Cohort-Based Spatial Similarity Can Predict Radiotherapy Dose Distribution

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PURPOSE / OBJECTIVE(s)

In head and neck (HN) cancer treatment, radiotherapy (RT) plans assigned to a given patient depend in large measure on the tumor location with respect to surrounding organs at risk (OARs). With the emergence of Big Data repositories, RT data from patients with similar tumor locations could be used to predict the RT plan for a new patient, as opposed to clinicians or institutional memory alone.

We propose an automated technique to evaluate RT plan similarity between HN cancer patients who have previously received radiotherapy, based on similarities in their tumor location with respect to OARs. We use this technique to predict and evaluate the RT dose distribution across organs in a new HN patient, using similar patients as a prior.

MATERIAL & METHODS

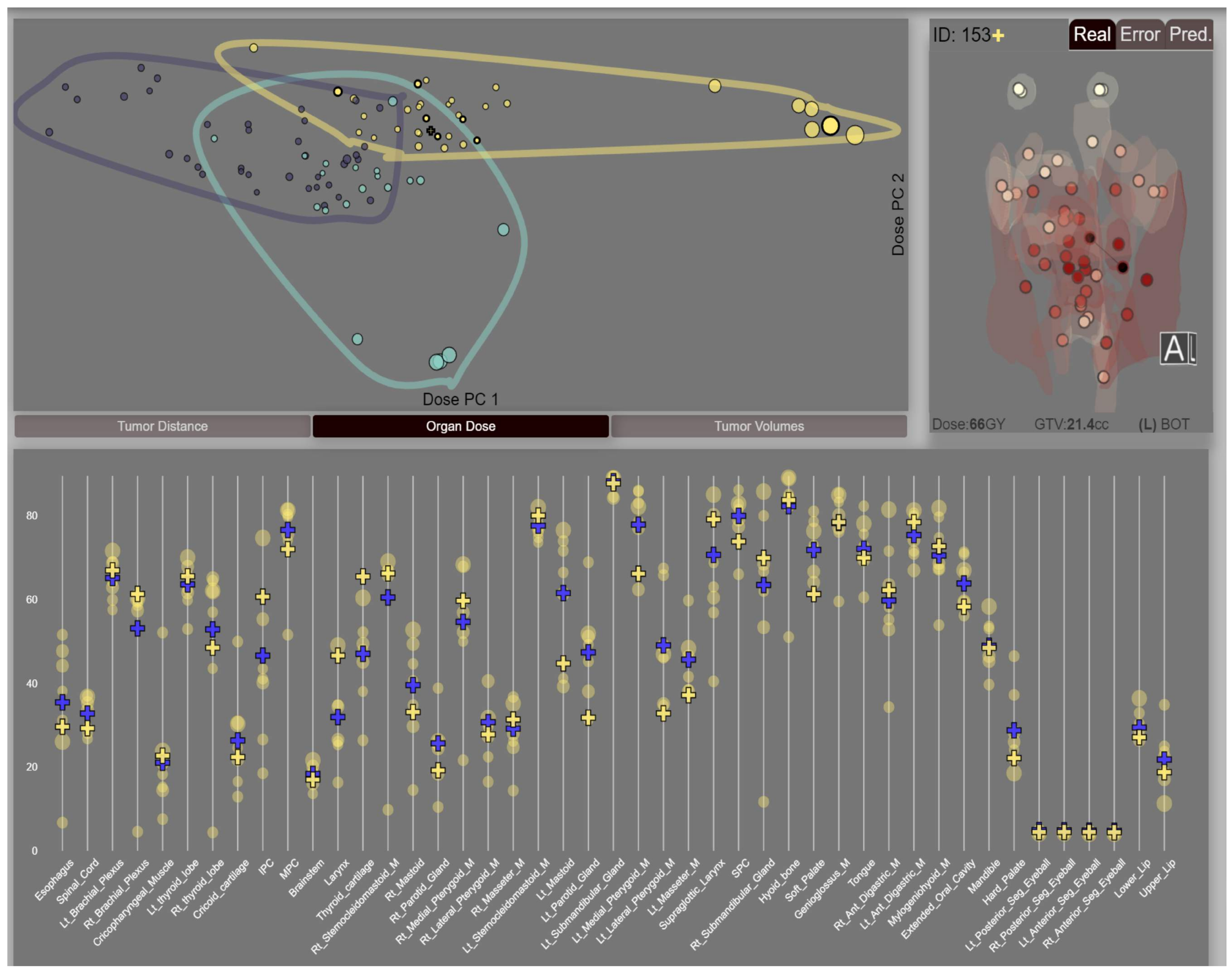
We retrospectively collected 92 oropharyngeal cancer (OPC) patients under an approved IRB. RT treatment plans were retrieved using commercially available software. We calculated distances between tumor and OARs, between OARs, and associated RT-DOSE grids using in-house developed Matlab code.

