Algorithms for Manipulating Quaternions in Floating-Point Arithmetic

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Résumé

Quaternions form a set of four global but not unique parameters, which can represent three-dimensional rotations in a non-singular way. They are frequently used in computer graphics, drone and aerospace vehicle control. Floating-point quaternion operations (addition, multiplication, reciprocal, norm) are often implemented "by the book". Although all usual implementations are algebraically equivalent, their numerical behavior can be quite different. For instance, the arithmetic operations on quaternions as well as conversion algorithms to/from rotation matrices are subject to spurious under/overflow (an intermediate calculation underflows or overflows, making the computed final result irrelevant, although the exact result is in the domain of the representable numbers). The goal of this paper is to analyze and then propose workarounds and better accuracy alternatives for such algorithms.

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