Brainlab **Novalis Circle**

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Prediction of clinical plan quality based on patient geometry for single isocenter multiple brain metastases stereotactic radiosurgery

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Purpose

Treatment planning for multiple brain metastases is challenging as it involves multi-dimensional plan quality trade-offs. Potentially, a priori knowledge about patient geometry can lead to more standardized treatment planning. The aim of the study is to predict plan quality for multiple brain metastases stereotactic radiosurgery (SRS) cases, based solely on patient geometry, using a model derived from clinical data sets.

Materials and Methods

We performed a retrospective dosimetric analysis of 181 clinical radiotherapy plans, which were delivered at the university hospitals LMU and UKE between 2016 and 2020 with LINAC-based SRS, using a single isocenter. Plan quality was defined by assessment of dose conformity, normal brain sparing, brainstem dose and monitor units. As a first step, a set of geometric parameters was defined to describe the distribution, morphology and size of the brain metastases. We then analyzed the correlations between the geometric parameters and the plan quality parameters and used our findings to develop random forest (RF) regressors to predict the latter.

Results

We found that (1) the conformity index (CI) worsens for less spherical target volumes and is dependent on the volume and the position of the target volumes, (2) the gradient index (GI) improves with increasing target volume, (3) the volume of normal brain tissue irradiated by a dose of at least 10 Gy (V_{10Gy}) is mainly affected by the total tumor volume, (4) the number of monitor units (MU) increases with a higher number of small target volumes, and (5) the maximum dose in the brainstem ($D_{Brainstem\_max}$) depends mainly on the proximity of the closest target volume to the brainstem.

Conclusion

It was shown that SRS plan quality for multiple brain metastases is correlated to the patient geometry. Based on this data, RF regressors were successfully built that allow the prediction of plan quality based on clinical treatment plan training data. The prediction has the potential to improve treatment planning in terms of efficiency, consistency and quality.

