SWGDE Technical Overview for Forensic Image Comparison

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1. Purpose

The purpose of this document is to provide image analysis practitioners information as to the historical background of Forensic Image Comparison, as well as the technical foundation, methodology, and limitations when engaging in Forensic Image Comparison.

2. Introduction

Forensic Image Comparison is an assessment of the correspondence between features in questioned items depicted in images and either questioned or known objects or images, for the purpose of rendering an expert opinion regarding identification or elimination (as opposed to a demonstrative exhibit). Forensic Image Comparison is a subtask of Image Analysis, and general best practices issues are discussed in the SWGDE document "Best Practices for Photographic Comparison for All Disciplines". This document addresses technical issues specific to Forensic Image Comparison.

3. Historical Background

Warren Commission Photo

A prominent public example of Forensic Image (Photographic) Comparison examinations took place as part of the Warren Commission investigation into the assassination of President Kennedy. Photographic comparisons in this investigation were used to help establish the rifle as being Oswald's, as well as to establish that the "Backyard Photos" were taken with Oswald's camera.

Another well-known example of image comparison occurred in 2002. During that time period, National Geographic magazine elected to investigate the fate of the individual depicted in a well-known image, the Afghan girl, shown in the image on the left. Image comparison showed the individual on the right was most likely the girl, based on correspondence between both class and individualizing characteristics present in the imagery. The conclusion of the examiner was later confirmed through iris scan technology.

(photographs captured by Steve McCurry, National Geographic)

Forensic Image Comparison examinations may be conducted on virtually any subject or item depicted in imagery. Common sources of imagery used in image comparison include surveillance video, booking photos, and images recovered from the Internet and mobile devices. Requests for comparison may include (but are not limited to) images depicting:

- Faces and other body parts/areas
- Vehicles
- Weapons
- Clothing
- Luggage
- Furniture
- Landscapes and structures

Forensic examiners may also be asked to compare a questioned image with a known camera to determine if the image was captured using that camera. For further information on this procedure, see SWGDE document "Best Practices for Image Authentication".

4. Expertise and Training

Before conducting forensic image comparisons, individuals should have expertise in imaging science, knowledge of the objects being compared, and an understanding of the comparison methodology. Image science expertise is necessary to understand the creation and evaluation of artifacts from the imaging process. Object knowledge is necessary to understand the significance of features. Such knowledge may be developed in response to the needs of a specific case. For instance, a comparison involving an item of clothing may require research into the clothing manufacturing process. Understanding the comparison methodology is necessary to assess the utility of the features for comparison leading to a conclusion. This combination of expertise may require both formal training and practical experience (i.e. on-the-job) among multiple disciplines, or it may require the involvement of multiple individuals with a variety of expertise.

A fundamental feature of image comparison is the ability to recognize features, and assign meaning for the formulation of a conclusion. Training should provide a basic level of competence, but the translation of training into practice requires real-world experience under supervision by qualified personnel.

For more information, see SWGDE document "*SWGDE Training Guidelines for Image Analysis, Video Analysis and Photography*".

5. Technical Foundations

There are a number of critical practices, processes, and factors that form a technical foundation for forensic photographic comparison. The relative importance of any one of these aspects may vary among cases and may assist in demonstrating and ensuring validity in the analysis. Class and individual characteristics, image conditions, and the availability of statistical models are important to consider when conducting photographic comparisons.

5.1 Class and Individual Characteristics

The basis for conclusions reached through forensic image comparison lies in the observation and evaluation of the correspondence or discordance of features of the items being compared. These features are referred to as class and individual characteristics.

Class characteristics are the observable characteristics which are used to divide objects into groups or classes through the sharing of common features. A correspondence of class characteristics may be useful for grouping subjects. Likewise, a discordance of class characteristics can be used to eliminate potential subjects. An example of a class would be all vehicles of the same make, model and year range, such as a 2004 Ford Freestar. Some class characteristics of the 2004 Ford Freestar include the shape of the headlights, the shape of the grill, the position and shape of the taillights, and the body shape. Classes may be further subdivided depending on the number of observable common features. An example of this would be further dividing the class of vehicle by tonality.

