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RAPID DATA COMPARISON TECHNIQUE DEVELOPMENT FOR N-RAY/X-RAY ANALYSIS

FINAL REPORT

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JOHN F. KENNEDY SPACE CENTER, NASA

DATA ANALYSIS FACILITY

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I. Accomplishment of Technical Objectives

A. <u>Develop more efficient data transfer routines to be used by existing image processing systems</u>.

This objective has been attained and realized by numerous programs used in N-ray/X-ray analysis. Execution times of one - tenth (0.1) the previous execution time are typical.

B. <u>Develop capability to store/analyze multiple N-ray/X-ray images</u>.

This capability has been completely developed and implemented. Change detection, time sequence analysis, and noise reduction via successive frame averaging now exist in a versatile and effective manner.

C. <u>Develop and implement an efficient 2-D Fast Fourier Transform</u>.

An efficient two-dimensional Fast Fourier Transform (FFT) has been developed for small image arrays (less than or equal to 19 x 19 picture elements) which is accurate to within 1% of a large array (512 x 512) FFT.

D. <u>Develop transfer function compensation capability which would correct for distortions and nonlinearities of N-ray/X-rays</u>.

This objective has been fully realized. Distortion correction has been accomplished for symmetrically blurred images and images with variable background shading.

II. Overall Assessment

Capability for rapid data comparison of N-ray/X-ray imagery now exists at the KSC Data Analysis Facility as a result of this study. Information, heretofore unattainable, can now be extracted from N-ray/X-ray image sets used in KSC support. N-ray/X-ray imagery used in KSC launch and support activities can now be analyzed more thoroughly and correctly. The capability for developing an operational N-ray/X-ray analysis system for various Shuttle problems has been realized.

This study has ascertained the ability of the N-ray/X-ray Rapid Data Comparison Techniques to provide:

1. Hydraulic fluid detection on/in Thermal Protection System (TPS) tiles.
2. Corrosion detection beneath TPS tiles.
3. Defective electrical device and printed circuit board detection.
4. Defective pyrotechnic device detection.
5. Restoration of blurred images from fast film and set up problems.

6. Change detection for corrosion tracking.
7. Reduction of image shading nonuniformities.
8. Identification of various materials via table look up techniques.

III. Applications of N-ray/X-ray Rapid Data Comparison Technique

A. <u>Thermal Protection System (TPS) tile with hydraulic fluid</u>

A N-ray/X-ray pair was taken of TPS tile test samples with hydraulic fluid injected at various points. A multichannel signature was developed exclusively for the hydraulic fluid. In addition, different concentrations of hydraulic fluid were found to have different signatures.

B. <u>Thermal Protection System (TPS) tile with corrosion</u>

A N-ray/X-ray pair was taken of TPS tile test samples with a corrosion material (aluminum hydroxide) injected at various areas. A multichannel signature was developed exclusively for the corrosion. A simple ratio of the N-ray to the X-ray, with appropriate scaling, extracted the corrosion areas "automatically". In addition, different concentrations of corrosion were found to have different signatures.

C. Thermal Protection System (TPS) tile debonding

A N-ray/X-ray pair was taken of TPS tile test samples with debonding present in certain areas. A multichannel signature could not be developed for the debond areas. It appears that the N-ray/X-ray combination did not detect any differences between bonded and debonded areas. One possible future approach is to use spatial frequency signatures for discrimination of debond.

D. Stainless steel tubing corrosion

A N-ray/X-ray pair was taken of stainless steel tubing samples with different types of internal corrosion present. A multichannel signature could not be developed for any type of corrosion. It appears that the N-ray/X-ray combination did not detect the difference between normal and corrosion-coated internal stainless steel areas.

E. Defective electrical devices and printed circuit (PC) boards

A N-ray/X-ray pair was taken of printed circuit boards containing etching, electrical component, and connection defects. A multichannel signature was developed exclusively for each defect. Of particular interest is that each component (e.g. resistor, capacitor, transistor) possessed a unique signature.

F. <u>Defective pyrotechnic devices</u>

A N-ray/X-ray pair was taken of assorted pyrotechnic devices containing certain defects. A multichannel signature was developed exclusively for each defect.

G. <u>Fast film restoration and deblur</u>

In order to save time, faster films can be used for N-rays or X-rays. The disadvantage is that the resultant image is more "grainy" and blurred compared to the slower film. In some cases, even slow films are blurred due to various set up problems. Example of these image degradations were processed using a general purpose digital filter. All but the most severe symmetrically distorted images were restored to acceptable form, using a high-emphasis filter function.

H. <u>Corrosion tracking over time</u>

A N-ray/X-ray pair was taken of aluminum test blocks undergoing progressive corrosion with time. Temporal sets of these images were analyzed for change detection using image subtraction techniques. Sharp delineation of the areas of change, time sequence display, and threshold detection were some of the results of the change detection techniques.

I. Reduction of source vignetting

N-ray and X-ray scanner systems may exhibit some degree of source vignetting (background shading non-uniformity). Examples of these nonlinearities were successfully put through transfer function compensation to correct the distortions. Subtractive and ratio techniques were employed for shading correction.

J. Identification of materials via table look up

N-ray/X-ray pairs were taken of O-rings, teflon parts, soft goods, etc. in addition to the other examples in this report. Most of these materials proved themselves amenable to a table look up approach of classification. In many cases, neither the N-ray or X-ray possessed a unique signature for a certain type of material. However, using both N-ray and X-ray images for multichannel signature analysis resulted in table look up potential.