Mesh registration using tracking of the direction of principal curvatures

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1 Introduction

Mesh registration is one of the disciplines of computer graphics. It can be used, for example, to reconstruct a complete object from partial scans or to add details to a less complex object. It calculates transformation, which can be applied locally or to the whole mesh. One approach to solving the registration issue is generating two sets of points - one for each of the two meshes. These two sets are then mapped on each other using some local information. That information can be based only on geometry or on specific information provided by the data, e.g., texture or physical quantity.

This work proposes a new algorithm for the rigid registration of meshes, which focuses on local information as well as the relationship between individual parts of meshes. That relationship can be represented as a curve going from one point in the direction of one of the principal curvatures. This approach provides a better description of a mesh than just a set of points.

2 Algorithm

The pipeline of the algorithm is divided into several blocks, some of which use already existing algorithms or their modification. Firstly, representations of surface lines on each mesh are created. These lines are distributed into a hash table and then passed into a variation of the Smith-Waterman algorithm. Matching parts of the lines are fed into the Kabsch algorithm, which computes a rigid transformation for each pair. These candidate transformations are then passed into a density block, presented by Hruda et al. (2019), which returns the final transformation.

The most significant contribution in this pipeline will be in the first two blocks and partly in the third one. Surface lines are run from a point on a surface and continue in the direction of one of the principal curvatures (particular curvature is chosen in advance and is constant for the duration of the algorithm). On each mesh, there are many such lines generated. Creating lines on the surface presents a challenge mainly in the representation because if all points forming this line were represented by floats, the line would not lie precisely on the surface. Each line is represented by three parameters, which describe the local neighbourhood of a point on the line - the maximal curvature value, the minimal curvature value and a deviation of the normal vector from the osculating circle of the line. The lines need to be locally described so matches can be found even if a line on one mesh starts at a different point than on the other.

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For the Smith-Waterman algorithm, which compares the similarity of two chains of values, continuous scores for a match or slight mismatch are used rather than discrete ones. Since the numbers representing the lines are decimal, there is a zero probability of a match. All differences between numbers more significant than a predefined threshold are considered a mismatch and given the same score.

3 Experiment

An experiment was proposed to test the first block and the idea behind this algorithm. The *Kac* dataset was used for this experiment. The dataset consists of two meshes not rotated or translated with respect to each other. Each was gained from a different point of view, so it contains information that the second does not. For the experiment, each line was run from a point on one mesh and a corresponding line from a nearly identical point on the other. Since the meshes are different, a point on the surface of one mesh can float above or below the other and vice-versa. Thus the chosen point from the first mesh was projected on the surface of the second mesh in a way that the distance between these two points is minimised. The lines follow the same pattern (see 1), supporting the presented algorithm's idea.

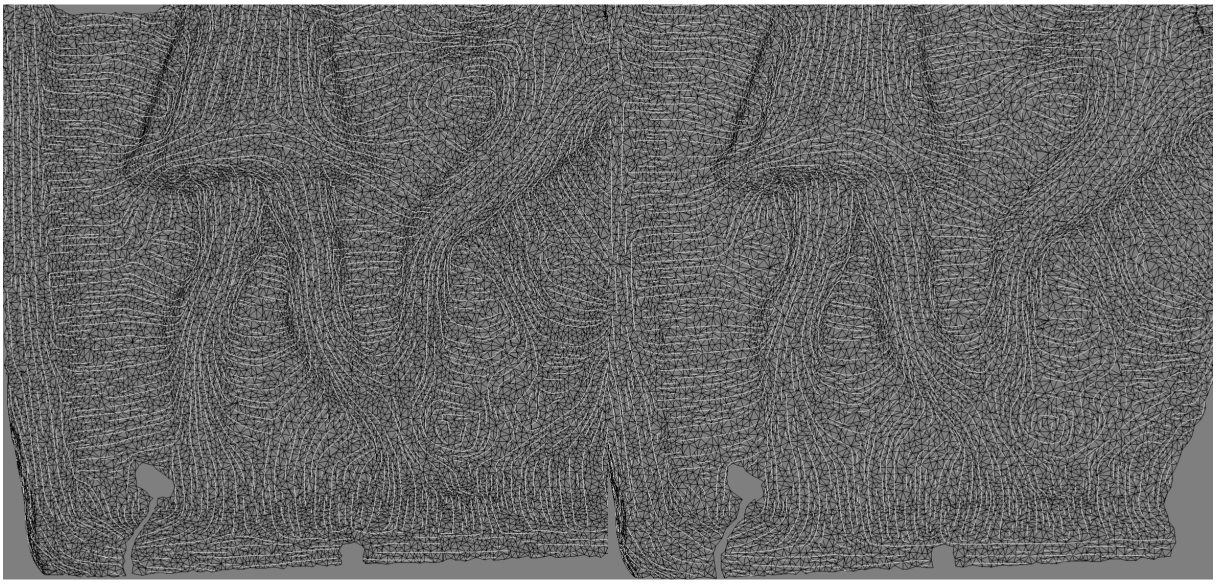

Figure 1: Comparison of lines run on two different meshes from the *Kac* dataset.

4 Conclusion

An algorithm for the rigid registration of meshes was proposed, and an experiment to support the idea behind the algorithm was presented. This algorithm could lead to better registration results, but more experiments must be designed and executed to test if it does.

References

Hruda, L., Dvořák, J., Váša, L. On evaluating consensus in RANSAC surface registration. *Computer Graphics Forum*, Volume 38, No. 5, pp. 175–186.