3D Geometric Data Structure, a Survey

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Abstract

We compare DSC with other index-based data structure (e.g. VTK) and cell complexes (generalized half edge, e.g. CGAL). DSC is 100 times faster than cell-complexes methods. In index-based category, DSC belong to good performance but high memory group.

Performance of DSC can still be increased: four times with additional three functions or ten times if full adjacency information are stored. This analysis is mainly based on theoretical, practice may differ.

Tetrahedral representation categories

- Index-based data structures: No adjacency (VTK [1]); with adjacent information [7, 8], DSC [6]; and reduced data structure with adjacent information [2, 4]
- Cells complex OpenVolume Mesh[5] and (CGAL) [3]

Comparison of index-based data structure

Adjacency references and comparison of time-use in DSC is shown in Fig. 1.

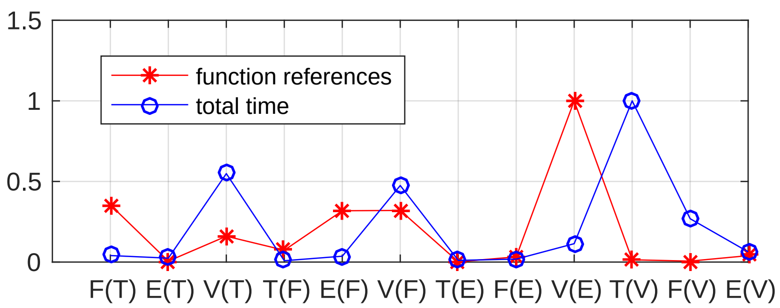

Figure 1: Comparison of adjacency references and total time used of each function in DSC. F(T) means get face on tet, V(E) means get vertices on edge, etc...

Comparison of DSC and other index-based methods in term of performance and memory[1] is shown in Fig. 2. We compare different way to store adjacency information, including DSC, nine other index-based mesh [4], DSC with additional storage of 3 functions (tet-vertex, vertex-tet and vertex-face), and full adjacencies (Fig. 4).

[1]We follow a theoretical comparison from [4]: A statistics of adjacencies references is measured by real usage of DSC (red line in Fig. 1), and the computation costs of functions to get adjacent information are estimated from the algorithms.

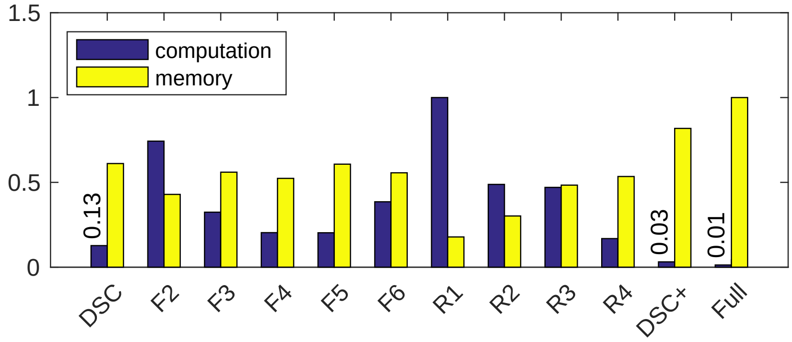

Figure 2: Memory and computation

Comparison between DSC and CGAL (linear cells complex [3]) is shown in Fig. 3

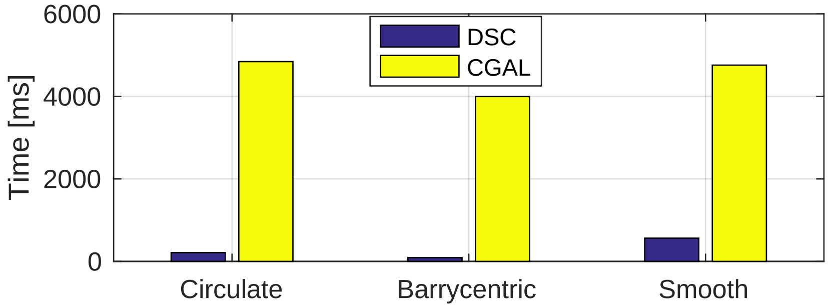

Figure 3: Comparison of DSC and CGAL

References

[1] Visualization Toolkit (VTK).

