Multicatheter Radioactive Implant Navigation with Machine Learning for Rapid, Efficient High Dose Rate (HDR) Brachytherapy Treatment Planning

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Brachytherapy is a cancer treatment procedure that implants applicators, often catheters and needles, for the delivery of a sealed radiation dose. While brachytherapy enables precise targeting of localized tumor regions with radiation, current treatment planning is largely performed manually, which can be time-consuming and operator-dependent. Automation of the manual steps in treatment planning would significantly decrease the treatment duration and risk of treatment error, contributing to enhanced medical care. In this research, a novel treatment planning workflow is developed with machine learning and computer vision techniques. Tomographic images of patient computed tomography (CT) scans were used to train an artificial neural network (ANN) for the segmentation of applicators. A backpropagation algorithm was applied to enable the ANN to accurately detect applicator points within the CT volume. 3D density-based spatial clustering was used to register the ANN detected applicator points under the specific applicators. The radiation source paths were delineated through computing the applicator centerlines, and incremental positions along the paths were identified as the locations of radiation dwells. Accurate determination of dwell positions is crucial for safe and functional dosimetry. A set of CT scans was used to verify the robustness of the developed implant navigation system, which can lead to bolstered efficiency and consistency in treatment planning. The system can also function as a quality check for applicator placement, rapidly evaluating the safety and effectiveness of the implant location prior to treatment.

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