IPNDV Working Group 3: Technical Challenges and Solutions
Chain of Custody (8)—Technology Data Sheet

October 3, 2017

Chain of Custody (CoC) Technology Name: Optical Change Detection

Physical Principle/Methodology of Technology:

Optical change detection uses an imaging device and change detection software to compare and to identify changes in two images of the same item taken at different times. An optical system such as a camera is used to acquire images of an item selected for inspection. The reference (or initial) image is compared using change detection software with an inspected image taken some time later. The pictures below highlight the footprints in the grass obtained by comparing two images.

Image #1 Reference (initial)	Image #2 Inspected (taken later in time)	Comparison of Images #1 and #2 Highlights footprint difference
		

Figure 1: Pictures comparing two images highlight the footprints in the grass. (Photo Credit: Idaho National Laboratory)

Change detection software is used to identify changes to images based upon software algorithms. There are many change detection algorithms available, including human image analysis elicited by flicker technique ("animation effect"), mathematical comparisons to create an image difference, and calculation of a correlation factor representing the magnitude of the two images difference. The open literature contains good descriptions of change detection algorithms (see references below).

The image analysis could be performed on a fixed computer system, which remains installed in an inspector station, which requires images to be transferred from the imaging device to the computer. More recently, research developments are pursuing a hand-held, mobile imaging device with an integrated software package, such as Idaho National Laboratory's mobile Icarus, to capture, categorize, align, and store large datasets of seal images.

Potential Monitoring Use Cases (e.g., chain of custody, nuclear material detection, explosives detection, etc.):

Monitoring use cases for optical change detection technology include inspection activities of tags, seals and tamper-indicating enclosures (TIE); and chain-of-custody verification for warheads, materials, equipment, devices, locked doors, and secure areas. The image analysis comparison of a reference and inspected image can be used to verify design information, verify the absence of undeclared changes, detect movement of containers, and verify containment of items and areas.

Physical Description of Technology (e.g., approximate size, weight):

Hand-held mobile imaging devices are small and light-weight with a range of sizes and weights for smartphones, phablets, tablets, and digital cameras: 100–900 g, 80–200 × 50-300 × 8–50 mm. A computer, laptop, or mobile platform system is needed for software analyses.

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Time Constraints (e.g., measurement times, time to install the equipment):

It takes less than 5 minutes for to install the software. Verification of images taken in the field will take significantly longer. The manual process of checking data logs, sorting images, and aligning and processing images of the same item is a time-consuming and tedious process. The imaging inspection, analysis, and review at an inspector review station will take approximately 1–2 minutes per item.

Technology Complexity (e.g., hardware, software, and ease of use by personnel):

Hardware: complex electronics for mobile devices.

Software: range of simple to complex imaging algorithms.

Use by personnel: Acquiring good quality images of inspection objects is relatively simple, but reproducibility can be improved with a camera adapter that provides consistent lighting and distance between the camera and selected item. Typically, inspectors require one day of training for using associated software to understand tampering signs of an item.

Infrastructure Requirements (e.g., electrical, liquid nitrogen, etc.):

Mobile, hand-held imaging devices are battery operated and do not have infrastructure requirements. Processing comparisons of images could require a standard, electrical facility connection for a desktop computer or a laptop computer.

Technology Limitations (e.g., detection limits for nuclear material, operational temperature range):

The image quality and consistency of field conditions (alignment, normalization of lighting and color) for acquired images of the same item can limit the sensitivity of the software to detecting changes. Some pre-processing software may be required to improve the image comparison assessment for tamper or change events.

Technology Development Stage (e.g., commercially available, development stage):

Readily available (9)

Cost Estimate:

USD $200–1,000 depending upon the digital platform. Commercial software packages can provide image processing, image analysis, and information extraction tools.

Additional System Functionality (e.g., outside the monitoring use case):

Current digital imaging devices (such as cameras and tablets) have Bluetooth and WiFi capabilities.

References:

A. Hegil and B. Bengtsson, “Diagnosis of Early Glaucoma with Flicker Comparisons of Serial Disc Photographs,” *Investigative Ophthalmology & Visual Science* 30 (1989): 2376–84.

S. Minu and A. Shetty, “Comparative Study of Change Detection Algorithms in Matlab,” *Aquatic Procedia* 4 (2015): 1366–73.

R.J. Radke, S. Andra, O. Al-Kofahi, and B. Roysam, "Image Detection Algorithms: A Systematic Study," *IEEE Transactions on Image Processing* 14, no. 3 (2005): 294–307.

ArcGIS Change Detection Software and Tool, available at http://solutions.arcgis.com/defense/help/image-change-detection/.

Harris Change Detection Analysis Software, available at http://www.harrisgeospatial.com/docs/ChangeDetectionAnalysis.html.