Title
Neutron Tomography and Space

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NEUTRON TOMOGRAPHY AND SPACE

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INTRODUCTION

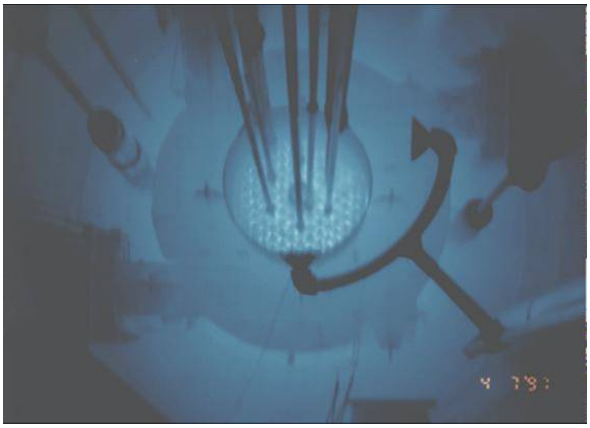
Computed Tomography (CT) has been discussed in origin and comparison in medical use, CAT Scan, and industrial applications[1]. Neutron Computed Tomography was presented for use in geology[2]. Neutron CT proved useful in determining hydrogen concentrations in castings[3]. Many others could be referenced. A common theme could be resolution or accuracy. This discussion asks, what does the customer need? It can be any of these previously discussed areas and maybe more?

1. THE NEUTRON SOURCE

The University of California, Davis-McClellan Nuclear Radiation Center (UCD-MNRC) is located at the former McClellan Air Force Base near Sacramento, California. The neutron source is a 2 Megawatts TRIGA reactor developed by General Atomics The facility was built between 1986 and 1990. Initial criticality was in 1990.

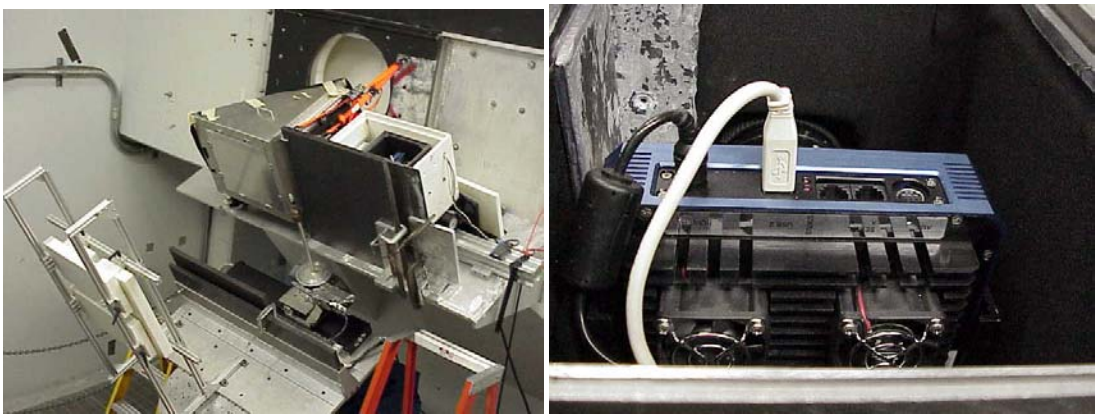
MNRC was turned over to The University of California at Davis, in February 2000, as part of the closure of the air force base. We have a balance of research and industrial partnerships, providing a variety of reactor related services:

- In core and in tank out of core irradiations, isotope production, and survivability
- Conventional film radiography
- Computed radiography(CR)
- Computed Tomography(CT)
- Real-time radiography
- Research use of the neutron beam



