ST 11 Verbesserung der Bestrahlungsplanung

Zeit: Dienstag 16:30–18:30 Raum: D

Hauptvortrag

ST 11.1 Di 16:30 D

Ein neues Konzept für die bild- und dosis- geführte Strahlentherapie — •Bernd-Michael Hesse, Simeon Nill, Thomas Tücking und Uwe Oelfke — DKFZ , Abt. Med. Physik, D-69120 Heidelberg

Voraussetzung für eine moderne adaptive Strahlentherapie ist die Möglichkeit einer bildgeführten und Strahlenapplikation. Hierzu haben wir in jüngster Zeit die Integration einer Röntgenröhre und eines Flat-Panel Detektors an ein Therapiegerätes in einer neuartigen Konfiguration vorgeschlagen [1]. Das neuartige in diesem Konzept besteht darin, dass die Röntgenröhre gegenüber der Therapiestrahlenquelle angeordnet ist und der FP-Detektor sich am Kopf des Beschleunigers, an der Strahleneintrittsseite vor dem Patienten befindet. Hiermit kann durch rotieren der Gantry ein Kegelstrahl-CT des Patienten in Bestrahlungssituation erstellt und zur Lagerungskontrolle verwendet werden. Andererseits wird aber auch die Möglichkeit geboten mittels fluoroskopischen Sequenzen quasi zeitgleich mit der Applikation des Therapiestrahls mögliche relevante Bewegungen des Zielgebietes zu erfassen und gegebenenfalls durch nachführen des Patienten oder durch Triggerung des Beschleunigers darauf zu reagieren. Weiterhin kann mit dem Detektor während der Bestrahlung die Eingangsfluenz gemessen werden. Aus diesen Messdaten lässt sich, nach entsprechender Aufbereitung, die applizierte Dosisverteilung mit einer hohen Genauigkeit dreidimensional rekonstruieren. Erste Ergebnisse in der klinischen Anwendung sollen präsentiert werden. [1] Hesse, Bernd M.,Device for performing and verifying a therapeutic treatment and corresponding program and control method WO 03/076016 A1, 2003

ST 11.2 Di 17:00 D

Bildgestützte Strahlentherapie am DKFZ — •Thomas Tücking, Simeon Nill, Bernd Hesse und Uwe Oelfke — Im Neuenheimer Feld 280, 69120 Heidelberg

Um die Methoden der hochpräzisen Photonenstrahlentherapie effektiv zur Tumorkontrolle bei gleichzeitig bestmöglicher Schonung angrenzender Organe nutzen zu können, ist eine exakte Lagerung des Patienten ebenso wie die genaue anatomische Kenntnis der durchstrahlten Körperregion notwendig. Meist liegen jedoch lediglich vor Therapiebeginn erzeugte CT-Datensätze vor. Da die Behandlungsdosis i.d.R. auf mehrere Termine fraktioniert wird, muss ebenso oft eine präzise Lagerung durchgeführt werden, und es können, speziell bei Läsionen im Abdomen, Organbewegungen oder -verformungen auftreten, deren Berücksichtigung den Behandlungserfolg begünstigt. Der Linearbeschleuniger wurde daher mit einer kV-Röntgenröhre an der gegenüberliegenden Seite des Strahlaustritts aufgerüstet und ein Flächendetektor direkt unterhalb des Kollimators installiert, so dass damit der aus dem Patienten austretende bildgebende kV-Röntgenstrahl und der dem Patienten applizierte Therapiestrahl detektiert wird. Dies ermöglicht verschiedene kV-Bildgebungsverfahren wie Kegelstrahl-CT und Fluoroskopie am Patienten in Bestrahlungsposition. Es wurden in verschiedenen Patientenanwendungen Kegelstrahl CTs zur Lagerungskontrolle erzeugt und damit gegenüber koventionellen Lagerungsmethoden unter Verwendung des Therapiestrahls erhebliche Dosiseinsparungen für die Patienten erzielt und zusätzlich 3D-Informationen in sehr guter Orts- und Kontrastauflösung von der aktuellen Patientenanatomie gewonnen.

