Multi-View Linear Tomography for Explosives Detection in Carry-On Luggage

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Abstract

Current helical scanning computed tomography scanners provide detailed 3D imagery in the medical and security domain, but can require significant power, cost, and space. Such helical scanning tomography machines are impractical for many field based applications where space and power are often limited, such as portal screening or point of care. We propose a method to achieve linear tomography without the need of conventional spinning gantries based on an extension of existing carry-on luggage screening hardware. The approach involves a conveyor belt, static point sources and flat panel detectors in a linear scanning configuration. The system produces tomographic information through motion induced disparity of the object projections and extracts this information through advanced reconstruction techniques. The new configuration should be smaller, less expensive, and more reliable than helical-based approaches.

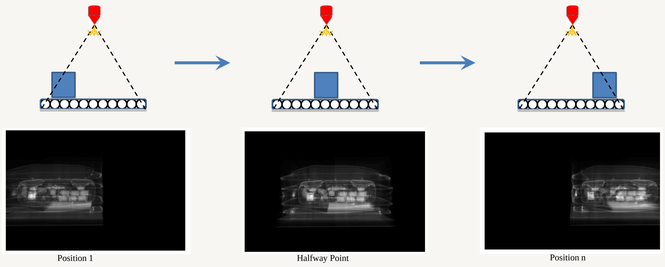
Relevance

- X-ray CT scanners provide 3-D separation of objects, increasing detection and lowering false alarms (e.g. laptops and sheet explosives)
- Existing CT security systems use helical scanning, are large and costly, and have been reserved for checked baggage
- Our proposed configuration would allow the benefits of 3-D target separation from a conventionally-based checkpoint system.
- Advanced reconstruction methods are necessary to compensate for the non-conventional geometry.

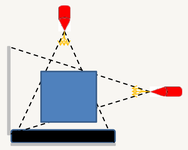
Technical Approach

Methodology

- Projection diversity created by moving object along a conveyor belt and taking sequential projections
- X-ray source and detector are static



- Second set of orthogonal source/sensor pair to improve out-of-plane resolution

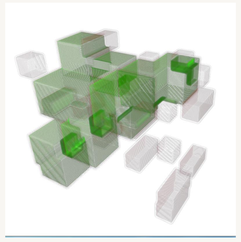


- Mathematically modeled using Siddon's Method
- Solved using iterative Krylov subspace methods

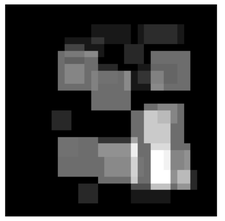
Experiments and Results

Block Phantom

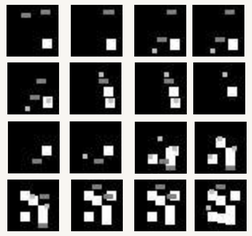
Original Render



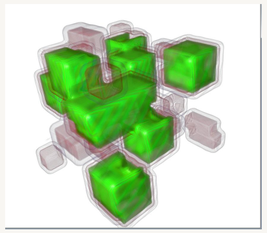
Simulated Planar Radiogram



Sample Slices

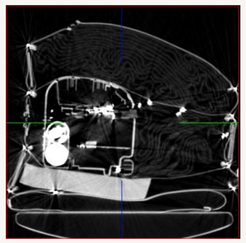


Reconstructed Render

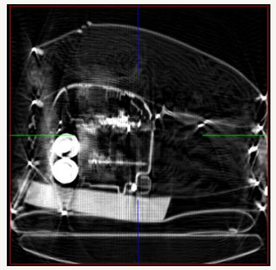


Suitcase with boombox

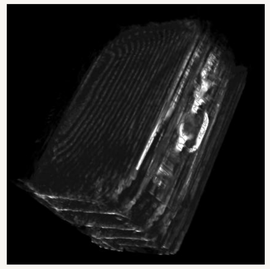
Original Sample Slice



Reconstructed Sample Slice



Reconstructed Render



Accomplishments Through Current Year

- New linear scanning configuration modeled and simulated
- Potential of technique demonstrated
- Voted Best Poster in Homeland Security and Defense Track at RICC 2010 by Industry and Government Attendees

Future Work

- Explore tomographic preconditioners to speed up convergence of iterative methods
- Explore statistical priors to improve reconstruction quality
- Optimize geometry/sampling for best reconstruction
- GPU implementations for algorithmic acceleration

Opportunities for Transition to Customer

- Linear tomography without large rotating gantries provides new possibilities for CT imaging
- New portal scanners could provide improved detection of threats and lower false alarm rates to improve passenger comfort during travels
- Doctors in constrained environments will benefit from having tomographic images to improve diagnosis of patient illnesses

Publications Acknowledging DHS Support

Sun, Z. & Karl, W. C. (2010). Non-Rotational Tomography for Luggage Screening Using Krylov Methods. Poster session presented at Research to Reality. 11th Annual Research and Industrial Collaboration Conference; 2010 Oct 19; Boston, MA.

Sun, Z & Karl, W. C. (2011). A Non-Rotational Approach to Computed Tomography for Checkpoint Explosives Screening. White paper submitted to Catastrophes & Complex Systems: Transportation. 5th Annual DHS Science Conference; 2011 Mar 29; Washington D.C.

Other References

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Siddon, R. L. (1985). Prism representation: a 3D ray-tracing algorithm for radiotherapy applications. *Physics in Medicine and Biology*, *30*(8), 817-824. doi: 10.1088/0031-9155/30/8/005

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