Summary: Constructive Solid Geometry (CSG) is one of the popular techniques that is widely applied in 3D modeling. It combines primitive solids using Boolean operations. However, the trade-off between efficiency and robustness of Boolean evaluation is difficult to balance. Previous methods sacrifice either efficiency or robustness to achieve advantages in one perspective. Recent works attempt to achieve excellent performance in both aspects through replacing the conventional vertex-based representations (V-reps) with plane-based representations (P-reps) of polyhedrons. Different from V-reps, the P-reps use plane coefficients as meta-data and can lead to benign robustness. However, methods using P-reps have disadvantages in efficiency compared to methods using V-reps. In this paper, we proposed a Boolean evaluation approach that absorbs both the efficiency of V-reps based methods and robustness of P-reps based methods. We design a Boolean evaluation method combining P-reps with V-reps. The P-reps information is utilized for exact predicate computation while information in V-reps is collected for fast topology query and coarse tests. Our proposed approach is variadic: it evaluates a Boolean expression regarding multi-input meshes as a whole rather than a tree of decomposed binary operations. We conduct massive experiments and compare our results with those generated by the state-of-the-art methods. Experimental results show that our approach is robust for solid inputs and has advantages in performance compared to some previous non-robust methods.

MSC:

65Dxx Numerical approximation and computational geometry (primarily algorithms)

Keywords:

Boolean operations; plane-based geometry; constructive solid geometry

Software:

CGAL; Cork; OBBTrec; ESOLID

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