Individual characteristics are the observable characteristics which differentiate objects within a class from one another. Individual characteristics arise from such events as random natural processes, manufacturing processes, intentional alteration, and wear-and-tear. The ability to identify a specific person or object requires a correspondence of individual characteristics. The analyst will determine the sufficiency of characteristics based on their expertise, through a careful consideration of the subject matter, as well as the quality, quantity, and persistence of details in the imagery. No arbitrary number of characteristics is required. An example of individualizing characteristics on the depicted 2004 Ford Freestar include scratches along the rear passenger door, the presence, position and details of the stickers on the rear and windshield of the vehicle, and possibly even the examination of debris spray patterns behind the passenger

side rear tire. An examiner should assign significance to the observed characteristics based on the level of detail and the perceived rarity of the feature to formulate a conclusion.

5.2 Imaging Conditions and Artifacts

In order to accurately interpret the content of an image under examination, it is imperative that the examiner recognize the conditions and limitations that occurred during image capture, processing or editing. Imaging conditions can impact the appearance of subjects or objects depicted. Important conditions to understand include, but are not limited to:

- Resolution – determines the degree of detail recorded in the image
- File properties - can cause the permanent loss of detail in the image through compression, sub-sampling, interference in the signal, player or playback characteristics (including the player perceived aspect ratio), etc.
- Optical defects – can cause visual effects due to lens aberrations, wide angle distortion, color shift, improper (or non-existent) cleaning of the lens, obscurations in the line-of-sight, etc.
- Sensor defects – can introduce noise, image artifacts, or 'hot' or 'dead' pixels, possibly due to imperfections or improper cleaning of the sensor
- Lighting conditions – can show, hide, or distort details, or change the tonality of an image, due to amount, angle, or type of lighting. Examples include, but are not limited to:
  - The emphasis of textures or reflections based on the angle of light to the subject (e.g. oblique lighting)
  - Obscuring details in shadows or bright light
  - Change in tonality due to improper settings for color temperature of available light
  - Capture of infra-red (IR) light (due to lack of or removable IR blocking filter) causing tonality shifts
- Atmospheric conditions – can vary the appearance of details based on weather, humidity, fog, time of day, celestial bodies (sun, moon, and stars)
- Motion or Focal Blur – can cause detail loss from movement of the camera or subject of the video, or improper focusing of the camera lens
- Post-processing - processing performed on imagery after the time of capture, including both at and after the time of initial storage. Post-processing can be implemented for a specific purpose (for instance, saving storage space or enhancing the image), and can be either beneficial or detrimental to the comparison process. Examples include, but are not limited to, lighting adjustments, sharpening, copy-paste (or cloning), re-compression, frame averaging, and Fourier transforms.

It is important to not mistake artifacts of the imaging process as the actual physical properties of the subject. For example, a watermark on a passport photograph should not be misinterpreted as a tattoo on the subject depicted. Likewise, imaging conditions may introduce artifacts that need to be recognized during the interpretation process.

In order to deal with the issues inherent to the imaging process, the selection of imagery is crucial. When available, the selection of multiple images allows the persistence of features to be examined, which can help an examiner distinguish between features and artifacts. Proper image selection allows the examiner to observe features visible only from specific perspectives. (E.g.

An examiner may need to select images depicting a vehicle from multiple angles, to see multiple class characteristics. Similarly, an examiner may only be able to see the sticker visible on the windshield from the front or the side, but not from the rear.)

5.3 5.3 Statistical models

Statistical models may exist or be developed which may provide a formal probabilistic basis for conclusion. Formalizing conclusions through statistical methods is recommended when available. Development of a statistical basis may not be possible or may not be practical in every situation.

The absence of a statistical model does not necessarily preclude formulating a sound conclusion. In such cases, experience is critical for the recognition of features and their significance. Experts must be able to explicitly state the underlying assumptions, observations, and chain of reasoning behind their conclusions in order to demonstrate that validity.

6. Acceptable Methodologies

6.1 Selection of Images for Comparison

If the submitted images include more than one depiction of the questioned and known objects, the practitioner should screen them based on quality and content to determine which images will be useful for analysis. Once selected, images are then processed as necessary.

6.2 Image Processing

Photographic comparisons commonly involve an examination and evaluation of features observed in a submitted image compared to features of a known subject. This process may require image processing to enhance features to make them more visible for comparison. Image processing should be conducted in accordance with the SWGDE document, "*SWGDE Image Processing Guidelines*."

6.3 Reconstruction

Often it is necessary to determine that issues of image creation, lighting, and composition do not create artifacts that affect the comparison. Reconstruction of the circumstances of the questioned image acquisition may be necessary.

This reconstruction may consist of photographing the object under comparable conditions as seen in the questioned image or otherwise duplicating them by real or virtual means.

6.4 Comparison Process

Multiple methodologies exist for image comparison. Any methodology applied to photographic comparison should incorporate an analysis of the imagery, a comparison of individual features, an evaluation of the significance of the comparison, and a verification of the comparison. The repeatability of the procedure and documentation of the workflow is of paramount importance. Additional information regarding the methodology of forensic image comparisons can be found

in the SWGDE document "*SWGDE Best Practices for Photographic Comparison for All Disciplines*."

7. Reporting Conclusions

In those cases where a statistical basis for decision making exists, the level of finding should reflect the appropriate probability. The underlying assumptions, particularly simplifying assumptions, for the statistical model should be reported.

In those cases, without a statistical basis, a clear indication of the strength of the conclusion should be given; this will necessarily be a descriptive statement and not a numerical probability. Agencies should employ a scale for reporting conclusions with identification at one end, elimination at the other, no conclusion in the middle, and some type of qualitative intermediate steps. In addition, the examiner may choose to clarify their conclusion with an indication of the suitability of the imagery used for comparison, particularly if the suitability precludes a finding.

Agency specific language may be required for both reporting and testimony, to ensure uniformity among examiners. This language should be reflected in agency quality assurance manuals or other documents (SOPs).

8. Limitations

The forensic image comparisons process can be affected by a number of factors. For example, an object with few unique characteristics will be difficult to distinguish from others of the same class, particularly when highly detailed images are unavailable.

Competent photographic comparison requires adequate technological and physical support, ranging from hardware and software to environments adequate for proper visualization.

A steady workload facilitates the development of experience. Agencies are encouraged to ensure that their image analysis experts are given a case load that is manageable, yet sufficient to maintain proficiency.

Managers should recognize that working a single case involves many factors beyond the processing of images for comparison and noting of similarities and dissimilarities. In addition to administrative and quality requirements, there may also be the need for additional research, testing, and consultation in order to achieve a conclusion. Failure to allocate sufficient time per case to the examiner may also eventually lead to error and incomplete examination.

Cognitive bias should be addressed through awareness, training, and quality assurance measures. These quality assurance measures should include the limiting of task irrelevant information.

9. Other Laboratory Factors

9.1 Evidence Management

Items subject to photographic comparison may also be analyzed by other forensic science disciplines. Laboratory management should be aware of the possibility of photographic examinations and its placement in the overall analytic work flow. The sequence of examination

is critical for photographic comparison examinations because other examinations may render the object unsuitable for comparison. For example, removal of fabric from clothing for DNA analysis can destroy visually significant features. Identification marks placed on shoes during footwear impression examinations can also adversely affect the comparison.

Similarly, the improper handling of an object during photographic comparison may contaminate or alter it, and adversely affect the outcome of subsequent examinations. For example, latent fingerprints may be destroyed, or DNA can be accidentally added to an item during examination.

9.2 Quality Control/Quality Assurance

An organization should strive to follow best practices in order to assure accurate results, through the use of appropriate quality assurance procedures. Organizations should have a quality assurance manual that includes standard operating procedures for examinations, including verifications, technical, and administrative review procedures, training manuals, methods for ensuring the competency of examiners, and criteria for calibration of equipment (when appropriate).

For more information on appropriate procedures, see the SWGDE document "*SWGDE Minimum Requirements for Quality Assurance in the Processing of Digital and Multimedia Evidence*."

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History

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