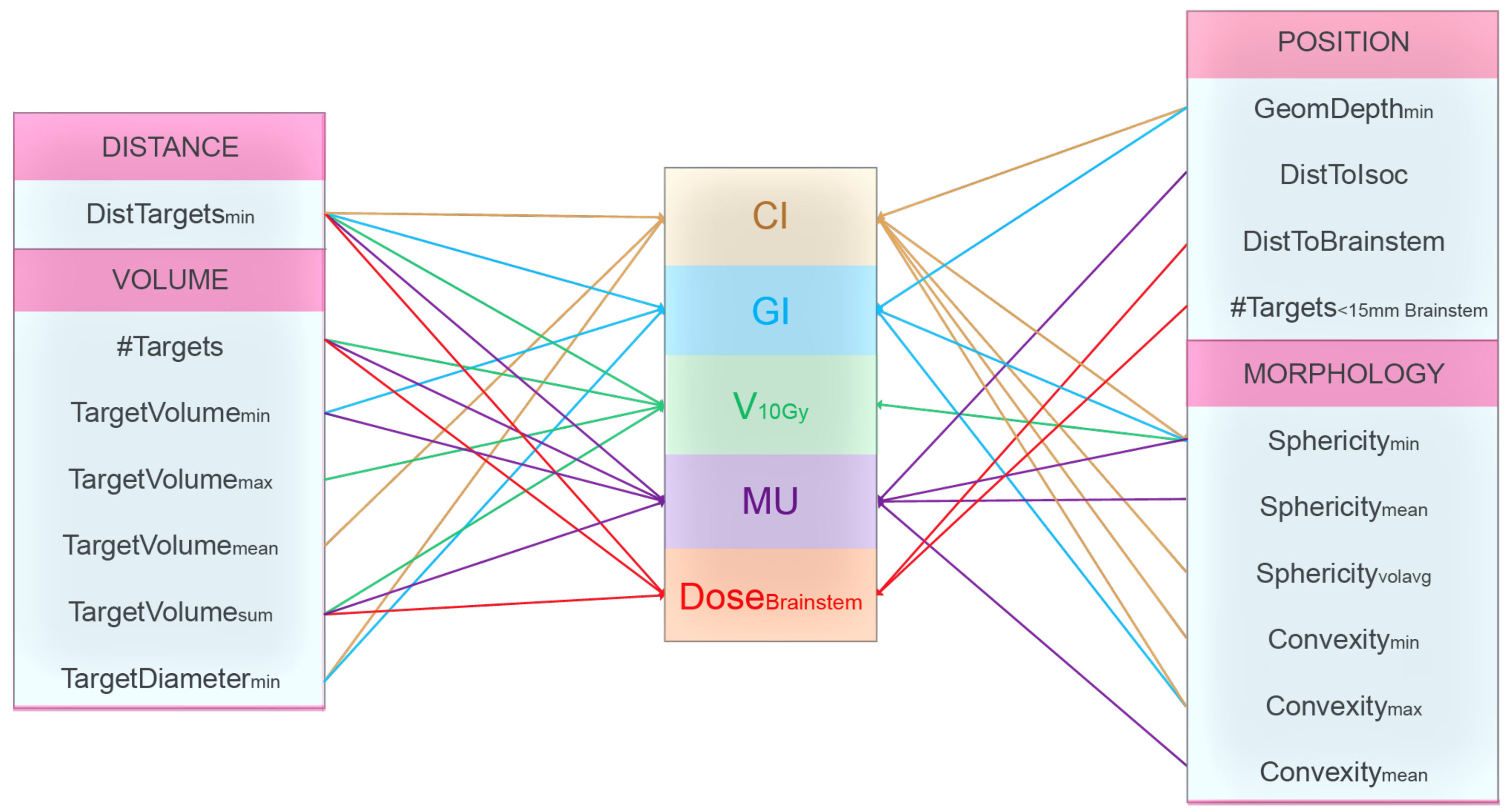

Figure 1: Overview of the geometric parameters that contribute to the supervised learning models which predict the plan quality parameters. The colors of the connections visualize which geometric parameter was selected for which plan quality parameter.

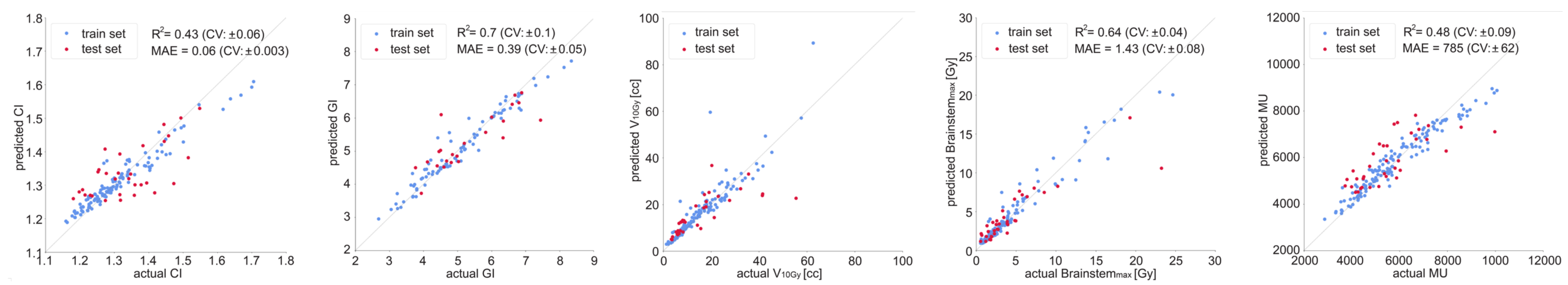

Figure 2: Model performance for the prediction of the plan quality parameters CI (a), GI (b), V_{10Gy} (c), MU (d) and $D_{max\_brainstem}$ (e). Predicted values plotted against actual values. Training set is compared with the test set. The dotted line represents the perfect prediction of the actual plan quality parameters. The performance parameter R^2 score and mean absolute error (MAE) of each model are displayed as well as the results of the performed cross-validation (CV).