Sphere-packing as a starting point for optimization of linear accelerator based radiosurgery

Linear accelerator based radiosurgery delivered with circular collimators is characterized by small , approximately spherical dose distributions with a very steep dose gradient. Circular beams may be used to create a highly conformal dose distribution in some cases by adjusting arc parameters (such as start / stop angles, or elimination of some arcs), but often the use of multiple isocenters is required to achieve conformation of the high dose region to an irregular target volume. A geometrically-based sphere packing technique is presented which automatically determines the radiosurgery plan isocenter locations and associated circular collimator sizes. The method involves applying an edge-detection algorithm to determine the characteristic spine of a three-dimensional simplicial complex. Successive applications of this process identify the deepest-lying target voxels. These regions are then selected as candidate isocenter locations, which are then input into a simple optimization routine to determine the best isocenter location and collimator size, based on geometry. A spherical region corresponding approximately to the 70% isodose shell is then removed from the volume, and the process is re-applied to the remaining target volume until only volumes smaller than a specified cutoff exist. The geometrically-generated radiosurgery plans thus generated are optimized by applying several simple treatment planning tools, such as isocenter and arc weighting tools. Initial results are promising, with a prototype implementation of this process generating conformal radiosurgery treatment plans for several irregularly shaped phantom and clinical targets.