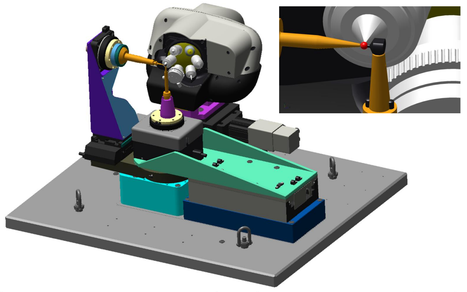
Improving NIF Target Capsule Debris Volume Calculations in the Presence of Low Contrast and Rough Texture

Joshua Senecal, Aaron Peer, and Salmaan H. Baxamusa
National Ignition Facility, Lawrence Livermore National Laboratory

The 4π inspection station images the surfaces of NIF target capsules, recording luminance and height for each pixel. These data are used to determine the locations and volumes of debris on the capsule surface. Volume calculations are currently done through height data analysis, but low contrast or rough texture makes finding object boundaries difficult. We obtain a more accurate boundary—and therefore volume—by using a Zernike fit for background-subtraction calculations on the height data. We obtain more boundary information from luminance data analysis, and by including areas of invalid height data.

The 4π System Finds and Measures Debris

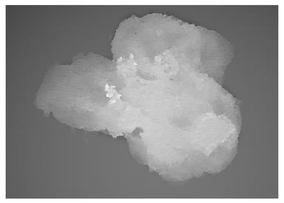


The surface of a capsule is imaged by the 4π imaging station's Leica confocal microscope, computing a luminance and height (Z) value per pixel. Analysis of "low-mag" luminance (50x) finds objects of interest. Analysis of Z data from "high-mag" (100x) images computes boundary and volume of each object.

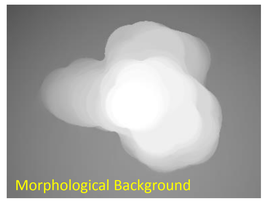
Analysis computes and subtracts out a background for each image. The LASNR algorithm [1] identifies objects, and automated, adaptive filling finds object boundaries. Some Z data is low-contrast, making objects hard to detect via LASNR. Object texture and artifacts in the background image thwart the fill.

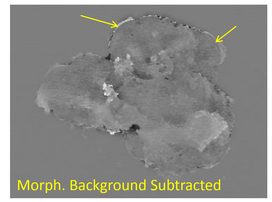
Artifact-Free Backgrounds With a Zernike Fit

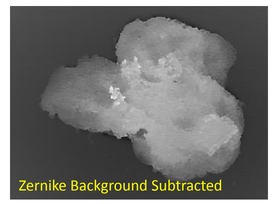
We perform background-subtraction on Z data to remove any background bias and make the foreground (objects) stand out. Previously, background computation used morphological operations. If an object (image below) is large compared to the structuring element, the background and background-subtracted data have artifacts that interfere with filling (top images at right).



A Zernike fit computes a background for the entire image, so the background and background-subtracted data (bottom images at right) are free of artifacts. Finding the boundary is easier.

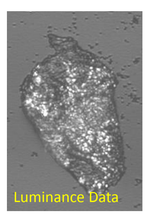


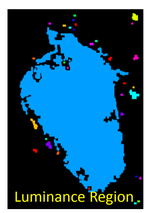


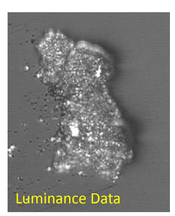


Boundary Information From Luminance and Invalid Data

If Z data (left) is still low-contrast or rough-textured, finding the boundary can be difficult. Luminance data (right) can provide additional boundary information, often with a simple threshold.





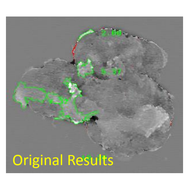


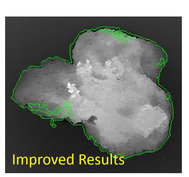
Sometimes the Leica is unable to determine a Z value at a pixel, due to the orientation or texture of an object (first image at left). The data at this pixel location is invalid (examples indicated in red, second image at left). Previously no special consideration was given to invalid Z data. Since the presence of invalid data indicates an object is present at the location we include regions of invalid Z data in the boundary computed from Z.

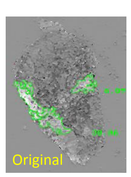
Zernike Backgrounds and Multiple Boundary Sources Yield More Accurate Volumes

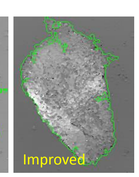
Boundaries identified in luminance and Z data are compared. If their sizes are similar, the Z-derived boundary is used. To guard against an incomplete or occasional "runaway" fill, if the Z boundary is much larger or smaller than the luminance one, the luminance boundary is chosen.

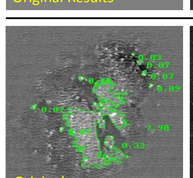
The Z data within this boundary is summed to compute the object volume.

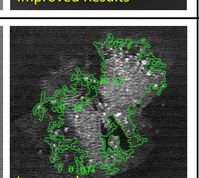


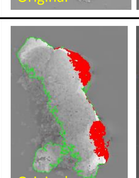


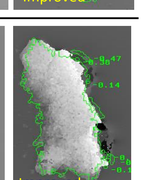












The image pairs at left show results using current production techniques (left image in pair) and using the proposed methods (right image in pair). The methods described here are currently undergoing testing and refinement prior to deployment for production use.

References

1. Kegelmeyer, Laura Mascio; et al. "Local area signal-to-noise ratio (LASNR) algorithm for image segmentation", Conference on Applications of Digital Image Processing XXX, ed. Tescher, AG, San Diego, CA, AUG 28-30, 2007

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

LLNL-POST-670455