Multi-Criteria Optimization

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Abstract

One of the main cancer treatments is radiotherapy (radiation therapy). In order to reduce the risk of radiation-related problems, it is important to provide the tumor with the specified radiation dose while limiting the unavoidable dose to the nearby healthy organs. The optimization of radiotherapy treatment plans looks for machine settings that produce desirable treatment schemes like pareto surface or weighted-sum methods. Large-scale nonconvex multi-criteria optimization is the challenge at hand.

Keywords: Radiotherapy, Multiple objectives, OAR in health services.

Method

2D Pareto surfaces were mostly created in the literature using Pareto optimization. The "e-constraints" 2D trade-off method, which involves changing one criterion into a constraint and doing so incrementally while the other criterion is optimized, has been expanded to n-dimensional surfaces. Yet, a 3D trade-off for a Pareto surface in radiotherapy treatment was provided by the weighted-sum approach. Representing the multi-criteria problem as a scalarized weighted-sum formulation is one of the straightforward methods:

$$\text{minimize} \sum_{i=1}^{n} w_i f_i(x)$$

$$\text{subject to } g(x) \leq 0$$

References

[1] American Cancer Society. Global cancer facts & figures (3rd ed.). http://www.cancer.org/acs/groups/content/@research/documents/document/acspc-044738.pdf, 2013. Accessed: Month Day, Year.

[2] World Health Organization. GLOBOCAN - estimated incidence, mortality and prevalence worldwide. http://globocan.iarc.fr/Pages/fact_sheets_cancer.aspx, 2012. Accessed: Month Day, Year.

Introduction

Cancer is treated using radiotherapy (or radiation therapy), typically when cancer has spread to just one area of the body and has become a tumor. Around 15 million people are diagnosed with cancer each year worldwide, and radiotherapy is utilized in around half of those cases, occasionally in conjunction with chemotherapy or surgery [1], [2]. Radiotherapy is used in about 40% of patients that are cured.

Result 2

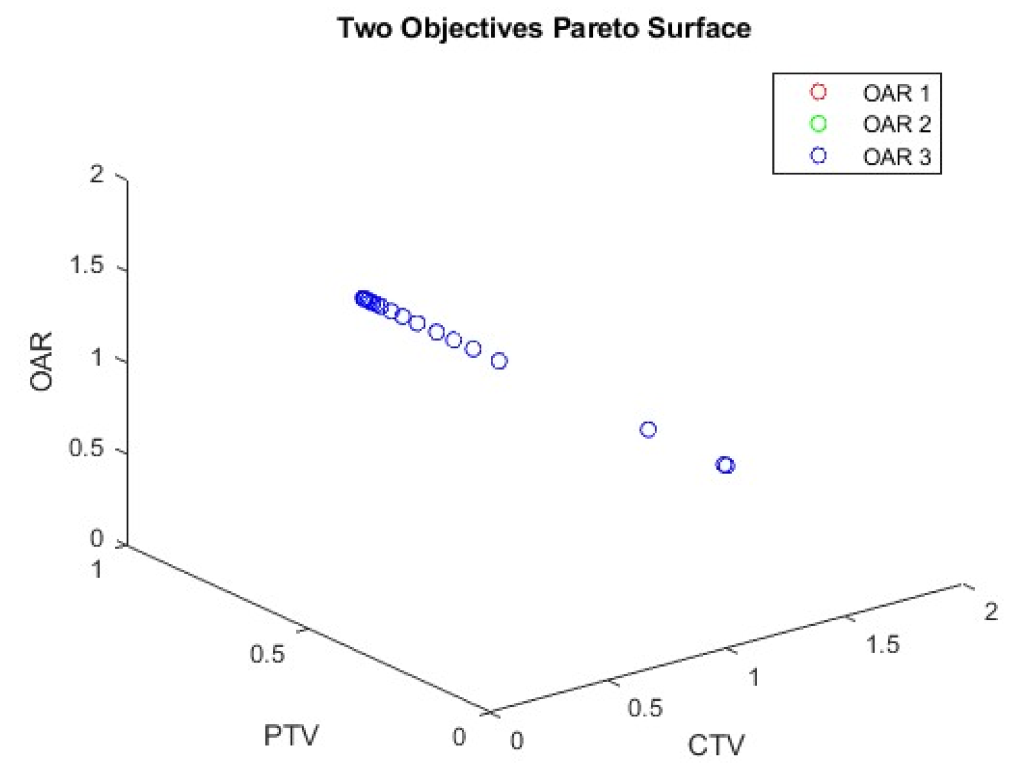

Figure 3: Shows a preliminary description of a 3D PS for OAR case

Result 1

Figure 1 shows the preliminary of a 3D PS for an L2-type objective for radiotherapy treatment. In radiotherapy, and medicine in general, there is not a "gold" standard for the best treatment. The sensitivity of the different tissues to radiotherapy is a priori unknown and differs greatly between patients.

