MO-F-213CD-08

Characterization of the Homogeneous Breast Tissue Mixture Approximation for Breast Image Dosimetry

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Purpose: To characterize the suitability of the use of a homogeneous mixture of adipose and glandular tissue approximation for breast imaging dosimetry**. Methods:** Fifteen patient breast computed tomography images (BCT) were classified into skin, adipose, and glandular tissue. The segmented breasts underwent simulated mechanical compression to mimic breast compression during mammographic acquisition. Using Monte Carlo simulations representing BCT and mammographic acquisitions, the radiation dose to the voxels representing glandular tissue for both the uncompressed and compressed breasts was estimated. The BCT simulations used both a 49 kVp and 80 kVp tungsten target spectrum, while the mammography simulations used the spectra corresponding to the patient's screening cranio-caudal view mammogram. The simulations were repeated by replacing the adipose and glandular voxels with voxels representing a homogeneous mixture of the two tissues in their corresponding proportions. The normalized glandular dose (DgN) of the true heterogeneous breast tissue distribution and the homogeneous approximation was compared using a paired t-test**. Results:** For mammography, the approximated homogeneous DgN was on average 61% higher than the heterogeneous DgN ($p<10-6$). For BCT, the homogeneous DgN overestimated dose by an average of 27% ($p<10-5$) and 12% ($p<10-4$) for the 49 kVp and 80 kVp spectra, respectively. For all conditions and all breasts the homogenous DgN was higher than the heterogeneous DgN except for one breast, in which they were equal for the BCT simulations**. Conclusions:** The homogeneous mixture approximation commonly used for breast imaging dosimetry significantly overestimates the actual dose to the glandular tissue. Although this may be adequate for technique, modality and/or system comparisons, it is inevitable that these dose estimates are used inappropriately (e.g. for risk estimates), making this overestimation undesirable. Further study with a larger number of patients is required to obtain appropriate correction factors to better estimate breast glandular dose in the future.

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PShield: An Algorithm for Optimization of PET/CT Shielding

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Purpose: Calculation of radiation shielding requirements for high-workload PET installations using the methods proposed by AAPM TG-108 can be difficult. The principle challenge that makes PET shielding design more complex than other diagnostic imaging modalities, aside from the higher photon energy, is that it is a multisource problem for which no unique solution exists. The PShield algorithm incorporates three-dimensional numerical methods to optimize PET shielding and deliver a cost-optimized solution while making no approximations. **Methods:** PShield uses a sequential quadratic programming routine to optimize PET shielding by minimizing a cost function in 3-dimensions using extrapolations of the TG-108 formulas. PShield makes no approximations and accounts for the contribution of every radiation source to the dose rate at every location in the problem using a discrete mesh. We used two simple examples of shielding problems to compare PShield with the TG-108 methods. **Results:** The benefit of applying an optimization routine to an indeterminate problem is the identification of the only solution to the problem that minimizes the desired cost function. Choosing a poorly optimized solution can **Result** in a shielding design that requires as much as 50% more shielding than an optimized design to reach the same dose rate at a given control point. The increased accuracy afforded by PShield ensures that dose rates at every point in a control area never exceed the design dose, whereas a reasonable design based on the TG-108 methods may have hot spots where the dose rate exceeds the design dose by a factor of 2 or more**. Conclusions:** PShield is an exact three-dimensional numerical solution for optimal PET shielding which identifies a singular solution which is cost-optimized. This is especially important for modern PET/CT suites, where increases in scanner capabilities have resulted in more complex shielding problems and the potential for high occupational doses.

Interactive Session Imaging Scientific Room 217BCD

Assessment of Image Quality in The New CT

MO-F-217BCD-01

Assessment of Image Quality in the New CT

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The emergence of fully volumetric CT imaging systems and statistical / iterative reconstruction methods present an immediate need for rigorous methods of image quality assessment. Major themes arising in the widespread utilization of such technologies include: 1.) the reduction of radiation dose in a manner that maintains imaging performance with respect to the imaging task; 2.) the need for quantitative standards in image quality assessment appropriate to various vendor hardware and reconstruction systems; 3.) imaging performance metrics that provide meaningful descriptors of fully 3D spatial resolution and noise characteristics; 4.) the dependence of these metrics on acquisition technique, reconstruction parameters, and their applicability (or lack thereof) to novel reconstruction methods that may defy conventional metrics founded in assumptions of linearity and shift invariance; and 5.) methods for physical measurement (e.g., phantoms) and theoretical analysis of image quality for these new and emerging CT technologies and their implications for dose reduction.

Learning Objectives:

1. Understand the methods and metrics of image quality assessment for fully volumetric (cone-beam) CT imaging using 3D filtered backprojection, including analysis of the 3D NPS, NEQ, and detectability index.
2. Understand the limitations and assumptions of such metrics with respect to linearity, stationarity, and novel reconstruction techniques.
3. Gain an understanding of how rigorous assessment of imaging performance can guide technique optimization, dose reduction, and the development of new CT technologies and applications.
4. Understand the factors of image quality assessment in nonlinear statistical / model-based 3D reconstruction techniques, including PSF and covariance estimation in nonstationary systems.
5. Gain perspective on image quality assessment standards, including methods for dose and image quality measurement on different vendor platforms and the implications for dose reduction.

Imaging Educational Course Room 217A

Magnetic Resonance 1 Establishing a 4D-MRI Program for Imaging Moving Tumors

MO-F-217A-01

Establishing a 4D MRI Program for Imaging Moving Tumors

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4D-CT has been widely used in radiotherapy for imaging moving tumors, especially in the thoracic regions. In other body sites such as the abdominal, 4D-CT is limited due to its low soft-tissue contrast. Additional concern for 4D-CT includes increased radiation dose to the patient. On the other hand, MRI has no known radiation hazard and has excellent soft-tissue contrast. It is desirable to develop 4D-MRI techniques to address the problems associated with 4D-CT. There are different methods of 4D-MRI imaging. One is to use sophisticated MR pulse sequence and/or use advanced software and hardware. Another method is to retrospectively sort slice MR images acquired continuously throughout the volume based on respiratory phases. The first method typically results in a temporal resolution of ~0.7 frame/s and a spatial resolution of 3-4 mm. The second method requires simultaneously acquired respiratory signals, either by using external surrogate or internal/image-based surrogate. The temporal resolution is ~ 3 frames/s, the in-plane spatial resolution is ~1.5-2 mm, and the slice thickness is ~ 3-5 mm. Both methods are doable using commercially available MR sequences. 4D-MRI can be used to improve the determination of patient specific tumor motion margin for radiation therapy, especially for the tumors in the abdominal regions where 4D-CT has limitations. We presented this topic as a joint imaging/therapy scientific symposium in 2011 AAPM annual meeting. This proposal aims to provide a follow up education on this topic and present technical details on how to establish the 4D-MRI program in the clinic.