2. THE NEUTRON COMPUTED TOMOGRAPHY SYSTEM

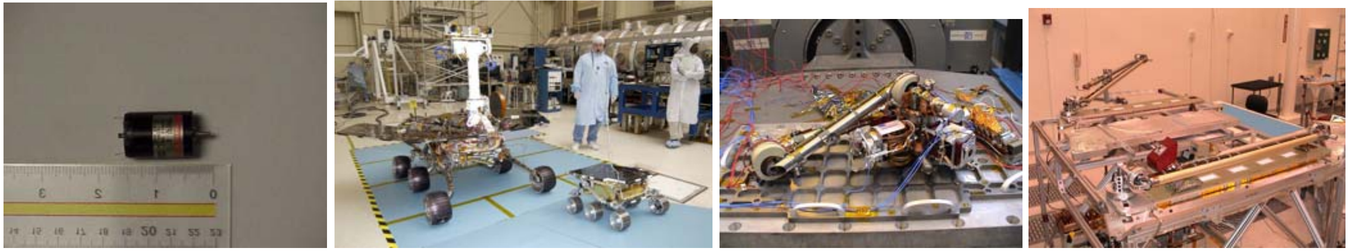
The CT system at UCD MNRC has recently been rebuilt from the description in [1] and [2]. The current MNRC CT capability is the product of an MNRC-Lawrence Livermore National Laboratory (LLNL) collaboration. The goals of the entire collaboration involved an upgrade of the current detector and motion hardware, an upgrade of the data acquisition and processing software, and the installation of a dual-modality scanning capability in Bay 5. MNRC staff designed a new camera housing which included a motorized translational stage to support focusing with the beam on the scintillator. The camera-scintillator detector was outfitted with a new APOGEE ALTA camera with a Marconi back-thinned CCD chip. In addition, new scintillators were purchased for use in both bays. NEWPORT object motion stages were purchased for both bays and installed in the system to support more precise object movements and scanning. Existing LLNL data acquisition software was adapted to the MNRC hardware enabling a direct interface to LLNL reconstruction software.



LLNL image processing and reconstruction software includes a variety of pre-processing options and reconstruction algorithms for use with DR/CT data. The software suite includes algorithms for parallel, fan-beam and cone-beam geometries. This software also has some extensions for "region-of-interest" scanning and some other limited-data configurations. A number of ray-normalization and ring-removal processing are part of the regular operation of the code. Functions in the code can be operated interactively or with the use of text-file-scripts to perform repetitive tasks. Lastly, the code can be operated on either a Windows or LINUX platform, however MNRC uses the Windows version almost exclusively. DR or CT data can be exported to other software in a number of different formats. While some visualization and dimensional measurement software are a part of the LLNL suite of tools, MNRC has a history of experience with the VOLUME GRAPHICS 3D software. Currently, data sets are processed in the LLNL tools and exported to the VOLUME GRAPHICS software for 3D evaluation and analysis.

3. THE TOMOGRAPHY PROJECT

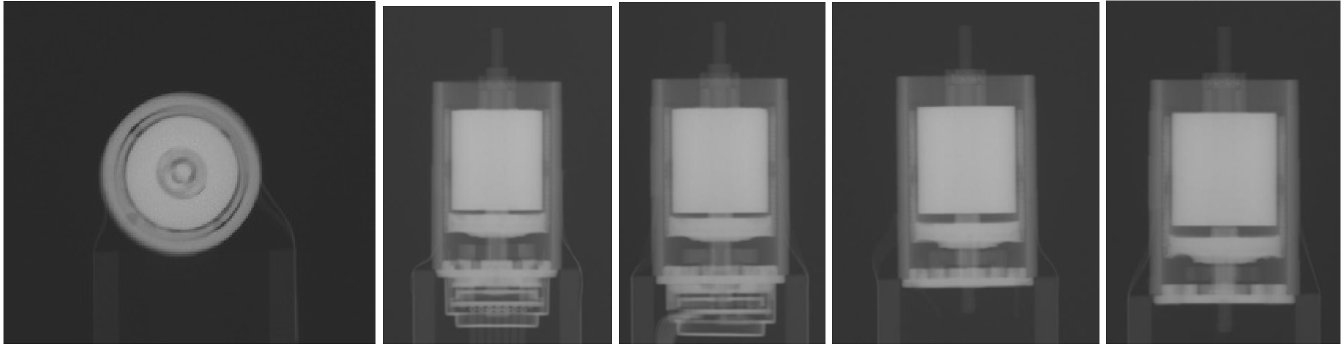
Jet Propulsion Laboratory (JPL), uses a small Maxom motor on applications for manipulators in some of their space projects.



Above is the motor and three examples (JPL description: D2002_1106_B209, IDD, and FM and EM Phoenix Robotic Arms) using the motor. They said they were unable to visually determine the motor’s brush quality using other methods. Because the brushes are carbon, we felt neutrons may have a good chance seeing them?

3.1. COMPUTED RADIOGRAPHY OF THE JPL/MAXON MOTORS

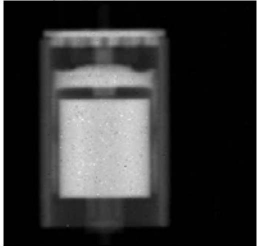
The motor is about 1 ½” high, ¾” in diameter. The brushes are carbon, about ½” across and about 1/16” high.



