Medical physics imaging jean pope pdf

Volume 14, Issue 3 p. 382-384 First published: May 1987 Radiation dose distributions are conventionally measured using ionization chambers or diodes in liquid phantoms, or in two dimensions using film. This work describes a new application of magnetic resonance imaging to radiation dose planning. Agarose gels containing ferrous sulfate, sulfuric acid, and benzoic acid have been irradiated with ^{137}Cs gamma rays and 6–14 MeV electrons, to doses of up to 20 Gy. The dose distributions have been imaged by magnetic resonance, making use of the effect on the T1 proton relaxation times of the radiolytic Fe^{3+}. The image intensity was proportional to doses of up to 10 Gy, and images were stable for at least 24 h postirradiation. The G value for Fe^{3+} production was about 100 (molecules per 100 eV absorbed). Your password has been changed Please check your email for instructions on resetting your password. 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Bushberg ebook The Essential Physics of Medical Imaging, The Essential Physics of Medical Imaging E-Books, Online The Essential Physics of Medical Imaging Book, pdf The Essential Physics of Medical Imaging, The Essential Physics of Medical Imaging E-Books, The Essential Physics of Medical Imaging Online , Read Best Book Online The Essential Physics of Medical ImagingThe Essential Physics of Medical Imaging Jerrold T Bushberg Book Info Sorry Have not added any PDF format description on The Essential Physics of This books The Essential Physics of Medical Imaging PDF Made by Jerrold T Bushberg About Books This renowned work is derived from the authors acclaiâ€¦Click Download or Read Online button to get the essential physics of medical imaging book now Jerrold T Bushberg rich dad poor dad pdf download span class news dt 24 08 2015 span nbsp 0183 32 Veja gr 225 tis o arquivo Essential Physics of Medical Imaging of medical imaging Jerrold T Bushberg in our book should do the trick J T B The Essential Physics of Medical Imaging has 53 ratings and 4 reviews Jerrold T Bushberg Reading this book and relearning all of the things that I have span class news dt 12 02 2011 span nbsp 0183 32 Medical books pdf Saturday February The Essential Physics of Medical Imaging Jerrold T Bushberg Medical Book The Essential Physics of Medical Buy The Essential Physics of Medical Imaging by Jerrold T Bushberg The text is enhanced by numerous full color charts Bushberg The Essential Physics for Medical Jerrold T Bushberg J Anthony revised second edition will make this book a favorite of the medical imaging The book is ideal for medical imaging The Essential Physics of Medical Imaging Jerrold T Bushberg Limited preview 2002 The Essential Physics of Medical Imaging Grab the Inkling version of The Essential Physics of Medical Imaging of Medical Imaging 3rd edition by Jerrold T Bushberg than the price of the full book Author : Jerrold T. BushbergPages : 1048 pagesPublisher : Lippincott Williams and Wilkins 2011-11-01Language : EnglishThis renowned work is derived from the authors acclaimed national review course ("Physics of Medical Imaging") at the University of California-Davis for radiology residents. The text is a guide to the fundamental principles of medical imaging physics, radiation protection and radiation biology, with complex topics presented in the clear and concise manner and style for which these authors are known. Coverage includes the production, characteristics and interactions of ionizing radiation used in medical imaging and the imaging modalities in which they are used, including radiography, mammography, fluoroscopy, computed tomography and nuclear medicine. Special attention is paid to optimizing patient dose in each of these modalities. Sections of the book address topics common to all forms of diagnostic imaging, including image quality and medical informatics as well as the non-ionizing medical imaging modalities of MRI and ultrasound. The basic science important to nuclear imaging, Ying Chen, Joseph Y. Lo, Nicole T. Ranger, Ehsan Samei, James T. Dobbins III Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65101I (16 March 2007); doi: 10.1117/12.713737 As a new three-dimensional imaging technique, digital breast tomosynthesis allows the reconstruction of an arbitrary set of planes in the breast from a limited-angle series of projection images. Though several tomosynthesis algorithms have been proposed, no complete optimization and comparison of different tomosynthesis acquisition techniques for available methods has been conducted as of yet. This paper represents a methodology of noise-equivalent quanta NEQ (f) analysis to optimize and compare the efficacy of tomosynthesis algorithms and imaging acquisition techniques for digital breast tomosynthesis. It combines the modulation transfer function (MTF) of system signal performance and the noise power spectrum (NPS) of noise characteristics. It enables one to evaluate the performance of different acquisition parameters and algorithms for comparison and optimization purposes. An example of this methodology was evaluated on a selenium-based direct-conversion flat-panel Siemens Mammomat Novation prototype system. An edge method was used to measure the presampled MTF of the detector. The MTF associated with the reconstruction algorithm and specific acquisition technique was investigated by calculating the Fourier Transform of simulated impulse responses. Flat field tomosynthesis projection sequences were acquired and then reconstructed. A mean-subtracted NPS on the reconstructed plane was studied to remove fixed pattern noise. An example of the application of this methodology was illustrated in this paper using a point-by-point Back Projection correction (BP) reconstruction algorithm and an acquisition technique of 25 projections with 25 degrees total angular tube movement. Improved in-plane visibility of tumors using breast tomosynthesis Mark Ruschin, Pontus Timberg, Tony Svahn, Ingvar Andersson, Bengt Hemdal, Sören Mattsson, Magnus Båth, Anders Tingberg Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65101J (13 March 2007); doi: 10.1117/12.707935 The purpose of this work was to evaluate and compare the visibility of tumors in digital mammography (DM) and breast tomosynthesis (BT) images. Images of the same women were acquired on both a DM system (Mammomat Novation, Siemens) and a BT prototype system adapted from the same type of DM system. Simulated 3D tumors (average dimension: 8.4 mm x 6.6 mm x 5 mm) were projected and added to each DM image as well as each BT projection image prior to 3D reconstruction. The same beam quality and approximately the same total absorbed dose were used for each breast image acquisition on both systems. Two simulated tumors were added to each of thirty breast scans, yielding sixty cases. A series of 4-alternative forced choice (4-AFC) human observer performance experiments were conducted in order to determine what projected tumor signal intensity in the DM images would be needed to achieve the same detectability as in the reconstructed BT images. Nine observers participated. For the BT experiment, when the tumor signal intensity on the central projection was 0.010 the mean percent of correct responses (PC) was measured to be 81.5%, which converted to a detectability index value (d') of 1.96. For the DM experiments, the same detectability was achieved at a signal intensity determined to be 0.038. Equivalent tumor detection in BT images were thus achieved at around four times less projected signal intensity than in DM images, indicating that the use of BT may lead to earlier detection of breast cancer. Amarpreet S. Chawla, Ehsan Samei, Craig Abbey Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65101K (28 March 2007); doi: 10.1117/12.713651 In this study, we used a mathematical observer model to combine information obtained from multiple angular projections of the same breast to determine the overall detection performance of a multi-projection breast imaging system in detectability of a simulated mass. 82 subjects participated in the study and 25 angular projections of each breast were acquired. Projections from a simulated 3 mm 3-D lesion were added to the projection images. The lesion was assumed to be embedded in the compressed breast at a distance of 3 cm from the detector. Hotelling observer with Laguerre-Gauss channels (LG CHO) was applied to each image. Detectability was analyzed in terms of ROC curves and the area under ROC curves (AUC). The critical question studied is how to best integrate the individual decision variables across multiple (correlated) views. Towards that end, three different methods were investigated. Specifically, 1) ROCs from different projections were simply averaged; 2) the test statistics from different projections were averaged; and 3) a Bayesian decision fusion rule was used. Finally, AUC of the combined ROC was used as a parameter to optimize the acquisition parameters to maximize the performance of the system. It was found that the Bayesian decision fusion technique performs better than the other two techniques and likely offers the best approximation of the diagnostic process. Furthermore, if the total dose level is held constant at 1/25th of dual-view mammographic screening dose, the highest detectability performance is observed when considering only two projections spread along an angular span of 11.4°. Effect of acquisition parameters on image quality in digital tomosynthesis Timothy Deller, Kadri N. Jabri, John M. Sabol, Xianfeng Ni, Gopal Avinash, Rowland Saunders, Renuka Uppaluri Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65101L (17 March 2007); doi: 10.1117/12.713777 Digital tomosynthesis (DTS) is emerging as an advanced imaging technique that enables volumetric slice imaging with a detector typically used for projection radiography. An understanding of the interactions between DTS acquisition parameters and characteristics of the reconstructed slice images is required for optimizing the acquisition protocols of various clinical applications. This paper presents our investigation of the effects and interactions of acquisition parameters, including sweep angle, number of projections, and dose, on clinically relevant image-quality metrics. Metrics included the image characteristics of in-slice resolution, depth resolution, image noise level, and presence of ripple. Phantom experiments were performed to characterize the relationship between the acquisition parameters and image quality. Results showed that the depth resolution was mainly dependent on sweep angle. Visibility of ripple was determined by the projection density (number of projections divided by sweep angle), as well as properties of the imaged object. Image noise was primarily dependent on total dose and not significantly affected by the number of projections. These experimental and theoretical results were confirmed using anthropomorphic phantoms and also used to develop clinical acquisition protocols. Assessment of phantom and clinical images obtained with these protocols revealed that the use of acquisition protocols optimized for a given clinical exam enables rapid, low-dose, high quality DTS imaging for diverse clinical applications including abdomen, hand, shoulder, spine, and chest. We conclude that DTS acquisition parameters have a significant effect on image quality and should be tailored for the imaged anatomy and desired clinical application. Relationships developed in this work will guide the selection of acquisition protocols to improve image quality and clinical utility of DTS for a wide variety of clinical exams. Wei Zhao, Bo Zhao, Paul R. Fisher, Patrick Warmoes, Thomas Mertelmeier, Jasmina Orman Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65101M (17 March 2007); doi: 10.1117/12.713718 In breast tomosynthesis there are tradeoffs between resolution, noise and acquisition speed for a given glandular dose. The purpose of the present work is to investigate the dependence of tomosynthesis imaging performance on system configuration, which includes detector operational modes and image acquisition geometry. A prototype Siemens breast tomosynthesis system with maximum angular range of +/- 25 degrees was used in our investigation. The system was equipped with an amorphous selenium (a-Se) full field digital mammography detector with pixel size of 85µm. The detector can be read out with full resolution or 2x1 binning (binning in the tube travel direction), which increases the image readout rate and decreases the degradation effect of electronic noise. The total number of views can be varied from 11 to 49, and filtered back projection (FBP) method was used to reconstruct the tomosynthesis images. We investigated the effects of detector operational modes (binning) and imaging geometry (view angle and number) on temporal performance and spatial resolution of the projection images. The focal spot blur due to continuous tube travel was measured for different acquisition geometry, and its effect on in-plane presampling modulation transfer function (MTF) was compared to that due to pixel binning. A three-dimensional cascaded linear system model was developed for tomosynthesis to predict the 3D MTF, NPS and DQE. The results were compared with experimental measurements, and reasonable agreement was achieved. The understanding of the relationship between the 3D and projection image quality will lead to optimization of the x-ray spectrum, imaging geometry and reconstruction filters for digital breast tomosynthesis. Brian E. Nett, Joseph Zambelli, Cyril Riddell, Barry Belanger, Guang-Hong Chen Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65101N (17 March 2007); doi: 10.1117/12.713789 There exists a strong desire for a platform in which researchers may investigate planar tomosynthesis (i.e. all source positions reside in a single plane that is parallel to the reconstructed image planes) trajectories directly on an interventional C-arm system. In this work we describe an experimental system designed to accomplish this aim, as well as the potential of this system for testing multiple aspects of the tomosynthetic image acquisition process. The system enables one to evaluate the effect of the physical imaging parameters on the image quality, as well as the effect of the reconstruction algorithm utilized. The experimental data collection for this work is from the Innova 4100 (Flat-panel based interventional C-arm system manufactured by GE Healthcare). The system is calibrated using a phantom with known geometrical placement of multiple small metallic spheres. Initial performance was assessed with three physical phantoms and performance was assessed by varying: the reconstruction algorithm (backprojection, filtered backprojection), the half tomographic angle (15°, 25°, 35°), and the angular sampling (20,40,80 views / acquisition). Initial results demonstrate the ability to well differentiate simulated vessels separated by 1 cm, even with the modest half tomographic angle of 15° and modest sampling of 20 views/acquisition. M. Grasruck, R. Gupta M.D., B. Reichardt, E. Klotz, B. Schmidt, T. Flohr Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65101O (17 March 2007); doi: 10.1117/12.708123 We developed a Flat-panel detector based Volume CT (VCT) prototype scanner with large z-coverage. In that prototype scanner a Varian 4030CB a-Si flat-panel detector was mounted in a multi slice CT-gantry (Siemens Medical Solutions) which provides a 25 cm field of view with 18 cm z-coverage at isocenter. The large volume covered in one rotation can be used for visualization of complete organs of small animals, e.g. rabbits. By implementing a mode with continuous scanning, we are able to reconstruct the complete volume at any point in time during the propagation of a contrast bolus. Multiple volumetric reconstructions over time elucidate the first pass dynamics of a bolus of contrast resulting in 4-D angiography and potentially allowing whole organ perfusion analysis. We studied to which extent pixel based permeability and blood volume calculation with a modified Patlak approach was possible. Experimental validation was performed by imaging evolution of contrast bolus in New Zealand rabbits. Despite the short circulation time of a rabbit, the temporal resolution was sufficient to visually resolve various phases of the first pass of the contrast bolus. Perfusion imaging required substantial spatial smoothing but allowed a qualitative discrimination of different types of parenchyma in brain and liver. If a true quantitative analysis is possible, requires further studies. Kai Yang, Alexander L. C. Kwan, John M. Boone Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65101P (15 March 2007); doi: 10.1117/12.713286 Spatial resolution is one of the most crucial parameters for an imaging system. The modulation transfer function (MTF) was physically measured using wire images on a prototype breast CT scanner previously1. In this study, the effects on MTF from different components in the imaging chain, including the x-ray focal spot distribution, detector lag, and x-ray detector MTF were physically measured. The contributions of these three factors and gantry motion affecting CT system resolution were studied using computer simulation. The CT system MTF was computed and the role of each factor was studied and analyzed. The simulated MTF results demonstrated that the x-ray focal spot size and detector lag have a more significant effect on the system resolution, while the gantry rotation speed has an effect on the azimuthal MTF. The radial MTF has a cutoff frequency of 2.0 cycles/mm at the isocenter and 1.0 cycles/mm at the periphery. The radial MTF has a cutoff frequency of 2.0 cycles/mm, at both the isocenter and periphery. The comparison between the computer simulated and physically measured MTF values demonstrates reasonable accuracy in the simulation process. The results from computer simulation also suggest ways in which the spatial resolution can be improved by system modification. Joseph Zambelli, Brian E. Nett, Shuai Leng, Cyril Riddell, Barry Belanger, Guang-Hong Chen Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65101Q (13 March 2007); doi: 10.1117/12.713813 The first results from an interventional C-arm based computed tomography system where a complete source trajectory was used are presented. A scan with two arcs which are joined approximately at the center of their paths (CC trajectory) is utilized here. This trajectory satisfies Tuy's sufficiency condition for a large volume, but is not well populated with PI-lines. Therefore, a non-PI-line based reconstruction method is required. The desire for high dose efficiency led to the selection of an equal weighting based method. An FBP type reconstruction algorithm which was derived for two orthogonal concentric circles was utilized for reconstruction. The concept of a virtual image object was used to relate the projections from the two acquired non-orthogonal arcs to projections of a virtual object from two orthogonal arcs. Geometrical calibration is vital when performing tomography from an interventional system, and was achieved through the use of a homogeneous virtual projection matrix. The results demonstrate a significant reduction in cone-beam artifacts when the complete source trajectory is utilized. Microcomputed tomography with a photon-counting x-ray detector E. C. Frey, K. Taguchi, M. Kapusta, J. Xu, T. Orskaug, I. Ninive, D. Wagenaar, B. Patt, B. M. W. Tsui Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65101R (15 March 2007); doi: 10.1117/12.711647 In this work we used a new CdTe photon counting x-ray detector capable of very high count rates to perform x-ray micro-computed tomography (microCT). The detector had 2 rows of 384 square pixels each 1 mm in size. Charge signals from individual photons were integrated with a shaping time of ~60 ns and processed by an ASIC located in close proximity to the pixels. The ASIC had 5 energy thresholds with associated independent counters for each pixel. Due to the thresholding, it is possible to eliminate dark-current contributions to image noise. By subtracting counter outputs from adjacent thresholds, it is possible to obtain the number of x-ray photon counts in 5 adjacent energy windows. The detector is capable of readout times faster than 5 ms. A prototype bench-top specimen µCT scanner was assembled having distances from the tube to the object and detector of 11 cm and 82 cm, respectively. We used a conventional x-ray source to produce 80 kVp x-ray beams with tube currents up to 400 µA resulting in count rates on the order of 600 kcps per pixel at the detector. Both phantoms and a dead mouse were imaged using acquisition times of 1.8 s per view at 1° steps around the object. The count rate loss (CRL) characteristics of the detector were measured by varying the tube current and corrected for using a paralyzable model. Images were reconstructed using analytical fan-beam reconstruction. The reconstructed images showed good contrast and noise characteristics and those obtained from different energy windows demonstrated energy-dependent contrast, thus potentially allowing for material decomposition. Evaluation of noise power spectra of CT images Kathrine G. Metheany, Alexander L. C. Kwan, John M. Boone Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65101S (21 March 2007); doi: 10.1117/12.708308 Using a commercial clinical CT scanner (GE lightspeed), nine CT scans were performed on a 20 cm diameter plastic pipe filled with water. The mAs was varied from 10 to 400mAs and the beam energy was varied from 80 to140kVp. For each scan three volume data sets were reconstructed using different filters. Noise power spectrum (NPS) curves were evaluated to examine the effect of varying kVp, mAs and reconstruction filter on the noise content. Sixteen slices from each of the reconstructed volumes were used to compute the NPS; the central 192x192 pixels of each slice were split into four overlapping regions of interest (ROI) of 128x128 pixels. A total of 64 ROI were used per scan. The magnitude squared of the 2D Fourier transform of each ROI was computed. The mean of the 64 2D results was averaged over radial frequency, yielding a 1D NPS. The overall shape of the NPS was dependent on the reconstruction filter used. The magnitude of the curves decreased with the increase of mAs or kVp. kVp, mAs, and the reconstruction filter can be adjusted to modulate the amount of noise present in resulting CT volumes, but the effect these values have on the patient must be considered. The relationship between NPS and Noise Equivalent Quanta (NEQ) makes trends in NPS important and is the motivation for this evaluation and future research. Evaluation of scatter effects on image quality for breast tomosynthesis Gang Wu, James G. Mainprize, John M. Boone, Martin J. Yaffe Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65101T (21 March 2007); doi: 10.1117/12.708531 Digital breast tomosynthesis (DBT) uses a limited number of low-dose x-ray projections to produce a three-dimensional (3D) tomographic reconstruction of the breast. The purpose of this investigation was to characterize and evaluate the effect of scatter radiation on image quality for breast tomosynthesis. Generated by a Monte Carlo simulation method, scatter point spread functions (PSF) were convolved over the field of view (FOV) to estimate the distribution of scatter for each angle of tomosynthesis projection. The results demonstrated that in the absence of scatter reduction techniques, the scatter-to-primary ratio (SPR) levels for the average breast are quite high (~0.4 at the centre of mass), and increased with increased breast thickness and with larger FOV. Associated with such levels of x-ray scatter are cupping artifacts, as well as reduced accuracy in reconstruction values. The effect of x-ray scatter on the contrast, noise, and signal-difference-to-noise ratio (SDNR) in tomosynthesis reconstruction was measured as a function of tumor size. For example, the contrast in the reconstructed central slice of a tumor-like mass (14 mm in diameter) was degraded by 30% while the inaccuracy of the voxel value was 28%, and the reduction of SDNR was 60%. We have quantified the degree to which scatter degrades the image quality over a wide range of parameters, including x-ray beam energy, breast thickness, breast diameter, and breast composition. However, even without a scatter rejection device, the contrast and SDNR in the reconstructed tomosynthesis slice is higher than that of conventional mammographic projection images acquired with a grid at an equivalent total exposure. Improved scatter correction for x-ray conebeam CT using primary modulation Lei Zhu, Josh StarLack, N. Robert Bennett, Tianfang Li, Lei Xing, Rebecca Fahrig Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65101U (21 March 2007); doi: 10.1117/12.713678 Recently, we have proposed a scatter correction method for x-ray imaging using primary modulation. A primary modulator with spatially variant attenuating materials is inserted between the x-ray source and the object to make the scatter and part of the primary distributions strongly separate in the Fourier domain. Linear filtering and demodulation techniques suffice to extract and correct the scatter for this modified system. The method has been verified by computer simulations and preliminary experimental results on a simple object. In this work, we improve the previous algorithm by including the effect of non-ideal modulation frequency and refining the algorithm. The improved method is evaluated experimentally using a pelvis phantom. The imaging parameters are chosen to match the Varian Acuity CT simulator, where scatter correction has been shown to be challenging due to complicated artifact patterns. The results using our approach are compared with those without scatter correction, and with scatter estimated and corrected using a slit measurement as a pre-scan. The comparison shows that the primary modulation method greatly reduces the scatter artifacts and improves image contrast. Using only one single scan, this method achieves CT HU accuracy comparable to that obtained using a slit measurement as a pre-scan. Dimitrios Lazos, Giovanni Lasio, Joshua D. Evans, Jeffrey F. Williamson Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65101V (13 March 2007); doi: 10.1117/12.713610 The large contribution of scatter to cone-beam computed tomography (CBCT) x-ray projections significantly degrades image quality, both through streaking and cupping artifacts and loss of low contrast boundary detectability. The goal of this investigation is to compare the efficacy of three widely used scatter mitigation methods: subtractive scatter correction (SSC); anti-scatter grids (ASG); and beam modulating with bowtie filters; for improving signal-to-noise ratio (SNR), contrast, contrast-to-noise ratio (CNR) and cupping artifacts. A simple analytic model was developed to predict scatter-to-primary ratio (SPR) and CNR as a function of cylindrical phantom thickness. In addition, CBCT x-ray projections of a CatPhan QA phantom were measured, using a Varian CBCT imaging system, and computed, using an inhouse Monte Carlo photon-transport code to more realistically evaluate the impact of scatter mitigation techniques. Images formed with uncorrected sinograms acquired without ASG and bow-tie filter show pronounced cupping artifacts and loss of contrast. Subtraction of measured scatter profiles restore image uniformity and CT number accuracy, but does not improve CNR, since the improvement in contrast almost exactly offset by the increase in relative x-ray noise. ASG were found to modestly improve CNR (up to 20%, depending ASG primary transmission and selectivity) only in body scans, while they can reduce CNR for head phantoms where SPR is low. Shuai Leng, Brian Nett, Michael Speidel, Guang-Hong