Internship proposal
Quadrilateral mesh topological cleaning

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1 Context

In computer science, geometric objects are most often represented by meshes. For this internship, we are interested in quadrilateral meshes. Generally speaking, a good quad mesh is to be as regular as possible, it should look like a deformed grid. In other words, ideally we would like to have all vertices incident exactly to 4 quads. Unfortunately, many of meshing methods produce highly irregular meshes, and the goal of the project is to decrease the number of vertices that are attached to too few or too many quads.

We want to experiment with the approach proposed by Bunin [Bun06, VT12]. The idea is pretty simple: first we select a patch with several irregular vertices (Figure 1–left, shown in red). Then let us say we want to remesh the patch with a single valency 3 vertex: it subdivides the patch into three regular grids (Figure 1–middle).

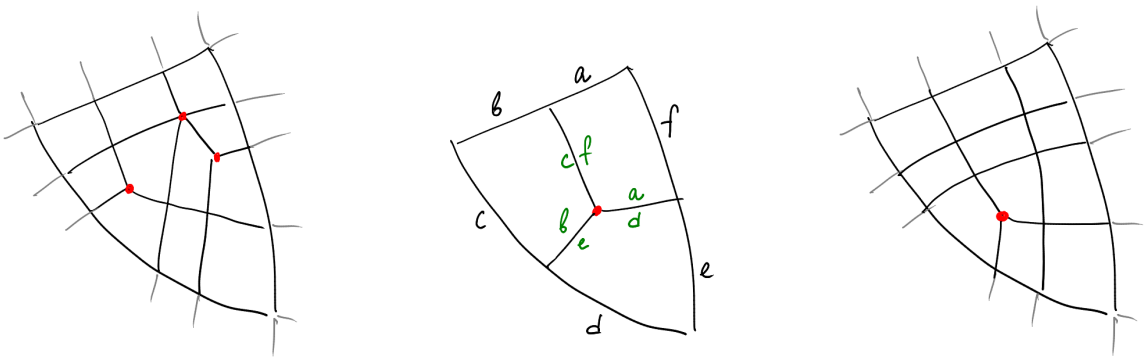

Figure 1: Three steps of a clean-up operation. **Left:** choose a patch to remesh. **Middle:** find the connectivity of the inner mesh with one singularity only. **Right:** the new nodes are given coordinates, and the whole mesh is smoothed.

We need to find the resolution of these grids. We note the resolutions as six variables a, b, c, d, e and f. Then, naturally we have some constraints: the grids are to be glued correctly one to another. In other words, $a = d$, $b = e$, $c = f$. We also need to glue the grids to the rest of the surrounding mesh, i.e. $a+b = 3$, $c+d = 5$, $e+f = 4$. In fact, we have a linear system to solve. The system gives us the solution $a = 2, b = 1, c = 3, d = 2, e = 1, f = 3$. This solution defines the connectivity of the mesh inside the patch, and the final step is to find geometric coordinates for the remeshing (Figure 1–right).

2 To do

The final goal is to create a prototype of quad mesh cleaner. While being conceptually simple, in order to obtain good results, there are many questions we need to address. For example, how to select the patches and in what order? Therefore, there is a lot of room for experiments.

3 Expected skills

The main quality expected is a desire to learn and to work as part of a team. On the other hand, it will be necessary to be sufficiently at ease with computer sciens and (basic) mathematics. The code should be fairly simple, since it essentially involves constructing the matrices and vectors corresponding to the discretization of the problem. The choice of programming language is up to you, but by default we would suggest C++.

References

[Bun06] Guy Bunin. Non-local topological clean-up. In Philippe P. Pébay, editor, *Proceedings of the 15th International Meshing Roundtable*, pages 3–20, Berlin, Heidelberg, 2006. Springer Berlin Heidelberg.

[VT12] Chaman Singh Verma and Tim Tautges. Jaal: Engineering a high quality all-quadrilateral mesh generator. In William Roshan Quadros, editor, *Proceedings of the 20th International Meshing Roundtable*, pages 511–530, Berlin, Heidelberg, 2012. Springer Berlin Heidelberg.