Sandia National Laboratories

Exceptional service in the national interest

SAND2016-6623D

Acquiring and Converting Energy-Discriminated X-ray Image Data

Erica Holswade

Colorado School of Mines – B.S. Applied Mathematics, May 2019

Judith Spomer (Manager), Dr. Edward S. Jimenez (Mentor), Org. 9525

Madison Devonshire

Brigham Young University – B.S. Computer Science, April 2018

Dennis Croessmann (Manager), Enrico Quintana (Mentor), Org. 1529

Sandia National Laboratories/NM, U.S. Department of Energy

July 26, 2016

Abstract

This project aims to read files outputted by the MultiX X-Ray Detector and display these files as TIFF (Tagged Image File Format) images using a graphical user interface (GUI). MultiX outputs energy-discriminated x-ray image data in binary format, so the data must go through processing to be viewed as understandable images. Thus far, processing efforts have made parts of the output viewable as images and future work will focus on melding those parts into a cohesive whole. An acquisition program is being built that will communicate with the detector, acquire data, and automatically reformat the output files into complete images.

Introduction

Modern x-ray detectors work by capturing light output from scintillators when hit with x-ray photons. This method, however, gives no distinction to the photon energies being used. MultiX is uniquely different in that the detector's individual pixels can detect up to 128 different x-ray photon energies, which allows us to get 128 distinctly different energy-discriminated x-ray images instead of one grayscale image. This information becomes very useful when taking x-rays of different materials, as all materials attenuate x-rays differently. With these new detectors we will be able to identify a material solely from its polychromatic x-ray image. Currently there is no way to view the images the detector produces, so our project focuses around creating software that easily works with the detector to acquire data and give the user back useable information.

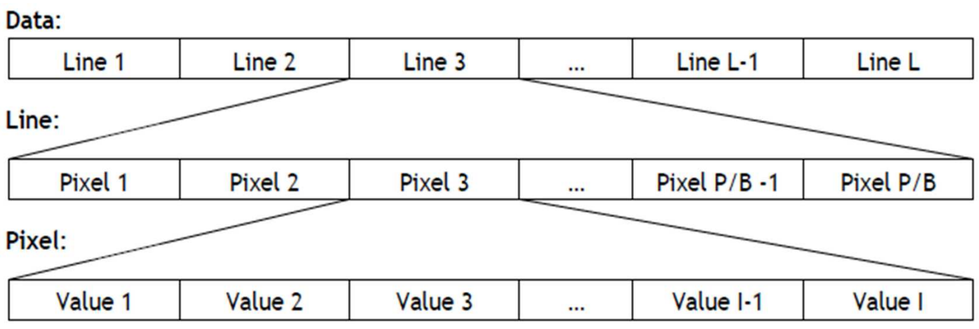

Figure 1: Structure of MultiX Output

MultiX Detector

The detector is comprised of five detection modules with 128 pixels each for a total of 640 pixels. Each pixel also contains a set of energy acquisition channels, the exact number of which can be customized before taking data. When x-rays are taken, the photon count of each channel within each pixel is recorded in an individual cell. A collection of cells, plotted as pixels vs. channels, is referred to as a "line" – a collection of stacked lines will form the final image. In order to display images, a program that both communicates with the detector to receive output files and converts those files to images has to be developed.

Methods

Research had to be done into the structure of TIFF images and in building GUIs before the project could be approached. To gain experience, a test project that displayed TIFF images and read information about the files was built using the Visual Basic programming language. From there, work moved researching and working with the MultiX detector so that reading output files could be accomplished without a loss of information.

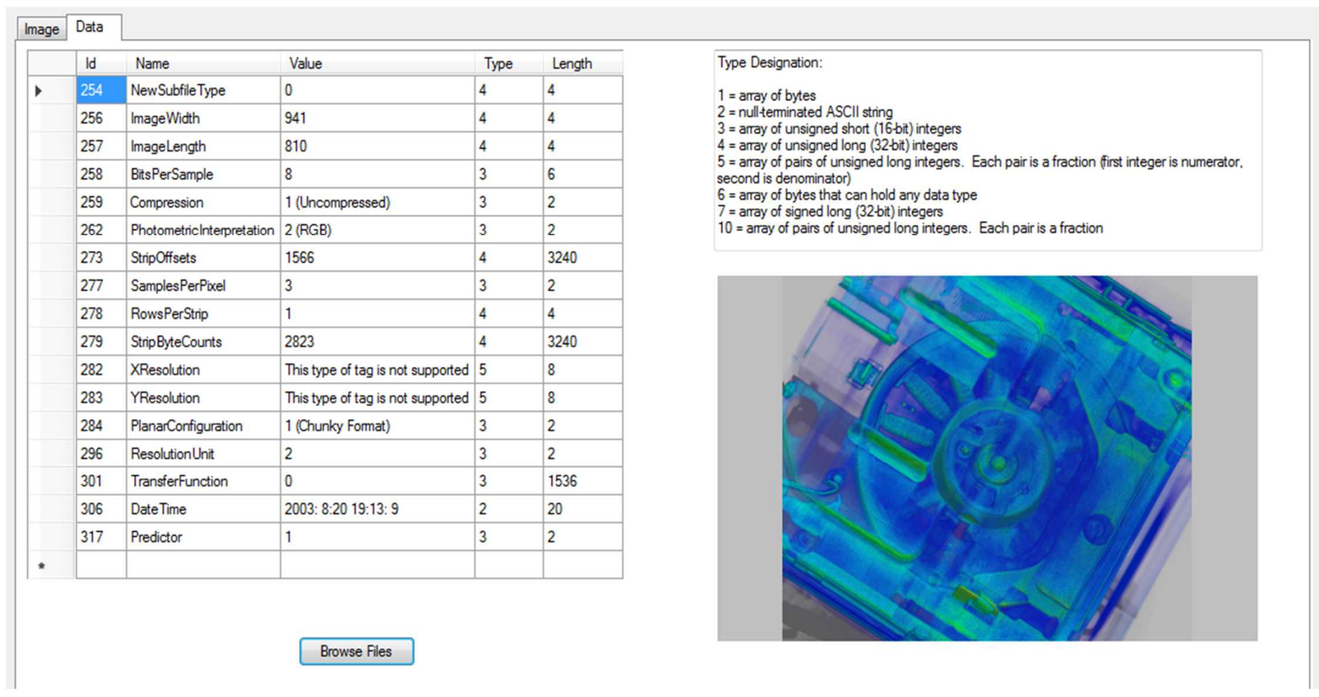

Figure 2: Example of a GUI that Reads and Displays TIFF Headers

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.
SAND No. 2011-XXXXP

Sandia National Laboratories

Exceptional service in the national interest

Results

Images

Images of individual lines were colored depending on the value of the cells within the line – the lowest value in the image corresponded to white and the highest value corresponded to black, with the other values colored on a linear scale between those values.

