CSE 591 Medical Imaging Conference (Fall 2011)

Tuesday, December 20, 2011

3:00 GPU-Accelerated Volume Rendering
Yuyang Wang

3:20 Exact CT
Jing Jin

3:40 Regularized Iterative CT #1 (ASD-POCS)
Fan Yang
Deepak Venkatachalam
Mirza Baig

4:40 Regularized Iterative CT #2 (Soft Thresholding)
Yu Zhang
Bill Piel

5:20 Compensation for Scattering
Phanindra Bhagavatula
Sichong Dai

6:00 Coffee Break

6:20 Beam Hardening and Poly-Energetic CT
Sanja Nedic

6:40 Dynamic CT
Anuj Goel and Shashank Dass

7:00 Iterative CT
Lei Hou and Chongjian Sun
Keerthi Yendamuri and Madhava Keralapura

7:40 Regularized Iterative CT #3 (Accelerated gradient method)
Salman Mahmood

8:00 Reference Database Regularization
Chengyang Liu

8:20 Lattices and Irregular Grids
Kang Sun

8:40 CT of Semi-Transparent Objects and Amorphous Phenomena
Hailin Ying and Lingbin Yang
Chen Ling and Fan Zhang

Abstracts

Yuyang Wang
Real-Time Volume Rendering Based On Modern GPGPU Technology

In scientific visualization and computer graphics, volume rendering is a set of techniques used to display 2D projections of 3D discretely sample data sets, such as CT & MRI scanning data. This technique is very helpful for physicians in examination and diagnosis, and with modern GPGPU technology, volume rendering can achieve a real-time interactive speed, thus is widely adopted in the medical imaging field. In this project, a real-time volume rendering application based on OpenCL is built up. The fundamental principle used is volume ray casting. Various rendering modes such as Colorization, X-Ray, Maximum-Intensity-Projection and Iso-Surface are also implemented.

Jing Jin
Exact CT using M-lines

M-line is a common approach to reconstruct CT images. This project mainly researches on the 2D fan-beam reconstruction using 1D filtering along the projection of M-lines. The fan-beam projection of the CT image is obtained from Matlab fanbeam function. In this function, the sensors are spaced equally along a circular, and need to specify a distance from the center of rotation. The reconstruction is done by applying a 1D convolution to a derivative of the CT data and then backprojecting this modified CT data over segments of trajectory bounded by the endpoints of the R-line. The 1D convolution is applied to the ray integrals in the plane containing the source and the M-line. This project is implemented by using Matlab and C++. The reconstruction result is given to compare with the filtered projection we did in the course project.

Fan Yang
Regularized iterative CT #1 (ASD-POCS)

In my project, through using Total Variation Minimization and SART Algorithm, the tomography images can be reconstructed to enforces local smoothness and reduce noise and streaks. I first had implemented the SART and TVM Algorithms in different images respectively. Then I compared the results and certain advantages can be revealed through such comparison.
Next, I implemented the ASD-POCS algorithm presented in paper "Image reconstruction in circular cone-beam computed tomography by constrained, total-variation minimization".
To implement ASD-POCS algorithm, first need to implement POCS algorithm that is also an iterative algorithm to estimate x (Ax=b) and update its value. By incorporating TVM into POCS, we can reconstruct the image very quickly through less iteration. Several comparisons also have made to accentuate the advantage of ASD-POCs algorithm.

Deepak Venkatachalam
Regularized Iterative CT # 1 (ASD-POCS)

In many cases during Ct reconstruction we face adverse imaging conditions like smaller number of projections, noisy projections and reduced angle. It would be very useful to use an iterative reconstruction method in these cases to improve the quality of the reconstructed images. Some of the famous methods are ART, SART and so on. When we reconstruct the images it would be useful to impose certain constraints during every iteration of the algorithm. These constraints can be useful to speed up the process at the same time give good reconstruction results. To do this here the Total Variation Minimization algorithm is used alongside the SART algorithm to improve the CT reconstruction results. Along with the SART and TVM algorithm which are alternated in every iteration certain conditions are used based on which the parameters which are used in the algorithms, are updated. The SART and TVM process are updated alternatively enforcing the above conditions at each iteration. This algorithm is tested for some adverse conditions as explained above.

Mirza Basim Baig
Regularized Iterative CT # 1 (ASD-POCS)

The paper I am working on basically comes up with an approach for doing iterative CT while using total variation minimization to make sure that the image turns out smooth. The main idea is to use non-negativity constraints on the intermediate images and dynamically select parameter values for running TVM. The technique is a combination of POCS (projection onto convex sets) and the new adaptive steepest descent used in the TVM part of the algorithm. The result of this technique is that it is robust against cone beam artifacts.

