UNIVERSITÄTSMEDIZIN MANNHEIM
MEDICAL FACULTY MANNHEIM OF HEIDELBERG UNIVERSITY
Master of Science in Biomedical Engineering

Automated Radiotherapy Treatment Planning Using Metadata Based Treatment Outcome Prediction

Author:
Franz David Schaefer

Thesis supervisor:
Prof. Dr. Jürgen Hesser

September 15, 2020

ABSTRACT

Radiotherapy treatment planning has seen the introduction of deep learning in various ways in the last few years. As the technology becomes more and more accessible, there have been novel implementations in segmentation, dose prediction, texture mapping and even automated treatment planning solutions. This thesis builds upon these previous advancements by implementing a fully connected neural network designed to predict the outcome of radiotherapy treatments by integrating the patient metadata. Additionally, we integrated our network into a radiotherapy treatment optimizer as a regularisation feature, allowing the automated creation of patient specific, personalised treatment plans, based on their individual metadata.

This thesis's primary aim was developing the prediction neural network, this was done by training the network on patient metadata such as age, sex and organ geometry and radiotherapy treatment planning metrics such as monitor units and dose volume histograms. This involved acquiring and extracting opensource DICOM data sets, followed by extraction and standardisation of the required features. We developed a score-based treatment outcome assessment metric to rate the quality of the applied plans. Autoencoding of the larger feature sets was used to avoid overwhelming the prediction network by reducing the number of input features, with high quality reconstruction and acceptable loss values. With the final prediction network having a stable prediction accuracy of 80%, with 80% in the training set, and 78% in the validation set.

The secondary aim of the thesis is was the integration of our prediction network into an existing radiotherapy planning software. This was done by using the prediction network as a feedback system, within the software's optimisation function. By integrating it into the objective and gradient functions our prediction network acted as a regularisation function and applied minor changes to the optimisation process to acquire the best possible prediction while still accounting for the physician prescriptions.

After implementation we observed patient specific manipulations of the treatment plan, when comparing plans generated with and without the prediction model regularisation, with changes in the D-95/50 and V-60/30 values depending on the patient's metadata. Furthermore, we measured significant improvements in the treatment score, especially in cases where the original treatment outcome was subpar, seeing up to 20-30% score improvement in some cases.