Project: "Mesh digitization with topological consistency"

Introduction

The objective of this project is to implement and evaluate a mesh digitization process in DGtal.

We expect from you:

- A short report with answers to the "formal" questions and a description of the your implementation choices and results.
- A C++ project (`CMakeLists.txt` plus several **commented** cpp program files).

1 Manifold case

The main problem is to convert a triangular mesh $\mathcal{M}$ into a digital object while maintaining some topological properties.

The input is thus a triangular mesh (in OFF format for instance, see `Mesh` and `MeshReader` classes in DGtal) and a grid step h and the output should be a 3D digital object.

Question 1 *Let us suppose that $\mathcal{M}$ (and its OFF file) is a correct combinatorial manifold (no holes). Implement a digitization process of the surface parametrized by h.*

At this point, several options exist (different digitization models, different parameters...) with several outcomes (create $k-$separating digital surfaces for some $k \in \{6, 18, 26\}$...). We have added some references at the end of the document but what ever your implementation choices, we expect you to clearly justify these choices in the report.

To be more precise, when implementing the digitization process, we would evaluate the algorithm in terms of:

- Topologically consistency (hole free if the input is a manifold)
- Scalablility (performances when either the resolution or the number of triangles increases)
- Invariance to (integer) translations, symmetry w.r.t. to grid axis or flip of triangle normal vectors

2 From digital surface to digital objects

Question 2 *Implement an algorithm that will fill the digital surface interior to obtain a digital object.*

The algorithm should

- handle multiply connected objects (or nested objects).
- be consistent with the digital surface topology

3 Non-manifold case

We now consider that the input triangulation is given by a collection of triangles without any topological relationship between them. Such input is not a manifold anymore and can even contain intersection triangles.

We suppose that gaps between triangles come from a erroneous reconstruction step of a manifold. Hence, we can assume that there is a (unknown) parameter ϵ such that all duplicate vertices lie in a ball of radius ϵ.

Many alternatives exist to digitize such surface while correcting the topology (mathematical morphology, distance based, topological thinning...).

Question 3 *Design and implement an algorithm to digitize such set of triangles. Please clearly discuss your choices (outcomes/drawbacks, topological guarantees).*

References

[COK97] D Cohen-Or and Arie Kaufman. 3D line voxelization and connectivity control. *Computer Graphics and Applications ...*, (December):80–87, 1997.

[Lai13] Samuli Laine. A Topological Approach to Voxelization. *Computer Graphics Forum*, 32(4):77–86, July 2013.

[SS10] Michael Schwarz and HP Seidel. Fast parallel surface and solid voxelization on GPUs. *ACM Transactions on Graphics (TOG)*, 2010.