MACHINE LEARNING APPROACH FOR PRE-PLANNING 12-GY ISODOSE VOLUME PREDICTION IN BRAIN STEREOTACTIC RADIOSURGERY (SRS) BASED ON TARGET AND PLAN PARAMETERS AS PREDICTORS ON RADIXACT TOMOTHERAPY.

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Purpose:

The 12-Gy isodose volume (V12Gy) is a well-established predictor of radiation-induced toxicity in brain stereotactic radiosurgery (SRS). Early estimation of V12Gy (cc) can contribute to safer treatment planning and guide prescription decisions. This study aims to develop and evaluate a Random Forest-based predictive model for V12Gy (cc) using target and plan-related parameters.

Methods:

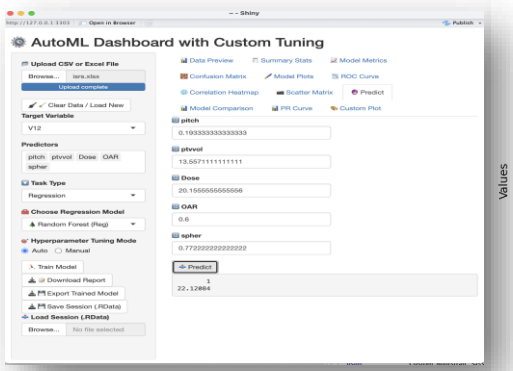
The retrospective 35 brain SRS treatments undergone on helical Tomotherapy were selected and planned optimally for different prescription doses and Pitch value on Accuray PrecisionTPS. For each case, the PTV volume, sphericity, degree of OAR overlap, and prescription dose , Pitch value were quantified. A Random Forest regression model was trained to predict the V12Gy (cc) from above parameters, and feature importance scores were extracted to assess the relative contribution of each variable. Model performance was evaluated using 5-fold cross-validation, mean absolute error, and coefficient of determination (R^2).

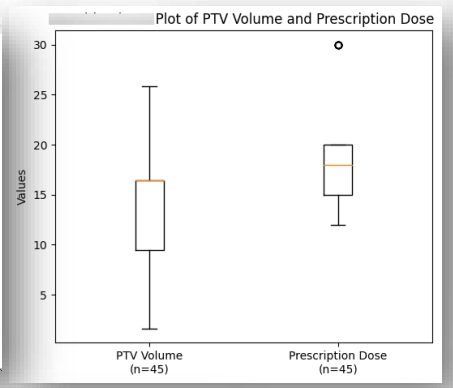
Extracted Features

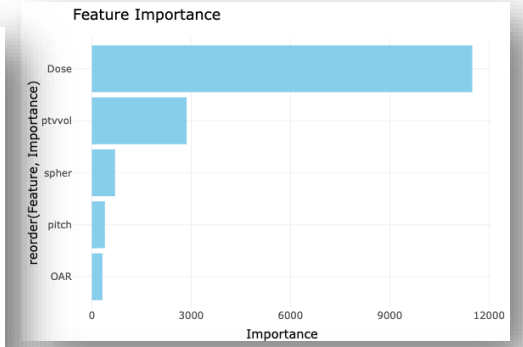
Feature Category	Feature	Description
Target Geometry	PTV Volume (cc)	Total planning target volume in cubic centimeters
Target Geometry	Sphericity	Visual inspection Sphere -1, Moderate sphere-0.75, irregular 0.5, highly irregular-0.25
OAR Relation	Degree of OAR Overlap	Extent of overlap or proximity between PTV and nearby organs at risk
Planning Parameter	Prescription Dose (Gy)	Dose prescribed to the target volume
Planning Parameter	Pitch Value	Helical tomotherapy pitch used during optimization
Dosimetric Output	V12Gy (cc)	Volume of normal brain receiving 12 Gy (prediction endpoint)

Results:

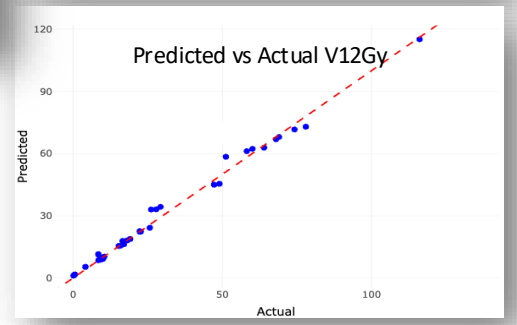
The Random Forest model demonstrated good predictive capabilities for estimating V12Gy across various lesion types and locations. PTV volume emerged as the most significant predictor, followed by prescription dose, PTV sphericity, and OAR overlap. Notably, lesions with the same PTV volume and prescription dose but different in sphericity exhibited varying V12Gy volumes. Lower sphericity was associated with larger V12Gy values. The ensemble approach effectively captured the nonlinear interactions between geometric and dosimetric factors that influence V12Gy. **The R^2 value for the selected model was 0.9785 and MAE 5.7 cc**







Parameter	Value
Model Type	Random Forest Regression
Number of Trees (ntree)	200
Variables per Split (mtry)	2
Training Dataset Size	35 Cases (total 315 Plans - Replanned for three pitch and 3 doses)
Validation Method	5-Fold Cross-Validation
Performance Metric (R^2)	0.9785
Mean Absolute Error (MAE)	5.7 cc
Predictor Variables	PTV Volume, Prescription Dose, Pitch, Sphericity, OAR Overlap, Spatial Location
Target Variable	V12Gy (cc)



Conclusion:

This tool has the potential to enhance pre-planning risk assessment, support personalized prescription strategies, and improve the overall safety of SRS treatments.

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