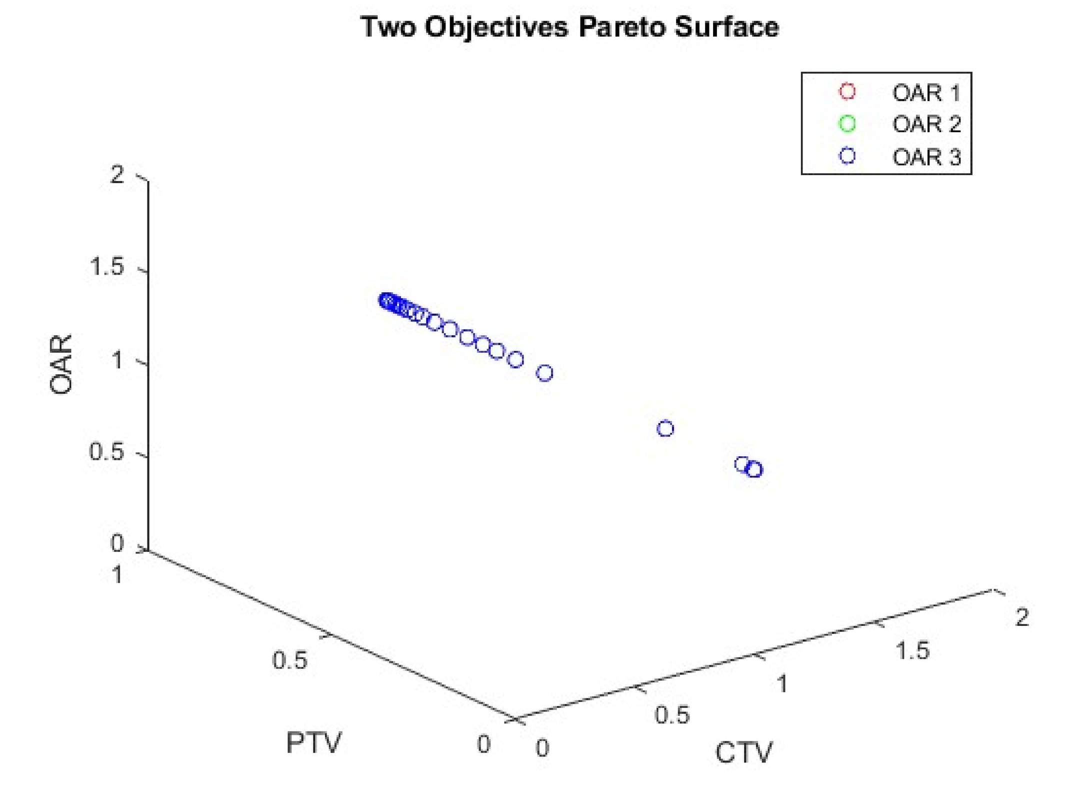

Figure 1: Plot of a preliminary description of a 3D PS trade-off for a radiotherapy treatment.

Conclusion

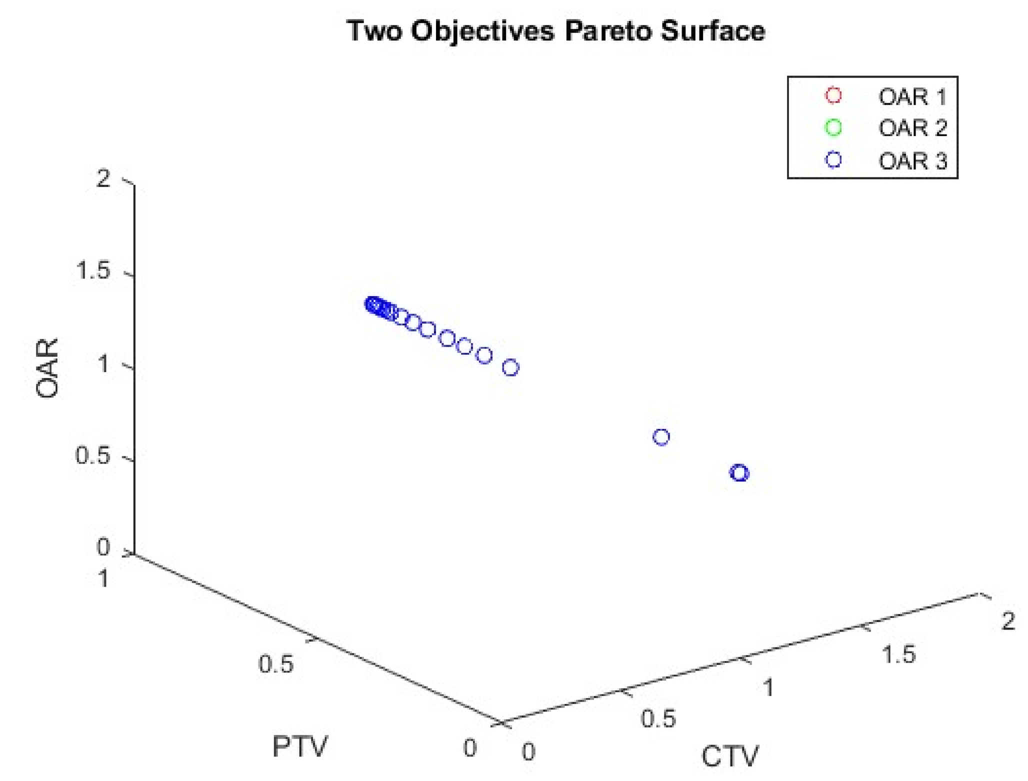

Figure 2: A preliminary description of a 3D PS for L2-type objective for a radiotherapy treatment

We present an algorithm for calculating well-placed points on a PS and applying it to the radiotherapy treatment planning problem. The algorithm requires that the feasible set and objective functions are convex, and in particular we satisfy this by staying in a linear programming environment with the use of MATLAB. The motivation for computing a database of PS plans comes from the observation that planners spend a lot of time tweaking input parameters until a suitable plan is found.

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