PhD Thesis Title: '2D Transit Dosimetry Using Electronic Portal Imaging Device'

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ABSTRACT:
The amorphous silicon electronic portal imaging device (a-Si EPID) was originally designed for positional verification in radiotherapy. Several features of the a-Si EPID, such as, the high-resolution detector array and ease of operation, have made this imaging device an attractive tool for dose measurements. The main challenge with a-Si EPID dosimetry is the deviation in scatter and dose response characteristics from a water-equivalent detector that makes the conversion of EPID signal to dose not straight forward.

The aim of this thesis is to develop a model to perform 2D transit dosimetry for patient-specific treatment verification with a-Si EPID. The transit model can be used for both pre-treatment and actual treatment verification to ensure safety in different stages of the radiotherapy process.

The model was based on a quadratic equation that relates the reduction in radiation intensity, represented by the ratio of exit to entrance dose, to the water-equivalent path length (EPL) of the attenuator. Coefficients in the quadratic equation were derived from a set of calibration dose planes measured for a reference beam with water phantoms of known thicknesses. Two sets of coefficients were derived separately from calibration dose planes measured with EPID and ionization chamber (IC) in water. Consequently, with two sets of coefficients, the EPL of any attenuator can be calculated using either EPID measured dose planes or treatment planning system (TPS) computed dose planes for the treatment field to be verified. The calculated EPL, which is a property of the attenuator and independent of the dosimeter, was used to link the different dosimetry systems and provide a two-way relationship for either: (Path 1) reconstruction of in-phantom or in-vivo dose from EPID measured dose planes, for comparison with TPS planned dose; or (Path 2) prediction of EPID transit dose from TPS computed dose planes, for comparison with EPID measurement during treatment.

The developed model was first tested with homogeneous and heterogeneous slab phantoms using open, enhanced dynamic wedge (EDW) and intensity modulated radiation therapy (IMRT) fields. Results showed that the model could accurately detect deviation between delivered and planned doses. Further evaluation, with an anthropomorphic pelvic phantom and 65 test fields (open, 3D conformal, EDW, IMRT) at

different gantry angles, showed a mean gamma pass rate (4%/4mm criterion) of 97.6% (range: 90.0% to 100%) for in-phantom exit dose comparisons (Path 1) and 97.1% (range: 92.9% to 99.8%) for EPID transit dose comparisons (Path 2). In addition, the methods in Path 1 were expanded to reconstruct dose at other levels besides the exit level. In-phantom isocentre dose comparisons resulted in a mean gamma pass rate of 98.2% (range: 91.7% to 100%).

Finally, clinical feasibility of the EPID transit dosimetry model was demonstrated for three patients (11 3D conformal fields, 18 verifications) who were undergoing radiotherapy treatment at the pelvic region. Gamma analyses with 5%/5mm criterion resulted in a mean pass rate of 97.0% (range: 92.4% to 99.6%) and 98.6% (range: 96.1% to 100%) for in-vivo comparisons at the exit level and isocentre level respectively (Path 1). The mean gamma pass rate for EPID transit dose comparisons (Path 2) was 95.6% (range: 90.7% to 99.9%).

In conclusion, the 2D EPID transit dosimetry model developed in this thesis has been proven to be valid and suitable for clinical implementation. The model is: (1) practical, involving only general measurements and does not require any modification to the EPID panel, (2) generic, with the methods applicable to all a-Si EPID and TPS regardless of manufacturer and (3) flexible, allowing users to verify the accuracy of treatment delivery either at multiple planes in-vivo or at the EPID level. These are important characteristics to encourage widespread implementation of EPID transit dosimetry in different clinical setting for safer radiotherapy.

References to author publications that relate specifically to the dissertation:

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