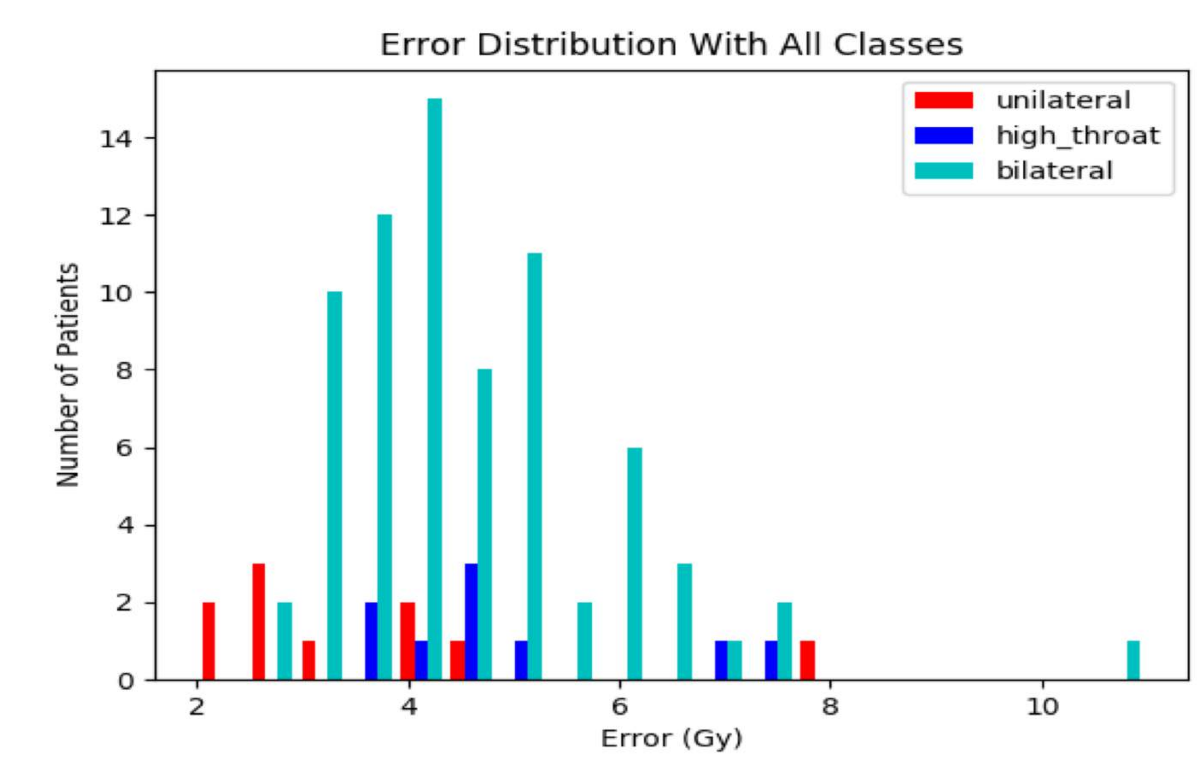
A similarity algorithm based on the structural similarity index (SSIM) and on an anatomical atlas was developed to compare each patient using only tumor and OAR distances. A web-based Graphical User Interface (GUI) allowing for visual exploration and analysis of data was developed, used to identify and discriminate different classes of radiation distribution, as captured by spatial similarity, which was used to group OPC patients before the prediction was generated.

