3D-EPUG-Overlay: Intersecting very large 3D triangulations in parallel

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We present 3D-EPUG-Overlay, an algorithm and preliminary
implementation for intersecting (aka overlaying) two 3D
triangulations. This operation is important in processing large
geometry datasets in additive manufacturing. Much of our
algorithm is a sequence of map-reduce operations, and so is easily
parallelizable. We completely avoid roundoff errors and the
associated topological problems by computing with rational
numbers. We will handle geometric degeneracies with Simulation of
Simplicity (SoS). Our target architecture is an inexpensive
workstation.

We have a complete 2D implementation, which has overlaid two 2D
maps maps, with a total of 54,000,000 vertices and 739,000 faces,
in only 322 elapsed seconds (excluding I/O) on a dual 8-core
3.4GHz Intel Xeon workstation. That time is using 16 cores, and
is 11x faster than using one core. Our 3D implementation is
complete except for SoS. It processes two 3D objects with a total
of 6,000,000 face triangles and 3,000,000 tetrahedra in 180
elapsed seconds on 16 cores. The parallel speedup for 16 cores is
a factor of 13. The execution time is almost linear in the data
size, and could process much larger datasets, perhaps billions of
triangles. We anticipate being able to process much larger
datasets than competing SW can, and for datasets small enough for
others to process, that we will be much faster and more robust on
special cases.

W. Randolph Franklin is a Professor in the Electrical, Computer,
and Systems Engineering Dept, Rensselaer Polytechnic Institute
(Troy NY USA). His current NSF research project is to understand
the mathematics of terrain.

His research hobby is designing and implementing small, simple,
and fast data structures and algorithms for large geometric
datasets. Note that efficiency in both space and time can become
more important as machines get faster. This research is applicable
to computational cartography, computer graphics, computational
geometry, and geographic information science.

During 2000-2002 Franklin served a rotation to the National
Science Foundation, as Director of the Numeric, Symbolic, and
Geometric Computation Program. He was one of the prime movers of
the two Computational Algorithms and Representations for Geometric
Objects (CARGO) solicitations, joint between NSF and DARPA.

Franklin's degrees are from Toronto (BSc, Computer Science), and
Harvard (AM & PhD, Mathematica Accomodata).

Recent awards, with students, include Best Paper (2nd place) at
AGILE (2012) for ''A new method for computing the drainage network
based on raising the level of an ocean surrounding the terrain'',
Best Paper at Geoinfo (2013) for ''A Parallel Sweep Line Algorithm
for Visibility Computation'', and coming 2nd in the ACM GIS Cup
programming contest (2015).

Salles Viana Gomes de Magalhães is an instructor at the Federal U
of Viçosa, Brazil. He is currently pursuing a PhD at RPI.