SWGDE Best Practices for the Forensic Use of Photogrammetry

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1. Purpose

The purpose of this document is to provide personnel with recommendations regarding appropriate practices when performing photogrammetric examinations as a part of forensic analysis.

2. Scope

This document provides basic information on the evidentiary value, methodology, and limitations when conducting photogrammetric examinations as a part of forensic analysis. The intended audience is examiners in a laboratory setting.

This document is not intended to be used as a step-by-step guide for conducting a proper forensic examination or reaching a conclusion. This document should not be construed as legal advice.

3. Limitations

Many forensic disciplines (e.g., image analysis, video analysis, crime scene reconstruction, bloodstain pattern analysis) utilize photogrammetric analysis. This document will only describe the analytical techniques and limitations associated with photogrammetry as applied to video and image analysis. For the purposes of this document, the word “imagery” may mean images, photographs, or still imagery derived from video.

4. Evidence Preparation

General guidelines concerning the preparation of evidence for photogrammetric analysis are provided as follows:

4.1. Complete an initial assessment of the imagery.

4.1.1. Determine if the submitted imagery is the original, or a bit-for-bit duplicate. If the submitted imagery is not a bit-for-bit duplicate, determine if one is available.

4.1.2. Determine if the submitted material is suitable for analysis. Suitability for analysis is determined by the requested examination. For example, in a subject height analysis, the practitioner may determine that the subject must be visible from head to toe, and the body length is at least 25% of the image. Further, the practitioner may examine the image for the presence of stationary objects in the foreground and background of known dimensions, and may make an assessment as to whether the angle of capture is conducive to examination.

4.1.3. Determine if all of the submitted material, or some subset of the material, is to be subjected to analysis.

4.2. Produce working copies of the imagery to be subjected to analysis. This may require digitization from negatives, prints, or conversion from other media.

4.3. Enhance images. Refer to *SWGIT Section 11 – Best Practices for Documenting Image Enhancement*.

5. Method

Multiple techniques exist for completing photogrammetric analysis, including reverse projection, analytical photogrammetry, and dimensional scanning. Practitioners of photogrammetry should have sufficient expertise in image science, which may include video engineering, to support conclusions and address potential sources of uncertainty in the measurement.

5.1. Determine if the criteria necessary for reaching a conclusion are present in the processed image.

5.2. Identify a methodology for reaching a conclusion. This may include reverse projection, analytical photogrammetry, or some other method.

5.2.1. Reverse projection photogrammetry involves the positioning of a camera and recording in the perspective and aspect ratio duplicating the original imagery. A calibrated measuring device may then be used to complete the requested analysis.

5.2.2. Analytical photogrammetry involves applying knowledge of the geometrical properties of the imaging process, and known measurements associated with the imagery, to obtain unknown measurements. Perspective based analysis and direct scaling are two approaches.

5.3. Enact chosen methodology and record results. If the chosen methodology is not discussed above, the methodology should be sufficiently documented and have a scientific basis.

6. Conclusions

Based on the observations and measurements, a conclusion should be reached. This may or may not involve a numerical result.

6.1. Report conclusions, as appropriate, for the requested analysis. The basis for, and uncertainty of, any conclusions should be documented and reported.

6.2. The results of the examination should undergo independent review by a comparably trained individual. If disputes during review arise, a means for resolution of issues should be in place.

7. Evidentiary Value and Limitations of Methodology

Photogrammetric analysis is a long-standing science that can aid in the exclusion and inclusion of items and people in forensic analysis. It can also answer specific questions regarding speed, location, and distances. Reference materials and case studies provide information as to the history, theory, and application of photogrammetric analysis.

In photogrammetric examinations, multiple sources of uncertainty and potential error can be examined. Uncertainty can result from the mechanics of the imaging process, as well as from contextual biases. An analysis of such uncertainty should be performed and documented. See **Appendix A** for further information.

It should be noted, the measured result might require interpretation by the examiner based on the identified sources of uncertainty (and potential error). For example, the individual frame of a subject selected for height analysis will affect results, as height will vary over time. The examiner can use the measured height, as well as calculated uncertainty, to determine whether a suspect can be excluded or included.

8. References

[1] Scientific Working Group on Imaging Technology, "Section 11: Best Practices for Documenting Image Enhancement". [Online]. https://www.swgit.org/documents/Current%20Documents

Appendix A: Reporting Conclusions through Quantitative Means

Photogrammetric evaluation is amenable to estimation of error, either through the propagation of error involved in the calculations, or in comparison with known measurements that may be present in an image. Both common kinds of error (imprecision and bias) should be estimated if possible, and if not possible, the limitations of the method should be mentioned in the final report.

Example: As in the workflow example, the practitioner is requested to complete a photogrammetric examination of a bank robber depicted in a DCCTV surveillance video. The police have two different suspects, and would like to determine if either can be eliminated based on height.

