Title

AI applications for treatment planning in IOeRT

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Purpose/Objective

Artificial Intelligence (AI) is already an integral part of our daily life and is rapidly transforming medicine, from diagnostics to personalized treatments. In radiotherapy, AI applications are making significant strides by reducing time-intensive tasks and enhancing precision with applications like automatic contouring and planning. Intraoperative radiotherapy (IORT) is no exception to this transformation. Various advances, such as the integration of 3D imaging technologies like a mobile Cone Beam CT (CBCT), have opened up new possibilities for AI-driven improvements in IORT. With the help of AI, IORT challenges related to the laborious and time-consuming nature of 3D image-based treatment planning, the need for precise applicator positioning and the creation for a dose summation plan for patients that receive additional external radiation therapy can be addressed.

Materials/Methods

A substantial amount of time would have to be spent on manually contouring organs at risk and target volumes on CBCTs for adaptive planning in an IORT setting. By providing contour suggestions through automatic segmentation of relevant regions, this time can be significantly reduced. Additionally, suggesting the position of the applicator within the treatment planning software could greatly improve the efficiency of radiation planning. While commercial software solutions and AI models for automatic contouring are available for 3D CT images, they are not available for contouring CBCT images taken within an IOeRT setting. Due to technical differences, such as the limited field of view in 3D imaging, these solutions cannot be directly applied. Therefore, the idea is to implement new artificial neural networks that can be used to automatically contour organs at risk and the applicator on CBCT scans, that were acquired with the mobile Imaging Ring-m during IORT procedures. In recent years, UNet [1] models were the most popular neural network architectures in the domain of medical image segmentation. However, transformer [2] architectures (well-known through ChatGPT) and extended Long Short-Term Memory (xLSTM) [3] architectures became the new trend for deep learning models. In order to enhance the segmentation accuracy, a combination of the UNet and Transformer and a combination of UNet and xLSTM network architecture are developed and trained. Those algorithms are trained, validated and tested using a dataset consisting of 101 CBCT scans, obtained from breast cancer patients undergoing IOeRT in the university clinic of radiotherapy in Salzburg. Building on the AI-based contouring model, an algorithm to accurately position the radiotranslucent applicator within the treatment planning software can be implemented. In addition to this, similar artificial neural networks to perform deformable image registration can be trained and used to create a dose summation plan for patients that receive additional external radiation therapy afterwards.

Results

Incorporating features from transformer and xLSTM architectures, the auto-segmentation task on IOeRT CBCTs has shown promising results compared to the standard UNet. This will ultimately help save time to allow for the adoption of 3D model-based treatment planning in an operative setting.

Conclusion

The synergy of artificial intelligence, advanced image processing and computational methods can allow for a 3D model-based adaptive treatment planning within the limited time frame of an operative setting.

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