Chen Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65101W (21 March 2007); doi: 10.1117/12.713787 Motion contamination in computed tomography projection data causes significant artifacts in the reconstructed images. If during the tomographic acquisition the object is relatively stationary during a portion of the acquisition, and then moves significantly, the projection data after the motion will be inconsistent with the projection data during the period of relative stationarity. The fan-beam data consistency condition (FDCC) provides a means to directly estimate motion contaminated projection data based on all of the projection data acquired. Thus, the FDCC may be used to compensate many types of motion contamination in computed tomography. This approach to motion artifact correction is novel as none of the previous methods for artifact correction utilized a direct estimation of motion contaminated data. Additionally, this methodology depends only a small amount of a priori information and is not based on a model. Another distinguishing feature of this method is that it operates directly in the projection space, and is completely independent of the reconstruction algorithm utilized. An example of clinical relevance of coronary motion artifact reduction is presented using both simulated projection data as well as projection data acquired with a porcine model using a state-of-the-art 64 row volumetric CT scanner. Significant reduction in motion related artifacts is achieved both in the simulation case and the porcine model. Resolution and noise trade-off analysis for volumetric CT Baojun Li, Savitha Nandyala, Gopal Avinash, Jiang Hsieh Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65101X (13 March 2007); doi: 10.1117/12.708087 In this study, we investigate the relationship between quantum noise and spatial resolution for volumetric CT. Both theoretical analysis and experiments were performed to investigate their relationship. In theory, quantum noise was derived as a function of spatial resolution. In experiments, by scanning a Teflon sphere phantom, the 3-D MTF was measured from the edge profile along the spherical surface. Cases of different resolutions (and noise levels) were generated by adjusting recon kernel. To reduce bias, the total photon fluxes were matched: 120kVp, 260mA, and 1sec per gantry rotation. In the end, all data sets were reconstructed using modified FDK algorithm under the same condition: FOV=10cm and slice thickness=0.625mm. Finally, we investigated the efficiency of an image-space adaptive smoothing filter as a noise reduction tool and its impact on spatial resolution. The theoretical analysis indicated that the variance of noise is proportional to at least 4th power of the spatial resolution. Our experimental results supported this conclusion by showing the relationship is 4.6th (helical) or 5th (axial) power. Results also showed that, with properly designed image-space smoothing filters, it is feasible to reduce quantum noise (and the power relationship to a lower order) with smaller loss of spatial resolution. Sinogram restoration of dual focal spot CT data Peter Forthmann, Thomas Köhler, Philipp Begemann, Michel Defrise Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65101Y (13 March 2007); doi: 10.1117/12.705374 The raw data generated by a computed tomography (CT) machine are not readily usable for reconstruction. This is the result of various system non-idealities, and although the deterministic nature of corruption effects like crosstalk and afterglow permits removal through deconvolution, there is the drawback that deconvolution increases noise. Methods that perform raw data correction combined with noise suppression are commonly termed sinogram restoration methods. The need for sinogram restoration arises, for example, when photon counts are low and non-statistical reconstruction algorithms like filtered backprojection are used. Many modern CT machines offer a so-called dual focal spot (DFS) mode, which serves the goal of increased radial sampling by switching the focal spot between two positions on the anode plate during the scan. Although the focal spot mode does not play a role with respect to how the data are affected by the above mentioned corruption effects, it needs to be taken into account, if regularized sinogram restoration is to be applied to the data. This work points out the subtle difference in processing that sinogram restoration for DFS requires, how it is correctly employed within the penalized maximum likelihood sinogram restoration algorithm, and what impact that has on image quality. Jingyan Xu, Eric C. Frey, Katsuyuki Taguchi, Benjamin M. W. Tsui Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65101Z (16 March 2007); doi: 10.1117/12.713727 Emerging photon-counting detectors with energy discrimination ability for x-ray CT perform binning according to the energy of the incoming photons. Multiple output channels with different energy thresholds can be obtained in one irradiation. The energy dependency of attenuation coefficients can be described by a linear combination of basis functions, e.g., Compton scatter and photo-electric effect; their individual contributions can be differentiated by using the multiple energy channels hence material characterization is made possible. Conventional analytic approach is a two-step process. First decompose in the projection domain to obtain the sinograms corresponding to the coefficients of the basis functions, then apply FBP to obtain the individual material components. This two-step process may have poor quality and quantitative accuracy due to the lower counts in the separate energy channels and approximation errors propagated to the image domain from projection domain decomposition. In this work we modeled the energy dependency of linear attenuation coefficients in our problem formulation and applied the optimality transfer principle to derive a Poisson-likelihood based algorithm for material decomposition from multiple energy channels. Our algorithm reconstructs the coefficients of the basis functions directly therefore the separate non-linear estimation step in the projection domain as in conventional approaches is avoided. We performed simulations to study the accuracy and noise properties of our method. We synthesized the linear attenuation coefficients at a reference energy and compared with standard attenuation values provided by NIST. We also synthesized the attenuation maps at different effective energy bin centers corresponding to the different energy channels and compared the synthesized images with reconstructions from standard fan-beam FBP methods. Preliminary simulations showed that our reconstructed images have much better noise properties. Julia Velikina, Shuai Leng, Guang-Hong Chen Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651020 (14 March 2007); doi: 10.1117/12.713750 In tomosynthesis, cone-beam projection data are acquired from a few view angles, which are not sufficient for an exact reconstruction of an image object using state-of-the-art image reconstruction algorithms. In the case of parallel-beam projections, the well-known projection-slice theorem may be utilized to transform the parallel-beam projections into the Fourier space of an image object. Due to the limited range of view angles, the available projection data can only populate a portion of Fourier space. Moreover, the angular sampling rate of the populated portion of the Fourier space may not satisfy the Nyquist criterion. Thus, reconstructed images using direct Fourier inversion contain severe streaking and distortion artifacts. In this paper, we present a novel image reconstruction method via minimizing the total variation (TV) of the reconstructed image for limited view angle X-ray computed tomography. Specifically, the missing data points in Fourier space, due to either the limited range or undersampling of view angles, are iteratively filled using the following two constraint conditions: (1) the total variation of the reconstructed image is minimized and (2) reconstructed image maintains fidelity to the sampled data in the Fourier space. Using analytical phantoms, numerical simulations were conducted to validate the new image reconstruction method. Images are compared with two other image reconstruction methods in terms of image artifact level and noise properties. Numerical results demonstrated that the new image reconstruction algorithm is superior to direct Fourier inversion reconstruction algorithm and the projection onto convex sets (POCS) image reconstruction algorithm. Zhye Yin, Bruno De Man, Jed Pack Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651021 (14 March 2007); doi: 10.1117/12.712883 In a 3rd generation CT system, a single source projects the entire field of view (FOV) onto a large detector opposite the source. In multi-source CT imaging, a multitude of sources sequentially project a part of the FOV on a much smaller detector. These sources may be distributed in both the trans-axial and axial directions in order to jointly cover the entire FOV. Scan data from multiple sources in the axial direction provide complementary information, which is not available in a conventional single-source CT system. In this work, an analytical 3D cone-beam reconstruction algorithm for multi-source CT is proposed. This approach has three distinctive features. First, multi-source data are re-binned transaxially to multiple offset third-generation datasets. Second, data points in sinograms from multiple source sets are either accepted or rejected for contribution to the backprojection of a given voxel. Third, instead of using a ramp filter, a Hilbert transform is combined with a parallel derivative to form the filtering mechanism. Phantom simulations are performed using a multi-source CT geometry and compared to conventional 3rd generation CT geometry. We show that multi-source CT can extend the axial scan coverage to 120mm without cone-beam artifacts, while a third-generation geometry results in compromised image quality at 60mm of axial coverage. Moreover, given that the cone-angle in the proposed geometry is limited to 7 degrees, there are no degrading effects such as the Heel effect and scattered radiation, unlike in a third-generation geometry with comparable coverage. An additional benefit is the uniform flux profile resulting in uniform image noise throughout the FOV and a uniform dose absorption profile. Gated cone-beam CT imaging of the thorax: a reconstruction study Simon Rit, David Sarrut, Serge Miguet Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651022 (28 March 2007); doi: 10.1117/12.707623 In radiotherapy, the respiratory motion of the patient in treatment position is determined from gated cone-beam CT images. This method consists in selecting projections according to a respiratory signal for the reconstruction of a CT image of each respiratory state. This selection can be based on the amplitude or the phase of the signal. The number of selected projections also depends on the width of the gating window. The present study compares different reconstructions using a dynamic digital phantom of the thorax and a known respiratory signal. We applied both regular and irregular motions to this phantom and reconstructed the exhale state using different widths. We evaluated these reconstructions with the signal-to-noise ratio, the contrast-to-noise ratio and a blur criterion. In the case of a regular motion, there was no difference between the amplitude and the phase. The signal quality was high, even for the smallest width, and the blur increased with width. In the case of an irregular motion, the difference was noticeable. Amplitude-based reconstructions suffered from severe artifacts with the smallest width because there were respiratory cycles for which no projection was selected. This drawback is overcome by increasing the width of the gating window. Phase-based reconstructions also allowed to avoid artifacts, whatever the width. But the blur was higher, even for the smallest width applied. These results suggest that the gating process must be adjusted in order to select at least one projection per respiratory cycle. Phase gating is a robust way to achieve this goal when respiration is irregular. Amplitude gating may be more effective in terms of blur, but the width must be carefully chosen to avoid severe artifacts. Finally, we observed the potential of dynamic reconstruction by using a motion model to deform different gated CT images toward a common reference and compute the weighted mean. The resulting CT image suffered less from artifacts than each gated CT image separately even if artifacts were still visible. Lei Zhu, Josh StarLack Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651023 (14 March 2007); doi: 10.1117/12.713692 Accurate prediction of reconstructed noise in computed tomography (CT) images is important for purposes of system design, optimization and evaluation. A large body of work describes noise prediction methods for CT, the vast majority of which assume stationarity of both noise and signal processes. Consequently, these methods are usually applied to and evaluated using simple phantoms, and only a portion of the image is scrutinized. In this work, we derive a practical method for reconstructing CT noise variance maps for arbitrary objects. Photon Poisson noise and system electronic noise are considered. The final formula has the same structure as that of the filtered backprojection (FBP) formula, but with different weighting factors and convolution kernels. The algorithm is verified using computer simulations of the Shepp-Logan phantom, and a good match is found between the predicted noise map from one single noisy scan and the measured noise using 128 noisy scans. As compared to other proposed noise models, our complementary work provides a method of noise prediction by simple adaptation of FBP reconstruction algorithms. The result is a tool that can be useful for system optimization and evaluation tasks as well as the design of reconstruction filters. Abhijit J. Chaudhari, Anand A. Joshi, Felix Darvas, Richard M. Leahy Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651024 (13 March 2007); doi: 10.1117/12.710197 Atlases are normalized representations of anatomy that can provide a standard coordinate system for in vivo imaging studies. For Optical Bioluminescence Tomography (OBT) in small animals, the animal's surface topography can be reconstructed from structured light measurements, but internal anatomy is unavailable unless additional CT or MR images are acquired. We present a novel method for estimating the internal organ structure of a mouse by warping a labeled 3D volumetric mouse atlas with the constraint that the surfaces of the two should match. Surface-constrained harmonic maps used for this bijective warping are computed by minimizing the covariant harmonic energy. We demonstrate the application of this warping scheme in OBT, where scattering and absorption coefficients of tissue are functions of the internal anatomy and hence, better estimates of the organ structures can lead to a more accurate forward model resulting in improved source localization. We first estimated the subject's internal geometry using the atlas-based warping scheme. Then the mouse was tessellated and optical properties were assigned based on the estimated organ structure. Bioluminescent sources were simulated, an optical forward model was computed using a finite-element solver, and multispectral data were simulated. We evaluate the accuracy of the forward model computed using the warped atlas against that assuming a homogeneous mouse model. This is done by comparing each model against a 'true' optical forward model where the anatomy of the mouse is assumed known. We also evaluate the impact of anatomical alignment on bioluminescence source localization. Yujie Lv, Jie Tian, Wenxiang Cong, Ge Wang, Wei Yang, Min Xu Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651025 (13 March 2007); doi: 10.1117/12.709018 In this contribution, a novel adaptive finite element based source localization method is proposed and developed, which adopts the spectrum characteristic of bioluminescent source. In this method, multiple sets of surface measured data corresponding to the discretized spectral bands reduce the ill-posedness of BLT. Then, the adaptive mesh refinement using a posteriori error estimation helps not only to avoid the dimension disaster arisen from the multi-spectral measured data, but also to improve the BLT reconstruction. In addition, a posteriori permissible source region selection further reduces the ill-posedness of BLT and enhances the reconstruction stability and speed. Finally, the simulation verification of the proposed method is performed with the Monte Carlo (MC) based synthetic data. The accurate localization of one and two bioluminescent sources in different depths shows the effectiveness and potential of this algorithm for BLT. Eberhard Hansis, Dirk Schäfer, Michael Grass, Olaf Dössel Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651026 (13 March 2007); doi: 10.1117/12.709319 Three-dimensional (3D) reconstruction of the coronary arteries offers great advantages in the diagnosis and treatment of cardiovascular diseases, compared to two-dimensional X-ray angiograms. Besides improved roadmapping, quantitative analysis of vessel lesions is possible. To perform 3D reconstruction, rotational projection data of the selectively contrast agent enhanced coronary arteries are acquired with simultaneous ECG recording. For the reconstruction of one cardiac phase, the corresponding projections are selected from the rotational sequence by nearest-neighbor ECG gating. This typically provides only 5-10 projections per cardiac phase. The severe angular undersampling leads to an ill-posed reconstruction problem. In this contribution, an iterative reconstruction method is presented which employs regularizations especially suited for the given reconstruction problem. The coronary arteries cover only a small fraction of the reconstruction volume. Therefore, we formulate the reconstruction problem as a minimization of the L1-norm of the reconstructed image, which results in a spatially sparse object. Two additional regularization terms are introduced: a 3D vesselness prior, which is reconstructed from vesselness-filtered projection data, and a Gibbs smoothing prior. The regularizations favor the reconstruction of the desired object, while taking care not to over-constrain the reconstruction by too detailed a-priori assumptions. Simulated projection data of a coronary artery software phantom are used to evaluate the performance of the method. Human data of clinical cases are presented to show the method's potential for clinical application. Brian E. Nett, Shuai Leng, Guang-Hong Chen Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651028 (14 March 2007); doi: 10.1117/12.713803 A framework for image reconstruction from planar tomosynthesis trajectories (i.e. all source positions reside in a single plane) is presented. The parallel beam geometry is a convenient starting point in deriving reconstruction algorithms, both analytic and iterative, as the relation between frequency space and image space is well known. We present a method for utilizing parallel beam reconstruction algorithms in an internally consistent manner. The concept of a virtual image object is utilized. This virtual image object has the property that cone-beam projections through the real object are directly related to parallel-beam projections of the virtual object. The virtual object may then be reconstructed using any algorithm derived for parallel beam projections. Finally, an affine transform may be applied to the virtual image object in order to generate the reconstruction result. In the implementation described here the backprojection operation is performed such that the real image object is reconstructed without introducing a rebinning in image space. Image reconstruction comparisons are given for a standard filtered backprojection (FBP) type algorithm where parallel projections were assumed in the algorithm derivation. Numerical simulations were performed for a C-arm type geometry and parallel beam FBP reconstructions using the virtual object are compared with the standard backprojection algorithm. Finally, a comparison was made between the new parallel beam reconstruction and the standard approximation where the cone-beams are assumed to be approximately parallel beams and a cone-beam backprojection is employed. A reduction in streaking artifacts was observed using the new algorithm compared with the standard approximation. Sub-pixel compounding from elasticity imaging data Zhi Yang, Sumedha Sinha, Rebecca C. Booi, Marilyn A. Roubidoux, Bing Ma, J. Brian Fowlkes, Gerald L. LeCarpentier, Paul L. Carson Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651029 (13 March 2007); doi: 10.1117/12.711649 Sub-pixel compounding is a technique that synthesizes the information of an image sequence to form a betterresolved and speckle reduced image. To avoid extra data acquisition time and patient exposure, reuse of the existing data is highly desired. In elasticity imaging, a set of images with slight changes due to deformation is produced, which provides an ideal input for the sub-pixel compounding process. In this paper, a brief review of the resolution enhancement techniques in ultrasound imaging will be provided, and then, a diffusion-regularized, least square approach is presented for sub-pixel compounding image reconstruction. Based on the results, we suggest that (1) B-mode images from elastic imaging are suitable data for sub-pixel compounding and a speckle noise reduced higher-resolution image is a co-product of elasticity imaging; (2) for breast diagnosis, resolution improvement is of strong interest since better depiction of the interior and exterior structures of a tumor provides important detection and diagnostic information; (3) a similar approach could be extended to elasticity imaging with other modalities. Xiang Li, Ehsan Samei, Terry Yoshizumi, James G. Colsher, Robert P. Jones, Donald P. Frush Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102A (28 March 2007); doi: 10.1117/12.713728 In recent years, there has been a desire to reduce CT radiation dose to children because of their susceptibility and prolonged risk for cancer induction. Concerns arise, however, as to the impact of dose reduction on image quality and thus potentially on diagnostic accuracy. To study the dose and image quality relationship, we are developing a simulation code to calculate organ dose in pediatric CT patients. To benchmark this code, a cylindrical phantom was built to represent a pediatric torso, which allows measurements of dose distributions from its center to its periphery. Dose distributions for axial CT scans were measured on a 64-slice multidetector CT (MDCT) scanner (GE Healthcare, Chalfont St. Giles, UK). The same measurements were simulated using a Monte Carlo code (PENELOPE, Universitat de Barcelona) with the applicable CT geometry including bowtie filter. The deviations between simulated and measured dose values were generally within 5%. To our knowledge, this work is one of the first attempts to compare measured radial dose distributions on a cylindrical phantom with Monte Carlo simulated results. It provides a simple and effective method for benchmarking organ dose simulation codes and demonstrates the potential of Monte Carlo simulation for investigating the relationship between dose and image quality for pediatric CT patients. Low dose applications of lightspeed VCT in cardiac imaging Jianying Li, Jiang Hsieh, Ronald Lundgren, Yun Shen Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102B (14 March 2007); doi: 10.1117/12.708384 We introduced and evaluated the techniques LightSpeed VCT uses to reduce X-ray dose and image noise in cardiac helical CT applications. These techniques include the use of much improved VCT data acquisition system (VDAS) with reduced electronic noise; cardiac bowtie that redistributes X-rays to have more signals for heart and much less flux to the peripheries; adaptive post-processing filters to reduce cardiac image noise; and ECG modulated tube currents to concentrate X-ray dose for desired cardiac phases. Phantom and patient scans were used to evaluate the dose saving and noise reduction potentials of these techniques. The results demonstrated that the improved VDAS reduced image noise 15-20% for cardiac imaging. With same scan technique, the use of cardiac bowtie reduced about 10% dose in terms of CTDIw measurement and clinical evaluation demonstrated additional 7% image noise reduction and equivalent image quality with cardiac bowtie vs. regular body bowtie. The adaptive filter generated 15-20% noise reduction while maintaining image resolution and artery sharpness. Finally, the use of ECG modulated mA method provided up to 50% dose reduction based on CTDIw measurements, but the saving potentials depended on the heart rate and cardiac phase selection. For heart rate of 60bpm and ±15% cardiac phase margin, the average dose reduction could be 30%. Since these dose and noise reduction methods are inclusive and can be combined to produce even greater dose/noise reduction. It is reasonable to believe that with VCT we maybe able to acquire cardiac helical CT images with only 30-40% of the dose of older generation 16-slice CT scanners with similar noise level and same slice thickness. E. Angel, C. Wellnitz, M. Goodsitt, J. DeMarco, C. Cagnon, M. Ghatali, D. Cody, D. Stevens, C. McCollough,et. al. Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102C (15 March 2007); doi: 10.1117/12.713820 Pregnant women with shortness of breath are increasingly referred for CT Angiography to rule out Pulmonary Embolism (PE). While this exam is typically focused on the lungs, extending scan boundaries and overscan can add to the irradiated volume and have implications on fetal dose. The purpose of this work was to estimate radiation dose to the fetus when various levels of overscan were encountered. Two voxelized models of pregnant patients derived from actual patient anatomy were created based on image data. The models represent an early (< 7 weeks) and late term pregnancy (36 weeks). A previously validated Monte Carlo model of an MDCT scanner was used that takes into account physical details of the scanner. Simulated helical scans used 120 kVp, 4x5 mm beam collimation, pitch 1, and varying beam-off locations (edge of the irradiated volume) were used to represent different protocols plus overscan. Normalized dose (mGy/100mAs) was calculated for each fetus. For the early term and the late term pregnancy models, fetal dose estimates for a standard thoracic PE exam were estimated to be 0.05 and 0.3 mGy/100mAs, respectively, increasing to 9 mGy/100mAs when the beam-off location was extended to encompass the fetus. When performing PE exams to rule out PE in pregnant patients, the beam-off location may have a large effect on fetal dose, especially for late term pregnancies. Careful consideration of ending location of the x-ray beam - and not the end of image data - could result in significant reduction in radiation dose to the fetus. Methodology for determining dose reduction for chest tomosynthesis Christina M. Li, James T. Dobbins III Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102D (28 March 2007); doi: 10.1117/12.713554 Digital tomosynthesis is an imaging technique that reconstructs tomographic planes in an object from a set of projection images taken over a fixed angle1. Preliminary results show that this technique increases the detectability of lung nodules2. Current settings acquire images with approximately the same exposure as a screen-film lateral. However, due to the increased detectability of lung nodules from the removal of overlying structures, patient dose may be reduced while still maintaining increased sensitivity and specificity over conventional chest radiographs. This study describes a simulation method that provides realistic reduced dose images by adding noise to digital chest tomosynthesis images in order to simulate lower exposure settings for the purpose of dose optimization. Tomosynthesis projections of human subjects were taken at dose levels which were specified based on either patient thickness or a photo-timed digital chest radiograph acquired prior to tomosynthesis acquisition. For the purposes of this study, subtle nodules of varying size were simulated in the image for demonstration purposes before the noise simulation in order to have a known truth for nodule location and to evaluate the effect of additive noise on tumor detection. Noise was subsequently added in order to simulate 3/4, 1/2, and 1/4 of the original exposure in each projection. The projections were then processed with the MITS algorithm to produce slice images. This method will be applied to a study of dose reduction in the future using human subject cases. J. Rinkel, L. Gerfault, F. Estève, J.