Computed Tomography (CT) for Industrial Components

Industrial Inspection

Purpose: The ISML Group conducts applied computer vision research and development addressing important issues in industrial and economic competitiveness, biomedical measurement science, and national security.

Recently, ISML staff members have focused their skills and capabilities on applying computed tomography to improving industrial processes.

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Industrial components present significant challenges for CT applications due to the wide variation in component size and resolution requirements and the strong contrast in attenuation between industrial materials and air. The Imaging, Signals and Machine Learning (ISML) Group has been working with industrial partners on methods to address these challenges and apply CT to industrial applications.

CT System Calibration and Performance Monitoring

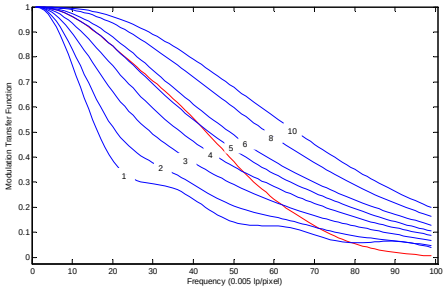
The wide range of size and resolution requirements presented in the industrial environment lead to the need for a CT system with a flexible geometry. A flexible system requires calibration and performance monitoring to verify proper setup and operation. ISML has implemented software algorithms for calibration of system geometry parameters and measurement of system performance (three-dimensional [3-D] resolution and contrast discrimination) from specific CT data sets collected by the system.

CT Reconstruction

Because of the strong attenuation contrast in industrial components, quick reconstruction techniques based on filtered backprojection are often insufficient for CT reconstruction. Artifacts from strong contrast edges will cause streaks that will interfere with measurements. The use of iterative reconstruction methods can significantly improve results for industrial components but are computer intensive in terms of both processing and memory requirements. ISML has worked in conjunction with researchers from the University of Tennessee in Knoxville to develop a parallel iterative reconstruction code for cone beam CT data. A key feature of this code is the ability to include prior information to speed convergence and allow region of interest reconstruction.

CT Data Processing

Registration techniques allow comparison of data sets in both the projection (radiograph) domain and the 3-D reconstructed domain. Oak Ridge National Laboratory has projection registration capabilities that can enable difference reconstruction for location of defects and out of tolerance dimensions.



Measurement of modulation transfer function (MTF) for comparison of Feldkamp and iterative reconstruction methods.

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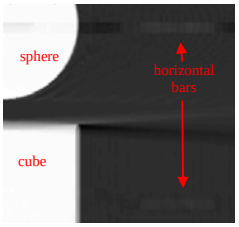
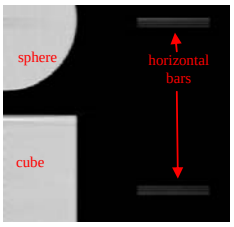


Feldkamp Reconstruction



Iterative Reconstruction

Comparison of slices through data reconstructed with both Feldkamp and iterative reconstruction methods.

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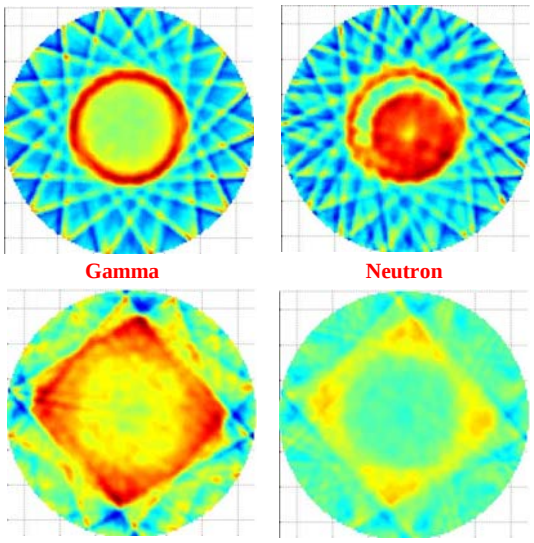
Projection registration is currently being applied to applications in which high-resolution region-of-interest reconstructions are desired. Registration can also provide a means for automated measurements within the CT results by determining the location and orientation of a component within the data set. We are currently working toward registration in the reconstructed data domain, and we are also beginning to apply capabilities developed for biomedical imaging in segmentation that will allow separation of components for volume measurements.

Neutron CT

Neutrons and X-rays are complementary radiography techniques due to the difference in attenuation between the two sources. Neutrons can easily penetrate metallic components, allowing inspection of lighter materials within these components. ISML is involved with neutron CT at reactors and with portable sources (deuterium-tritium generators and fission sources).

Capabilities and Resources

- Backprojection reconstruction.
- Iterative reconstruction.
- MTF measurement code.
- Contrast discrimination measurement code.
- Projection registration capabilities.
- 3-D segmentation capabilities.
- MicroCAT CT acquisition system.
- Access to neutron radiography.



Slices from neutron and gamma CT taken simultaneously using time of flight and a californium source. (top) Plastic annulus within lead pipe; (bottom) lead box with circular interior wall.

Contact Information

To find out more about using computed tomography to improve your industrial processes, please contact Philip Bingham (binghampr@ornl.gov) at 865-574-5680.