Yu Zhang
Regularized Iterative CT # 2 (Soft Thresholding)

In the medical imaging field, discrete gradient transform (DGT) is widely used as a sparsifying operator to define the total variation (TV). Recently, TV minimization has become a hot topic in image reconstruction and is usually implemented using the steepest descent method (SDM). Since TV minimization with the SDM takes a long computational time, here we construct a pseudo-inverse of the DGT and adapt a soft-threshold filtering algorithm, whose convergence and efficiency have been theoretically proven. Also, a pseudo-inverse of the discrete difference transform (DDT) and an algorithm for L1 minimization of the total difference are designed and constructed. These two methods are evaluated in numerical simulation. The results demonstrate the merits of the proposed techniques.

Bill Piel
Regularized Iterative CT # 1 (Soft Thresholding)

They offer two methods. One is called a pseudo-inverse of the discrete-gradient transform. The other is called a pseudo-inverse of the discrete-difference transform. The Figure below that I obtained from my program uses neither but only uses SART, their Eq. 3.6. I used lambda = 2 for the relaxation parameter. I am using fan-beam geometry with 50 linear detectors, a 32 X 32 pixel phantom, which is of size 34 X 34 cm^2, an anode x-ray source that is 0.2 cm in height and 21 projection angles that are evenly spaced over the range from one degree to 231 degrees. The images that I obtain using their pseudo-inverse of the discrete gradient transform are visually comparable to using SART-only but the rmsError value is always slightly worse, typically about 15% larger. So far I haven't been able to find a case where their method outperforms SART-only. I've tried values of lambda from one to three and threshold values, w, from 0.05 to 2.

Phanindra Bhagavatula
Monte Carlo Simulation of CT scans. Scatter estimation and Reconstruction of improved images

Compton scattering is a dominant effect in CT scanning. There are many ways to avoid scattered rays and estimate the effect of scattering. Monte Carlo simulation of x-rays has proven to be one of the very effective ways. The stochastic nature of involved processes such as X-ray photons generation, interaction with matter and detection makes MC the ideal tool for accurate modeling. MC calculations can be used to assess the impact of different physical design parameters on overall scanner performance, clinical image quality and absorbed dose assessment in CT examinations, which can be difficult or even impossible to estimate by experimental measurements and theoretical analysis. Simulations can also be used to develop and assess correction methods and reconstruction algorithms aiming at improving image quality and quantitative procedures. This project focuses on implementation of these Monte Carlo simulations of CT imaging and estimation of scattered rays and reconstruction of the original Image.

Sichong Dai
CUDA Based Spatial Subdivision Accelerated Real-time Medical Model Rendering

The object of my project is to perform a realistic real-time rendering for medical models using NVidia CUDA. By using the parallel structure of CUDA, I can already do a quite fast rendering. To make it even more fast, I implemented a Spatial Subdivision acceleration structure to further improve the performance. With a medical model with more than 10,000 polygons, my engine can maintain 10 frames per second.

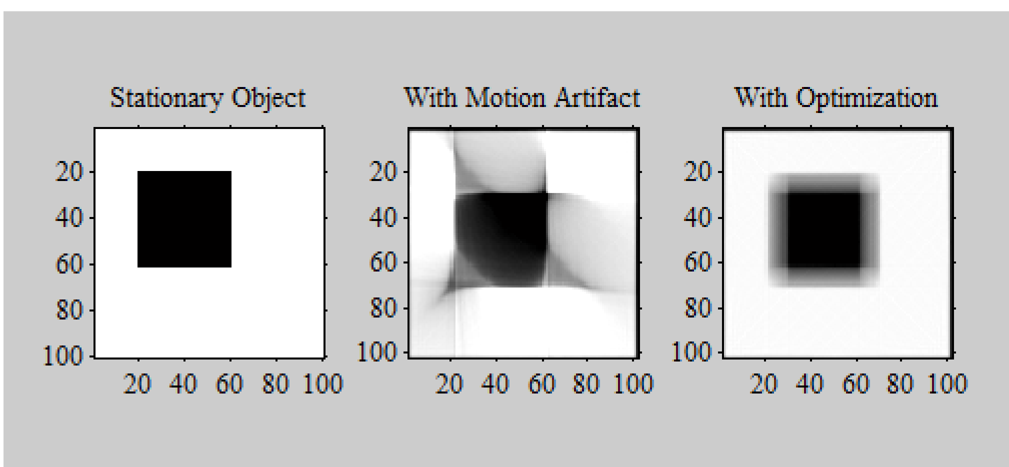
Sanja Nedic
Beam Hardening and Poly-Energetic CT

X-ray attenuation properties of human tissue are energy dependent and x-ray sources used in CT usually emit broad spectra. These polychromatic x-ray sources can cause artifacts in the reconstructed image due to non-linearity. Beam hardening is one such artifact: average energy of the x-ray beam increases as the beam passes through a material as lower energy rays get preferentially attenuated. X ray beam reaching a particular point inside the material from different directions may have different spectra and be attenuated differently at that point. I use x-ray spectra from published literature to illustrate beam hardening effect for certain simulated cross sections. I assume that the x-ray beam can be approximated by a discrete spectrum of energies. I also discuss available post reconstruction beam hardening correction methods.

