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Uncertainty-aware Machine Learning for Proton Therapy Range Verification with a Digital Tracking Calorimeter

Wednesday 31 January 2024 16:35 (5 minutes)

Proton therapy is highly sensitive to range uncertainties due to the nature of the dose deposition of charged particles. To ensure treatment quality, range verification methods can be used to verify that the individual spots in a pencil beam scanning treatment fraction match the treatment plan. We employ uncertainty-aware deep neural networks to predict the Bragg peak depth in an anthropomorphic phantom based on secondary charged particle detection in a silicon pixel telescope designed for proton computed tomography. The subsequently predicted Bragg peak positions, along with their uncertainties, are compared to the treatment plan to determine the quality of the treatment fraction.

The range verification model is a multi-task multilayer perceptron, predicting the beam range in water as well as the Bragg peak position in the patient. The two task losses are weighed against each other by automatically learning their respective homoscedastic uncertainties. Along with the predicted values, we additionally predict the aleatoric uncertainty. The epistemic uncertainty is estimated with Monte Carlo Dropout. The Bragg peak is predicted with a mean absolute error of 1.1 mm and the predicted uncertainties are sufficiently accurate to derive the quality of the treatment fraction.

Publication: Alexander Schilling et al, 2023, Uncertainty-aware spot rejection rate as quality metric for proton therapy using a digital tracking calorimeter, Phys. Med. Biol. 68 194001

Would you like to be considered for an oral presentation?

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Session Classification: Poster Session

Track Classification: 2 ML for analysis : event classification, statistical analysis and inference, including anomaly detection