A Direct Compensator Profile Optimization Approach for Intensity Modulated Radiation Treatment Planning

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Radiation therapy accounts for treatment of over one million cancer patients each year in the United States alone, and its use will continue to grow rapidly in the coming years. Recently, many important advancements have been developed that greatly improve the outcomes and effectiveness of this treatment technique, the most notable being Intensity Modulated Radiation Therapy (IMRT). IMRT is a sophisticated treatment technique where the radiation dose is conformed to the tumor volume, thereby sparing nearby healthy tissue from excessive radiation dose. While IMRT is a valuable tool in the planning of radiation treatments, it is not without its difficulties. This research has created, developed, and tested an innovative approach to IMRT treatment planning, coined Direct Compensator Profile Optimization (DCPO), which is shown to eliminate many of the difficulties typically associated with IMRT planning and delivery using solid compensator based treatment. The major innovation of this technique is that it is a direct delivery parameter optimization approach which has adopted a parameterized surface representation using Non-Uniform Rational B-Splines (NURBs) to replace the conventional beamlet weight optimization approach. This new approach brings with it three key advantages: 1) a reduced number of parameters to optimize, reducing the difficulty of numerical optimization; 2) the ability to ensure complete equivalence of planned and actual manufactured compensators; and 3) direct inclusion of delivery device effects during planning with no performance penalties, eliminating the degrading fluence-to-delivery parameter conversion process. Detailed research into the affects of the DCPO approach on IMRT planning has been completed and a thorough analysis of the developments is provided herein. This research includes a complete description of the DCPO surface representation scheme, inverse planning process, as well as quantification of the manufacturing constraint control procedure. Results are presented which demonstrate the performance and innovation offered by this new approach and show that the resulting compensator shapes can be manufactured to nearly 100 percent of the designed shape.