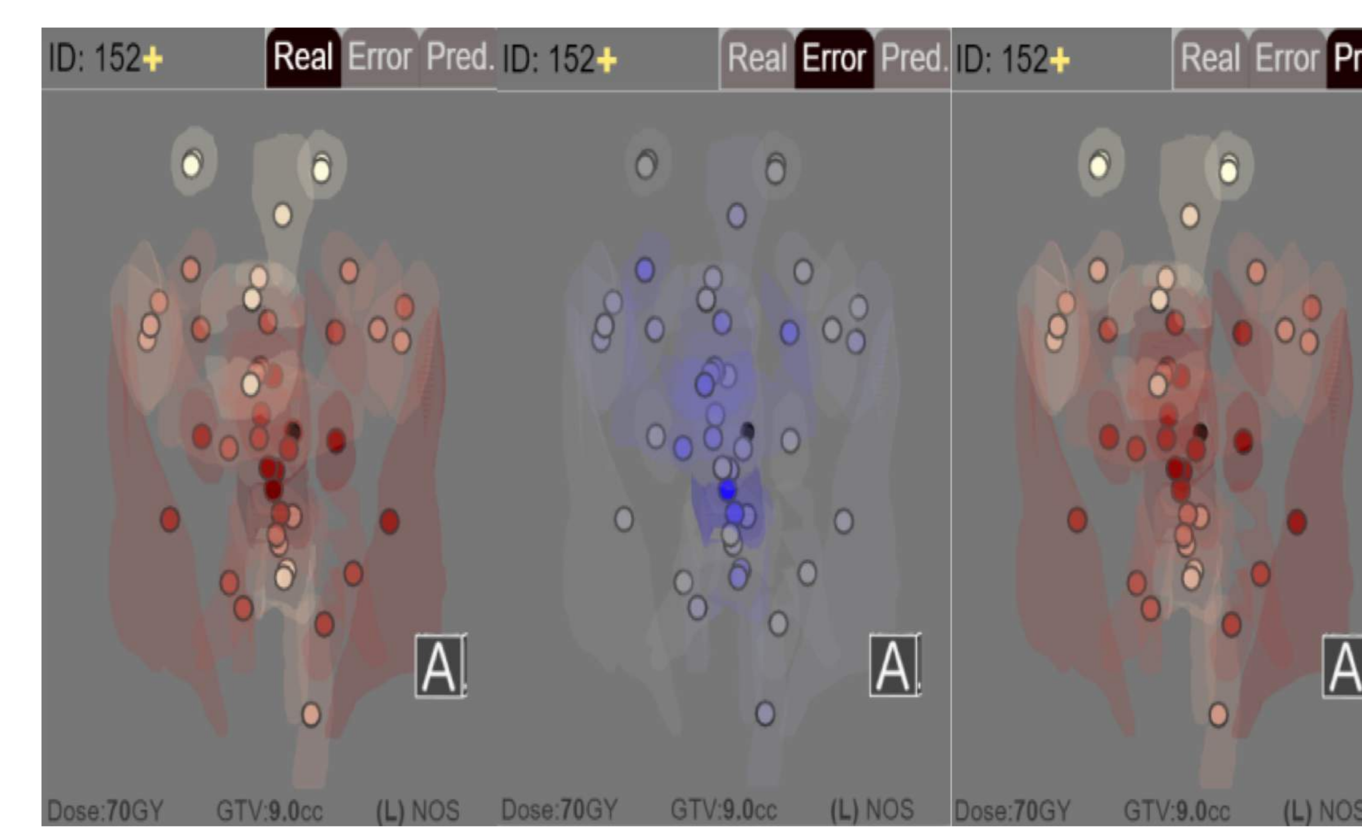
Using the same similarity algorithm, each patient was matched with the most-similar patients in their group, whose RT plans were used to generate a predicted radiation dose for the patient. The predicted value for each organ was compared to the actual RT dose from the dataset.

RESULTS

Accuracy was measured by calculating the mean per-organ difference between predicted and actual radiation dose (Gy) for 92 patients. The similarity metric and GUI analysis allowed us to divide the dataset into four main clusters. The mean and median prediction error using the four clusters was 4.56 Gy and 4.30 Gy, respectively. Comparing prediction error for the case where the spatial similarity metric is used showed a statistically significant improvement over the naive prediction before clusters were introduced, which yielded a mean error of 7.6 Gy (p=0.0015), as well when only comparing between clusters, which yielded a mean error of 6.1 Gy (p=.07). An analysis of the effect of patients number used in the matching showed that our algorithm performed best with 10-15 patients, with additional matches gradually reducing prediction accuracy.







SUMMARY / CONCLUSION

The spatial similarity method is able to capture important correlations in patients with similar therapy plans and can predict RT radiation dosage, and spatial similarity with other factors as the number of secondary tumors in RT plans are relevant.

REFERENCES / ACKNOWLEDGEMENTS

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