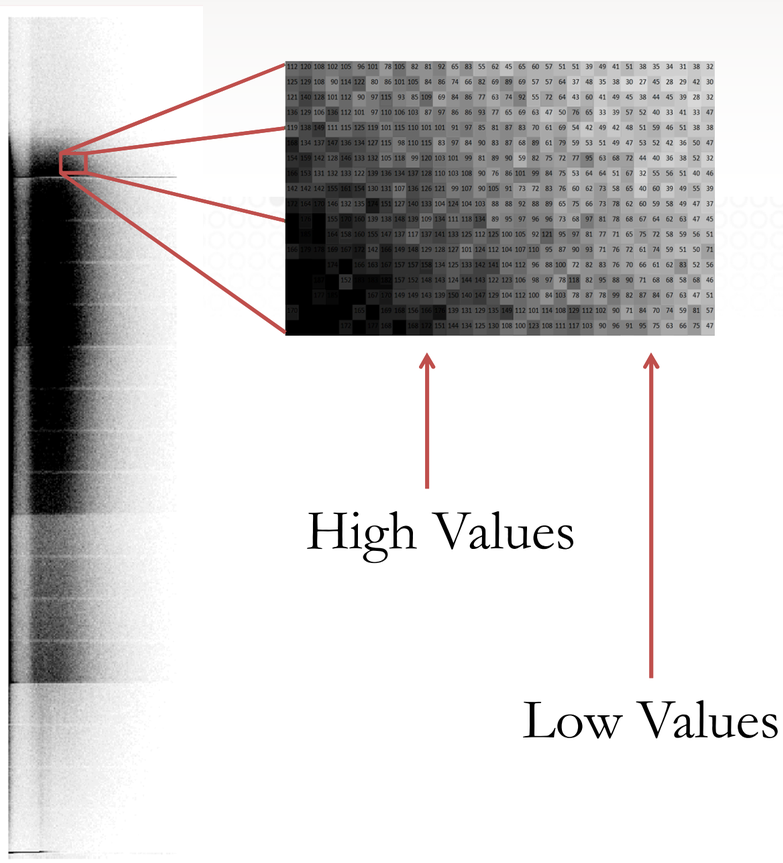

Figure 3: Cells Colored According to Value

User Interface

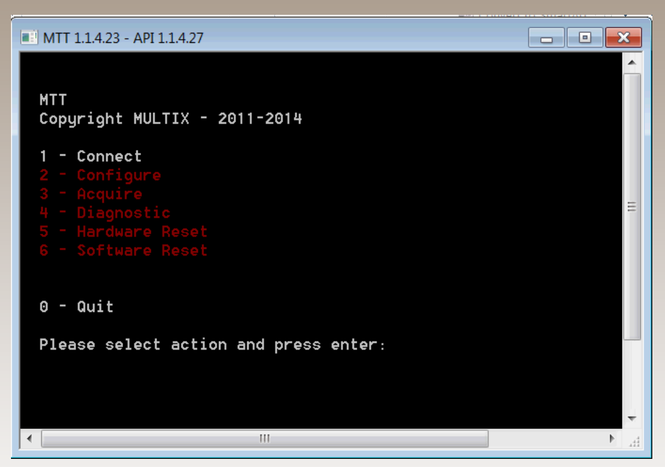

Figure 4: UI Included with MultiX

The current detector software runs off a command line program and is extremely inefficient and unintuitive. One of our goals is to build a GUI program that gives the user easy and effortless control over the detector's functionality. The new program interfaces directly with the detector and houses more functional features and also provides a better user experience.

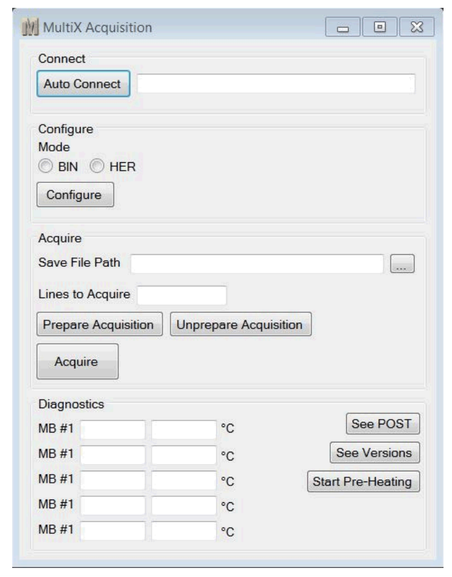

Figure 5: Developed UI

Correcting Error in Results

The detector had three poorly-functioning pixels that introduced error into the final results. While most cells in a line had values ranging from 10 to 100, the malfunctioning pixels often resulted in cells with values in the thousands. Due to the coloring scheme used, this resulted in only a few pixels being colored black with the others being mostly white or grey, as the erroneously high pixel values threw off the coloring scale. To remedy this problem, any value within the 90th percentile of values was colored black, instead of only the highest value receiving that coloring.

A line from the MultiX detector colored on a linear scale, with the lowest value set to white and the highest set to black. The only cells that appear dark are those contained within the wild pixels

Figure 6

The same line as Figure 6 now colored with a scheme where every value in the 90th percentile is black. This allows the detail of the line to be discerned

Figure 7

Future Work

- Integrate UI into the detector's software
- Create a program that stacks lines in order to obtain images
- Convert final images to TIFF files
- Make the entire process seamless; ideally, the detector's output would be converted into image format while the detector is still acquiring data
- Pseudo-color the images based on the energy of the x-rays

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.
SAND No. 2011-XXXXP

U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration