A "Multigrid" Method For Accelerating Three-Dimensional Photon Dose Calculations

The FOCUS superposition algorithm utilizes a number of optimizations to accelerate dose calculations. One of these, the use of mixed-resolution representations, has general applicability to other calculation methods, including Monte Carlo. The key to the approach is automatic identification of regions where high dose gradients are likely. Dose in potential high-gradient regions, which exist at beam edges and at tissue interfaces, is calculated using superposition on a fine grid. In low-gradient regions, superposition calculations are applied on a coarse grid and then interpolated onto the fine grid. Hence the term "multigrid." This is a highly effective method of acceleration, since superposition computation times are directly related to the number of points that must be calculated. Finding beam edges is fairly trivial, while identifying tissue interfaces can present a technical challenge: Tissue interfaces must be found in a way that is both accurate and inexpensive computationally. We have adapted Laplacian operators, a standard tool used in image processing for identifying edges in pictures, to locate tissue interfaces in computed tomography data. Since we use Fast Fourier Transform methods to apply the Laplacian operator in three dimensions, calculation of the gradient map is rapid---only about 4% of total calculation time. A speed up of almost 4 times with a decrease in accuracy of less than 0.5% is typically observed using this method.

*Supported by Computerized Medical Systems, Inc.