[2] Mark W Beall and Mark S Shephard. A general topology-based mesh data structure. *International Journal for Numerical Methods in Engineering*, 40(9):1573–1596, 1997.

[3] CGAL. Linear Cells Complex.

[4] Rao V. Garimella. Mesh data structure selection for mesh generation and FEA applications. *International Journal for Numerical Methods in Engineering*, 55(4):451–478, 2002.

[5] M Kremer, D Bommes, and L Kobbelt. Open VolumeMesh–A Versatile Index-Based Data Structure for 3D Polytopal Complexes. *Proceedings of the 21st International Meshing Roundtable*, pages 531–548, 2013.

[6] Marek Krzysztof Misztal and Jakob Andreas Bærentzen. Topology-adaptive interface tracking using the deformable simplicial complex. *ACM Transactions on Graphics*, 31(3):1–12, may 2012.

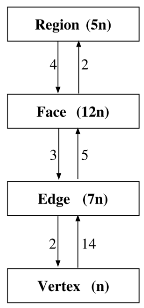

Figure 2: Mesh Representation F1 - Full one-level upward and downward adjacencies.

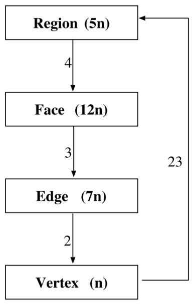

Figure 3: Mesh representation F2 with full downward and vertex-region upward adjacency.

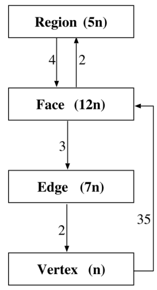

Figure 4: Mesh representation F3 with all downward adjacencies and upward adjacencies from vertices to faces and faces to regions

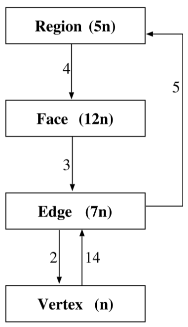

Figure 5: Mesh representation F4

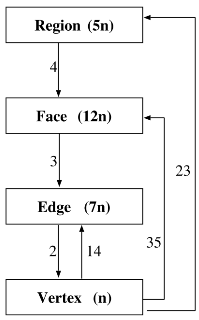

Figure 6: Mesh representation F5

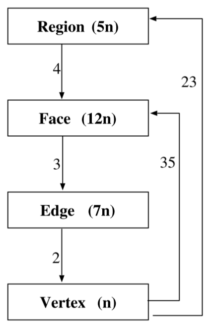

Figure 7: Mesh representation F6

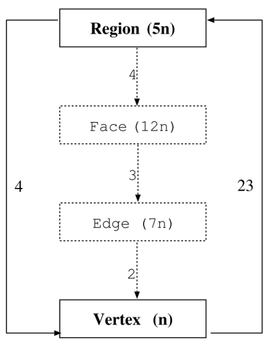

Figure 8: Mesh representation R1

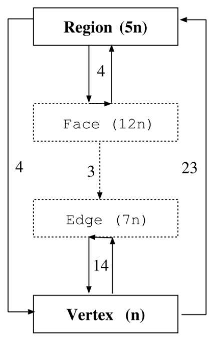

Figure 10: Reduced mesh representation R2

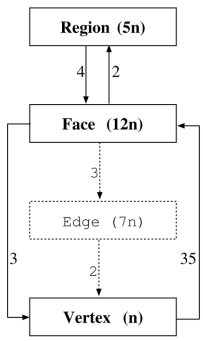

Figure 11: Reduced mesh representation R3

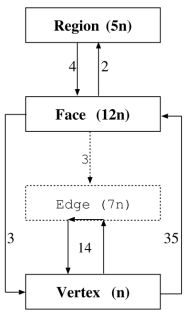

Figure 12: Reduced mesh representation R4

DSC +

- tet - vertex
- vertex - tet
- vertex - face

Full

Figure 4: Methods for comparison of index-based data structure [4]

[7] W. J. Schroeder and M. S. Shephard. Geometry-based fully automatic mesh generation and the delaunay triangulation. *International Journal for Numerical Methods in Engineering*, 26(11):2503–2515, nov 1988.

[8] Mark S. Shephard and Marcel K. Georges. Automatic three-dimensional mesh generation by the finite octree technique. *International Journal for Numerical Methods in Engineering*, 32(4):709–749, sep 1991.