

Computer-assisted treatment planning for linac-based radiosurgery is still an open research problem, especially for multiple isocenter procedures, due to its high complexity and computational requirements. This report focuses on the optimization of multiple-isocenter treatment planning for linac systems, and addresses several important issues associated with it, such as dose conformality, homogeneity, and approaches for isocenter position optimization.

The key idea behind our approach is that the desired dose distribution can be decomposed into a number of fundamental components. In the current paper, each component is given by an analytical form, the so-called Ellipsoidal Dose Distribution Estimation (EDDE) model, which quantifies the dose resulting from a collection of arcs, as a function of distance from the isocenter. We establish ways (arc configuration) of achieving such ellipsoidal doses of arbitrary position, orientation, and size. Since the EDDE model is described by relatively few parameters, it allows the estimation of the dose distribution corresponding to a particular isocenter very quickly and thus makes the optimization of isocenter position very efficient. It is further used in a framework for optimal treatment planning, in which a number of ellipsoidal dose distributions, each corresponding to a different isocenter, are optimally placed to cover the tumor while sparing healthy tissue.

The general ellipsoidal dose distribution of linac-based radiosurgery is summarized as a mathematical model through supporting experiments. Comparisons between the EDDE-optimized and clinically implemented plans are made, revealing superior performance of the former. In addition, a dramatic reduction in planning time is achieved using the EDDE model.