The Enhancement of the Mesh Morphing Algorithm by the Use of Skeletal Structures

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Abstract

Creation of a digital, patient specific 3-dimensional model of human tissues from medical imaging data is a widely investigated problem [1]. Many approaches to the problem are atlas-based [2]. One of the essential steps in atlas-based model creation involves the use of various non-rigid transformations which allow to adjust the reference model to the actual tissue structure. In [3], such a role has been appointed to the morphing algorithm. The algorithm allows for a fast transformation of surface and tetrahedral meshes into the desired volume shape with the use of only a few measurements of the target structure. However, in its basic version the morphing algorithm is only applicable to the longitudinal shapes.

In the current paper we present the extension of the morphing procedure which improves the quality of the transformation and allows to apply it also to other shape types, not only longitudinal ones. The major modification relies on replacing the morphing axis (arbitrarily chosen in the prior version of the algorithm) with an automatically created skeletal structure based on the Reeb graph [4]. The use of Reeb graphs allows us to combine the information about the topology as well as the geometry of the described shape. The new approach makes it possible to detect the holes in the mesh and also, to divide the structure subject to the transformation into different regions which are morphed along separate parts of the graph.

The morphing algorithm is tested on the meshes representing bone structures of the human pelvis region. The meshes are created on the basis of CT data. Then, the Reeb graph structures are created for the real data model and the atlas data. The graphs topologies and geometrical attributes are adjusted by modifying Reeb algorithm parameters. After that, the new morphing algorithm is applied.

References

1. M. L. Neal and R. Kerckhoffs. Current progress in patient-specific modeling. Briefings in Bioinformatics (2010) 11 (1) 111–126.
2. T. Rohlfing and R. Brandt and R. Menzel and D. B. Russakoff and C. R. Jr. Maurer . Quo Vadis, Atlas-Based Segmentation?. Handbook of Biomedical Image Analysis, Volume III: Registration Models 2005 435-456.
3. J. Starzyński and Z. Krawczyk and B. Chaber and R. Szmurło. Morphing algorithm for building individualized 3D skeleton model from CT data. Applied Mathematics and Computation 267 (2015) 655-663.
4. S. Biasotti and D. Giorgi and M. Spagnuolo and B. Falcidieno. Reeb graphs for shape analysis and applications. Theoretical Computer Science, Computational Algebraic Geometry and Applications 392 (2008) 5–22.