Anuj Goel and Shashank Dass
Dynamic CT

The primary objective of this project is to obtain a better understanding of the effect of motion on the CT image reconstruction.

To analyze this, we have simulated a moving object in 2–dimensional space on a computer. We have used Matlab's library function, RADON(I,THETA) to capture projections at different angles during the motion of the object. We compute a sinogram using all the 180 degree projections. This sinogram can be used to reconstruct the CT image of the object. As expected, the reconstructed image was blurred due to the motion of the object. Then we have used our algorithm to reduce the blurring due to motion artifacts and reconstructed the image. The below figure shows the results obtained by using the various methods.



The first image is the reconstruction of the stationary object. The second image is the reconstruction using the normal method. The image is blurred showing the motion of the object in various directions. The third image is the reconstruction after applying our algorithm. As visible from the figure, this algorithm manages to remove the blurring by a huge amount.

Lei Hou and Chongjian Sun
Iterative CT

Keerthi Yendamuri and Madhava Keralapura
Evaluation of Iterative Reconstruction Algorithms

Iterative CT algorithms are considered as better, but computationally more expensive alternative to Filtered Back Projection methods to reconstruct images. Filtered Back Projection algorithms reconstruct the image in a single iteration and are enhanced by filtering the CT data. Iterative CT algorithms on the other hand have roots in linear optimization. They start from an estimate of the reconstruction and iteratively correct the reconstructed image. In our paper, we aim to compare the capabilities of 4 iterative CT algorithms - Simultaneous Algebraic Reconstruction Technique (SART), Steepest Descent Method, Conjugate Gradients Method, Maximum Likelihood Expectation Maximization (ML-EM), with respect to 4 parameters - number of iterations, limited angle projections, reduced angle projections and noisy projections.

Salman Mahmood
Low-dose CT Regularization by RNLM Filter and Reference Image Database

Total-variation based CT image reconstruction is very effective in reconstructing sparse view data. However, computationally this is a very expensive process, as a result the process is not real time. This paper proposes two accelerated gradient based algorithm which optimize the problem. It is also important to note that both methods are memory efficient and they have stopping criteria. The first algorithm, GPBB, uses Barzilai-Borwein(BB) step size selection and non-monotone line search. The second algorithm UPN uses auxiliary points to achieve better results. In the end the algorithms are compared and UPN emerges as the most efficient technique.

Chengyang Liu
Low-dose CT Regularization by RNLM Filter and Reference Image Database

In this report we discuss a novel image denoising method proposed by Xu et al for low-dose CT regularization. This approach extends the traditional non-local means filter by searching for similar patches in a comprehensive reference image database instead of limiting the search in local region. Using properly simulated artifacts and search+match strategy, our experiment replicates the result of Xu et al and shows the method is as efficient as the local NLM approach while produces much better results.

Kang Sun
Lattice and Irregular Grids

My main task is the implement of BCC lattice and irregular grids for CT 3D reconstruction using matlab. Compared the results with normal CC lattice and regular grids. Analysis the difference between these methods.

Hailin Ying and Lingbin Yang
CT reconstruction of transparent objects

Given the assumption that: 1) we know the object's refraction index, also know light source and camera's position; 2) we know the direction of light path (except for the part of path when light is traveling within object); 3) light refracts with object twice. Our method searches and compares all possible pair of intersection points and output the best of them. This method works with both 2D & 3D environment. An example within 2D environment is provided.

Chen Ling and Fan Zhang
Reconstruction of Transparent Objects by Three-colored Laser

Nowadays capturing the shape of one object inside another objects is pretty simple and easy by using the CT and reconstruction method. However, capture a transparent object is still an open problem for computer graphics and computational vision community. There are some methods like by putting the object into a cylinder of water and then get the shape of that method by using a similar way of CT. However, the method they are using does have a lot of inconvenience because we need to put the object into some liquids such as salt water and it may do damage to the object itself. So we can using another method to get the shape of the object by using the three-colored laser and the theory of refraction to get the upper and lower boundary of the object, thus we can reconstruct the shape of the object. This article is mainly about the fundamental method of reconstructing a object's surface by using three-colored laser and some other methods that may help us do the reconstruction. It also discussed the problem we have so far and the things we need to do later in order to make our theory into experiments.