ST 11.3 Di 17:10 D

Probabilistic treatment planning to incorporate organ motion into IMRT optimization — •Jan Unkelbach and Uwe Oelfke — Department of Medical Physics in Radiation Oncology, German Cancer Research Center (DKFZ), Im Neuenheimer Feld 280, 69120 Heidelberg, Germany

We present an off-line approach to incorporate organ motion into the treatment plan optimization for fractionated intensity modulated radiotherapy (IMRT). Organ movements are described in terms of a mathematical model that represents the basis of the treatment plan optimization process. The motion model contains random variables in order to describe the stochastic nature of organ movements. As a consequence, the predicted dose distribution in the patient has to be considered as a random variable aswell. It is characterized by an expectation value of the dose and its variance. For treatment plan optimization incorporating the motion model, the expectation value of a quadratic cost function is minimized, which can be expressed as the sum of the variance of the dose and the quadratic difference of expected and prescribed dose. The resulting treatment plans show a reduction of the dose in regions where tumor tissue is located only rarely. This is compensated for by delivering a higher dose to neighboring regions that are mostly occupied by tumor tissue. Due to the organ movements during the course of treatment, a widely homogeneous cumulative dose distribution is delivered to the tumor. The method potentially allows for a better sparing of healthy tissues from dose burden compared to the standard safety margin approach.

ST 11.4 Di 17:20 D

Time resolved patient imaging in treatment position — •Siri Jetter, Lars Dietrich, Thomas Tücking, Simeon Nill, Bernd Hesse, and Uwe Oelfke — Department of Medical Physics, DKFZ Heidelberg, Germany

To investigate the correlation between diagnostic time resolved computer tomography (4D CT) data and 4D cone beam CT (CBCT) data for breathing motion we developed a method for the acquisition and reconstruction of 4D CBCT data. Our cone beam imaging system, integrated into a treatment machine allows for the acquisition of images of the patient in treatment position. The breathing phase is monitored with a respiratory gating system (RGS) based on a pressure sensor in a fixation belt positioned on the patient's abdomen. To evaluate the correlation between breathing signal and inner organ motion the position of the diaphragm is compared to the output of the RGS. For different breathing phases cone beam CT images are reconstructed and compared to the images obtained with a diagnostic 4D-CT scanner. We show that external signal and the movement of the diaphragm correlate closely in amplitude and phase. Comparison of 4D CBCT images with corresponding diagnostic 4D CT data allows for a repositioning of the patient in spite of respiratory movement. Furthermore inner organ and tumor movements can be evaluated. These data are essential for the design of time adapted treatment strategies.

ST 11.5 Di 17:30 D

Klinische Anforderungen an die bildgesteuerte Bestrahlung — •Daniel Zips — Klinik für Strahlentherapie TU Dresden, OncoRay Zentrum für Innovationskompetenz Medizinische Strahlenforschung in der Onkologie, Fetscherstrasse 74, 01307 Dresden

Die Einbeziehung von 4D-Bildinformationen, die vor und während Therapie erzeugt werden, ist die Grundlage der adaptiven, bildgesteuerten Bestrahlung. Die Rationale ergibt sich aus der Lagevariabilität des Tumors während Strahlentherapie sowie aus der Notwendigkeit der Berücksichtigung anatomischer und funktioneller Tumoreigenschaften. Folgende Anforderungen sind aus klinischer Sicht an die bildgesteuerte Bestrahlung zu stellen: -hochauflösende anatomische Darstellung von Tumor und Normalgeweben -Einbeziehung funktioneller, strahlenbiologisch relevanter Informationen -exakte Beschreibung des Tumoraufenthaltsraumes -rasche Datenverarbeitung zur dynamischen Anpassung der Sicherheitsabstände -zeitnahe Kalkulationen der Dosisverteilung -systematische Verringerung der Sicherheitsabstände bei vollständiger Zielvolumenerfassung zur Dosissteigerung im Tumor bei gleicher oder verminderter Toxizität -individuell angepasste Protokolle zur Minimierung des Zeitaufwandes -systematische Datenerfassung zur Kosten/Nutzenanalyse

ST 11.6 Di 17:40 D

Assessment of a new Multileaf Collimator Concept using Geant4 Monte Carlo simulations — •Martin Tacke, Hanitra Szymanowski, and Uwe Oelfke — Deutsches Krebsforschungszentrum, Im Neuenheimer Feld 280, D-69120 Heidelberg

The aim of the work was to investigate the dosimetric properties of a new multileaf collimator (MLC) concept with the help of Monte Carlo (MC) simulations prior to prototype production. The MC code Geant4 allows the implementation of new geometrical designs like the leaf packages which were imported with the help of CAD (Computer Aided Design) data. An experimentally validated phase space combined with a virtual Gaussian-shaped source model was employed to simulate a 6 MV therapy beam. First, transmission values for different tungsten alloys were extracted using the MC codes Geant4 and BEAMnrc and experimental measurements. High resolution simulations were performed to detect leakage. The 20%-80% penumbra was determined using 10x10 cm^2 fields shifted along the center axes. The transmission values, determined as linear absorption coefficients for different sinter, showed a good agreement with experimental measurements. Simulations with varying widths of the radiation source showed its impact on leakage and penumbra: for widths of 2 mm and 4 mm, the interleaf leakage is below 0.3% and 0.75%. The results for penumbra (4.7 ± 0.5mm) and leakage also agreed well with the measurements. As shown by this study, Geant4 is an appropriate tool for the dosimetric investigation of an MLC. The quantification of leakage, penumbra, and tongue-and-groove effect and an evaluation of the impact of different beam parameters was possible.

