Automated Baseline Change Detection (ABCD) for Robotic Drum Inspection

Developer: Lockheed Martin
Contract Number: DE-AR21-94MC31191
Crosscutting Area: Robotics

Mixed Waste FOCUS AREA

Problem:

Regulations require weekly inspections of thousands of barrels of mixed waste stored at Department of Energy (DOE) sites. Manual inspection processes are time consuming, of inconsistent quality, and expose humans to toxic and radioactive materials. Other DOE projects are addressing the automated acquisition of optical images and partial image analysis with the Stored Waste Autonomous Mobile Inspector (SWAMI), the Intelligent Mobile Sensor System (IMSS), and A Robotic Inspection Experimental System (AIRES). But these image analyses do not detect all required potential failures.

Solution:

This project enhances both the reliability and validity of barrel inspection by detecting any change in the visual appearance of a barrel. This is done by comparing a current inspection image with an archived baseline image, hence the name Baseline Change Detection (BCD). Thus ABCD is not limited to only known changes. Any change, whether it is recognized as a potential hazard or not, is identified. If further interpretative analysis, such as rust detection, verifies that the change is benign, then no further action is required. If interpretative analysis is not familiar with the observed type of change, or if the change is not benign, then human operators are notified of the potentially hazardous change. Note that depending upon operational considerations, no operator action is mandatory for benign changes. Benign changes may still be used for trend analysis.

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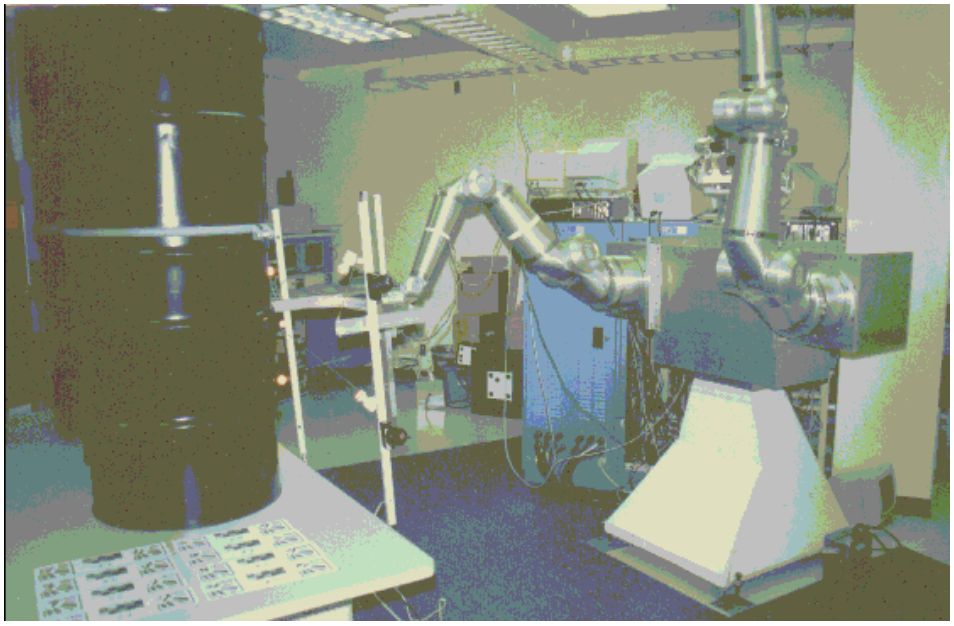
Benefits:

- Automatic detection of any visual change on the barrel surfaces
- Decreased risks and increased efficiency



▸Reliable early warning of storage problems with minimal image understanding or human inspection

Technology:

Lockheed Martin's ABCD sensor system integrates robot control, image processing, and the Kinetic Sciences, Inc. Eagle Eye system to produce a system that acquires and identifies the target, computes sensor pose, and rapidly and precisely repositions the sensor. The ABCD project embodies two key technical strategies: (1) practical, real-time determination barrel identification with full 3-D pose (position and orientation) relative to the sensors and (2) application of image registration to change detection through sensor repositioning and image transformation to match the pose of an archived image.

The main components of the ABCD system are shown in the figure. In routine operation, the base platform moves the sensor to a stack of barrels and stops when the sensor is nearly centered on the identification and pose label. The sensor precision-positioning system repositions the camera into the same relative pose that was used for an archived reference image. A new image is compared to the baseline reference image. Because the camera is precisely repositioned the image comparison is based on image subtraction with minimal translation for registration.

Changes, if any, are compared to operational criteria. Change analysis may be performed, such as spectral analysis and image interpretation, and additional images may be saved for later inspection and record keeping. For example, image interpretation may be used to reduce potential false positive changes.

If image interpretation concludes that the change is benign, the unit passes inspection. But if not benign or if still uncertain, then other actions, such as human notification, can be taken. In this manner, there is very low risk of inspection failure and human involvement is focused on the most important cases.

ABCD is one of three drum inspection technologies to participate in a "bake-off" among other similar and competing technologies. The other two systems are the IMSS (also developed by Lockheed Martin) and the Intelligent Inspection and Survey Robot (ARIES, developed by the South Carolina Universities Research and Education Foundation).

Project Conclusion:

The project concluded in October 1997. The ABCD was integrated with the IMSS and tested at the DOE Fernald and Idaho National Engineering and Environmental Laboratory (INEEL) sites. Currently, the system is being further testing at INEEL and thereafter, will be used to inspect drums at INEEL in order to assess the reliability and performance of the system.

Contacts:

The Automation & Robotics Laboratory of Lockheed Martin's Palo Alto Research Laboratories develops key advanced technologies for teleoperations, telerobotics, and supervised, autonomously controlled robotic systems. It is supported in ABCD by Kinetics Sciences, Inc., developers of the Eagle Eye Vision Software System. For information on this project, the contractor contact is:

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