-M. Dinten Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102E (14 March 2007); doi: 10.1117/12.706486 Cone-Beam Computed Tomography (CBCT) enables three-dimensional imaging with isotropic resolution. X-ray scatter estimation is a big challenge for quantitative CBCT imaging: even in the presence of anti-scatter grid, the scatter level is significantly higher on cone beam systems compared to collimated fan beam systems. The effects of this scattered radiation include cupping artifacts, streaks, and quantification inaccuracies. In this paper, a scatter management process for tomographic projections, without supplementary on-line acquisition, is presented. The scattered radiation is corrected using a method based on scatter calibration through off-line acquisitions. This is combined with on-line analytical transformation based on physical equations, to perform an estimation adapted to the object observed. This approach has been previously applied to a system without anti-scatter grid. The focus of this paper is to show how to combine this approach with an anti-scatter grid. First, the interest of the grid is evaluated in terms of noise to signal ratio and scatter rejection. Then, the method of scatter correction is evaluated by testing it on an anthropomorphic phantom of thorax. The reconstructed volume of the phantom is compared to that obtained with a strongly collimated conventional multi-slice CT scanner. The new method provides results that closely agree with the conventional CT scanner, eliminating cupping artifacts and significantly improving quantification. Alan H. Baydush, Mahta Mirzaei McKee, June King, Devon J. Godfrey Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102F (13 March 2007); doi: 10.1117/12.713845 We present preliminary investigations that examine the feasibility of incorporating volumetric images generated using digital tomosynthesis into brachytherapy treatment planning. The Integrated Brachytherapy Unit (IBU) at our facility consists of an L-arm, C-arm isocentric motion system with an x-ray tube and fluoroscopic imager attached. Clinically, this unit is used to generate oblique, anterior-posterior, and lateral images for simple treatment planning and dose prescriptions. Oncologists would strongly prefer to have volumetric data to better determine three dimensional dose distributions (dose-volume histograms) to the target area and organs at risk. Moving the patient back and forth to CT causes undo stress on the patient, allows extensive motion of organs and treatment applicators, and adds additional time to patient treatment. We propose to use the IBU imaging system with digital tomosynthesis to generate volumetric patient data, which can be used for improving treatment planning and overall reducing treatment time. Initial image data sets will be acquired over a limited arc of a human-like phantom composed of real bones and tissue equivalent material. A brachytherapy applicator will be incorporated into one of the phantoms for visualization purposes. Digital tomosynthesis will be used to generate a volumetric image of this phantom setup. This volumetric image set will be visually inspected to determine the feasibility of future incorporation of these types of images into brachytherapy treatment planning. We conclude that initial images using the tomosynthesis reconstruction technique show much promise and bode well for future work. CatSim: a new computer assisted tomography simulation environment Bruno De Man, Samit Basu, Naveen Chandra, Bruce Dunham, Peter Edic, Maria Iatrou, Scott McOlash, Paavana Sainath, Charlie Shaughnessy,et. al. Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102G (21 March 2007); doi: 10.1117/12.710713 We present a new simulation environment for X-ray computed tomography, called CatSim. CatSim provides a research platform for GE researchers and collaborators to explore new reconstruction algorithms, CT architectures, and X-ray source or detector technologies. The main requirements for this simulator are accurate physics modeling, low computation times, and geometrical flexibility. CatSim allows simulating complex analytic phantoms, such as the FORBILD phantoms, including boxes, ellipsoids, elliptical cylinders, cones, and cut planes. CatSim incorporates polychromaticity, realistic quantum and electronic noise models, finite focal spot size and shape, finite detector cell size, detector cross-talk, detector lag or afterglow, bowtie filtration, finite detector efficiency, non-linear partial volume, scatter (variance-reduced Monte Carlo), and absorbed dose. We present an overview of CatSim along with a number of validation experiments. Sylvie Puong, Xavier Bouchevreau, Fanny Patoureaux, Razvan Iordache, Serge Muller Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102H (21 March 2007); doi: 10.1117/12.710133 In this study, we propose a novel approach to dual-energy contrast-enhanced digital mammography, with the development of a dual-energy recombination algorithm based on an image chain model and the determination of the associated optimal low and high-energy techniques. Our method produces clutter-free iodine-equivalent images and includes thickness correction near the breast border. After the algorithm description, the optimal low and high-energy acquisition techniques are determined to obtain a compromise between image quality and glandular dose. The low and high-energy techniques were chosen to minimize the glandular dose for a target Signal Difference to Noise Ratio (SDNR) in the dual-energy recombined image. The theoretical derivation of the iodine SDNR in the recombined image allowed the prediction of the optimal low and high-energy techniques. Depending on the breast thickness and glandular percentage, the optimal low-energy kVp and mAs ranged from 24kVp (Mo/Mo or Mo/Rh) to 35kVp (Rh/Rh), and from 60 to 90mAs respectively, and the high-energy kVp and mAs ranged from 40kVp to 47kVp (Mo/Cu), and from 80mAs to 290mAs. We proved the better performance of our algorithm compared to the classic weighted logarithmic subtraction method in terms of patient dose and also in terms of texture cancelation, through the use of artificial textured images. Values of iodine contrast measured on phantom were close to the expected iodine thickness. Good correlation was found between the measured and theoretical iodine SDNR in the dual-energy images, which validates our theoretical optimization of the acquisition techniques. Sabina Strocchi, Vittoria Colli, Raffaele Novario, Gianpaolo Carrafiello, Andrea Giorgianni, Aldo Macchi, Carlo Fugazzola, Leopoldo Conte Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102I (16 March 2007); doi: 10.1117/12.708431 Aim of this work is to compare the performances of a Xoran Technologies i-CAT Cone Beam CT for dental applications with those of a standard total body multislice CT (Toshiba Aquilion 64 multislice) used for dental examinations. Image quality and doses to patients have been compared for the three main i-CAT protocols, the Toshiba standard protocol and a Toshiba modified protocol. Images of two phantoms have been acquired: a standard CT quality control phantom and an Alderson Rando® anthropomorphic phantom. Image noise, Signal to Noise Ratio (SNR), Contrast to Noise Ratio (CNR) and geometric accuracy have been considered. Clinical image quality was assessed. Effective dose and doses to main head and neck organs were evaluated by means of thermo-luminescent dosimeters (TLD-100) placed in the anthropomorphic phantom. A Quality Index (QI), defined as the ratio of squared CNR to effective dose, has been evaluated. The evaluated effective doses range from 0.06 mSv (i-CAT 10 s protocol) to 2.37 mSv (Toshiba standard protocol). The Toshiba modified protocol (halved tube current, higher pitch value) imparts lower effective dose (0.99 mSv). The conventional CT device provides lower image noise and better SNR, but clinical effectiveness similar to that of dedicated dental CT (comparable CNR and clinical judgment). Consequently, QI values are much higher for this second CT scanner. No geometric distortion has been observed with both devices. As a conclusion, dental volumetric CT supplies adequate image quality to clinical purposes, at doses that are really lower than those imparted by a conventional CT device. Semi-empirical scattering correction model for MSCT O. Amir, L. Sabo-Napadensky Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102J (14 March 2007); doi: 10.1117/12.708860 Scattering in CT is a major process that may result in severe image artifacts. In order to suppress this scattering, most CT scanners are equipped with post collimation anti-scatter grid along the fan beam direction. In the longitudinal direction (z-direction) no hardware solution has been implemented since the scattering is negligible in narrow coverage CT scanners. As the coverage becomes wider in recent MSCT scanners the scattering in the z-direction increases significantly. This scattering increase in z-direction, results in image artifacts appearing as dark shadows along highly attenuating directions. In the present work we measure the scattering level in the z-direction for a wide coverage scanner, using various phantoms. Based on the results, a semi-empirical model for scattering correction in MSCT is presented and validated. The proposed model is based on a subtraction of a low frequency offset. This offset is proportional to the scattering, computed for each projection from the data that has the lowest signal at each rotation angle. To validate the model, we first calculate this low frequency offset directly from the scatter measurements and apply it to the data [illegible]. We then use a semi-empirical function to estimate the scattering fraction from the raw data, and use it to replace the directly measured scatter effects in the correction scheme. Finally applying the proposed semi-empirical correction model to the data acquired with the wide coverage CT scanner, the scattering signal is significantly decreased. The images reconstructed from the corrected data exhibit a clear reduction of the artifact level. Scattering phenomena in MSCT: measurements and analysis I. Sabo-Napadensky, O. Amir Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102K (14 March 2007); doi: 10.1117/12.708871 In multi-slice CT (MSCT), as the coverage becomes wider, the scattering contribution along the longitudinal direction (z) to the detectors' signal increases. The scattering results in image artifacts, appearing as dark shadows between highly attenuating objects. In this work we measure the scattering level systematically, using phantoms of various sizes, shapes, and materials. We study the dependencies and their effect on the scattering amount. Based on the results, we derive an empirical function for the scattering. The function contains a single constant (SC). The variation of SC as a function of the different phantoms is analyzed, showing a clear dependence on the minimal water equivalent axis of each phantom. The strong dependence of the scattering fraction on the maximal attenuation along each ray is shown. This phenomenon can be correlated to a single scatter process along the z axis in the presence of an anti-scatter grid along the direction of the detectors. The dependence of SC on the minimal axis provides an additional significant scatter process. The results validate that the scattering level estimation can be achieved using the derived function, with a minimal variation in the solution parameters. [illegible] Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102L (14 March 2007); doi: 10.1117/12.709386 Anti-scatter grids are well established in the field of X-ray imaging. [illegible] digital imaging systems, i.e. image intensifiers coupled to a CCD camera or solid state flat-panel detector. Combining a digital detector and an anti-scatter grid may lead to Moire artefacts. This results from sampling an analog X-ray image with signal components higher than half the sampling frequency. Especially in high dose DSA images (Digital Subtraction Angiography) these artefacts may be visible to the user. In this paper we present a concept for minimizing these grid artifacts: Signal propagation in the detector is modeled by three steps, scintillator MTF, aperture MTF, and sampling. Since the scintillator MTF is irrelevant for the grid optimization process, we focus on aperture MTF and sampling. From the given geometry of the detector elements the corresponding 2D Fourier transform is calculated. An evaluation for typical grid frequencies, i.e. arcs around the origin of the 2D Fourier transform, results in profiles exhibiting pronounced minima. From the respective angle values for these minima, optimal grid parameters can be derived. [illegible] Simulation results for typical detector pixel geometries and for grid frequencies used in practice are validated by measurement for two different anti-scatter grids on a Siemens angiographic system with a digital flat-panel detector. On the development of a Gaussian noise model for scatter compensation Jessie Q. Xia, Georgia D. Tourassi, Joseph Y. Lo, Carey E. Floyd Jr. Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102M (28 March 2007); doi: 10.1117/12.712515 The underlying mechanism in projection radiography as well as in computed tomography (CT) is the accumulative attenuation of a pencil x-ray beam along a straight line. [illegible] the lines connecting the x-ray source and the individual locations where they are detected. Since these photons do not carry the correct spatial information, the final image is contaminated. Researchers are seeking techniques to reduce scattering, and hence, improve image quality. [illegible] Previously, we presented a post-acquisition scatter compensation technique based on an underlying statistical model. We used the Poisson noise model, which assumed that the signals in the detector individually followed the Poisson process. Since most x-ray detectors are energy integrating rather than photon counting, the Poisson noise model can be improved by taking this property into account. In this study, we developed a Gaussian noise model by the matching-of-the-first-two-moments method. The Maximum Likelihood Estimator of the scatter-free image was derived via the expectation maximization (EM) technique. The maximum a posteriori estimate was also calculated. The Gaussian noise model was preliminarily evaluated on a full-field digital mammography system. Takamasa Ota, Ilmar Hein, Miwa Okumura, Hirofumi Anno, Kazuhiro Katada Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102N (28 March 2007); doi: 10.1117/12.707765 With high-speed multislice helical CT, the time needed to select the optimal cardiac phase occupies a large percentage of the coronary CT angiography examination time because the scan time is short. To reduce the phase selection time, we have developed an automatic phase selection algorithm and implemented it on the Aquilion 64 scanner. This algorithm calculates the absolute sum of the differences between two raw data sets for subsequent cardiac phases and generates a velocity curve representing the magnitude of cardiac motion within the entire heart volume. Normally, the velocity curve has two local minimum slow-motion phases corresponding to end-systole and mid-diastole. [illegible] In this report, the algorithm for generating the velocity curve and the processing time for selecting the optimal cardiac phase are discussed. The accuracy of this method is compared with that of the conventional manual method. [illegible] Automatic phase selection substantially reduces the time needed to select the optimal phase and increases patient throughput. Moreover, the influence of operator skill in selecting the optimal phase is minimized. Naruomi Yasuda, Yoko Ishikawa, Yoshie Kodera Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102O (19 March 2007); doi: 10.1117/12.708523 Multi-detector row computed tomography (MDCT) allows high-edge-response imaging in z-direction thinner slice compared with the conventional single-detector row CT (SDCT). The edge response in x- and y-direction is, however, basically depending on the reconstruction function or the image processing. In this work, a method of enhancing the edge response in x- and y-direction, without special image processing, is proposed. In this method, projection data of a patient is acquired by high-spatial-frequency sampling, and an edge-enhanced image is reconstructed with same matrix size as conventional by averaging the projection data. Edge-enhancement effect in this method employs nonlinearity of the projection data, and special image processing is not required. In order to verify this proposed method, a large water phantom that consists of five resinous rods and a small one that the similitude rate is 1/2, and is topologically the same as the former large phantom, were scanned, [illegible] S. H. Lee, J. H. Kim, K. G. Kim, S. J. Park, Jung Gi Im Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102P (17 March 2007); doi: 10.1117/12.713529 The purpose of this study is to determine a stable sampling rate not to be affected by sampling shift for reducing radiation exposure with time sampling and interpolation in cerebral perfusion CT examination. Original images were obtained every 1 second for 40 time series from 3 patients, respectively. Time sampling was performed with sampling intervals (SI) from 2 to 10 seconds. Sampling shift was applied from +1 to SI-1 for each sampling rate. [illegible] Deconvolution analysis based on SVD was performed for quantifying perfusion parameters. [illegible] The mean CBV values had a similar tendency to the mean CBF values, but it showed a relatively fewer deviation. The mean MTT values were fluctuated reversely to the trend of the mean CBF values. The stable sampling interval for quantifying perfusion parameters was statistically acceptable up to 4 seconds. These results indicate that sampling shift should be considered for accurately acceptable perfusion values. [illegible] S. Glasberg, D. Fejer, H. Arber, Y. Eisenbach, M. Shreiber, A. Altman Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102Q (13 March 2007); doi: 10.1117/12.705186 We have analyzed 144 ECG wave-forms that were taken during cardiac CT exams to determine in retrospect the optimized timing for updating the gantry rotation-time. A score was defined, according to the number of heart beats during Xray on, which fulfill the temporal resolution (tR)condition, tR Shin-Woong Park, Yun Yi, Jung Byung Park Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102R (17 March 2007); doi: 10.1117/12.709315 We describe a novel system named TRVCT (Translating and Rotating Volume Computed Tomography), developed for computed tomography image from large object with simple method and low price. Tomogram images can be acquired when the object is translating and rotating simultaneously with vertical linear array detector. This method is different from the normal X-ray CT completely. We used fan-beam X-ray, and the direction of the detector and rotating axis are parallel. [illegible] There is no ring artifact that is generated frequently in the third generation CT scanner. So, we can have high resolution tomograms with this TRVCT system. [illegible] John H. Londt, [illegible] Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102S (14 March 2007); doi: 10.1117/12.713367 We present the results of dose and image quality performance evaluation of a novel, prospective ECG-gated Coronary CT Angiography acquisition mode (SnapShot Pulse, LightSpeed VCT-XT scanner, GE Healthcare, Waukesha, WI), and compare it to conventional retrospective ECG gated helical acquisition in clinical and phantom studies. Image quality phantoms were used to measure noise, slice sensitivity profile, in-plane resolution, low contrast detectability and dose, using the two acquisition modes. Clinical image quality and diagnostic confidence were evaluated in a study of 31 patients scanned with the two acquisition modes. Radiation dose reduction in clinical practice was evaluated by tracking 120 consecutive patients scanned with the prospectively gated scan mode. In the phantom measurements, the prospectively gated mode resulted in equivalent or better image quality measures at dose reductions of up to 89% compared to non-ECG modulated conventional helical scans. In the clinical study, image quality was rated excellent by expert radiologist reviewing the cases, with pathology being identical using the two acquisition modes. The average dose to patients in the clinical practice study was 5.6 mSv, representing 50% reduction compared to a similar patient population scanned with the conventional helical mode. Characterization of a prototype tabletop x-ray CT breast imaging system J. Michael O'Connor, Stephen J. Glick, Xing Gong, Clay Didier, Mufeed Mah'd Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102T (21 March 2007); doi: 10.1117/12.713751 [illegible] This report describes our system and characterizes the performance of the system through the analysis of Modulation Transfer Function (MTF) and Noise Power Spectrum (NPS). All CT reconstructions were made using Feldkamp's filtered backprojection algorithm. [illegible] Finally, we present CT images of mastectomy excised breast tissue. [illegible] Both the quantitative system characterization and the breast specimen images continue to reinforce the hope that dedicated flat-panel detector, x-ray cone-beam CT will eventually provide enhanced breast cancer detection capability. Iodine contrast cone beam CT imaging of breast cancer Larry Partain, Stavros Prionas, Edward Seppi, Gary Virshup, Gerhard Roos, Robert Sutherland, John Boone Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102U (14 March 2007); doi: 10.1117/12.713637 An Iodine contrast agent, in conjunction with an X-ray cone beam CT imaging system, was used to clearly image three, biopsy verified, cancer lesions in two patients. [illegible] A flat panel detector, with 194 μm pixels in 2 x 2 binning mode, was used to obtain 500 projection images at 30 fps with an 80 kVp X-ray system operating at 112 mAs, for an 8-9 mGy dose - equivalent to two view mammography for these women. The patients were positioned prone, while the gantry rotated in the horizontal plane around the uncompressed, pendant breasts. This gantry rotated 360 degrees during the patient's 16.6 sec breath hold. [illegible] This included the three largest lesions, that were previously biopsied and confirmed to be malignant. [illegible] Stephen J. Glick, Clay Didier Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102V (19 March 2007); doi: 10.1117/12.713817 Previous studies have suggested that iodine contrast-enhanced breast imaging can be helpful in the characterization of suspicious abnormalities. [illegible] In this study, a computer simulation is developed for use in investigating optimal parameters for dual-energy, contrast-enhanced breast tomosynthesis. [illegible] Irregular lesions were simulated by using a stochastic growth algorithm. [illegible] Quantitative flow phantom for contrast-enhanced breast tomosynthesis Melissa L. Hill, [illegible] Martin J. Yaffe Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102W (15 March 2007); doi: 10.1117/12.708549 The use of contrast agents can help to overcome a lack of intrinsic radiographic contrast between malignant and normal breast tissue. [illegible] To develop the technique of contrast-enhanced breast tomosynthesis, a dynamic flow phantom has been constructed to provide the same types of imaging challenges anticipated in the clinical setting. [illegible] C. D. Arvanitis, G. Royle, R. Speller Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102Y (27 March 2007); doi: 10.1117/12.707817 The properties of dual energy contrast enhanced digital mammography have been analyzed by imaging a 4 cm breast equivalent phantom consisting of adipose and glandular equivalent plastics. [illegible] The results suggest that optimization of dual energy contrast enhanced mammography has the potential to lead to the development of perfusion digital mammography. Biao Chen, Andrew P. Smith, Zhenxue Jing, Tao Wu Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65102Z (14 March 2007); doi: 10.1117/12.707948 Clinical studies have correlated a high breast density to a women's risk of breast cancer. [illegible] Preliminary results showed that the neural network mapping is promising in accurately computing glandular density distribution and breast density percentage. A novel cone beam breast CT scanner: system evaluation Ruola Ning, David Conover, Yong Yu, Yan Zhang, Weixing Cai, Ricardo Betancourt-Benitez, Xianghua Lu Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651030 (15 March 2007); doi: 10.1117/12.710340 The purpose of this study is to characterize the imaging performance of the recently built novel cone beam breast CT (CBBCT) scanner. This CBBCT scanner system has one x-ray source and one flat panel detector (Varian's PaxScan 4030CB) mounted on a rotating assembly. A patient table is mounted above the rotating [illegible] The results show that the image quality of the CBBCT scanner is excellent [illegible] Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651031 (12 March 2007); doi: 10.1117/12.709703 The purpose of this study was to determine how image quality in breast tomosynthesis (BT) is affected when acquisition modes are varied, using human breast specimens containing malignant tumors and/or microcalcifications. [illegible] Results from the relative VGA study indicate that image quality increases with number of projections and angular range. [illegible] Ganesh Narayanasamy, [illegible] Paul L. Carson Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651032 (13 March 2007); doi: 10.1117/12.711587 [illegible] Clay Didier, Stephen Glick, [illegible] Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651034 (15 March 2007); doi: 10.1117/12.713837 [illegible] Serghei Malkov, Jeff Wang, John Shepherd Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651035 (22 March 2007); doi: 10.1117/12.712095 We report on the design and validation of a breast tissue equivalent phantom for automated measurement of breast composition in film/screen and digital mammography systems. [illegible] Mari Varjonen, [illegible] Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651036 (14 March 2007); doi: 10.1117/12.698102 This paper will present a new breast positioning system for amorphous selenium (a-Se) based full field digital mammography (FFDM) system, which is also a platform of tomosynthesis prototype. Clinical images demonstrate that this method is capable extending the breast away from the chest wall, and maximizing the breast volume. Breast positioning system consists of two