PP06

Statistical modeling of the eye for multimodal treatment planning for external beam radiotherapy of intraocular tumors

Rüegsegger M[1], Cuadra M[2], Pica A[3], Amstutz C[4], Rudolph T[1], Aebersold D[3], Kowal J[1]

[1]ARTORG Ophthalmic Technologies, [2]Inselspital, University of Berne; Signal Processing Laboratory (LTS[5]), [3]Radiation Oncology, [4]Ecole Polytechnique Fédérale de Lausanne, Lausanne; Department of Ophthalmology, University Hospital Zurich

Objective. Ocular anatomy and radiosensitivity provide unique challenge for external beam radiotherapy. For treatment planning precise modelling of organs at risk and tumor volume is crucial. We present the development and application of a statistical shape model as a novel method for precise eye modelling for external beam radiotherapy of intraocular tumors.

Materials and methods. CT slice stacks with a resolution of 0.39×0.39×0.6 mm (LightSpeed Ultra CT scanner from GE Medical Systems) from 17 patients (8 woman, 9 men, mean age 55±11 years, mean eye length 23±1.5 mm, tumor free) have been used as a training set for the eye model construction as well as for its validation. A 3D statistical shape model of the cornea, lens, sclera as well as of the optic nerve head position was constructed by building an atlas, automatic extraction of landmarks from the atlas and subsequent propagation of these landmarks to the manual segmented training shapes. Furthermore, an active shape model was built to enable automatic fitting of the eye model to the CT slice stacks. Cross-validation was performed based on a leave-one-out test for all training shapes by measuring the dice similarity coefficient and the mean segmentation error between the automatic segmentation and the manual segmentation done by an expert.

Results. Cross-validation revealed a dice similarity coefficient of 95±2% for the sclera and cornea and 91±2% for the lens. Overall, a mean segmentation error of 0.3±0.1 mm was measured in a mean segmentation time of 14±2 s with a standard PC.

Conclusion. Our results show that the presented eye model is well suited for high accuracy modelling and clearly overcomes state of the art methods in terms of accuracy, reliability and robustness. An increased modelling accuracy will consequently lead to an improved treatment planning accuracy. Due to the fact, that the presented eye model shape as well as it is variability learned from a training set instead of making assumptions (e. g. spherical or elliptical eye model) it is also very well suited for modelling nonspherica and non-elliptical shaped eyes.

PP07

Acceptance and commissioning of a modern kilovoltage X-ray therapy unit

Aspradakis MM, Zucchetti P, Seiler R, Götzfried Th, von Deschwanden A

Institute of Radiation Oncology, Cantonal Hospital of Lucerne, 6000 Lucerne 16

Objective. Describe the performance characteristics of the kilovoltage (superficial and orthovoltage) X-ray therapy unit by Wolf Medizintechnik GmbH.

Materials and methods. The WOmed T-200 kV machine in our chosen configuration produces X-ray energies from tube potentials between 30 to 200 kV. Six applicators, eight kV and filter combinations are available with beam filters rotating on a carrousel. The machine runs only through an integrated patient database and beam verification software system. Acceptance of the non-dosimetric aspects of the machine included a radiation protection survey, checks of tube head leakage, alignment of the focal spot and beam axis with the axis of the applicator, examination of applicator construction, tests on machine interlocks and the machine timer. Beam qualities (HVL) were measured under narrow beam geometry. Percentage depth doses (PDD) were measured in water and in Plexiglas with cylindrical (PTW TW30006, Wellhöfer IC-15) and parallel-plate ionization chambers (NACP02 and PTW M23342). Beam flatness and uniformity were evaluated with 2D detector arrays and film. Dose determination was based on national and international dosimetry protocols. Further assessment of dosimetric performance included a verification of beam start-up characteristics (time-end error), dose rate linearity and reproducibility.

Results. The results from mechanical checks were satisfactory. Beam qualities range between 0.55–4.72 mm Al and 0.16–1.78 mm Cu. In the low energy range (≤100 kV) and for all applicators surface dose rates varied between 0.2–1.5 Gy/min. In the medium energy range (≥100 kV) dose rates at the depth of 2 g/cm2 varied between 0.6–1.5 Gy/min. Time-end errors were negligible. PDDs measured with different detectors in water were in good agreement with each other. PDDs measured in Plexiglas do not agree with those in water, but match published data (BJR Supplement 25).

Conclusion. Published guidance on the determination of HVL and PDD in kilovoltage beams is contradicting. For the determination of reference surface dose rate in the low energy range the reference instrument is calibrated by METAS/PTB without the use of necessary foils that would ensure a measurement under electronic equilibrium and without the influence of contaminant electrons from the applicators on the reading. This increases the uncertainty in the determination of absorbed dose. For a reliable set of PDD data in water, ionization at shallow depths was carefully determined through curve fitting to the measurement instead of simply extrapolating to zero depth. PDDs measured in Plexiglas are not appropriate for clinical use.

PP08

Experimental verification of rescanning and gating for moving tumours with fast proton spot scanning

Schätti A, Zakova M, Meer D, Lomax T

Centre for Proton Therapy, Paul Scherrer Institute, Villigen AG

Objective. The new Gantry 2 for active, scanned proton therapy at PSI has been specifically designed to be able to treat tumours with considerable intrafraction motion. Simulation studies have shown that rescanning is a feasible technique to mitigate the interplay effect for amplitudes up to 5 mm. We intend to treat moving tumours with a combination of rescanning and gating or breath-hold for any motion scenario. The goal of this work is to find out if experimental results can live up to the expectations from the theoretical work.

Materials and methods. In an extensive series of measurements in a plexiglas phantom we assessed rescanning and gating of spot scanning on Gantry 2. Data acquisition was achieved by a scintillating screen combined with a CCD system. Spheres and a clinical example were chosen as target volumes. 1D motion was performed according to the Lujan model and tumour trajectories extracted from 4D MRI sequences. The gating signal was generated by an LED distance sensor.

Results. No difference between motion parallel and orthogonal to the scan direction was observed. As predicted by simulations, scaled rescanning performed better than iso-layered rescanning in terms of homogeneity of the dose distribution but the irradiation time was considerably longer. Neither technique is able to reach an arbitrarily low homogeneity due to technical constraints. This point is often not discussed in theoretical studies. Volumetric rescanning was clearly beneficial but this might not be true or not even feasible for systems with a slower energy change. Only for volumetric scaled rescanning with motion amplitudes up to 5 mm were clinically acceptable distributions achieved. For 1 cm amplitude, cold spots can be avoided by gating with a small enough duty cycle (DC; 30% in our case). What is more, in this case it is not necessary to add an ITV to the target volume and more normal tissue is spared. In combination with rescanning, larger DCs can be selected (40% and 55%).

Conclusion. To sum up, rescanning and gating have been shown experimentally to be feasible to treat moving targets. The right combination