Treatment planning for IMRT is challenging due to both the size of the computational problems and the multi-objective, imprecise nature of the goals. We apply hierarchical programming to IMRT treatment planning. In this formulation, treatment planning goals/objectives are ordered in an absolute hierarchy, and the problem is solved from the top down, such that more important goals are optimized in turn. After each objective is optimized, that objective function is converted into a constraint when optimizing lower-priority objectives. We also investigate the use of mean-tail-dose (mean dose to the hottest fraction of a given structure). This facilitates computational efficiency and ensures convex feasibility spaces and convex objective functions. To widen the search space without seriously degrading higher priority goals, we allowed higher priority constraints to relax or 'slip' a clinically negligible amount during lower priority iterations. This method was developed and tuned for both external beam prostate planning and head and neck planning and subsequently tested using a suite of patient datasets (10 prostate, 6 head and neck). In all cases, good dose distributions were generated without individual plan parameter adjustments. It was found that allowance for a small amount of 'slip' often resulted in improved normal tissue dose burdens. Compared to the conventional IMRT treatment planning objective function formulation using a weighted linear sum of terms representing very different dosimetric goals, this method: (1) is completely automatic, requiring no user intervention, (2) ensures high-priority planning goals are not seriously degraded by lower-priority goals, and (3) ensures that lower priority, yet still important, normal tissue goals are separately pushed as far as possible without seriously impacting higher priority goals.

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