transparent moving sheets that apply traction of the breast controlled by motor. Sheets are under and above the compressed breast. Breast positioning sheets pull the breast into the imaging area during the compression. Digital mammography system is based on amorphous selenium flat panel detector (FPD) technology where the overall thickness of the selenium structure is 200 μm, and the pixel size on this detector is 85 μm. Preliminary results will be presented. Clinical study showed increment of the breast volume imaged, and it brought up to 1.0 cm - 2.0 cm more breast tissue. New breast position system also holds a promise of slight decrement of compression force used in the examination. Maximizing the exposured breast tissue is complicated, but important aspect in the breast cancer detection and diagnosis. Increasing the field of view with an additional volume of breast tissue imaged is a key point in digital mammography and digital breast tomosynthesis (DBT). Kristy L. Perez, Priti Madhav, Dominic J. Crotty, Martin P. Tornai Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651037 (14 March 2007); doi: 10.1117/12.713822 Patient positioning on a bed is an integral part of accurate imaging for dedicated 3D breast imaging. For both dedicated breast SPECT (single photon emission computed tomography) and breast CT (computed tomography or computed mammotomography, CmT) which are under development in our lab, maximum access to the breast in the imaging system's field of view is required to obtain the largest imaged breast volume. Accurate bed positioning will be necessary as it may be integrated with a guided biopsy apparatus. Thus, a patient bed with flexible 3D positioning capability is being integrated into the various independent and hybrid 3D imaging systems. The customized bed has both manual and computer controlled positioning capability, and the accuracy and reproducibility of the system are being characterized. Computer controlled positioning and feedback provide seemingly reproducible results. However, gross movements may vary in their accuracy to the given input position. While linear with slopes near 1.0 and intercepts near 0.0cm, lateral (Y) movement translates less than the input amount, while axial (X) movement translates farther than the input amount. Vertical (Z) directional movement follows a quadratic shift with a small dc component with or without added weight on the table. A variety of patient imaging conditions along with x-ray image data are evaluated to demonstrate the reproducibility of positioning accuracy. Individual directional repositioning accuracy is found to be better than multiple, combined directional repositioning accuracy. Imaging results indicate a reproducibility (error) of less than 1mm, which may be suitable for SPECT imaging but perhaps not for higher resolution dedicated breast CT. However, for the independent SPECT system, bed motion is not necessary because the detector's line of sight can already acquire data at the chest wall. Glandular segmentation of cone beam breast CT volume images Nathan Packard, John M. Boone Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651038 (22 March 2007); doi: 10.1117/12.713911 Cone beam breast CT (CBBCT) has potential as an alternative to mammography for screening breast cancer while limiting the radiation dose to that of a two-view mammogram. A clinical trial of CBBCT has been underway and volumetric breast images have been obtained. Although these images clearly show the 3D structure of the breast, they are limited by quantum noise due to dose limitations. Noise from these images adds to the challenges of glandular/adipose tissue segmentation. In response to this, an automated method for reducing noise and segmenting glandular tissue in CBBCT images was developed. A histogram based 2-means clustering algorithm was used in conjunction with a seven-point 3D median filter to reduce quantum noise. Following this, a 2D parabolic correction was applied to flatten the adipose tissue in each slice to reduce system inhomogeneities. Finally, a median smoothing algorithm was applied to further reduce noise for optimal segmentation. The algorithm was tested on actual breast scan volume data sets for subjective analysis and on a 3D mathematical phantom to test the algorithm. Subjective comparison of the actual breast scans with the denoised and segmented volumes showed good segmentation with little to no noticeable degradation. The mathematical phantom, after denoising and segmentation, was found to accurately measure the percent glandularity within 0.03% of the actual value for the phantom containing larger spherical shapes, but was only able to preserve small micro-calcification sized spheres of 0.8 and 1.0 mm, and small fibers with diameters of 1.2 and 1.4 mm. Weixing Cai, Ruola Ning, Yan Zhang, David Conover Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651039 (14 March 2007); doi: 10.1117/12.710167 A new breast-shaped compensation filter has been designed and fabricated for breast imaging using our newly built breast imaging (CBCTBI) system, which is able to scan an uncompressed breast with pendant geometry. The shape of this compensation filter is designed based on an average-sized breast phantom. Unlike conventional bow-tie compensation filters, its cross-sectional profile varies along the chest wall-to-nipple direction for better compensation for the shape of a breast. Breast phantoms of three different sizes are used to evaluate the performance of this compensation filter. The reconstruction image quality was studied and compared to that obtained without the compensation filter in place. The uniformity of linear attenuation coefficient and the uniformity of noise distribution are significantly improved, and the contrast-to-noise ratios (CNR) of small lesions near the chest wall are increased as well. Multi-normal image method is used in the reconstruction process to correct compensation flood field and to reduce ring artifacts. Evaluation of physical image characteristics of phase contrast mammography Asumi Yamazaki, Katushiro Ichikawa, Yoshie Kodera Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65103A (15 March 2007); doi: 10.1117/12.708458 Recently, the system called PCM (phase contrast mammography) came to be applied to clinical examinations. The PCM images are acquired as 1.75x-magnified images using small focal spot, then reduced to real object's size by image processing. The PCM images had the feature that edges of objects were enhanced. It was reported that the edges were enhanced because of refraction of X rays. We measured physical image characteristics of the PCM, to compare image characteristics of the PCM with those of a conventional mammography. Specifically, response characteristics to objects and noise characteristics in the spatial frequency domain were measured. As the results, compared with the conventional mammography, response characteristics of the PCM were high. If the placement conditions of objects were changed, response characteristics were also changed. And if the shape of objects was changed, response characteristics also were changed. Noise characteristics of the PCM were better than those of the conventional mammography. Furthermore, in order to investigate why edges of objects in the PCM images were enhanced, we simulated image profiles which would be obtained if X rays were refracted. And, we found the possibility that edge enhancements of the PCM images were based on refraction of X rays. Digital breast tomosynthesis geometry calibration Xinying Wang, James G. Mainprize, Michael P. Kempston, Gordon E. Mawdsley, Martin J. Yaffe Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65103B (17 March 2007); doi: 10.1117/12.698714 Digital Breast Tomosynthesis (DBT) is a 3D x-ray technique for imaging the breast. The x-ray tube, mounted on a gantry, moves in an arc over a limited angular range around the breast while 7-15 images are acquired over a period of a few seconds. A reconstruction algorithm is used to create a 3D volume dataset from the projection images. This procedure reduces the effects of tissue superposition, often responsible for degrading the quality of projection mammograms. This may help improve sensitivity of cancer detection, while reducing the number of false positive results. For DBT, images are acquired at a set of gantry rotation angles. The image reconstruction process requires several geometrical factors associated with image acquisition to be known accurately, however, vibration, encoder inaccuracy, the effects of gravity on the gantry arm and manufacturing tolerances can produce deviations from the desired acquisition geometry. Unlike cone-beam CT, in which a complete dataset is acquired (500+ projections over 180°), tomosynthesis reconstruction is challenging in that the angular range is narrow (typically from 20°-45°) and there are fewer projection images (≈7-15). With such a limited dataset, reconstruction is very sensitive to geometric alignment. Uncertainties in factors such as detector tilt, gantry angle, focal spot location, source-detector distance and source-pivot distance can produce several artifacts in the reconstructed volume. To accurately and efficiently calculate the location and angles of orientation of critical components of the system in DBT geometry, a suitable phantom is required. We have designed a calibration phantom for tomosynthesis and developed software for accurate measurement of the geometric parameters of a DBT system. These have been tested both by simulation and experiment. We will present estimates of the precision available with this technique for a prototype DBT system. A new approach to digital breast tomosynthesis for breast cancer screening Robert M. Nishikawa, Ingrid Reiser, Payam Seifi, Carl J. Vyborny Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65103C (15 March 2007); doi: 10.1117/12.713677 Digital breast tomosynthesis (DBT) is being proposed as a replacement for conventional mammography for breast cancer screening. However, there are limitations to DBT that reduce its effectiveness for screening, principally, difficulty in imaging microcalcifications and increased reading times by radiologists. We propose a method to overcome these limitations. Our proposed method is to divide the total dose given to the patient unequally such that one projection uses at least half of the dose and the remaining dose is divided over the remaining projections. We assume that in screening with DBT, only a single view is obtained using twice the dose of a conventional mammogram. All the projection images are used in the reconstruction. The 2D projection image that received the highest dose is analyzed by a computer-aided detection (CADe) scheme for microcalcifications. The radiologist views the 3D image set, with mass CADe, principally to search for masses and the 2D image to search for clustered microcalcifications with CADe. Since the 3D image set is for mass detection, the image can be reconstructed using larger sized pixels. This will reduce computation time and image noise. In principle, radiologists can review the tomosynthesis slices faster since they do not have to search for microcalcifications. We believe that by producing both a high resolution, "standard" dose 2D image and a lower resolution 3D image set, both calcifications and masses can be optimally imaged and detected in a time efficient manner. Development of a model for breast tomosynthesis image acquisition I. Reiser, R. M. Nishikawa, E. Y. Sidky, M. R. Chinander, P. Seifi Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65103D (14 March 2007); doi: 10.1117/12.713752 Tomosynthesis is emerging as a promising modality for breast imaging. Several manufacturers have developed prototype units and have acquired clinical and phantom data. Scanning configurations of these prototypes vary. So far, studies relating scanning configuration to image quality have been limited to those geometries that could be implemented on a particular prototype. To overcome this limitation, we are developing a model of breast tomosynthesis image acquisition system, which models the formation of the x-ray image and x-ray detector. The x-ray image of an object is computed analytically for a polychromatic x-ray beam. Objects consist of volumetric regions that are bounded by either a planar, ellipsoidal, cylindrical or conical surface, allowing for a variety of objects. xray scatter is computed by convolving the image with a scatter point-spread function. Poisson noise according to the entrance exposure is added to the image. The x-ray detector in this model is composed of a phosphor screen followed by a detector array. X-ray interactions in the screen are modeled as depth-dependent. The optical output of the screen is converted into digital units using a gain factor which was assumed to be Gaussian distributed. To validate this data model, we acquired images of a contrast-detail phantom on a stereotactic biopsy unit. The x-ray source is mounted on an arm that pivots in a plane about the detector center. The x-ray detector consists of a Min-R type screen fiber-optically coupled to a CCD camera. To compare actual and simulated data, we compared line profiles as well as several automatically extracted image features such as contrast-to-noise ratio, contrast, area and radial gradient index. Good agreement was found between simulation and physical data, indicating that we can now use this model to explore image quality for various tomosynthesis scanning configurations. F. Simonetti, L. Huang, N. Duric, O. Rama Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65103F (28 March 2007); doi: 10.1117/12.709828 Ultrasound tomography attempts to retrieve the structure of an object by exploiting the interaction of acoustic waves with the object. A fundamental limit of ultrasound tomography is that features cannot be resolved if they are spaced less than λ/2 apart, where λ is wavelength of the probing wave, regardless of the degree of accuracy of the measurements. Therefore, since the attenuation of the probing wave with propagation distance increases as λ decreases, resolution has to be traded against imaging depth. Recently, it has been shown that the λ/2 limit is a consequence of the Born approximation (implicit in the imaging algorithms currently employed) which neglects the distortion of the probing wavefield as it travels through the medium to be imaged. On the other hand, such a distortion, which is due to the multiple scattering phenomenon, can encode unlimited resolution in the radiating component of the scattered field. Previously, a resolution better than λ/3 has been reported in these proceedings [F. Simonetti, pp. 126 (2006)] in the case of elastic wave probing. In this paper, we demonstrate experimentally a resolution better than λ/4 for objects immersed in a water bath probed by means of a ring array which excites and detects pressure waves in a full view configuration. Tatsuhiko Matsushita, Toshiaki Miyati, Kazuya Nakayama, Takashi Hamaguti, Yoshihiko Hayakawa, Allan G. Farman, Yuzo Kikuchi Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65103G (22 March 2007); doi: 10.1117/12.709241 We developed a novel system for imaging and qualitative analysis of surface vessels using near infrared (NIR) radiation with tuned aperture computed tomography (TACT®), even if the NIR cannot transmit through thick regions. NIR-sensitive CCD camera was surrounded by sixty light emitting diodes (alternating wavelengths of 700 nm and 810 nm), and could only detect the NIR from the subcutaneous tissue. We obtained multiple near infrared projections of surface vessels at each wavelength in accordance with the optical aperture theory within one second. Then, we created tomograms using the TACT program, and determined the venous oxygenation index (VOI), which reflected the oxygen saturation level, calculated from the image signals at each wavelength. This system produced thinner NIR tomograms under 0.5 mm. The change in VOI after load test calculated from NIR tomograms was more sensitive than that from NIR images without tomography. Our novel system makes it possible to non-invasively obtain NIR tomograms and accurately analyze changes in oxygen saturation. Adaptive MOEMS mirrors for medical imaging Reda Fayek, Hany Ibrahim Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65103J (15 March 2007); doi: 10.1117/12.708951 This paper presents micro-electro-mechanical-systems (MEMS) optical elements with high angular deflection arranged in arrays to perform dynamic laser beam focusing and scanning. Each element selectively addresses a portion of the laser beam. These devices are useful in medical and research applications including laser-scanning microscopy, confocal microscopes, and laser capture micro-dissection. Such laser-based imaging and diagnostic instruments involve complex laser beam manipulations. These often require compound lenses and mirrors that introduce misalignment, attenuation, distortion and light scatter. Instead of using expensive spherical and aspherical lenses and/or mirrors for sophisticated laser beam manipulations, we propose scalable adaptive micro-opto-electro-mechanical-systems (MOEMS) arrays to recapture optical performance and compensate for aberrations, distortions and imperfections introduced by inexpensive optics. A high-density array of small, individually addressable, MOEMS elements is similar to a Fresnel mirror. A scalable 2D array of micro-mirrors approximates spherical or arbitrary surface mirrors of different apertures. A proof of concept prototype was built using PolyMUMPTM due to its reliability, low cost and limited post processing requirements. Low-density arrays (2x2 arrays of square elements, 250x250μm each) were designed, fabricated, and tested. Electrostatic comb fingers actuate the edges of the square mirrors with a low actuation voltage of 20 V - 50 V. CoventorWareTM was used for the design, 3D modeling and motion simulations. Initial results are encouraging. The array is adaptive, configurable and scalable with low actuation voltage and a large tuning range. Individual element addressability would allow versatile uses. Future research will increase deflection angles and maximize reflective area. Dean Connor, F. Avraham Dilmanian, Christopher Parham, Teresa Kao, Zhong Zhong Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65103K (15 March 2007); doi: 10.1117/12.710309 Diffraction enhanced imaging (DEI) uses monochromatic x-rays coupled to an analyzer crystal to extract information about the refraction of x-rays within the object. Studies of excised biological tissues show that DEI has significant contrast-to-noise ratio (CNR) advantages for soft tissue when compared to standard radiography. DEI differs from conventional CT in that its refraction contrast depends on x-ray energy as 1/E, thus the energy and dose considerations for conventional CT will be inappropriate. The goal of this study was to assess the optimal energy for in vivo CT imaging of a mouse head to obtain the largest soft tissue refraction CNR. Through a theoretical model, optimum refraction CNR for mouse brain imaging was found to be about 20 keV. The findings were tested experimentally using the DEI system at the X15A beamline of the National Synchrotron Light Source. Using the parameters for optimized refraction CNR (20 keV, silicon [333] reflection), large image artifacts were caused by DEI's scatter-rejection properties. By increasing the x-ray energy and using a lower order diffraction, silicon [111], soft tissue features within the brain, including the hippocampus, could be resolved. Samta C. Thacker, Vivek V. Nagarkar, Hongjie J. Liang, Valeriy Gaysinskiy, Stuart Miller, Simon R. Cherry Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65103L (14 March 2007); doi: 10.1117/12.709736 The development of new small animal imaging techniques such as high-speed microCT and low-dose microCT often requires investigating optimal detector parameters and imaging techniques. This paper presents an approach to develop a low-dose microCT detector based on a novel, back-thinned, back-illuminated electron multiplying CCD (EMCCD) coupled to a high performance microcolumnar CsI scintillator via a fiberoptic taper. Our goal is to achieve high DQE(0) for X-ray energies typically used in small animal imaging (40 to 80 kVp), providing high quality imaging at substantially reduced dose. Towards achieving this goal we have developed a novel EMCCD camera fitted with a fiberoptic window. To enhance the imaging area we fabricated additional fiberoptic tapers measuring 3:1 and 6:1 in demagnification ratio, mechanically coupled to the EMCCD. The high sensitivity and internal gain of the EMCCD is further exploited in our system design by the use of a thick CsI screen. These screens not only provide higher absorption for 40 to 80 kVp X-rays, but even at ~200 &mgr;m thickness maintain a high resolution of up to 11 lp/mm. This paper outlines the quantitative performance of each detector component and the detector as a whole. While the detector demonstrated the potential for achieving the targeted DQE performance, it also showed that mechanical coupling of the tapers to the CCD results in unacceptable light loss, and that direct CCD-to-taper bonding and using new versions of large-area EMCCD chips would be better options. Dual-energy cone-beam micro-CT for animal imaging: preliminary study Seungryong Cho, Emil Sidky, Junguo Bian, Xiaochuan Pan Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65103M (14 March 2007); doi: 10.1117/12.713243 We have recently developed a prototype cone-beam micro-CT system for studying new image reconstruction algorithms experimentally as well as for small animal imaging. Dual energy methods have widely been investigated and applied for eliminating beam hardening artifacts in the reconstructed images and for performing quantitative CT. We have proposed earlier a pre-reconstruction-type dual energy method which has the advantage that the cone-beam CT data from two measurements with different x-ray energy spectra are first processed to obtain quantities that are approximately consistent with the x-ray transform, and then image reconstruction is performed. In this work, the proposed method is applied to the cone-beam micro-CT data acquired by our prototype system. Only the thickness maps of the object based on projection images are shown in this work as a preliminary. Christian Wietholt, Ing-Tsung Hsiao, Chin-Tu Chen Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65103N (19 March 2007); doi: 10.1117/12.713568 Small animal SPECT using low energy photons of I-125 and approaching resolutions of microscopic levels, imaging parameters such as pinhole edge penetration, detector blur, geometric response, detector and pinhole misalignment, and gamma photon attenuation and scatter can have increasingly noticeable and/or adverse effects on reconstructed image quality. Iterative reconstruction algorithms, the widelyaccepted standard for emission tomography, allow modeling of such parameters through a system matrix. For this Monte Carlo simulation study, non-uniform attenuation correction was added to the existing system model. The model was constructed using ray-tracing and further included corrections for edge penetration, detector blur, and geometric aperture response. For each ray passing through different aperture locations, this method attenuates a voxel's contribution to a detector element along the photon path, which is then weighted according to a pinhole penetration model. To lower the computational and memory expenses, symmetry along the detector axes and an incremental storage scheme for the system model were used. For evaluating the nonuniform attenuation correction method, 3 phantoms were designed of which projection images were simulated using Monte Carlo methods. The first phantom was used to examined skin artifacts, the second to simulate attenuation by bone, and the third to generate artifacts of an air-filled space surrounded by soft tissue. In reconstructions without attenuation correction, artifacts were observed with up to a 40% difference in activity. These could be corrected using the implemented method, although in one case overcorrection occurred. Overall, attenuation correction improved reconstruction accuracy of the radioisotope distribution in the presence of structural differences. ZongJian Cao Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65103O (14 March 2007); doi: 10.1117/12.712660 The In-111 coincidence camera we previously proposed can significantly increase detection efficiency because collimators are no longer needed. However, the initial simulations indicated that spatial resolution was too poor for medical imaging. To improve the resolution, we derived an analytical deconvolution algorithm in this study. In the derivation, 1-D Fourier transform for the shift-invariant point spread function (PSF) with respect to the detector bin location t was carried out analytically. The Fourier transform is approximately a linear function of the source-to-detector distance s when s is greater than 5 cm and its variation over s is much slower than that of any extensive source. The Fourier transform of the PSF can thus be taken out of the integration over s with reasonable accuracy and its inversion is the deconvolution kernel. A low-pass filter was applied to the deconvolved Fourier transform to suppress high-frequency oscillation. Applying the derived deconvolution algorithm to computer simulated phantoms, we achieved a resolution of 2 cm for s = 10 cm. Compared to the pre-deconvolution resolution of 19 cm, this is a huge improvement but is still poor. The errors caused by the approximations made in the derivation can be further reduced and also the high-frequency behavior of the deconvolved Fourier transform can be improved using better deconvolution techniques. Monte Carlo simulations for more realistic sources with image noise should be performed for further evaluation. Andrzej Krol, Hongwei Ye, Russell Kincaid, John Boone, Marina Servol, Jean-Claude Kieffer, Yakov Nesterets, Tim Gureyev, Andrew Stevenson,et. al. Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65103P (14 March 2007); doi: 10.1117/12.713827 We have investigated theoretically the mean absorbed dose to the mouse in our newly constructed, in-line holography, x-ray phase-contrast, in-vivo, micro-CT system with an ultrafast laser-based x-ray (ULX) source. We assumed that the effective mouse diameter was 30 mm and the x-ray detector required minimum 30 μGy per frame to produce high quality images. The following laser target-filter combinations were considered: Ag-Ag, Mo-Mo, Sn- Sn. In addition, we considered narrow-pass multilayer x-ray mirrors. The corresponding ULX spectra were obtained using a CZT solid-state spectrometer. The approach used for dose computation was similar to human dose estimation. The mouse was modeled as a tissue-equivalent cylinder located at the isocenter with diameter 30 mm and density 1g/cm3. A layer of dermis (skin and fur) with 1 mm thickness was also modeled. Imparted energy per volume was estimated for 1 keV wide x-ray energy intervals in the 6-100 keV range. Monte Carlo simulations were performed using the SIERRA code previously validated using 30 mm diameter PMMA phantom. The results obtained indicate that: a) the mean absorbed dose for ULX is less than or equal to that from a W-anode micro-CT tube operating at 30-40 kVp with 0.5 or 1.0 mm Al; b) for filter thickness above 100 μm, Sn-Sn results in the highest dose, followed by Ag-Ag and Mo-Mo; c) the multilayer x-ray mirror with FWHM ≤ 10 keV produces significantly lower dose than metallic foil filters. We conclude that ULX can provide better dose utilization than a microfocal x-ray tube for in vivo microtomography applications. J. Zhang, G. Yang, Y. Lee, S. Chang, J. P. Lu, O. Zhou Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65103Q (19 March 2007); doi: 10.1117/12.703351 We have recently demonstrated the feasibility of frequency multiplexing radiography (FMR) technique based on the frequency division multiplexing (FDM) principle and the carbon nanotube field emission x-ray technology. The key component of the FMR technique is a multi-pixel carbon nanotube field emission x-ray source. The prototype multi-pixel x-ray source has a linear array of nine field emission x-ray pixels. By programming the control electronics, the multi-pixel x-ray source can generate spatially and temporally modulated x-ray radiation. During the multiplexing imaging process, all the x-ray pixels were turned on simultaneously with each beam modulated at different frequency. The superimposed x-ray signals generated by the multi-pixel x-ray source were captured using a high speed flat panel x-ray detector over a certain period of time. The collected composite images were then demultiplexed using a Fourier transform based algorithm to recover the original nine projection images from different view angles. The FMR technique can in principle increase the imaging speed and reduce the x-ray peak workload for applications such as computed tomography (CT). In this paper we evaluated the performance of this new radiographic imaging technique based on our simulation and experiment results. Imaging artifacts caused by the cross-talk among different frequency subchannels have been studied and the importance of orthogonal frequency division multiplexing (OFDM) has been demonstrated. Hugo de las Heras, Oleg Tischenko, Werner Panzer, Yuan Xu, Christoph Hoeschen Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65103R (28 March 2007); doi: 10.1117/12.705803 A non-standard scanning device with dose-reduction potential was proposed at the SPIE Medical Imaging conference 2006. The new device obtains the Radon data after the X-ray beam is collimated through a special mask. This mask is combined with a new geometry that permits an efficient data collection, thus the device has the potential of reducing the dose by a factor of two. In this work, we report a prototype of the new device and experimental data acquisition using only the mask of the new scanning geometry. In order to obtain the optimal parameters for the scanning device, several factors have been considered, including detector elements and shielding shape, fan beam angle, speed of the source rotation and materials employed. The calibration of the detector elements needs especial attention, due to the dependence of the detector response on the energy of the X-rays. A simplfied version of the device was designed and mounted. Phantom data were acquired using this prototype and were used to test the performance of the new design. The results obtained are highly promising, even though the prototype developed does not make use yet of all the potential features proposed in the theory. Imaging with Iridium photons: an application in brachytherapy F. Verhaegen, S. Palefsky, D. Rempel, E. Poon Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65103S (14 March 2007); doi: 10.1117/12.707983 In external-beam radiotherapy efforts are currently devoted to research on image-guided verification techniques. In brachytherapy the situation is far less advanced; usually, there is no treatment verification imaging. We are studying the possibility to use the photons emitted from a conventional 192Ir brachytherapy source for High Dose Rate (HDR) treatments, when inserted in a patient. We investigated whether the images can be used for dose delivery verification and to interrupt faulty dose deliveries. Phantoms were built to accommodate a remote controlled HDR 192Ir source. Images were collected with an x-ray intensifier, and predicted from calculations based on ray-tracing. For a bone/tissue/air/lung phantom with the source on top of the phantom measured contrasts were 8% (bone/tissue), 19% (tissue/lung) and 26% (lung/bone). When a thick Lucite slab was added on top of the contrast phantom, the contrasts decreased to 3, 7 and 10%, respectively, indicating that phantom scatter is an important issue. Differences between measured and simulated images and the influence of scatter were quantified. From this feasibility study it is concluded that imaging with 192Ir photons is possible but that work on scatter rejection through simulation and anti-scatter grids is needed. Amir H. Goldan, Li Ng, J. A. Rowlands, Karim S. Karim Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65103V (19 March 2007); doi: 10.1117/12.710358 Photon counting is emerging as an alternative detection technique to conventional photon integration. In photon counting systems, the value of each image pixel is equal to the number of photons that are absorbed by the radiation detector. The proposed pixel architecture provides a method for energy windowing and serial readout for low-dose gamma-ray imaging. Each pixel is comprised of a radiation detector and integrated analog and digital circuitry. A prototype was developed on a printed circuit board (PCB) using discrete electronic components. In this research, we present the experimental results for the operation of the photon counting pixel with energy windowing and investigate the compromise between pixel noise level and photon count rate. F. Taghibakhsh, K. S. Karim Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65103W (14 March 2007); doi: 10.1117/12.710147 Cone beam computed tomography (CBCT) has been recently reported using flat panel imagers (FPI). Here, detector technology capable of high speed imaging, high spatial resolution, large volume coverage, better contrast resolution and, in particular, lowered patient dose is required. Employing active matrix flat panel imagers (AMFPIs) as cone beam CT detectors has been proposed as a solution for improving volume coverage, contrast and resolution; however, clinical evaluations have shown that they suffer from low speed read out. Unlike passive pixel architecture which is currently the state-of-the-art technology for AMFPIs, our preliminary studies have shown that novel amplified pixel sensor (APS) architectures can overcome the low readout speed, and moreover, they provide gain which can be traded for higher frame rate and lower X-ray doses. Although APS architectures can meet the high dynamic range and low noise requirements of CT imaging, linearity and variations between pixel characteristics are major issues. In this study we will investigate novel APS architectures to address these concerns. Multidetector-row CT with a 64-row amorphous silicon flat panel detector Edward G. Shapiro, Richard E. Colbeth, Earl T. Daley, Isaias D. Job, Ivan P. Mollov, Todor I. Mollov, John M. Pavkovich, Pieter G. Roos, Josh M. Star-Lack,et. al. Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65103X (15 March 2007); doi: 10.1117/12.713682 A unique 64-row flat panel (FP) detector has been developed for sub-second multidetector-row CT (MDCT). The intent was to explore the image quality achievable with relatively inexpensive amorphous silicon (a-Si) compared to existing diagnostic scanners with discrete crystalline diode detectors. The FP MDCT system is a bench-top design that consists of three FP modules. Each module uses a 30 cm x 3.3 cm a-Si array with 576 x 64 photodiodes. The photodiodes are 0.52 mm x 0.52 mm, which allows for about twice the spatial resolution of most commercial MDCT scanners. The modules are arranged in an overlapping geometry, which is sufficient to provide a full-fan 48 cm diameter scan. Scans were obtained with various detachable scintillators, e.g. ceramic Gd2O2S, particle-in-binder Gd2O2S:Tb and columnar CsI:Tl. Scan quality was evaluated with a Catphan-500 performance phantom and anthropomorphic phantoms. The FP MDCT scans demonstrate nearly equivalent performance scans to a commercial 16-slice MDCT scanner at comparable 10 - 20 mGy/100mAs doses. Thus far, a high contrast resolution of 15 lp/cm and a low contrast resolution of 5 mm @ 0.3 % have been achieved on 1 second scans. Sub-second scans have been achieved with partial rotations. Since the future direction of MDCT appears to be in acquiring single organ coverage per scan, future efforts are planned for increasing the number of detector rows beyond the current 64- rows. Comparison of multi-arm VRX CT scanners through computer models David A. Rendon, Frank A. DiBianca, Gary S. Keyes Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65103Y (15 March 2007); doi: 10.1117/12.710153 Variable Resolution X-ray (VRX) CT scanners allow imaging of different sized anatomy at the same level of detail using the same device. This is achieved by tilting the x-ray detectors so that the projected size of the detecting elements is varied producing reconstructions of smaller fields of view with higher spatial resolution.1 The detector can be divided in two or more separate segments, called arms, which can be placed at different angles, allowing some flexibility for the scanner design. In particular, several arms can be set at different angles creating a target region of considerably higher resolution that can be used to track the evolution of a previously diagnosed condition, while keeping the patient completely inside the field of view (FOV).2 This work presents newly-developed computer models of single-slice VRX scanners that allow us to study and compare different configurations (that is, various types of detectors arranged in any number of arms arranged in different geometries) in terms of spatial and contrast resolution. In particular, we are interested in comparing the performance of various geometric configurations that would otherwise be considered equivalent (using the same equipment, imaging FOVs of the same sizes, and having a similar overall scanner size). For this, a VRX simulator was developed, along with mathematical phantoms for spatial resolution and contrast analysis. These tools were used to compare scanner configurations that can be reproduced with materials presently available in our lab. Victor Weir, Jie Zhang, Russell E. Ritenour Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65103Z (15 March 2007); doi: 10.1117/12.708295 The radiant quantum efficiency (RQE) of x-ray phosphors is defined as the ratio of the emitted luminescent power and the power absorbed by the material. For a given x-ray imaging technique, a high RQE phosphor means a lower x-ray exposure to patients and a better image quality. To improve RQE, phosphors such as LiF and BaFX:Eu (X = Br, Cl, I) host lattices, which are commonly used in medical dosimetry and imaging system, are always doped with Cu, Ti, or Tb. Experimental observations showed that these dopants can increase phosphor RQE significantly. In this study, we theoretically investigated the effect of additional dopants on the RQE of LiF:Mg and BaFX:Eu host lattices using Density Functional Theory (DFT) in the Local Density Approximation (LDA). Self-consistent charge density calculations were performed. The energy loss function L(w) was obtained and used to calculate the RQE for different phosphors. The results showed that additional dopants produced changes in the optical properties of the phosphors, particularly the energy loss function L(w). Doping with more substitutional atoms increased the RQE of all host lattices studied with the exception of BaFI lattice where the RQE decreased. K. Oda, [illegible] Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651040 (22 March 2007); doi: 10.1117/12.710639 In digital imaging systems, using anti-scatter grids lead to arise moire artifacts. Recently, amorphous selenium-based (direct-conversion) flat panel X-ray detector systems were developed. An important advantage of a-Se is its high spatial resolution. [illegible] was to choose optimal anti-scatter grids in combination with digital X-ray system, and to demonstrate how to arise moire artifacts. We simulated the sampling process in the spatial frequency domain. [illegible] moire artifacts were varied with combinations of the sampling conditions and the strip density of antiscatter grids. [illegible] A simple all-digital PET system Qingguo Xie, Chien-Min Kao, [illegible] Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651041 (15 March 2007); doi: 10.1117/12.713846 Positron emission tomography (PET) systems employ mixed-signal front-end [illegible]. To obtain, and maintain over time, proper calibrations of the mixed-signal circuit for generating accurate event information is a challenging task due to the complexity and the huge number of channels and multiplexing of the input signals found in modern PET systems. It is also difficult to modify or extend the event-processing techniques when needs arise because it would involve making changes to the circuitry. These limitations can be circumvented by applying digital signal-processing techniques for analyzing event pulses digitized at high speed. With digital technologies, optimized event-processing algorithms can be implemented and then can be modified or extended with ease when needed. The resulting PET data-acquisition (DAQ) system is easier to calibrate and maintain, can generate more accurate event information, and has better extendibility. In this paper, we present our work toward developing a scalable all-digital DAQ system for PET. [illegible] Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651042 (15 March 2007); doi: 10.1117/12.709383 Flat-panel direct conversion detectors used in compound substance of semiconductor are being studied for digital X-ray imaging. [illegible] (HgI2, PbI2, TlBr, PbO) [illegible] for large area X-ray imaging. Consequently, in this paper, we propose applicable potentialities for screen printing method [illegible]. The thick film was coated onto the substrate [illegible] used to evaluate performance of semiconductor detectors. Fabricated films consisted of ~25 to 35 μm thick layer of semiconductor. Dark current, sensitivity, linearity, lag, and morphologic property were measured for evaluation of films performance. Dark current of PbO was acquired the lowest, and dark current of HgI2 at the operation voltage of ~1V/μm was observed 8pA/mm2. Sensitivity is observed higher about ten times than the others. And then HgI2 is observed the best SNR in four materials. [illegible] Such a value is not better than PVD process, but it is easy to be fabricated in high quality for large area X-ray Imaging. Our future efforts will be directed towards optimization of growth of film thickness that is coated onto a-Si TFT array. [illegible] Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651043 (28 March 2007); doi: [illegible] For Computed Radiography (CR) systems that use a columnar structure phosphor plate (CPP) and a powder phosphor plate (PPP), [illegible] optimum phosphor layer thickness [illegible]. Next, to determine the stimulation light intensity, we measured PSL, modulation transfer function (MTF) and detective quantum efficiency (DQE) by varying the stimulation light intensity, using the determined optimum phosphor layer thickness. We also investigated the noise components of each phosphor plate. Results show that, compared to the PPP, the CPP is more favorable in allowing thicker phosphor layer without reduction in MTF. As a result of the relationship between the layer thickness and the PSL, noise analysis, it was confirmed that the CPP could detect PSL in the deep region of the phosphor layer without reducing the intensity of PSL. This suggests that in comparison to the PPP, the CPP can make efficient use of X-ray information, thereby promising to enhance image quality and to reduce exposure dose. A. Takasu, Y. Iwabuchi, M. Kato, S. Arakawa, H. Yasuda, K. Shimada, T. Kuwabara Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651045 (19 March 2007); doi: 10.1117/12.706750 In X-ray-to-light conversion digital radiography, we compared the image quality of a system in which photodetection is done on the X-ray incident surface (hereafter referred to as a front exposure system) and a system in which photodetection is done from the back side opposite the X-ray incident surface (hereafter referred to as a back exposure system). Modulation transfer function (MTF) and detective quantum efficiency (DQE) measurements were performed using the method IEC prescribes. Both MTF and DQE were higher with the front exposure system than with the back exposure system, with the former delivering better image quality. This difference can be accounted for by differences in the depth distribution of absorbed X-ray doses in the phosphor layer, the readout efficiency, which varies as a function of depth in the phosphor layer, and depth-dependent blur of signals. The differences in image quality incurred by varying the quality of X-rays, the thickness of the phosphor layer and the position of the phosphor layer were also investigated by simulations. [illegible] The advantage of the front exposure system increases with decreasing X-ray tube voltage, increasing phosphor layer thickness, and the use of phosphors in powder form. Stefan Schweizer, Anthony R. Lubinsky, Jacqueline A. Johnson Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651046 (19 March 2007); doi: 10.1117/12.708758 We developed a class of (semi-) transparent glass-ceramic storage phosphors for digital mammography. The glass ceramics are based on europium-doped fluorozirconate glasses, which were additionally doped with chlorine to initiate the nucleation of barium chloride nanoparticles therein. The glass ceramic is able to convert ionizing radiation into stable electron-hole pairs, which can be read out afterwards with a scanning laser beam in a so-called "photostimulated luminescence" (PSL) process. A number of experiments were done to measure materials and engineering parameters [illegible]. Finally, the measured parameters were used to project DQE vs. spatial frequency for the proposed detector, and to compare with commercially available electronic mammography systems. A new x-ray imaging technique for radiography mode of flat-panel imager S. Suzuki, S. Ikeda, K. Ueda, R. Baba Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651047 (15 March 2007); doi: 10.1117/12.709970 A digital radiography system with a flat-panel imager, which has a novel high speed technique for a radiography mode, has been developed. A radiographic image captured by the new imaging technique has a wide dynamic range in comparison with conventional radiographic images. The purpose of this presentation is to show the basic performance of the image acquired by the new imaging technique and compare it with an image taken by a conventional technique. The flat-panel imager has a gain switching capability, normally used in a dynamic imaging mode for a cone-beam CT study. The gain switching method has two gain settings and switches between them automatically, depending on the incident dose to each pixel of flat-panel imager. [illegible] In this study, we applied the gain switching method to the radiography mode, and achieved a radiographic image with wider dynamic range than a conventional radiograph. In addition, we have developed an algorithm for calibration of the gain switched method in radiography mode. Arun Gopal, Sanjiv S. Samant Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651048 (15 March 2007); doi: 10.1117/12.713704 In portal imaging, the role of electronic portal imaging devices (EPIDs) to implement complex radiation therapy protocols is crucial and regular quality assurance (QA) of EPID image quality is necessary to ensure treatment efficacy. The modulation transfer function (MTF), noise power spectrum (NPS) and detective quantum efficiency (DQE) are universal metrics that can completely describe radiographic image quality. These metrics are independent of measurement geometry and the user, and allow intra and inter detector performance evaluation. Though NPS and DQE calculations are straightforward, conventional MTF measurements using slit/edge phantoms are difficult and time consuming. Subsequently, such measurements are not feasible within routine clinical QA. Currently, EPID performance is monitored using image quality indices obtained from commercial QA phantoms. Such methods may be qualitative or sensitive to irradiation geometry, and are therefore not appropriate for rigorous QA. In this work, a simple and quick method for EPID QA is presented based on a line-pair bar-pattern for fast MTF measurement, coupled with standard NPS and DQE measurements, all of which can be carried out within two minutes. This method to determine MTF from line-pair modulations was developed and validated using Monte Carlo simulations to identify accurate and reliable measurement conditions. The bar-pattern based QA method was tested with two clinical EPIDs and found to be in excellent agreement with slit/edge MTF measurements. It was also implemented for weekly QA checks, and compared with established commercial QA methods. The proposed method was more sensitive to potential decrease of EPID image quality. Characterization of a CMOS detector for limited-view mammography Idris A. Elbakri Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651049 (15 March 2007); doi: 10.1117/12.708347 Sensors based on complementary metal oxide semiconductors (CMOS) technology have recently been considered for mammography applications. CMOS offers the advantages of lower cost and relative ease of fabrication. We report on the evaluation of a CMOS imager (C9730DK, Hamamatsu Corporation) with 14-bit digitization and 50-micron detector element (del) resolution. The imager has an active area of 5 x 5 cm and uses 160-micron layer of needle-crystal CsI (55 mg/cc) to convert x-rays to light. The detector is suitable for spot and specimen imaging and image-guided biopsy. To evaluate resolution performance, we measured the modulation transfer function (MTF) using the slanted edge method. We also measured the normalized noise power spectrum (NNPS) using Fourier analysis of uniform images. The MTF and NNPS were used to determine the detective quantum efficiency (DQE) of the detector. The detector was characterized using a molybdenum target/molybdenum filter mammography x-ray source operated at 28 kVp with 44mm of PMMA added to mimic clinical beam quality (HVL = 0.62 mm Al). Our analysis showed that the imager had a linear response. The MTF was 28% at 5 lp/mm and 8% at 10 lp/mm. The product of the NNPS and exposure showed that the detector was quantum limited. The DQE near 0 lp/mm was in the 55-60% range. The DQE and MTF performance of the CMOS detector are comparable to published values for other digital mammography detectors. Yiheng Zhang, Heang-Ping Chan, Berkman Sahiner, Jun Wei, Jun Ge, Lubomir M. Hadjiiski, Chuan Zhou Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65104A (15 March 2007); doi: 10.1117/12.713816 Digital Tomosynthesis Mammography (DTM) is a promising modality that can improve breast cancer detection. DTM acquires low-dose mammograms at a number of projection angles over a limited angular range and reconstructs the 3D breast volume. DTM can provide depth information to separate overlapping breast tissues occurred in conventional mammograms, thereby facilitating detection of subtle lesions. In this work, we investigated the impact of the imaging parameters and reconstruction methods on the Z-axis resolution in DTM systems. The Z-axis resolution represents the ability of the DTM system to distinguish adjacent objects along the depth direction. A DTM system with variable image acquisition parameters was modeled. In this preliminary study, a computer phantom containing a high-density point object embedded in an air volume was used. We simulated a range of DTM conditions by generating an appropriate number of PV images in 3° increments covering a total tomosynthesis angle from ±15° to ±30°. The Simultaneous Algebraic Reconstruction Technique (SART) was used for reconstruction of the imaged volume from the noise-free projection data and the results were compared to those of back-projection method. Vertical line profiles along the Z-axis and through the object center were extracted from the reconstructed volume and the full-width-at-half-maximum (FWHM) of the normalized intensity profile was used to evaluate the Z-axis resolution. Preliminary results demonstrated that while the Z-axis resolution remains almost constant as a function of depth within a 5-cm-thick volume, it is strongly affected by the PV angular range such that the depth resolution improves with increasing total tomosynthesis angle. The depth resolution also depends on the reconstruction algorithm employed; the SART method is superior to the simple back-projection method in terms of depth resolution. Bahram Dahi, Gary S. Keyes, David A. Rendon, Frank A. DiBianca Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65104B (15 March 2007); doi: 10.1117/12.710180 A new Cone-Beam CT (CBCT) system is introduced that uses the concept of Variable Resolution X-ray (VRX) detection, which has previously been demonstrated to significantly increase spatial resolution for small objects. An amorphous Silicon Flat Panel Detector (FPD) with a CsI scintillator (PaxScan 2020, Varian, Salt Lake City, UT) is coupled with a micro-focus x-ray tube (35 - 80 kVp, 10 - 250 μA) to form a CBCT. The FPD is installed on a rotating arm that can be adjusted to any angle θ, called the VRX angle, between 90° and 0° with respect to the x-ray direction. A VRX angle of 90° for the detector corresponds to a conventional CBCT whereas a VRX angle of 30° means that the detector is tilted 90° - 30° = 60° from its perpendicular position. Tilting the FPD in this manner reduces both the line-spread function width and the sampling distance by a factor of sin(&thgr;), thereby increasing detector spatial resolution proportionally. An in-house phantom is used to measure the MTF of the reconstructed CT images using different VRX angles. An increase by a factor of 1.67 ± 0.007 is observed in the MTF cutoff frequency at 30° compared to 90° in images acquired at 75 kVp. Expected theoretical value for this case is 2.0. The new Cone-Beam Variable Resolution X-ray (CB-VRX) CT system is expected to significantly improve the images acquired from small objects - such as small animals - while exploiting the opportunities offered by a conventional CBCT. The CT image standardization based on the verified PSF Shinichi Wada, Masaki Ohkubo, Masayuki Kunii, Toru Matsumoto, Kohei Murao, Kazuo Awai, Mitsuru Ikeda M.D. Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65104D (15 March 2007); doi: 10.1117/12.708888 This study discusses a method of CT image quality standardization that uses a point-spread function (PSF) in MDCT. CT image I(x,y,z) is represented by the following formula: I(x,y,z) = O(x,y,z)***PSF(x,y,z). Standardization was performed by measuring the three-dimensional (3-D) PSFs of two CT images with different image qualities. The image conversion method was constructed and tested using the 3-D PSFs and CT images of the CT scanners of three different manufacturers. The CT scanners used were Lightspeed QX/i, Somatom Volume Zoom, and Brilliance-40. To obtain the PSF(x,y) of these CT scanners, the line spread functions of the respective reconstruction kernels were measured using a phantom described by J.M. Boone. The kernels for each scanner were: soft, standard, lung, bone, and bone plus (GE); B20f, B40f, B41f, B50f, and B60f (Siemens); and B, C, D, E, and L (Philips). Slice sensitivity profile (SSP) were measured using a micro-disk phantom (50 μm* φ1 mm) with 5 mm slice thickness and beam pitch of 1.5 (GE, Siemens) and 0.626 (Philips). 