Similar-case-based optimization of beam arrangements in stereotactic body radiation therapy

This work addresses a difficult problem on determination of appropriate beam arrangements for lung stereotactic body radiotherapy (SBRT). We have studied the feasibility of a proposed method for computer-aided determination of beam arrangements in lung SBRT based on similar planning cases in a radiation treatment planning (RTP) database constructed by experienced planners.

Selection of similar cases
Similar cases were searched by considering the weighted Euclidean distance of image feature vectors between an objective case and each case in the RTP database. The weighted Euclidean distance \( d_{\text{image}} \) was calculated by the following equation:

\[
d_{\text{image}} = \sqrt{\sum_{i=1}^{G} w_i (x_i - y_i)^2},
\]

where \( G \) is the number of image features, \( w_i \) is the weight of the \( i \)-th image feature, \( x_i \) is the \( i \)-th image feature for the objective case, and \( y_i \) is the \( i \)-th image feature for each case in the RTP database. We gave a large weight to the spinal cord positional features for reducing extra dose to the spinal cord.

 Determination of beam directions based on similar cases
The beam angles of an objective case were determined by registration of similar cases (Figure 1) followed by a local beam angle optimization. First, an affine transformation matrix to register the lung regions of each similar case with that of the objective case was calculated by using a least square method based on eight feature points, which were automatically selected for the registration in vertices of the circumscribed parallelepiped of lung regions. Second, beam directions of the similar case were modified by using the same affine transformation matrix as a registration in terms of lung regions. Finally, the beam directions of the objective case were locally optimized based on the Meyer’s method (1).

![Figure 1. Illustration of the determination of beam directions of an objective case by registration of the similar case to the objective case with respect to lung regions.](image)
Comparison of dose distributions
Figure 2 shows dose distributions obtained from an original beam arrangement of an objective case and the corresponding similar-case-based beam arrangement. Figure 3 shows the DVH of the original plan and the similar-case-based plan (Figure 2). The beam arrangement proposed by our method resulted in better PTV conformity as well as better sparing of the lung tissue and spinal cord compared with the original beam arrangement.

Our proposed method could be used as a tool for educating less experienced treatment planners using an RTP database of more experienced planners. Therefore, the quality of radiotherapy could thus be normalized among planners having different levels of experience in SBRT.

Figure 2. Illustration of an original plan and similar-case-based plan, respectively.

Figure 3. Dose volume histogram comparison between plans based on the original beam arrangement (solid lines) and similar-case-based beam arrangement (dotted lines): planning target volume (red), lung (blue), and spinal cord (green).

Reference: