A Hybrid Fast Capacitance Solver

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In this paper, we discuss a hybrid fast capacitance solver that can be 4 to 30 times faster than using the traditional fast multipole algorithm. This speed up is achieved by drawing ideas from the Appel algorithm, Barnes-Hut algorithm, and the Rokhlin-Greengard multipole algorithm. The combined algorithm is much faster than the Rokhlin-Greengard algorithm as well as being error-controllable.

The Appel algorithm and the Barnes-Hut algorithm were originally written for the calculation of Coulombic forces governing the movement of stars in galaxies. Later Rokhlin and Greengard developed a systematic way to perform these calculations demonstrating that they are error controllable.

The central idea of Appel and Barnes-Hut algorithms was to expand the gravitational field in terms of the center of mass of a cluster of stars. In this manner, the gravitational field can be efficiently represented. This also follows from the physical fact that the gravitational field is a solution of Laplace's equation, and hence, it cannot convey information long range. Consequently, all gravitational fields eventually appear to be coming from a monopole or a single source if one is far enough from the cluster of stars. A monopole representation is an efficient representation of the far field of a cluster of sources.

Recently, Shi, Liu, Kakani, and Yu suggested using Appel algorithm to expedite fast capacitance solution (IEEE Trans. CAD ICS, March 2002). We present an alternate way of expediting FastCap (White) which is based on the Rokhlin-Greengard algorithm. Our algorithm makes a combined use of ideas from Rokhlin-Greengard, Appel, and Barnes-Hut algorithms. It retains the systematic nature of the Rokhlin-Greengard algorithm, but exploits some physics of Laplacian field as was done in the Appel and Barnes-Hut algorithms. In this manner, the algorithm is error controllable, but at the same time, is more efficient than a plain Rokhlin-Greengard algorithm.