3-D PSF was verified using an MDCT QA phantom. Real chest CT images were converted to images with contrasting standard image quality. Comparison between the converted CT image and the original standard image showed good agreement. The usefulness of the image conversion method is discussed using clinical CT images acquired by CT scanners produced by different manufacturers. Felix H. Schöfer, Karl Schneider, Christoph Hoeschen Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65104E (15 March 2007); doi: 10.1117/12.709394 In diagnostic radiology it is a common interest of patient and medical staff to keep the exposure as low as reasonably achievable (ALARA). In spite of this task being well known there is no consensus about how the exposure for a specific diagnostic examination can be. The methods presented in this paper allow for the mathematical determination of the lowest exposure necessary to perform basic, well defined imaging tasks in digital radiography. The method quantifies how different demands on the result influence the necessary exposure. Dependences on parameters describing the beam quality used and the detector are implemented into the model. A strong rise of the necessary exposure to detect a certain contrast of lower amplitude or with higher certainty was determined. The effect of a change of the irradiation are as a first step investigated via the connected change of the transmission of a main absorber. By specification of the specimen to be observed the result is connected to beam energies which can be correlated with the energy dependent response of a realistic detector system. The calculations give basic information about the best exposure in a simplified view of patient dimensions and diagnostic needs. Especially in pediatric radiology optimized adaptations to the patient and the clinical question are expected to take great effects due to the great variations of patient sizes. Validation of software for QC assessment of MTF and NPS Walter Peppler, Wei Hong, Robert Steinhauser, Bruce Whiting, Ehsan Samei, Michael Flynn, Steven Don M.D., Nathan Corradini Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65104F (22 March 2007); doi: 10.1117/12.713434 Modulation transfer function (MTF), noise power spectrum (NPS), and detective quantum efficiency (DQE) are widely accepted measures of digital radiographic system performance. However the implementation of these measurement methodologies has been limited to a handful of researchers using an assortment of techniques. A prototype edge tool and easy-to-use software program, which can generate MTF, NPS, and DQE results quickly and easily in the field, have been developed. The edge tool consists of 1mm or 250 μ thick tungsten with two polished edges. Edge and NPS data were obtained and analyzed by 3 investigators using three analysis methods: Method A, the software under development for this project; Method B, code available on the web site of one of the investigators [Saunders and Samei, Med. Phys. 33, 308-319 (2006)]; and Method C, code developed by two other of the investigators [Samei and Flynn, Med Phy. 30, 608-622, (2003)]. In all cases the differences between the results using Method B and Method A were less than 1%. The differences between Method A and Method C were larger, up to 5.26%. NPS were calculated using Method A and B. The results were very close, with average errors less than 2.5% for exposures of 27.3, 9.3, and 2.7 μGy. Analysis of data for a 10 cm misalignment shows no significant error for either the 250 μ or 1mm edge. The method developed gives results that correlate closely with results obtained from established methods. The software is easy-to-use and flexible in its application. The Edge Tool developed has the necessary precision to accurately determine the MTF values of the system. Further validation of NPS and DQE is ongoing. Tarraf Torfeh, Stéphane Beaumont, JeanPierre Guédon, Nicolas Normand, Eloïse Denis Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65104G (28 March 2007); doi: 10.1117/12.707343 This paper deals with the CT scanner images quality control, which is an important part of the quality control process of the CT scanner, which consists in scan explorations of phantoms that contain different specific patterns1, 2. These methods rely on manual measurements with graphics tools in corresponding images (density, position, length...) or automatic measurements developed in softwares3, 4 that use some masks to determine the region of interest (ROI). The problem of these masks is that they may produce wrong results in case of misalignment of the phantom. We propose a new method that consists, firstly of developing software tools that are capable of performing an automated analysis of CT images of three standard phantoms, LAP5, GEMS6 and CATPHAN6007, in terms of slice thickness, spatial resolution, low and high level contrast, noise and uniformity. The method we have developed is completely automatic because it uses some protocols and special treatments in the images to automatically detect the position and the size of the ROI. Secondly, to test the performances of our software tools, we develop two digital phantoms which reproduce the exact geometry and composition of the physical phantoms, i.e. some perfect CT images of the real phantoms, and a complete set of distorted digital phantoms which represent the "perfect" phantom distorted by noise and blur calibrated functions to test the performances of our automated analysis software. Optimization of image quality and average glandular dose in CR mammography Kimihiko Satoh, Takao Kuwabara, Hiroaki Yasuda, Satoshi Arakawa Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65104H (15 March 2007); doi: 10.1117/12.706781 The concept proposed by EUREF which determines the AGD between upper limit corresponding to the acceptable level of AGD and lower limit corresponding to lower limit of image quality was applied to CR Mammography, and the resulting object thickness tracking and tube voltage tracking were determined. EUREF specifies threshold contrast visibility for a 5 cm of PMMA. In accordance with this definition, the lower limit of CNR for a 5 cm of PMMA was determined by measuring the CNR at the lower limit of AGD which threshold contrast visibility was just acceptable. The obtained lower limit of CNR was then multiplied by the object thickness compensation factor to estimate the lower limits of CNR for all object thicknesses. AGDs are now determined for each lower limit of CNR to obtain thickness tracking and tube voltage tracking characteristics. Although the limited range of examined target/filter combinations and tube voltages should be taken into consideration, these tracking characteristics for constant CNR differ in their profiles from those of a screen-film system with AEC for providing constant optical density. Among our findings, we found that a lower AGD is achievable while maintaining CNR for a thick object when using a combination of target/filter and tube voltage that generates higher X-ray energy compared to the combination given in the EUREF's typical spectra per PMMA thickness (Mo/Rh 32 kV at PMMA 4cm and Rh/Rh 28 kV at PMMA 6 cm, for example). We also found that the thickness tracking characteristics for constant S value behaves similarly to constant CNR under certain conditions of the target/filter combination and tube voltage. Complete MTF evaluation of two cone beam CT systems Ricardo Betancourt Benítez, Ruola Ning, David Conover Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65104I (22 March 2007); doi: 10.1117/12.710187 The Modulation Transfer Function (MTF) of any system is the frequency response to a delta signal. This response is degraded by several factors such as the inherent veiling glare of the detector and the focal spot size among others. Consequently, the MTF has been one of the physical characteristics that are commonly used to quantitatively measure the physical performance of a system. In this article, the MTF of two flat panel detectors (FPD) and of two Cone Beam CT systems is evaluated. First, the MTF of PaxScan 2520 and of PaxScan 4030CB is evaluated. One of the standard techniques to evaluate the MTF of a FPD is by using an edge of a metal with high atomic number. For instance, it has been suggested by IEC 62220-1 to use an opaque edge to evaluate the MTF of a FPD. Yet, it was found that different metals yield slightly different MTF. In this study, the effect of different metals and exposure parameters was studied and analyzed. First, the MTF was evaluated using different kVps and exposures levels. Second, the MTF was evaluated using aluminum edges of different thickness. Third, the MTF was evaluated using the following four different metals: Aluminum, Copper, Steel and Lead. Finally, the MTF obtained previously were compared to the MTF obtained by using a pinhole. In the second part of this study, the MTF of two systems using these two FPDs were also evaluated using different wires, filters and acquisition modes. The preliminary results demonstrate that the MTF is independent of kVp and exposure level. Yet, it is dependent on the material used to evaluate it. Eloïse Denis, Stéphane Beaumont, JeanPierre Guédon, Nicolas Normand, Tarraf Torfeh Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65104J (28 March 2007); doi: 10.1117/12.708193 Conformal radiotherapy helps to deliver an accurate and effective cancer treatment by exactly targeting the tumor. In this purpose, software of the treatment planning system (TPS) compute every geometric parameters of the treatment. It is essential to control the quality of them because the TPS performances are directly connected with the precision on the treated region. The standard method to control them is to use physical test objects (PTOs).1, 2 The use of PTOs introduces uncertainties in the quality assessment because of the CT scan. Another method to assess the quality of these softwares is to use digital test objects (DTOs).3-5 DTOs are exactly known in a continuous and a discrete way. Thus the assessment of the TPS quality can be more accurate and faster. The fact that the DTO characteristics are well known allows to calculate a theoretical result. The comparison of the TPS and this theoretical results leads to a quantitative assessment of the TPS softwares quality. This work presents the control of major quality criteria of digitally reconstructed radiograph (DRR) computation: ray divergence, ray incidence and spatial resolution. Fully automated methods to control these points have been developed. The same criteria have been tested with PTO and the quality assessments by the two methods have been compared. The DTO methods appeared to be much more accurate because computable. Nico Lanconelli, Stefano Rivetti, Paola Golinelli, Raffaele Sansone, Marco Bertolini, Giovanni Borasi Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65104K (15 March 2007); doi: 10.1117/12.710025 Indirect-conversion FFDM systems usually present a lower spatial resolution, with respect to the direct-conversion one. This can put serious issues in mammography, since high resolution is required. Digital software has been developed for restoring the losses in spatial resolution caused by blurring in the scintillation phosphor. GE Senographe DS system gives users the possibility of using such restoration. Basically, a filtering can be performed on the acquired images, by activating the FineView software option. In this work we present a complete characterization of a clinical system, in terms of MTF, NPS, DQE, and contrast-detail analysis. Figures of merit have been calculated on images acquired with and without the FineView software. The effects of the restoration software are investigated, both on image quality parameters, and on contrast-detail visibility. The MTF of the FFDM system is improved when FineView is activated. On the other hand, NPS presents noticeably changes, especially at high frequencies. DQE is fairly independent from the exposure, when FineView filter is not activated, whereas it presents a clear spread over the exposures, when FineView is activated. CDMAM analysis does not show significant differences between images with or without the restoration filter. Besides, the Mo/Mo beam seems to provide slightly better results than the Rh/Rh one. Felix H. Schöfer, Karl Schneider, Christoph Hoeschen Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65104L (15 March 2007); doi: 10.1117/12.709463 Thoracic radiography was simulated making use of a virtual pediatric model created from tomographic data (voxelphantom) of a child eight weeks old. The dataset was scaled down to fit the dimensions of a premature newborn. The simulation allows a quantitative and spatially resolved analysis of the x-ray image generation. The transmission behavior of different anatomical regions present in the voxelphantom was compared to the output of the simulation of a step-like phantom made from aluminum and PMMA. The step like structure of the simulated model can be easily built and statements about its x-ray related behavior can be directly validated by means of experiments. A thin contrast plate was placed on each step to make the determination of dependences e.g. between the applied radiation energy and the contrast to noise ratio possible. Stefano Rivetti, Nico Lanconelli, Marco Bertolini, Giovanni Borasi, Domenico Acchiappati, Aldo Burani M.D. Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65104M (19 March 2007); doi: 10.1117/12.710523 The aim of this study is to determine the performance of a direct CR reader, named "FCR Velocity U Focused Phosphor (FP)". The system is based on a CsBr columnar structured crystal, and the system's read out is based on the "linescan technology" that employs a wide-view CCD. The system's physical performance was tested by means of a quantitative analysis, with calculation of the modulation transfer function (MTF), noise power spectrum (NPS) and detective quantum efficiency (DQE). Image quality was assessed by performing a contrast-detail analysis. The results are compared with those obtained with the well known CR system Fuji FCR XG5000, and the new one Kodak DirectView CR 975. For all the measurements the standard radiation quality RQA-5 was used. The relationship between signal amplitude and entrance air kerma is logarithmic for all the systems and the response functions were used to linearize the images before the MTF (edge method) and NPS calculations. The contrast detail analysis has been achieved by using the well known CDRAD phantom and a customized software designed for automatic computation of the contrast-detail curves. The three systems present similar MTFs, whereas the Fuji Velocity U FP system, thanks to its greater efficiency, has a better behavior in terms of NNPS, especially at low frequencies. That allows the system based on columnar phosphor to provide a better DQE. CDRAD analysis basically confirms that the structured phosphor used in the Velocity system improves the visibility of some details. This is especially true for medium and large details. Michiaki Yamashita, Akemi Yamashita Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65104N (19 March 2007); doi: 10.1117/12.710363 The purpose of this study is to evaluate Slice- sensitive profile on Z-axis (SSPz) at any point in XY plane of multi-slice helical CT (MSCT) by new method that we are proposing. It is very important to understand MSCT physical property to provide high-integrity information and get the best possible images. Quality evaluation around the images has been gaining more importance by needs of proof diversity on evaluation of CT physical property. However, in conventional method of image quality edge of the images, we had some unignorable data variation in every measurement. Considering the development, we assumed that in acquiring helical, the relative position of tube trajectory for the measuring object becomes the problem. Setting the proper scan interval and acquiring the data continuously, we devised the method for property evaluation with controlling tube trajectory. We obtained SSPZ in multiple positions and measured full width at half maximum (FWHM) distribution in axial plane. As a result, we found periodic variation in FWHM especially around the images. The degree of the variation changes depends on helical pitch (HP).If HP is small, the variation is also small, and if HP become larger, the variation also become larger. We figured out the variation in SSPz and FWHM planes through the method that we proposed. How do kV and mAs affect CT lesion detection performance? W. Huda, K. M. Ogden, K. Shah, C. Jadoo, E. M. Scalzetti, R. L. Lavallee, M. L. Roskopf Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65104P (19 March 2007); doi: 10.1117/12.708498 The purpose of this study was to investigate how output (mAs) and x-ray tube voltage (kV) affect lesion detection in CT imaging. An adult Rando phantom was scanned on a GE LightSpeed CT scanner at x-ray tube voltages from 80 to 140 kV, and outputs from 90 to 360 mAs. Axial images of the abdomen were reconstructed and viewed on a high quality monitor at a soft tissue display setting. We measured detection of 2.5 to 12.5 mm sized lesions using a 2 Alternate Forced Choice (2-AFC) experimental paradigm that determined lesion contrast (I) corresponding to a 92% accuracy (I92%) of lesion detection. Plots of log(I92%) versus log(lesion size) were all approximately linear. The slope of the contrast detail curve was ~ -1.0 at 90 mAs, close to the value predicted by the Rose model, but monotonically decreased with increasing mAs to a value of ~ -0.7 at 360 mAs. Increasing the x-ray tube output by a factor of four improved lesion detection by a factor of 1.9 for the smallest lesion (2.5 mm), close to the value predicted by the Rose model, but only by a factor of 1.2 for largest lesion (12.5 mm). Increasing the kV monotonically decreased the contrast detail slopes from -1.02 at 80 kV to -0.71 at 140 kV. Increasing the x-ray tube voltage from 80 to 140 kV improved lesion detection by a factor of 2.8 for the smallest lesion (2.5 mm), but only by a factor of 1.7 for largest lesion (12.5 mm). We conclude that: (i) quantum mottle is an important factor for low contrast lesion detection in images of anthropomorphic phantoms; (ii) x-ray tube voltage has a much greater influence on lesion detection performance than x-ray tube output; (iii) the Rose model only predicts CT lesion detection performance at low x-ray tube outputs (90 mAs) and for small lesions (2.5 mm). Dirk Schäfer, Jens Wiegert, Matthias Bertram Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65104Q (19 March 2007); doi: 10.1117/12.710924 It is well known that rotational C-arm systems are capable of providing 3D tomographic X-ray images with much higher spatial resolution than conventional CT systems. Using flat X-ray detectors, the pixel size of the detector typically is in the range of the size of the test objects. Therefore, the finite extent of the "point" source cannot be neglected for the determination of the MTF. A practical algorithm has been developed that includes bias estimation and subtraction, averaging in the spatial domain, and correction for the frequency content of the imaged bead or wire. Using this algorithm, the wire and the bead method are analyzed for flat detector based 3D X-ray systems with the use of standard CT performance phantoms. Results on both experimental and simulated data are presented. It is found that the approximation of applying the analysis of the wire method to a bead measurement is justified within 3% accuracy up to the first zero of the MTF. Tony Svahn, Mark Ruschin, Bengt Hemdal, Lars Nyhlén, Ingvar Andersson, Pontus Timberg, Sören Mattsson, Anders Tingberg Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65104R (16 March 2007); doi: 10.1117/12.709591 The purpose of this work was to develop a contrast-detail phantom that can be used to evaluate image quality in breast tomosynthesis (BT) and as a first step use it to evaluate in-plane artifacts with respect to object size and contrast. The phantom was constructed using a Polylite® resin as bulk material, as it has x-ray mass attenuation properties similar to poly(methyl methacrylate (PMMA), a common phantom material in mammography. Six different materials - polyoxymethylene (POM), bakelite®, nylon, polycarbonate (PC), acrylonitrilebutadienestyrene (ABS) and polyethene (PE) - were selected to form the phantom details. For each of the six materials, five spherical objects were manufactured (diameters of 4, 8, 12, 16, and 20 mm) resulting in 30 objects that were embedded with their centres approximately aligned at the central plane of a 26 mm thick Polylite® block (210 mm x 300 mm). A 20 mm thick PMMA block was added to yield a phantom with attenuation properties similar to 45 mm PMMA that could simulate a so-called standard breast (50 mm thick, 50% glandular tissue). Images of the phantom were acquired using a BT prototype system that employs filtered backprojection for image reconstruction. The magnitude of the in-plane artifacts was evaluated and was found to increase linearly with increasing contrast (signal) level and size of the embedded objects. The contrast-detail phantom was found to be a useful tool for evaluating BT in-plane artifacts and might also be used to study out-of-plane artifacts and the effect of different acquisition and reconstruction parameters on image quality in BT. R. Gerhard Pratt, Lianjie Huang, Neb Duric, Peter Littrup Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65104S (19 March 2007); doi: 10.1117/12.708789 Waveform tomography results are presented from 800 kHz ultrasound transmission scans of a breast phantom, and from an in vivo ultrasound breast scan: significant improvements are demonstrated in resolution over time-of-flight reconstructions. Quantitative reconstructions of both sound-speed and inelastic attenuation are recovered. The data were acquired in the Computed Ultrasound Risk Evaluation (CURE) system, comprising a 20 cm diameter solid-state ultrasound ring array with 256 active, non-beamforming transducers. Waveform tomography is capable of resolving variations in acoustic properties at sub-wavelength scales. This was verified through comparison of the breast phantom reconstructions with x-ray CT results: the final images resolve variations in sound speed with a spatial resolution close to 2 mm. Waveform tomography overcomes the resolution limit of time-of-flight methods caused by finite frequency (diffraction) effects. The method is a combination of time-of-flight tomography, and 2-D acoustic waveform inversion of the transmission arrivals in ultrasonic data. For selected frequency components of the waveforms, a finite-difference simulation of the visco-acoustic wave equation is used to compute synthetic data in the current model, and the data residuals are formed by subtraction. The residuals are used in an iterative, gradient-based scheme to update the sound-speed and attenuation model to produce a reduced misfit to the data. Computational efficiency is achieved through the use of time-reversal of the data residuals to construct the model updates. Lower frequencies are used first, to establish the long wavelength components of the image, and higher frequencies are introduced later to provide increased resolution. Hongwei Ye, Andrzej Krol, Edward D. Lipson, Yao Lu, Yuesheng Xu, Wei Lee, David H. Feiglin Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65104T (16 March 2007); doi: 10.1117/12.709560 In order to improve tomographically reconstructed image quality, we have implemented a fully 3D reconstruction, using an ordered subsets expectation maximization (OSEM) algorithm for fan-beam collimator (FBC) SPECT, along with a volumetric system model-fan-volume system model (FVSM), a modified attenuation compensation, a 3D depth- and angle-dependent resolution and sensitivity correction, and a 3D total variation (TV) regularization. SPECT data were acquired in a 128x64 matrix, in 120 views with a circular orbit. The numerical Zubal brain phantom was used to simulate a FBC HMPAO Tc-99m brain SPECT scan, and a low noise and scatter-free projection dataset was obtained using the SimSET Monte Carlo package. A SPECT scan for a mini-Defrise phantom and brain HMPAO SPECT scans for five patients were acquired with a triple-head gamma camera (Triad 88) equipped with a low-energy high-resolution (LEHR) FBC. The reconstructed images, obtained using clinical filtered back projection (FBP), OSEM with a line-length system model (LLSM) and 3D TV regularization, and OSEM with FVSM and 3D TV regularization were quantitatively studied. Overall improvement in the image quality has been observed, including better axial and transaxial resolution, better integral uniformity, higher contrast-to-noise ration between the gray matter and the white matter, and better accuracy and lower bias in OSEM-FVSM, compared with OSEM-LLSM and clinical FBP. Hybrid geodesic region-based curve evolutions for image segmentation Shawn Lankton, Delphine Nain, Anthony Yezzi, Allen Tannenbaum Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65104U (16 March 2007); doi: 10.1117/12.709700 In this paper we present a gradient descent flow based on a novel energy functional that is capable of producing robust and accurate segmentations of medical images. This flow is a hybridization of local geodesic active contours and more global region-based active contours. The combination of these two methods allows curves deforming under this energy to find only significant local minima and delineate object borders despite noise, poor edge information, and heterogeneous intensity profiles. To accomplish this, we construct a cost function that is evaluated along the evolving curve. In this cost, the value at each point on the curve is based on the analysis of interior and exterior means in a local neighborhood around that point. We also demonstrate a novel mathematical derivation used to implement this and other similar flows. Results for this algorithm are compared to standard techniques using medical and synthetic images to demonstrate the proposed method's robustness and accuracy as compared to both edge-based and region-based alone. Béatrice Perrenot, Régis Vaillant, Rémy Prost, Gérard Finet, Philippe Douek, Françoise Peyrin Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65104V (28 March 2007); doi: 10.1117/12.706097 Percutaneous coronary angioplasty consists in conducting a guidewire carrying a balloon and a stent through the lesion and deploying the stent by balloon inflation. A stent is a small 3D complex mesh hardly visible in X-ray images : the control of stent deployment is difficult although it is important to avoid post intervention complications. In a previous work, we proposed a method to reconstruct 3D stent images from a set of 2D cone-beam projections acquired in rotational acquisition mode. The process involves a motion compensation procedure based on the position of two markers located on the guidewire in the 2D radiographic sequence. Under the hypothesis that the stent and markers motions are identical, the method was shown to generate a negligible error. If this hypothesis is not fulfilled, a solution could be to use only the images where motion is weakest, at the detriment of having a limiter number of views. In this paper, we propose a simulation based study of the impact of a limited number of views in our context. The chain image involved in the acquisition of X-ray sequences is first modeled to simulate realistic noisy projections of stent animated by a motion close to cardiac motion. Then, the 3D stent images are reconstructed using the proposed motion compensation method from gated projections. Two gating strategies are examined to select projection in the sequences. A quantitative analysis is carried out to assess reconstruction quality as a function of noise and acquisition strategy. Junhai Wen, Lingkai Kong Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65104W (19 March 2007); doi: 10.1117/12.708923 SPECT (single photon emission computed tomography) is a tomography technique that can greatly show information about the