

Stochastic beam weight optimization: the differential evolution algorithm

Some problems in automated radiotherapy treatment planning are expected to have multiple-local minima, e.g. beam weight optimization using dose-volume constraints or some types of radiobiological objective functions. Recent advances in stochastic global optimization programming techniques which are potentially capable of optimization in the presence of multiple local minima include the differential evolution algorithm (Price, K., and Storn, R. Differential Evolution: A Simple Evolution Strategy for Fast Optimization. *Dr. Dobb's Journal*, (1997) 264, 18-24). This algorithm evolves a 'population' of feasible beam-weight vectors between iterations. The primary process for evolving the population is to generate trial vectors which are a linear combination of a randomly chosen beam weight vector and the difference between two other randomly chosen vectors. A trial vector is accepted into the new population if it results in a lower objective function than another randomly chosen vector from the old population. In this way the algorithm is 'self-tuning' as the optimization process progresses, which is potentially an advantage over other stochastic methods such as simulated annealing. It is important to note that any stochastic algorithm is likely to provide results which can be improved upon (if only slightly) by finishing with local search methods. We have used this algorithm to optimize IMRT dose distributions for Soederstroem and Brahme's 2D cervical example (*Int J Radiat Oncol Biol Phys*, (1995) 33:1, 151-9), and achieved good dose distributions (i.e. with minimum gross target volume doses of about 90 Gy) for just 3 fields.