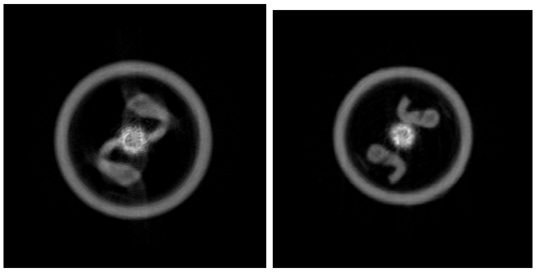
Computed Radiography (CR) was performed on both motors. The first image is an exposure into the end of the motor showing nothing. The brushes can not be seen because of the attenuation by the armature. Two exposures of the motors were performed with 90 degrees rotation. The brushes can be seen in each radiograph. As will be shown later, the motor in the two images on the right has improperly assembled brushes. Examination of the brush area of the two motors shows inconsistencies in shape and clarity. From this alone, it is not clear which one is the good motor and which one is the bad motor?

3.2. COMPUTED TOMOGRAPHY OF THE JPL/MAXON MOTORS

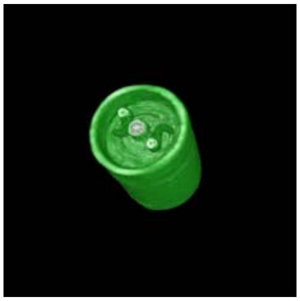
Half degree projections were acquired for tomography. The acquisition, reconstruction, and Volume Graphics rendering took about four and a half hours. From this attenuation radiograph, no more can be seen than was seen in the CR images.



However, the reconstruction of the brush area clearly shows the improper assembly of the brushes. Compare the brushes of the good motor on the left to those on the motor on the right.

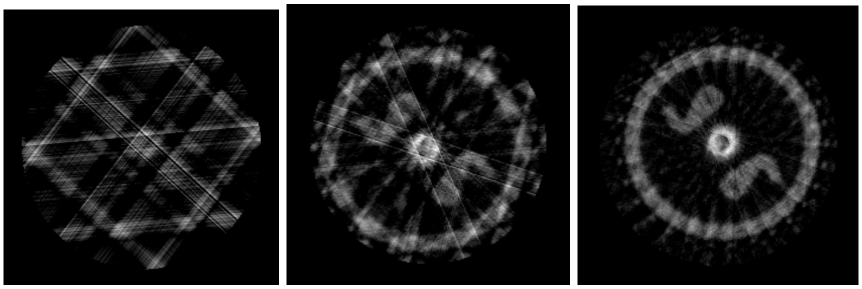


And, as normally, Volume Graphics provides a great presentation.



And, if that was our objective, this would be great. A beautiful representation of the motor and the brush area. Can we show the customer what he wants to know in less time and expense?

In what areas can we cut time? Presentation? Sure, no presentation needed in this case. Maybe fewer projections? That would be less acquisition time and less processing time. But, how few projections can be used? We chose to start ridiculously low. The first image is four projections, then eight projections. Then we took sixteen projections and, from this image, it can be clearly seen the brushes are installed incorrectly.



CONCLUSIONS

The customer's position following the first reconstruction of one half degree projections was that the inconsistence between the good and bad CR images would be enough to discard the bad motor. If they were to need evaluation of several motors, the cost would preclude CT. The time requires to setup, collect sixteen projections, and reconstruct the brush area was only slightly more than half and hour. Only a little longer than the CR process and with conclusive results, not merely an evaluation based on inconsistencies between two radiographs. Further investigations will be performed. Looking at the combination of a restricted number of projections combined with multiple samples at one time. Possibly a lazy Susan arrangement? That may lead to further discussions?

ACKNOWLEDGMENTS

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REFERENCES

[1] H. E. Martz, S. G. Azevedo, J. M. Brase, K. E. Waltjen, and Dan Schneberk, "Computed Tomography Systems and their Industrial Applications", February 1990.

[2] Martin Wilding, Charles E. Lesher, Kevin Shields, "Applications of neutron computed tomography in the geosciences", Nuclear Instruments and Methods in Physics Research., Section A, Elsevier 2005.

[3] Matthew R. Gibbons, Wade J. Richards, Kevin Shields, "Optimization of neutron tomography for rapid hydrogen concentration inspection of metal castings", Nuclear Instruments and Methods in Physics Research., Section A, Elsevier 1999.