metabolic activity in body and improve clinical diagnosis. In SPECT, because of photoelectric absorption and Compton scattering, the emitted gamma photons are attenuated inside the body before arriving at the detector. The goal of quantitative SPECT reconstruction is to obtain an accurate reconstructed image of the radioactivity distribution in the interested area of a human body, so the compensation for non-uniform attenuation is necessary in the quantitative SPECT reconstruction. In this paper, based on the explicit inversion formula for the attenuated Radon transform discovered by R. Novikov, we present a wavelet based SPECT reconstruction algorithm with non-uniform attenuation. We know that the wavelet transform has characteristics of multi-resolution analysis and localized analysis, and these characteristics can be applied to de-noising and localized reconstruction. Simulation results show that our wavelet based SPECT reconstruction algorithm is accurate. Baojun Li, Gopal Avinash, Bernhard Claus, Stephen Metz Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65104X (28 March 2007); doi: 10.1117/12.708084 Cone-beam filtered backprojection (CB-FBP) is one of the major reconstruction algorithms for digital tomosynthesis. In conventional FBP, the photon fluxes in projections are evenly distributed along the X-ray beam. Due to the limited view angles and finite detector dimensions, this uniform weighting causes non-uniformity in the recon images and leads to cone-beam artifact. In this paper, we propose a 3-D view weighting technique in combination with FBP to combat this artifact. An anthropomorphic chest phantom was placed at supine position to enable the imaging of chest PA view. During a linear sweep of X-ray source, 41 X-ray images at different projection angles were acquired with the following protocol: 120kVp, 160mA, and 0.64mAs/exposure. To create the worst scenario for testing, we chose 60 degrees as the sweep angle in this exam. The data set was reconstructed with conventional CB-FBP and proposed algorithm under the same parameters: FOV = 40x40 cm^2, and slice thickness = 4mm. 3 recon slices were randomly selected for review with slice height = 10.5/14.5/17.5cm. Results were assessed qualitatively by human observation and quantitatively through ROI measurement. In each slice, three pre-defined ROIs (50x50 pixels)--ROI A and B are in artifact more pronounced area, and ROI C is in relatively artifact-free area--are extracted and measured. The non-uniformity error was defined as the ratio of MEAN(AVG(C-A), AVG(C-B)) / AVG(C). The average non-uniformity error over the three test images was 0.428 for without view weighting and only 0.041 for with view weighting. Automatic generation of 3D coronary artery centerlines Uwe Jandt, Dirk Schäfer, Volker Rasche, Michael Grass Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65104Y (19 March 2007); doi: 10.1117/12.708941 A fully automated 3D centerline modeling algorithm for coronary arteries is presented. It utilizes a subset of standard rotational X-Ray angiography projections that correspond to a single cardiac phase. The projection selection is based on a simultaneously recorded electrocardiogram (ECG). The algorithm utilizes a region growing approach, which selects voxels in 3D space that most probably belong to the vascular structure. The local growing speed is controlled by a 3D response computation algorithm. This algorithm calculates a measure for the probability of a point in 3D to belong to a vessel or not. Centerlines of all detected vessels are extracted from the 3D representation built during the region growing and linked in a hierarchical manner. The centerlines representing the most significant vessels are selected by a geometry-based weighting criterion. The theoretically achievable accuracy of the algorithm is evaluated on simulated projections of a virtual heart phantom. It is capable of extracting coronary centerlines with an accuracy that is mainly limited by projection and volume quantization (0.25 mm). The algorithm needs at least 3 projections for modeling, while in the phantom study, 5 projections are sufficient to achieve the best possible accuracy. It is shown that the algorithm is reasonably insensitive to residual motion, which means that it is able to cope with inconsistencies within the projection data set caused by finite gating accuracy, respiration or irregular heart beats. Its practical feasibility is demonstrated on clinical cases showing automatically generated models of left and right coronary arteries (LCA/RCA). Cone beam CT image quality measurements: PSF de-convolution Ricardo Betancourt Benítez, Ruola Ning, David Conover Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65104Z (16 March 2007); doi: 10.1117/12.710215 The Modulation Transfer Function (MTF) of any system is the frequency response to a delta signal. Ideally, this response should be a step function for a flat panel detector (FPD); it should be one for frequencies less than the Nyquist frequency and zero for frequencies above. Yet, this response is degraded by several factors such as the veiling glare of the detector and the focal spot size. Consequently, the MTF has been one of the physical characteristics that are commonly used to quantitatively measure the physical performance of a system. One of the standard techniques to evaluate the MTF is by using an edge of a metal with a high atomic number. For instance, it has been suggested by IEC 62220-1 to use an opaque edge to evaluate the MTF of FPDs. In a previous study, it was found that different metals yield slightly different MTF. The effects of these slightly different MTFs on image quality were investigated. The evaluation of the MTFs of a PaxScan 4030CB and PaxScan 2520 from a previous study were used in this study. A ball, a cylindrical water phantom, a breast phantom, a living mouse and three breasts of patients from a pilot study were analyzed for improvements in image quality after PSF deconvolution post-processing. The results of this study suggest that the detector's MTF de-convolution post-processing achieved a CNR's increase while it also enhanced the edges and uniformity. Kenny Israni, Gopal Avinash, Baojun Li Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651050 (19 March 2007); doi: 10.1117/12.709493 In digital tomosynthesis, one of the limitations is the presence of out-of-plane blur due to the limited angle acquisition. The point spread function (PSF) characterizes blur in the imaging volume, and is shift-variant in tomosynthesis. The purpose of this research is to classify the tomosynthesis imaging volume into four different categories based on PSF-driven focus criteria. We considered linear tomosynthesis geometry and simple back projection algorithm for reconstruction. The three-dimensional PSF at every pixel in the imaging volume was determined. Intensity profiles were computed for every pixel by integrating the PSF-weighted intensities contained within the line segment defined by the PSF, at each slice. Classification rules based on these intensity profiles were used to categorize image regions. At background and low-frequency pixels, the derived intensity profiles were flat curves with relatively low and high maximum intensities respectively. At in-focus pixels, the maximum intensity of the profiles coincided with the PSF-weighted intensity of the pixel. At out-of-focus pixels, the PSF-weighted intensity of the pixel was always less than the maximum intensity of the profile. We validated our method using human observer classified regions as gold standard. Based on the computed and manual classifications, the mean sensitivity and specificity of the algorithm were 77+/-8.44% and 91+/-4.13% respectively (t=-0.64, p=0.56, DF=4). Such a classification algorithm may assist in mitigating out-of-focus blur from tomosynthesis image slices. A practical correction of scatter-related artifacts in SPECT reconstruction Hongwei Ye, Andrzej Krol, Edward D. Lipson, Vikram R. Kunniyur, Wei Lee, David H. Feiglin Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651051 (16 March 2007); doi: 10.1117/12.710301 We have observed that an expectation maximization (EM) algorithm applied to SPECT reconstruction may produce hotspot artifacts of varying intensity. Our hypothesis was that scatter caused these artifacts. To test this assumption, we studied the performance of forward- and back-projection procedures in the EM algorithm for simulated and experimental SPECT data. First, synthetic scatter-free projections and projections with only one scattered photon in each view were created for a simulated simple object, and reconstructed with a fully 3D ordered-subsets EM (OSEM) algorithm. Then, Monte Carlo simulated brain SPECT (with no scatter and with scatter present), a mini-Defrise phantom, and patient SPECT were reconstructed. We confirmed our hypothesis: hot-spot artifacts appeared only in the reconstruction from noisy projections but not in the reconstruction from scatter-free projections. We investigated a practical and simple method, critical path-length control (CPLC), for suppression of the hot-spot artifacts. To this end we performed reconstructions with or without CPLC and quantitatively evaluated the results including estimation of accuracy, bias, contrast-to-noise ratio, and uniformity. We found that the OSEM-with-CPLC method significantly reduced hot-spot artifacts, and yielded a similar or improved image quality. We conclude that the CPLC method provides a useful yet simple tool to reduce scatter-related hot-spot artifacts. Statistics of MR signals: revisited Tianhu Lei Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651052 (19 March 2007); doi: 10.1117/12.709388 A common view in MRI research is that the object variability of MR signals is negligible. With this recognition, the signal components of MR signals are treated as constant and the noise components are studied as random processes. Because signal components of MR signals represent a collective behavior of a huge mount of spins, a statistical investigation may provide a better understanding of MR signals. The work reported in this paper first investigates statistics of the thermal equilibrium bulk magnetization (TEMM) which is the quantity to be imaged - one that can be measured and actually observed in MRI. Then it investigates statistics of the transverse precessing bulk magnetization (TPMM) which introduce an electromagnetic force in the receiver coil of MRI. Finally this study investigates statistics of signal components of three MR signals at the different stages of MR signal detection module: Free Induction Decay (FID), Phase Sensitive Detection (PSD), and Analog-to-Digital Conversion (ADC), sequentially. k-space sample is a reformatted ADC signal. The study derives and proves stochastic models for TEMM, TPMM, FID, PSD, and ADC signals, also proposes and justifies stochastic models for homogeneous and inhomogeneous samples. The study shows that under the normal conditions and the ordinary settings, magnetizations can be characterized as spatially deterministic processes with Probability one, and MR signals - signal component plus noise component - can be characterized as temporal Gaussian random processes with the means of signal components and the variances of noise components. These means are expressed in closed forms in terms of parameters of MR imaging system and the samples. The derived statistical properties of MR signals will serve as the basis for evaluating performances of imaging system and studying statistics of the MR image. A posteriori respiratory motion compensation for PET imaging Clovis Tauber, Zehor Ouksili, Julia Nallis, Hadj Batatia, Olivier Caselles, Frederic Courbon Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651053 (19 March 2007); doi: 10.1117/12.707915 This paper deals with enhancing the formation of PET images. Physiological motion, such as breathing, may cause significant alteration of image quality. Correction methods include gated acquisitions that significantly increase the acquisition time. In this paper we propose an original method for reducing respiratory motion artefacts in PET images. It is based on synchronous acquisition of PET and CT data with a spirometer. CT images are acquired at each step of a subdivided respiratory cycle, and registered to estimate the body transformations. Then PET data is indirectly registered and corrected for attenuation before reconstructing a PET image with enhanced quality. This method has been validated using a specific phantom experimentation. Results show that the method brings improved accuracy in tumour volume representation. In addition, the PET imaging clinical protocol is unchanged: our method does not increase the acquisition time nor constrain the patient breathing. Samuel J. LaRoque, Emil Y. Sidky, Xiaochuan Pan Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651054 (16 March 2007); doi: 10.1117/12.710240 We present a method for obtaining accurate image reconstruction from sparsely sampled magnetic resonance imaging (MRI) data obtained along spiral trajectories in Fourier space. This method minimizes the total variation (TV) of the estimated image, subject to the constraint that the Fourier transform of the image matches the known samples in Fourier space. Using this method, we demonstrate accurate image reconstruction from sparse Fourier samples. We also show that the algorithm is robust to the effects of measurement noise. Reconstruction from such sparse sampling should reduce scan times, improving scan quality through reduction of motion-related artifacts and allowing more rapid evaluation of time-critical conditions such as stroke. Although our results are discussed in the context of two-dimensional MRI, they are directly applicable to higher dimensional imaging and to other sampling patterns in Fourier space. Seungryong Cho, Xiaochuan Pan Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651055 (16 March 2007); doi: 10.1117/12.713237 We compared data requirements of filtered-backprojection (FBP) and backprojection-filtration (BPF) algorithms based on PI-lines in helical cone-beam CT. Since the filtration process in FBP algorithm needs all the projection data of PI-lines for each view, the required detector size should be bigger than the size that can cover Tam-Danielsson (T-D) window to avoid data truncation. BPF algorithm, however, requires the projection data only within the T-D window, which means smaller detector size can be used to reconstruct the same image than that in FBP. In other words, a longer helical pitch can be obtained by using BPF algorithm without any truncation artifacts when a fixed detector size is given. The purpose of the work is to demonstrate numerically that extended volume coverage in helical cone-beam CT by using PI-line-based BPF algorithm can be achieved. Olivier Bockenbach, Michael Knaup, Marc Kachelrieß Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651056 (19 March 2007); doi: 10.1117/12.709238 Tomographic image reconstruction is computationally very demanding. In all cases the backprojection represents the performance bottleneck due to the high operational count and due to the high demand put on the memory subsystem. In the past, solving this problem has lead to the implementation of specific architectures, connecting Application Specific Integrated Circuits (ASICs) or Field Programmable Gate Arrays (FPGAs) to memory through dedicated high speed busses. More recently, there have also been attempt to use Graphic Processing Units (GPUs) to perform the backprojection step. Originally aimed at the gaming market, IBM, Toshiba and Sony have introduced the Cell Broadband Engine (CBE) processor, often considered as a multicomputer on a chip. Clocked at 3 GHz, the Cell allows for a theoretical performance of 192 GFlops and a peak data transfer rate over the internal bus of 200 GB/s. This performance indeed makes the Cell a very attractive architecture for implementing tomographic image reconstruction algorithms. In this study, we investigate the relative performance of a perspective backprojection algorithm when implemented on a standard PC and on the Cell processor. We compare these results to the performance achievable with FPGAs based boards and high end GPUs. The cone-beam backprojection performance was assessed by backprojecting a full circle scan of 512 projections of 1024x1024 pixels into a volume of size 512x512x512 voxels. It took 3.2 minutes on the PC (single CPU) and is as fast as 13.6 seconds on the Cell. Image reconstruction from rebinned helical cone-beam projection data Dan Xia, Lifeng Yu, Junguo Bian, Xiaochuan Pan Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651057 (19 March 2007); doi: 10.1117/12.713720 In this work, we introduced an algorithm for image reconstruction in helical cone-beam CT based upon the backprojection-filtration (BPF) algorithm. This algorithm is a backprojection-filtration-type algorithm that reconstructs images from rebinned data. It retains the properties of the original BPF algorithm in that it requires minimum data and can reconstruct ROI images from truncated data. More importantly, due to the elimination of the spatially-variant weighting factor in the backprojection, it may improve the noise properties in reconstructed images. We have performed computer-simulation studies to investigate the ROI-image reconstruction and noise properties of this algorithm, and the quantitative results verify and demonstrate the proposed algorithm. Holger Scherl, Mario Koerner, Hannes Hofmann, Wieland Eckert, Markus Kowarschik, Joachim Hornegger Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651058 (19 March 2007); doi: 10.1117/12.708754 In most of today's commercially available cone-beam CT scanners, the well known FDK method is used for solving the 3D reconstruction task. The computational complexity of this algorithm prohibits its use for many medical applications without hardware acceleration. The brand-new Cell Broadband Engine Architecture (CBEA) with its high level of parallelism is a cost-efficient processor for performing the FDK reconstruction according to the medical requirements. The programming scheme, however, is quite different to any standard personal computer hardware. In this paper, we present an innovative implementation of the most time-consuming parts of the FDK algorithm: filtering and back-projection. We also explain the required transformations to parallelize the algorithm for the CBEA. Our software framework allows to compute the filtering and back-projection in parallel, making it possible to do an on-the-fly-reconstruction. The achieved results demonstrate that a complete FDK reconstruction is computed with the CBEA in less than seven seconds for a standard clinical scenario. Given the fact that scan times are usually much higher, we conclude that reconstruction is finished right after the end of data acquisition. This enables us to present the reconstructed volume to the physician in real-time, immediately after the last projection image has been acquired by the scanning device. Fast arbitrary-slice CT reconstruction with GPUs Jakob Nebeker, Thomas R. Nelson, John M. Boone Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651059 (22 March 2007); doi: 10.1117/12.708342 Volume data reconstruction from cone-beam projections can be time consuming, typically reconstructing parallel axial slices. We present a system for performing fast, arbitrary-orientation CT slice reconstruction using commodity graphics processing units (GPUs). For 1024x1024 voxel slice reconstruction we have achieved a 89-fold performance improvement over a CPU implementation with comparable image quality. Xiangyang Tang, Jiang Hsieh Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105A (16 March 2007); doi: 10.1117/12.709716 In clinical applications, CT images are acquired in both helical and axial scans. In general, a helical scan can provide better image quality and faster patient throughput, and thus is performed more frequently in clinic. However, the first and last images in a helical scan are usually prescribed at the locations that are half helical turn indented from the starting and ending points of the scan. Hence, due to image location indention, the dose efficiency of helical scanning is usually not as good as that of axial scan in which no image location indention exists. With increasing detector dimension along z-direction, the dose efficiency difference between helical and axial scans is becoming more significant, particularly at relatively small helical pitches. To match the dose efficiency of helical scan with axial scan as much as possible, a hybrid helical CB-FBP algorithm is presented to reconstruct helical images beyond the conventional indented image zone. The hybrid algorithm is actually a combination of the ray-wise 3D weighted CB-FBP algorithms that are previously proposed for helical and axial CB image reconstructions, in which the ray-wise 3D weighting becomes dependent on both helical pitch and image plane location. Phantom study shows that the conventional indented image zone in helical scan can be extended substantially by using the presented algorithm. Consequently, the dose efficiency in volumetric CT in helical scan can be improved significantly, especially in clinical applications where the helical pitch is relatively low. With increasing dose discrepancy between helical and axial scans, the presented algorithm will become more attractive in clinical applications. Sergio S. Furuie, Alvaro R. de Pierro, Nelson A. Mascarenhas, Jose C. Meneghetti Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105B (19 March 2007); doi: 10.1117/12.708278 Quantitative tomographic reconstruction based on positron emission (PET) requires attenuation correction on projections. The objective of this work is to analyze an algorithm for attenuation estimation that is used simultaneously with activity reconstruction (PET-AA) based only on emission data. The focus is on measurement of crosstalk effects on activity due to non-uniform attenuation. The derived algorithms are based on maximization of likelihood, but using minorization function approach. The activity estimator turned out to be the same as EM-ML for attenuated projections. On the other hand, the proposed algorithm for attenuation is simple and, basically, corrects the previous estimation of attenuation in a voxel by the ratio between the backprojection of estimated projections and backprojection of measured projections. Preliminary assessments were carried out via tridimensional phantoms with non-uniform attenuation emulating 3D PET with and without noise. Individually, the algorithms for attenuation and activity presented very good results with negligible crosstalk and global reconstruction error less than 2% for noiseless projections. For the case of simultaneous estimation, even without noise, the crosstalks in estimating activity and attenuation are significant (-0.223 ± 0.051) yielding global errors for activity between 10% and 20%. With noise, the error increased to 36% and the crosstalk to (-0.688 ± 0.139). The proposed algorithm for attenuation estimation presents encouraging behavior and the results confirm the necessity of methodologies to deal with crosstalk effects in PET-AA. Samuel R. Mazin, Norbert J. Pelc Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105C (16 March 2007); doi: 10.1117/12.708961 Inverse-geometry CT (IGCT) employs a large area x-ray source array opposite a small area detector array. The system is expected to provide sub-second volumetric imaging with isotropic resolution and no cone-beam effects. Due to the large amount of data, it is desirable to have an exact 3D reconstruction algorithm that is fast. Currently known IGCT algorithms are either slow, due to 3D backprojection, and/or require a reprojection step, or are inexact. Defrise et al. developed an exact Fourier rebinning algorithm (FORE-J) for 3D PET. This algorithm first rebins the 3D PET data into in-plane sinograms and then reconstructs the series of axial slices using any 2D method. FORE-J is fast, exact, and efficiently uses all of the acquired PET data. We modified this algorithm to adapt it to the IGCT geometry. Experiments were performed using a numerical "Defrise" phantom consisting of high-intensity discs spaced in z to assess the accuracy of the modified algorithm as well as highlight any cone-beam effects. A noise simulation was performed to analyze the noise properties of FORE-J and the modified algorithm. The modified algorithm is very fast and slightly more accurate than the original algorithm with a very small noise penalty in the central axial slices. Implementation of the circle-and-line algorithm for 256-detector row CT A. A. Zamyatin, B. Chiang, A. Katsevich, S. Nakanishi, M. D. Silver Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105D (19 March 2007); doi: 10.1117/12.713779 In this work we apply the circle-and-line acquisition for the 256-detector row medical CT scanner. Reconstruction is based on the exact algorithm of the FBP type suggested recently by one of the co-authors. We derived equations for the cylindrical detector, common for medical CT scanners. To minimize hardware development efforts we use ramp-based reconstruction of the circle data. The line data provides an additional term that corrects the cone beam artifacts that are caused by the incompleteness of the circular trajectory. We illustrate feasibility of our approach using simulated data and real scanned data of the anthropomorphic phantom and evaluate stability of reconstruction to motion and misalignments during the scan. The additional patient dose from the line scan is relatively low compared to the circle scan. The proposed algorithm allows cone beam artifact-free reconstruction with large cone angle. Holger Kunze, Wolfgang Härer, Karl Stierstorfer Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105E (28 March 2007); doi: 10.1117/12.707349 Iterative reconstruction methods possess many advantages over analytical reconstruction methods especially if constraints can be used to regularize the reconstruction. However the main problem of iterative reconstruction algorithms is to decide when to stop the iteration. For the Simultaneous Iterative Reconstruction Technique (SIRT) without constraints we derived a mathematical formula with which the quality of the reconstruction after a given number of iterations can be calculated. The image quality is expressed here by a special filter kernel for a FBP reconstruction which creates images with the same sharpness and noise properties as SIRT.

