesh surface. The distance to the cutting borders, evaluated as alpha value, allows for improved visualization. Utilizing these regions defined on the surface, closed mesh representations are derived by randomized dilation, allowing further sub-classification. Based on these regions placed on the surface and the generated sub-meshes, the entire input dataset can be partitioned with respect to the resolution as *level-of-detail* (LOD) but also according to anatomy at different levels of granularity. For each of the topologically fragmented meshes, further anatomical classification information can be marked on the surface.

3 RESULTS

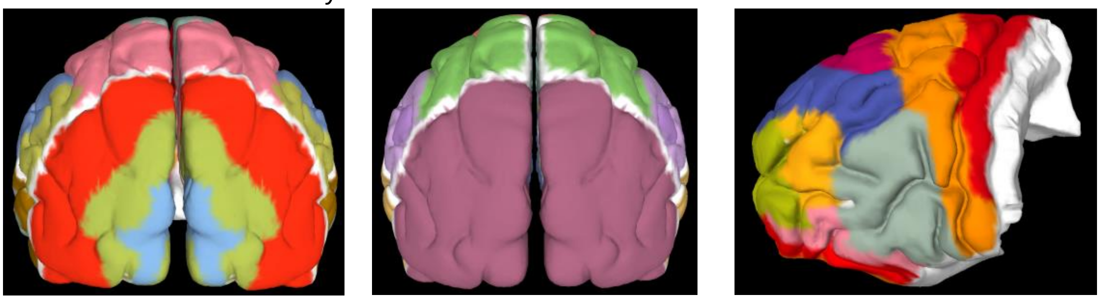
For the four brain lobes and the cingulate cortex, closed surface mesh representations are robustly derived from marked surface areas utilizing randomized dilation, see Fig. 1 (a-b).



(a) (b) (c)

Figure 1. About 50% of the surface must be complemented to achieve a closed surface mesh representation (a). While the presented randomized dilation based approach leads to good result quality (b), border interweaving with `vtkFillHolesFilter` functionality of VTK is insufficient (c).

As proof of concept Brodmann areas [5] and functional areas are prepared, see Fig. 2. At any node of the topological and level-of-detail sub-mesh hierarchy, an arbitrary number of anatomical classifications can be manifested and utilized by preparing spline-driven classification regions in a semi-automated way.



(a) (b) (c)

Figure 2. Frontal view of anatomical classifications Brodmann areas (a) and neurological centers (b) defined via semi-automated spline definition. Classification is also applicable to sub-parts, like frontal lobe (c).

4 CONCLUSIONS

Randomized dilation is newly introduced for generation of closed sub-meshes. Together with the developed hierarchical 3D mesh data format and the Spline-based region specification, a topological fragmentation of input surface data and the preparation of various levels of details become feasible. In combination with the discussed concepts, the classification regions prepared for the surface mesh can be utilized as anatomical classification or as input for randomized dilation based sub-mesh generation.

LITERATURE

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