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Machine Learning Methods for Radiobiological Outcomes Modeling

Purpose: Radiobiological outcomes models are important predictors of irradiation induced effects in terms of achieving tumor control or causing damage to surrounding normal tissues. They are also used to rank the quality of treatment plans. Outcomes models may depend on many variables such as dose-volume metrics and clinical factors. *In particular, the best outcome model itself may vary depending on patient or treatment characteristics.* General non-linear models, such as neural-networks, potentially allow us to capture this natural variation in models.

Method and Materials: We studied feed-forward (FFNN) and general regression neural networks (GRNN). As representative data, we used a cohort 166 non-small cell lung cancer patients who received radiotherapy treatment, with endpoints of pneumonitis and esophagitis. Dosimetric variables were extracted using CERR.

Results: We used resampling (bootstrap) methods to select optimal parameters for the networks, which include the number of neurons in FFNN's and the 'width' (σ) in GRNN's. In modeling pneumonitis, the optimal FFNN had 3 layers and 5 neurons in the hidden layer, with spearman rank correlation 0.49±0.27 in training and 0.11±0.07 in testing. The GRNN with σ=1.25, achieved a training spearman of 0.25±0.08 and testing spearman of 0.20±0.3. In modeling esophagitis, the FFNN had 5 neurons, with a spearman of 0.59±0.09 in training and 0.3±0.21 in testing. GRNN with σ=1.25, achieved a training spearman of 0.38±0.06 and a testing spearman of 0.39±0.12.

Conclusion: We evaluated two machine learning algorithms to model outcome in cases of pneumonitis and esophagitis. Our preliminary results indicate that the GRNN was more straightforward to implement and, more importantly, had better generalizability than that of FFNN. Our experience to date indicates that neural networks may perform as well or better than multi-term logistic regression methods.