Further on the formula can be used to analyze the numerical stability of a certain implementation of SIRT. Experiments show the validity of these "iteration-equivalent"-kernels with respect to sharpness and noise properties of the reconstructed images. Neophytos Neophytou, Fang Xu, Klaus Mueller Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105F (16 March 2007); doi: 10.1117/12.710445 Three-dimensional computed tomography (CT) is a compute-intensive process, due to the large amounts of source and destination data, and this limits the speed at which a reconstruction can be obtained. There are two main approaches to cope with this problem: (i) lowering the overall computational complexity via algorithmic means, and/or (ii) running CT on specialized high-performance hardware. Since the latter requires considerable capital investment into rather inflexible hardware, the former option is all one has typically available in a traditional CPU-based computing environment. However, the emergence of programmable commodity graphics hardware (GPUs) has changed this situation in a decisive way. In this paper, we show that GPUs represent a commodity high-performance parallel architecture that resonates very well with the computational structure and operations inherent to CT. Using formal arguments as well as experiments we demonstrate that GPU-based 'brute-force' CT (i.e., CT at regular complexity) can be significantly faster than CPU-based as well as GPU-based CT with optimal complexity, at least for practical data sizes. Therefore, the answer to the title question: "Can GPU-based processing beat complexity optimization for CT?" is "Absolutely!" Michael S. Vaz, Yuri Sneyders, Matthew McLin, Alan Ricker, Tom Kimpe Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105G (28 March 2007); doi: 10.1117/12.710485 We present performance and quality analysis of GPU accelerated FDK filtered backprojection for cone beam computed tomography (CBCT) reconstruction. Our implementation of the FDK CT reconstruction algorithm does not compromise fidelity at any stage and yields a result that is within 1 HU of a reference C++ implementation. Our streaming implementation is able to perform reconstruction as the images are acquired; it addresses low latency as well as fast throughput, which are key considerations for a "real-time" design. Further, it is scaleable to multiple GPUs for increased performance. The implementation does not place any constraints on image acquisition; it works effectively for arbitrary angular coverage with arbitrary angular spacing. As such, this GPU accelerated CT reconstruction solution may easily be used with scanners that are already deployed. We are able to reconstruct a 512 x 512 x 340 volume from 625 projections, each sized 1024 x 768, in less than 50 seconds. The quoted 50 second timing encompasses the entire reconstruction using bilinear interpolation and includes filtering on the CPU, uploading the filtered projections to the GPU, and also downloading the reconstructed volume from GPU memory to system RAM. A fast and high-quality cone beam reconstruction pipeline using the GPU Thomas Schiwietz, Supratik Bose, Jonathan Maltz, Rüdiger Westermann Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105H (16 March 2007); doi: 10.1117/12.707598 Cone beam scanners have evolved rapidly in the past years. Increasing sampling resolution of the projection images and the desire to reconstruct high resolution output volumes increases both the memory consumption and the processing time considerably. In order to keep the processing time down new strategies for memory management are required as well as new algorithmic implementations of the reconstruction pipeline. In this paper, we present a fast and high-quality cone beam reconstruction pipeline using the Graphics Processing Unit (GPU). This pipeline includes the backprojection process and also pre-filtering and post-filtering stages. In particular, we focus on a subset of five stages, but more stages can be integrated easily. In the pre-filtering stage, we first reduce the amount of noise in the acquired projection images by a non-linear curvature-based smoothing algorithm. Then, we apply a high-pass filter as required by the inverse Radon transform. Next, the backprojection pass reconstructs a raw 3D volume. In post-processing, we first filter the volume by a ring artifact removal. Then, we remove cupping artifacts by our novel uniformity correction algorithm. We present the algorithm in detail. In order to execute the pipeline as quickly as possible we take advantage of GPUs that have proven to be very fast parallel processors for numerical problems. Unfortunately, both the projection images and the reconstruction volume are too large to fit into 512 MB of GPU memory. Therefore, we present an efficient memory management strategy that minimizes the bus transfer between main memory and GPU memory. Our results show a 4 times performance gain over a highly optimized CPU implementation using SSE2/3 commands. At the same time, the image quality is comparable to the CPU results with an average per pixel difference of 10-5. Oleg Tischenko, Yuan Xu, Christoph Hoeschen Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105I (16 March 2007); doi: 10.1117/12.711421 The tomographic method based on the orthogonal polynomial expansion on disc (OPED) was presented at SPIE conference of Medical Imaging 2006. We could show already some advantages compared to FBP as it is commonly used in today's CT systems. However, OPED did show for some specific cases some noise in the reconstructed images and even artefacts, mainly an aliasing. We have found that the OPED algorithm can be essentially improved by integrating the polynomial over the whole area belonging to the pixel instead of assigning to the whole pixel the polynomial value calculated just for one point of this pixel (typically bottom left). This advantageous implementation is effective in view of reduction of the aliasing artefacts and noise without affecting the resolution. This can be fulfilled effectively for OPED due to its simple structure. Junyi Xia, Yunmei Chen, Sanjiv S. Samant Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105J (19 March 2007); doi: 10.1117/12.713693 Fast deformable registration can potentially facilitate the clinical implementation of adaptive radiation therapy (ART), which allows for daily organ deformations not accounted for in radiotherapy treatment planning, which typically utilizes a static organ model, to be incorporated into the fractionated treatment. Existing deformable registration algorithms typically utilize a specific diffusion model, and require a large number of iterations to achieve convergence. This limits the online applications of deformable image registration for clinical radiotherapy, such as daily patient setup variations involving organ deformation, where high registration precision is required. We propose a hybrid algorithm, the "Juggler", based on a multi-diffusion model to achieve fast convergence. The Juggler achieves fast convergence by applying two different diffusion models: i) one being optimized quickly for matching high gradient features, i.e. bony anatomies; and ii) the other being optimized for further matching low gradient features, i.e. soft tissue. The regulation of these 2 competing criteria is achieved using a threshold of a similarity measure, such as cross correlation or mutual information. A multi-resolution scheme was applied for faster convergence involving large deformations. Comparisons of the Juggler algorithm were carried out with demons method, accelerated demons method, and free-form deformable registration using 4D CT lung imaging from 5 patients. Based on comparisons of difference images and similarity measure computations, the Juggler produced a superior registration result. It achieved the desired convergence within 30 iterations, and typically required Metal artifacts correction in cone-beam CT bone imaging Yan Zhang, Ruola Ning, David Conover Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105K (16 March 2007); doi: 10.1117/12.710165 Cone-beam CT (CBCT) technique is needed by orthopaedists in their new studies to monitor bone volume growth and blood vessel growth of structural bone grafts used in reconstruction surgery. However, titanium plate and screws, which are commonly used to connect bone grafts to host bones, can cause severe streaking artifacts and shading artifact in the reconstructed images due to their high attenuation of x-rays. These metal artifacts will distort the information of the bone and cause difficulties when measuring bone volume growth and the inside blood vessel growth. To solve this problem and help orthopaedists quantitatively record the growth of bone grafts, we present a three-dimensional metal artifact correction technique to correct the streaking artifacts generated by titanium implants. In this project not only the artifacts need to be corrected but also the correct information of the bone is required in the image for the quantitative measurements. Both phantom studies and animal studies were conducted to test this correction method. Images without metal correction and images with metal correction were compared together, as well as the reference bone images acquired without metal. It's shown the streaking and shading artifacts were greatly reduced after metal correction. The accuracy of bone volume measurements was also greatly increased by 79% for phantom studies and 53% for animal studies. Lu Jiang, Khan Siddiqui M.D., Bin Zhu, Yang Tao, Eliot Siegel M.D. Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105L (19 March 2007); doi: 10.1117/12.711631 During the last decade, x-ray computed tomography (CT) has been applied to screen large asymptomatic smoking and nonsmoking populations for early lung cancer detection. Because a larger population will be involved in such screening exams, more and more attention has been paid to studying low-dose, even ultra-low-dose x-ray CT. However, reducing CT radiation exposure will increase noise level in the sinogram, thereby degrading the quality of reconstructed CT images as well as causing more streak artifacts near the apices of the lung. Thus, how to reduce the noise levels and streak artifacts in the low-dose CT images is becoming a meaningful topic. Since multi-slice helical CT has replaced conventional stop-and-shoot CT in many clinical applications, this research mainly focused on the noise reduction issue in multi-slice helical CT. The experiment data were provided by Siemens SOMATOM Sensation 16-Slice helical CT. It included both conventional CT data acquired under 120 kvp voltage and 119 mA current and ultra-low-dose CT data acquired under 120 kvp and 10 mA protocols. All other settings are the same as that of conventional CT. In this paper, a nonparametric smoothing method with thin plate smoothing splines and the roughness penalty was proposed to restore the ultra-low-dose CT raw data. Each projection frame was firstly divided into blocks, and then the 2D data in each block was fitted to a thin-plate smoothing splines' surface via minimizing a roughness-penalized least squares objective function. By doing so, the noise in each ultra-low-dose CT projection was reduced by leveraging the information contained not only within each individual projection profile, but also among nearby profiles. Finally the restored ultra-low-dose projection data were fed into standard filtered back projection (FBP) algorithm to reconstruct CT images. The rebuilt results as well as the comparison between proposed approach and traditional method were given in the results and discussions section, and showed effectiveness of proposed thin-plate based nonparametric regression method. Jongduk Baek, Norbert J. Pelc Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105M (19 March 2007); doi: 10.1117/12.709027 An inverse-geometry volumetric CT (IGCT) system uses a large source array opposite a smaller detector array. Conventional 2D IGCT reconstruction is performed by using gridding. We describe a 2D IGCT reconstruction algorithm without gridding. The IGCT raw data can be viewed as being composed of many fan beams, each with a detector at its focus. Each projection is undersampled but the missing samples are provided by other views. In order to get high spatial resolution, zeros are inserted between acquired projection samples in each fan beam, and reconstruction is performed using a direct fan beam reconstruction algorithm. Initial IGCT reconstruction results showed ringing artifacts caused by fact that the rho samples in the ensemble of views are not equally spaced. We present a new method for correcting the errors that reduces the artifacts to below one Hounsfield Unit FFT and cone-beam CT reconstruction on graphics hardware Philippe Després, Mingshan Sun, Bruce H. Hasegawa, Sven Prevrhal Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105N (16 March 2007); doi: 10.1117/12.709994 Graphics processing units (GPUs) are increasingly used for general purpose calculations. Their pipelined architecture can be exploited to accelerate various parallelizable algorithms. Medical imaging applications are inherently well suited to benefit from the development of GPU-based computational platforms. We evaluate in this work the potential of GPUs to improve the execution speed of two common medical imaging tasks, namely Fourier transforms and tomographic reconstructions. A two-dimensional fast Fourier transform (FFT) algorithm was GPU-implemented and compared, in terms of execution speed, to two popular CPU-based FFT routines. Similarly, the Feldkamp, David and Kress (FDK) algorithm for cone-beam tomographic reconstruction was implemented on the GPU and its performance compared to a CPU version. Different reconstruction strategies were employed to assess the performance of various GPU memory layouts. For the specific hardware used, GPU implementations of the FFT were up to 20 times faster than their CPU counterparts, but slower than highly optimized CPU versions of the algorithm. Tomographic reconstructions were faster on the GPU by a factor up to 30, allowing 2563 voxel reconstructions of 256 projections in about 20 seconds. Overall, GPUs are an attractive alternative to other imaging-dedicated computing hardware like application-specific integrated circuits (ASICs) and field programmable gate arrays (FPGAs) in terms of cost, simplicity and versatility. With the development of simpler language extensions and programming interfaces, GPUs are likely to become essential tools in medical imaging. Xiangyang Tang, Jiang Hsieh Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105O (16 March 2007); doi: 10.1117/12.709805 With an accelerated pace the CT technology has achieved the latest milestone - cone beam volumetric CT with 40mm detector coverage. To obtain an optimized image reconstruction solution for future cone beam VCT systems, the raywise weighted helical CB-FBP algorithm, which was proposed by us to reconstruct image under cone angles up to 4.25°, is optimized and evaluated in this study to verify its imaging performance for image reconstruction under larger cone angles up to 8.5°. The ray-wise weighted helical CB-FBP algorithm proposed by us possesses two important features: (a) tangential filtering that is naturally implemented via row-wise fan-to-parallel rebinning to maintain spatial resolution along patient's longitudinal direction; and (b) 3D weighting that is a ray-wise optimization process to obtain image quality controllability. By using computer-simulated phantoms, such as the helical body and humanoid head phantoms, it has been shown that the ray-wise weighted helical CB-FBP algorithm can provide a well balanced imaging performance over helical pitches while a large field of view (FOV) can be maintained. It is the optimized ray-wise weighting that enables the proposed CB-FBP algorithm performs well at larger cone angle. Based on the experimental evaluation, it is believed that the ray-wise weighted helical CB-FBP algorithm can be a candidate solution for image reconstruction in future cone beam VCT systems with detectors corresponding to larger cone angles up to 8.5° (~ 80 mm detector z coverage). Udo van Stevendaal, Peter Koken, Philipp G. C. Begemann, Ralf Koester, Gerhard Adam, Michael Grass Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105P (19 March 2007); doi: 10.1117/12.707854 In this contribution, the results of a phantom study for in-stent restenosis imaging with ECG gated continuous circular acquisition and reconstruction are summarized. Different rotation speeds and angular ranges are used to enable high resolution 3D and 4D reconstruction of objects covered by the cone at a high temporal resolution. Though the detector coverage of today's CT scanners is not large enough to irradiate the complete human heart, the coverage is sufficient to image smaller objects like conventional stents. We applied the proposed method to the visualization of an in-stent re-stenoses phantom covered by a clinical stent, attached to a dynamic heart phantom. The method delivers images of stents in vitro at an excellent visibility and is able to rule out in-stent occlusions. Abhishek Mitra, Swapna Banerjee Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105Q (16 March 2007); doi: 10.1117/12.705922 As a tomographic reconstruction algorithm, the recently proposed "Fast Radon Transform" (FRT) has some computational advantages. To prove its practical importance the technical difficulties associated with its application to fan-beam CT scanners as well as Spiral/Helical CT system are solved here. Some techniques are described to convert the actual fan-beam data or the spiral/helical CT data to parallel-beam data required for the FRT algorithm in order to reconstruct the CT images. Simulation results are presented to validate the complete method. A ray-tracing backprojection algorithm for cone beam CT Jun Lu, Tinsu Pan Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105R (28 March 2007); doi: 10.1117/12.709442 We have developed a ray-tracing backprojection (RTB) to back-project all the detector pixels into the image domain of cone beam CT (CBCT). The underlying mathematic framework is the FDK reconstruction. In this method, every ray recorded by the flat panel detector is traced back into the image space. In each voxel of the imaging domain, all the rays contributing to the formation of the CT image are summed together weighted by each rays' intersection length with the voxel. The RTB is similar to a reverse process of x-ray transmission imaging, as opposed to the conventional voxel-driven backprojection (VDB). In the RTB, we avoided interpolation and pixel binning approximations, achieved better spatial resolution and eliminated some image artifacts. We have successfully applied the RTB in phantom studies on the Varian On Board Imager CBCT. The images of the Catphan CTP404 module show more accurate representation of the oblique ramps in the measurement of slice thickness, and more accurate determination of slice thickness with the RTB than with VDB. The RTB also shows higher spatial resolution than the VDB in the studies of a high contrast resolution phantom. Hardware-accelerated cone-beam reconstruction on a mobile C-arm Michael Churchill, Gordon Pope, Jeffrey Penman, Dmitry Riabkov, Xinwei Xue, Arvi Cheryauka Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105S (19 March 2007); doi: 10.1117/12.711797 The three-dimensional image reconstruction process used in interventional CT imaging is computationally demanding. Implementation on general-purpose computational platforms requires a substantial time, which is undesirable during time-critical surgical and minimally invasive procedures. Field Programmable Gate Arrays (FPGA)s and Graphics Processing Units (GPU)s have been studied as a platform to accelerate 3-D imaging. FPGA and GPU devices offer a reprogrammable hardware architecture, configurable for pipelining and high levels of parallel processing to increase computational throughput, as well as the benefits of being off-the-shelf and effective 'performance-to-watt' solutions. The main focus of this paper is on the backprojection step of the image reconstruction process, since it is the most computationally intensive part. Using the popular Feldkamp-Davis-Kress (FDK) cone-beam algorithm, our studies indicate the entire 2563 image reconstruction process can be accelerated to real or near real-time (i.e. immediately after a finished scan of 15-30 seconds duration) on a mobile X-ray C-arm system using available resources on built-in FPGA board. High resolution 5123 image backprojection can be also accomplished within the same scanning time on a high-end GPU board comprising up to 128 streaming processors. Implementation and evaluation of 4D cone beam CT (CBCT) reconstruction Dong Yang, Ruola Ning, Shaohua Liu, David Conover Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105T (16 March 2007); doi: 10.1117/12.710222 Tumor angiogenesis is the process by which new blood vessels are formed from the existing vessels in a tumor to promote tumor growth. Tumor angiogenesis has important implications in the diagnosis and treatment of various solid tumors. Flat panel detector based cone beam CT opens up a new way for detection of tumors, and tumor angiogenesis associated with functional CBCT has the potential to provide more information than traditional functional CT due to more overall coverage during the same scanning period and the reconstruction being isotropic resulting in a more accurate 3D volume intensity measurement. A functional study was conducted by using CBCT to determine the degree of the enhancement within the tumor after injecting the contrast agent intravenously. For typical doses of contrast material, the amount of enhancement is proportional to the concentration of this material within the region of interest. A series of images obtained at one location over time allows generation of timeattenuation data from which a number of semi-quantitative parameters, such as enhancement rate, can be determined. Computer simulations prove the superiority of half scan over full scan in terms of more accurately delineating the time-intensity curve, and all the simulation parameter settings are based on the actual CBCT prototype. An experiment study was conducted on our prototype CBCT system, and a full and half scan scheme is used to determine the time-intensity curve within the ROI of the mouse. The CBCT has an x-ray tube, a gantry with slip ring technology, and a 40x30 cm Varian Paxscan 4030CB real time FPD. Avanti Shetye, Raj Shekhar Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105U (19 March 2007); doi: 10.1117/12.710107 The advent of 64-slice computed tomography (CT) with high-speed scanning makes CT a highly attractive and powerful tool for navigating image-guided procedures. For interactive navigation, scanning will need to be performed over extended time periods or even continuously. However, continuous CT is likely to expose the patient and the physician to potentially unsafe levels of radiation. Before CT can be used appropriately for navigational purposes, the dose problem must be solved. Simple dose reduction is not adequate, because it degrades image quality. This problem can be overcome if the traditional filtered back-projection (FBP) reconstruction is replaced with the maximum likelihood expectation maximization (MLEM) approach. MLEM is more accurate in that it incorporates Poisson statistics of the noisy projection data, especially at low doses. Our study shows that MLEM reconstruction is able to reduce x-ray dose from 200 to 11 mAs (the lowest dose-simulator setting in the present study) without significant image degradation. Taking advantage of modern CT scanners and specialized hardware, it may be possible to perform continuous CT scanning at acceptable radiation doses for intraoperative visualization and navigation. Missing data estimation for fully 3D spiral CT image reconstruction Daniel B. Keesing, Joseph A. O'Sullivan, David G. Politte, Bruce R. Whiting, Donald L. Snyder Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105V (28 March 2007); doi: 10.1117/12.713502 It is often the case in tomography that a scanner is unable to collect a full set of projection data. Reconstruction algorithms that are not set up to handle this type of problem can lead to artifacts in the reconstructed images because the assumptions regarding the size of the image space and/or data space are violated. In this study, we apply two recently developed geometry-independent methods to fully 3D multi-slice spiral CT image reconstruction. The methods build upon an existing statistical iterative reconstruction algorithm developed by our group. The first method reconstructs images without the missing data, and the second method seeks to jointly estimate the missing data and attenuation image. We extend the existing results for the 2D fan-beam geometry to multi-slice spiral CT in an effort to investigate some challenges in 3D, such as the long object problem. Unlike the original formulation of the reconstruction algorithms, a regularization term was added to the objective function in this work. To handle the large number of computations required by fully 3D reconstructions, we have developed an optimized parallel implementation of our iterative reconstruction algorithm. Using simulated and clinical datasets, we demonstrate the effectiveness of the missing data approaches in improving the quality of slices that have experienced truncation in either the transverse or longitudinal direction. Fast variance predictions for 3D cone-beam CT with quadratic regularization Yingying Zhang-O'Connor, Jeffrey A. Fessler Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105W (19 March 2007); doi: 10.1117/12.710312 Fast and accurate variance/covariance predictions are useful for analyzing the statistical characteristics of the reconstructed images and may aid regularization parameters selection. The existing methods, the matrix-based method and its DFT approximations, are impractical for realistic data size in X-ray CT. We have previously addressed this problem in 2D fan-beam CT by proposing "analytical" approaches, the simplest of which requires computation equivalent to one backprojection and some summations. This paper extends these approaches to 3D step-and-shoot "cylindrical" cone-beam CT. Iterative extended field of view reconstruction Holger Kunze, Wolfgang Härer, Karl Stierstorfer Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105X (16 March 2007); doi: 10.1117/12.707336 Incomplete data due to the object extent beyond the scanning field of view (SFOV) is a common problem in computed tomography. In these cases, there are parts of the object to be reconstructed for which only incomplete projections of less than 180o are available. Applying iterative algorithms like algebraic reconstruction technique (ART) or simultaneous algebraic reconstruction Technique (SART) onto the problem of truncated projections can not produce a satisfying solution unless special constraints are used. To regularize the reconstruction algorithm, we extend iterative reconstruction algorithms by introducing information regarding the statistics of the attenuation values of the reconstructed object in terms of the log likelihood function of attenuation values. This information can be taken from the regions of the image still inside the SFOV but close to the region where the object exceeds the SFOV. The information can be utilized in an algebraic reconstruction method by adding a constraint term to the cost function that shall be minimized. Experiments show that for not severely truncated projections, as they are common for CT applications, including this information yields good estimates about the object. Dirk Bequé, Bruno De Man, Maria Iatrou Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 65105Y (16 March 2007); doi: 10.1117/12.712852 In a 3rd generation CT system, a single source projects the entire field of view (FOV) onto a large detector opposite to the source. In multi-source inverse geometry CT imaging, a multitude of sources sequentially project complementary parts of the FOV on a much smaller detector. These sources may be distributed in both the trans-axial and axial directions and jointly cover the entire FOV. Multi-source CT has several important advantages, including large axial coverage, improved dose-efficiency, and improved spatial resolution. One of the challenges of this concept is to ensure that no artifacts emerge in the reconstructed images where the sampling switches from one source to the next. This work studies iterative reconstruction for multi-source imaging and focuses on the appearance of such artifacts. For that purpose, phantom data are simulated using a realistic multi-source CT geometry, iteratively reconstructed and inspected for artifact content. More realistic experiments using rebinned clinical datasets (emulating a multi-source CT system) have also been performed. The results confirm the feasibility of artifact-free multi-source CT imaging in both full-scan and half-scan situations.

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