Preliminary study for dose super-resolution in volumetric modulated arc therapy using cascaded networks

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Purpose: Dose grid size is one of factors that affect accuracy of dose calculation. Although use of a small grid can improve the accuracy, it is not typically used in clinic due to hard computation. The purpose of this study is to propose cascaded networks to predict high-resolution doses (i.e., a 1 mm grid) from low-resolution doses (i.e., a 3- mm grid) with reduced calculation time.

Materials and Methods: Our deep learning architecture consisted of two networks: (1) feature-learning and (2) super-resolution networks. Each network was independently trained using 2D slice-by-slice manner. Doses of 1- and 3-mm grids for 20 patients (training: 16, test: 4), which were calculated by prostate volumetric modulated arc therapy plan (prescription: 78 Gy) and AXB algorithm, were used. The doses of a 1-mm grid were downsampled to a matrix size of doses with a 3-mm grid to generate two training data pairs: (1) doses with a 3-mm grid/downsampled dose and (2) downsampled dose/doses with a 1-mm grid. The first and second pairs were used to train the feature-learning and super-resolution networks, respectively. The trained networks were connected in a cascaded manner by using output of the first network (feature-learning network) as input of the second network (super-resolution network). Predicted doses from our networks were compared with doses with 1-mm grid (baseline) using dose-volume histogram (DVH) and dice similarity coefficient (DSC).

Results: The DVH of planning-target-volume (PTV) for the predicted doses were visually similar to those for doses with a 1-mm grid (baseline) than with a 3-mm grid. Mean/maximum doses of the PTV for the predicted doses were similar to those for baseline doses. Average minimum dose differences were 1.9±0.4% of the prescription (predicted doses vs. baseline doses) and 7.7±7.4% (doses with a 3-mm grid vs. baseline doses), respectively. The DSC values between the predicted doses and the baseline doses were closer to 1 compared to those between doses with a 3-mm grid and the baseline doses.

Conclusions: The proposed method accurately predicted doses of small grid from those of large grid. The predicted doses were comparable to baseline dose with 1-mm grid.

Keywords: deep learning, cascaded networks, dose super-resolution, dose grid size