ST 11.7 Di 17:50 D

Linac based kV cone-beam CT for extended field-of-views — •Annette Seeber, Simeon Nill, Thomas Tücking, and Uwe Oelfke — Deutsches Krebsforschungszentrum, Medizinische Physik (E040), INF 280, 69120 Heidelberg

In our approach towards adaptive radiotherapy the patient anatomy is imaged directly prior to the treatment with a linac-integrated kV cone-beam CT system. The 3D-reconstruction field-of-view (FOV) is currently restricted to 26cm at isocenter due to the size of available flat panel imagers (FPIs). The acquisition of imaging data for larger patient volumes can be realised with a laterally shifted FPI. A Feldkamp-based reconstruction algorithm was modified to account for this asymmetric detector setup by a weighting operation on the projections prior to filtered back-projection.

Following successful simulations with synthetic projection data, experiments were performed with humanoid phantoms and special contrast phantoms, using different detector offsets corresponding to FOVs of up to 48cm. The achieved image quality was analysed as a function of the detector offset and the distance from the central slice by comparison with images obtained from our normal cone-beam setup and from a diagnostic CT scanner.

The achievable FOV increase permits the use of the existing cone-beam CT system also for extra-cranial regions, retaining good image quality for structure matching and adaptive therapy planning.

ST 11.8 Di 18:00 D

Verification of Monte Carlo simulations of proton dose distributions in biological media — •Hanitra Szymanowski, Simeon Nill, and Uwe Oelfke — DKFZ Heidelberg

Monte Carlo codes are a tool of choice for the validation of dose calculation for proton therapy, provided that the physics of particle transport in biological tissue is appropriately simulated. Hence a thorough validation of the performances of a Monte Carlo code using measured data or exact analytical predictions is needed prior to the use of the code as a benchmarking tool. Coulomb interactions have a predominant effect on the dose deposition pattern of protons used in radiotherapy. In this work we suggest a quantitative method to verify the ability of the Monte Carlo code GEANT4 at simulating Coulomb interactions of protons in water and in biological materials.

ST 11.9 Di 18:10 D

Towards risk adapted inverse planning for protons: Avoiding risks due to lateral tissue inhomogeneities — •Daniel Pflugfelder, Jan Wilkens, Hanitra Szymanowski, and Uwe Oelfke — DKFZ Heidelberg

Treatment planning of intensity modulated radiotherapy with proton beams leads to a highly degenerated space of solutions. Due to the huge number of degrees of freedom it is possible to find many solutions which have a dose distribution equivalent to the optimal solution. We use this fact to search for plans which not only have an acceptable dose distribution, but are also safe to deliver. As a first risk factor we focused on lateral tissue inhomogeneities, and introduced a homogeneity number H to quantify these inhomogeneities for each beamspot. Additionally we calculate the dose calculation error of each beamspot by comparing the commonly used pencil beam algorithm to the gold standard, namely Monte Carlo simulations. A clear correlation between the dose calculation error and the homogeneity number can be seen. A correlation between H and the sensitivity of a beamspot to setup errors is also observed. Since H can be calculated very fast we conclude that it is a useful tool to rate individual beamspots. This information can be used to exclude or penalize potentially dangerous beamspots in the optimization, or simply to recalculate individual beamspots by a more accurate but computationally more demanding algorithm like finesampling of the pencil beam or Monte Carlo simulations.

ST 11.10 Di 18:20 D

Activation Products in Different Brands of Medical Linear Accelerators — •Ben Tabot and Helmut W. Fischer — Universität Bremen, Landesmessstelle für Radioaktivität

A portable high resolution gamma spectrometer was used to determine radioisotopes generated in different brands of medical linear accelerators in the high energy photon mode under clinical irradiation scenarios. The results from the spectroscopic analysis were used to compute the "apparent" activity at the isocenter and the resulting dose rate. In all accelerators the same isotopes are dominating in terms of dose rate: Al-28 (2.3min), Cu-62 (9.7min), Mn-56 (2.6h), Cu-64 (12.7h) and W-187 (23.8h). The sum of the contributions of all isotopes was calculated from the data and compared to dose rate measurements obtained using a portable dose rate meter. Measured values range from 1.4 to 4.6 uSv/h 2min after beam off for a 400MU irradiation. Calculated values are lower, but show the same behaviour with time. The difference is attributed to beta radiation. Detailed results and conclusions for radiation protection of clinical and service staff will be presented.