The practitioner elects to use the recommended workflow for photogrammetry, incorporating reverse projection as the analytical methodology. Photogrammetric measurement estimates the height of the individual to be 6’1”. This measurement is based on the vertical distance from the floor to the top of the individual’s headwear, in a single selected image.

However, multiple areas of uncertainty can be calculated, and multiple limitations in this measurement should be noted in the analytical report.

1. In photogrammetric examinations, the estimated uncertainty relies on the overall resolution of the imagery. When the number of pixels representing a given area (or a line of video) in an image increases, the practitioner will be able to narrow the uncertainty based on resolution. This uncertainty may need to be calculated at two points when completing two examinations, as in an analysis of the velocity of a subject.
2. In photogrammetric examinations, the estimated uncertainty relies on the ability of the practitioner to locate the position in which the subject was located at the time the original image was captured. This uncertainty can be calculated by determining the uncertainty in the measured distance within a given radius of position, based on geometric principles.
3. In subject height analysis, the measurement is captured at only a single moment of time. Given that multiple factors can change a subject’s stature, including choice of footwear, choice of headwear, positioning in gait, and the natural circadian rhythms of the human body, the measured height can be no more than an estimation.
4. In the case of a velocity analysis, the calculated value for velocity relies upon a known, regular frame rate. The uncertainty in the calculated value must be examined based on these assumptions, based on principles of video engineering.
5. Ideally, a practitioner of photogrammetry should strive to be unbiased in examination. To avoid potential bias, the practitioner should avoid contextual information that would tend to bias results prior to release of report, such as the measured height of a suspect.

Appendix B: Work Flow Examples

Scenario: A local police agency asks the crime lab to determine the height of the individual depicted robbing a bank in a surveillance video, captured by a DCCTV system. The agency has two suspects of different heights, and would like the crime lab to determine if either can be excluded on this basis.

Following the workflow delineated above, the practitioner proceeds as follows:

1. The practitioner determines that the imagery is the original video, not a transcoded copy.
2. The practitioner reviews the material and determines if images exist conducive to an accurate photogrammetric examination
3. The practitioner determines if more than one examination is appropriate to complete the request.
4. The practitioner transfers the contents of the video file to a working file.
5. The practitioner processes the video files.
    a. Still images are output from the video files, and images conducive to an accurate photogrammetric analysis are selected.
    b. Standard image processing techniques, such as brightness and contrast adjustments, are applied to the working images.
6. The practitioner imports the images into a photogrammetric application and conducts analysis. This analysis results in a calculated value for the robber's height, as well as a determination of the accuracy and precision of this result.
7. The practitioner writes the report. Per the crime lab's standard operating procedures, the report includes a review of the materials received, the request, the methods used, the results obtained, the basis for the conclusion, the conclusion, and an estimate of the accuracy and precision.
8. The report is administratively and technically reviewed prior to release.

Scenario: A local police agency asks the crime lab to determine the velocity of a vehicle, as it is driven toward impact. The vehicle is captured for approximately four seconds, just prior to collision. The agency would like to know the vehicle's velocity as a possible aggravating factor in the investigation of the collision.

The practitioner proceeds as follows:

1. The practitioner determines that the imagery is the original video, not a transcoded copy.
2. The practitioner reviews the material and determines if images exist conducive to an accurate photogrammetric examination.

3. The practitioner determines if more than one examination is appropriate to complete the request.
4. The practitioner transfers the contents of the video file to a working file.
5. The practitioner processes the video files.
    a. Still images are output from the video files, and images conducive to an accurate photogrammetric analysis are selected, taking into account the known time elapsed between the images.
    b. Standard image processing techniques, such as brightness and contrast adjustments, are applied to the working images.
6. The practitioner imports the images into a photogrammetric application and conducts analysis. This analysis results in a calculated value for the vehicle's velocity, as well as a determination of the accuracy and precision of this result.
7. The practitioner writes the report. Per the crime lab's standard operating procedures, the report includes a review of the materials received, the request, the methods used, the results obtained, the basis for the conclusion, the conclusion, and an estimate of the accuracy and precision.
8. The report is administratively and technically reviewed prior to release.

Appendix C: Sample Questions Asked in Forensic Photogrammetry

- How tall is the individual?
- How fast was the vehicle/person/object traveling?
- What time of day was the photograph taken?
- Where is the scene depicted in the image?
- What are the dimensions of this object?
    - (e.g., how long is this firearm?)
- Where was the camera at the time this photograph was taken?
- Can you determine the location of this object within the scene?
    - How far apart were the two objects/people?

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History

Revision	Issue Date	Section	History
1.0	06/04/2015	All	Original working draft created. Voted for release as a Draft for Public Comment.
1.0	06/20/2015	All	Formatting and tech edit for release as a Draft for Public Comment.
1.0	09/17/2015	None	SWGDE voted to release as an Approved Document.
1.0	09/29/2015	All	"Section 3 – Definitions" was removed and the terms were moved to the latest iteration of the SWGDE Glossary as part of final publication process. Formatting and technical edit performed for release as an Approved Document.