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Quantitativer Vergleich von Gesichtsoberflächen
Quantitative Comparison of Facial Soft Tissue Surfaces

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Purpose

This contribution presents an improvement in computer aided oral and maxillofacial surgery. We present a new quantitative method to compare free-form surfaces in 3D-space, especially facial soft tissue surfaces obtained by optical 3D-measurements. This is firstly needed to evaluate the surgery result and monitor its long-term stability, secondly for an intraoperative actual-nominal comparison.

Methods and Material

The distance between two surfaces represented by triangle meshes is measured usually by calculating the distance of closest-points from one mesh to the other. However the closest-point operator is not symmetrical and therefore this distance measure is non-commutative, especially in case of meshes which are not close together and differ in shape (Fig. 1). In order to avoid this drawback and to achieve higher accuracy we have developed a new method. The basic idea of our algorithm is to project all vertices of the first mesh onto the second mesh. We distinguish two cases of projection directions. Firstly, the average normal of the entire surface is taken, i.e. to use the same direction for all vertices. Secondly, the locally averaged vertex normal is taken, i.e. the projection direction is varying for different vertices. It depends on the geometry of the surfaces, which projection direction is chosen. The distance of a vertex A to the other mesh is given by the distance to its projection A*. The difference volume is given by the sum of all prism volumes ABCA*B*C* (Fig. 2). The results like point distances and intersection lines of the surfaces are visualized.

We imitated swelling by placing plasticine on a plastic model head. The 3D-data (Fig. 3) of the head's surface with (surface M) and without (surface N) the plasticine was obtained by an optical sensor based on phase-measuring triangulation. We took 10 measurements, deforming the plasticine after each one.

Results

We computed the mean distance between surface M and N in the region of the imitated swelling for all 10 measurements. We compared the results obtained by taking either surface M or N as reference. The "closest-point-method" yields a mean deviation of 11.1% caused by the choice of the reference mesh. Using the "projection-method" the mean deviation is 0.4%.
We also computed the difference volume between the two surfaces. In case of using closest-points the mean deviation of the volume is 4.5% caused by the choice of the reference mesh. With our projection-method it is 0.04%. Additionally, the volume of the plasticine was determined to be 10.12 cm^3 using water displacement. The mean volume computed by using closest-points is 10.64 cm^3, using "projection" it is 10.21 cm^3. The computation time of our algorithm for the distance and volume computation of these datasets with about 30.000 triangles is 0.3 sec (2.8 GHz, 512 MB RAM).

Conclusion

The results show that our method is almost independent of the choice of the reference mesh proving its commutativity. Moreover, the difference volume is computed more accurately by using our method.

Acknowledgment

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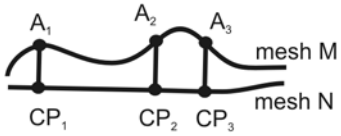
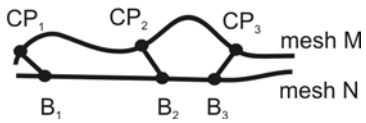
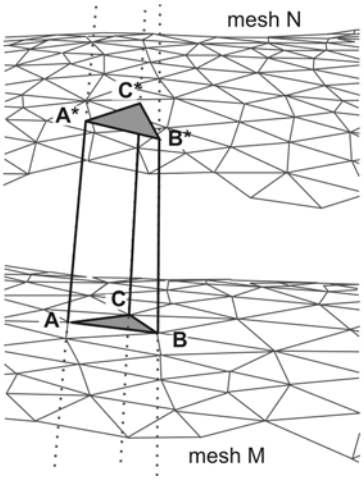
a) mesh M as reference mesh



b) mesh N as reference mesh




mesh N
C*
A*
B*
C
A
B
mesh M