OSAC 2021-S-0037 Standard Guide for Forensic Photogrammetry

Video/Imaging Technology Analysis Subcommittee
Digital/Multimedia Scientific Area Committee (SAC)
Organization of Scientific Area Committees (OSAC) for Forensic Science

OSAC Proposed Standard

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Designation: 2021-S-0037

1. Scope

1.1 This standard provides basic information on conducting photogrammetric examinations as a part of forensic analysis. The intended audience is examiners in a laboratory and/or field setting.

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

1.3 This standard cannot replace knowledge, skills, or abilities acquired through education, training, and experience, and is to be used in conjunction with professional judgment by individuals with such discipline-specific knowledge, skills, and abilities.

1.4 This standard does not purport to address all the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 ASTM Standards:

2.1.1 E2825 Standard Guide for Forensic Digital Image Processing

2.2 SWGIT Material:

2.2.1 SWGIT, Section 13: Best Practices for Maintaining the Integrity of Digital Images and Digital Video, updated January 13, 2012

2.2.2 SWGIT, Section 11: Best Practices for Documenting Image Enhancement, updated

January 15, 2010

2.3 SWGDE Material:

2.3.1 SWGDE Training Guidelines for Video Analysis, Image Analysis, and Photography, updated February 8, 2016

2.3.2 SWGDE Best Practices for the Forensic Use of Photogrammetry, updated September 29, 2015

2.3.3 SWGDE Guidelines for Forensic Image Analysis, updated February 21, 2017

2.4 Edelman, G., Alberink, I., and Hoogeboom, B., Comparison of the Performance of Two Methods for Height Estimation, Journal of Forensic Sciences, Vol 55, No 2, March 2010

2.5 Hoogeboom, B. and Alberink, I., Measurement When Estimating the Velocity of an Allegedly Speeding Vehicle from Images, Journal of Forensic Sciences, Vol 55, No 5, September 2010

2.6 Hoogeboom, B., Alberink, I., and Goos, M., Body Height Measurements in Images, Journal of Forensic Sciences, Vol 54, No 6, 2009

2.7 Criminisi, et al., A New Approach to Obtain Height Measurements from Video, SPIE Vol 3576, November 1998

3. Terminology

3.1 Definitions:

3.1.1 analytical photogrammetry, n-a method of photogrammetry in which solutions are obtained by mathematical methods

3.1.2 reverse projection photogrammetry, n-a method of photogrammetry in which a measuring device is recorded within a scene and the resulting image is overlaid on the evidentiary image to measure an object

3.1.3 3D scanning, n-the process of capturing 3-dimensional representation of an object or scene with equipment that measures the distance between the scanner and the object to create a point cloud of data from the surfaces of the object or scene

3.1.4 photogrammetric analysis, n—process of obtaining dimensional information regarding objects and people depicted in an image. E2916

3.1.5 photogrammetry, n—the art, science, and technology of obtaining reliable information about physical objects and the environment through the processes of recording, measuring, and interpreting photographic images and patterns of electromagnetic radiant energy and other phenomena. E2916

4. Summary of Practice

4.1 The original image or video shall be preserved. Any processing shall only be applied to a working copy of the image or video.

4.2 The practice may include:

4.2.1 Evaluating the imagery to determine the most suitable photogrammetric method

4.2.2 Obtaining scene-based reference data

4.2.3 Applying a photogrammetric process to obtain measurements

4.2.4 Identifying and reporting sources of uncertainty and apply to the measurements

4.2.5 Reporting findings

4.3 Steps taken and methods used shall be documented to permit a qualified practitioner to understand and be able to recreate the examination performed, as well as to assess and evaluate the results reached.

5. Significance and Use

5.1 Photogrammetric analysis is a long-standing science that can aid in the exclusion and inclusion of items and people in forensic investigations. It can also answer specific questions regarding speed, size, location, and distance of objects, areas, etc. in the field of view.

5.2 This guide addresses the following three phases of photogrammetric examination:

5.2.1 Evidence Preparation

5.2.2 Methodology

5.2.3 Interpretation of Results

6. Evidence Preparation and Assessment

6.1 Evidence preparation is any process intended to preserve and prepare an image for photogrammetric analysis.

6.1.1 The original imagery shall be protected from any alteration.

6.1.2 The examination shall be conducted on working copies of the imagery. Preparation of a working copy may require digitization or transcoding from other formats.

6.2 Complete an initial assessment of the imagery

6.2.1 Determine if the submitted imagery is the best available evidence, such as the original media, or a bit-for-bit duplicate. If the submitted imagery is not a bit-for-bit duplicate, determine if one is available. For additional information on this topic, see SWGDE Guidelines for Forensic Image Analysis.

6.2.2 Determine which subset of the submitted material is suitable for analysis. Suitability for analysis may vary by the examination requested. Criteria to be considered include whether:

6.2.2.1 The entire area, subject, or object to be measured is visible,

6.2.2.2 The entire area, subject, or object is recorded at a sufficient native resolution to make a meaningful measurement,

6.2.2.3 The angle of capture or camera perspective is conducive to examination,

6.2.2.4 The position and orientation of the subject or object in the frame is affected by lens properties such as distortion. DOF and focal length,

6.2.2.5 The scene contains fixed objects/features which can be used as reference data.

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

6.2.4 Observations, decisions, and opinions made during preparation and assessment shall be documented.

6.3 Process the working copy to enhance and/or restore the image content, if necessary. For further information, see ASTM E2825 Guidelines for Forensic Digital Image Processing.

7. Methodology

7.1 Multiple techniques exist for performing photogrammetric analysis including reverse projection and analytical photogrammetry. This guide does not limit the use of other available methods.

7.2 The examiner should consider both the evidentiary imagery and details of the scene to select the most suitable method for examination.

7.3 The chosen methodology should be validated and have a scientific basis.

7.4 Reverse projection photogrammetry -- involves the positioning of a camera to capture an image in the same perspective and aspect ratio as the evidentiary imagery and using a calibrated measuring device to complete the requested analysis.

7.4.1 The first step in the process is to assess the scene depicted in the evidentiary image.

7.4.1.1 Determine if the depicted scene is physically accessible.

7.4.1.2 Decide if the significant fixed objects and features in the depicted scene are still present at the scene and suitable as reference targets.

7.4.1.3 Determine the recording system that captured the evidentiary image is still in place, accessible, and suitable for the examination.

7.4.1.4 If still present, determine whether the original camera has been moved or changed.

7.4.2 The examination process includes the following steps:

7.4.2.1 Decide whether to use the original recording system, if available, or different recording equipment to collect new data.

7.4.2.2 Place the measuring device in the correct position and calibrate.

7.4.2.3 Measure from multiple device positions to mitigate measurement uncertainty.

7.5 Analytical photogrammetry – involves applying knowledge of the geometrical properties of the imaging process, and known measurements associated with the imagery, to obtain unknown measurements.

7.5.1 Perspective-based analysis and direct scaling are two approaches. When using an analytical photogrammetry method, the following issues should be considered and documented:

7.5.1.1 Decide whether there are sufficient reference features available within the imagery to resolve the geometry of the scene, including three-dimensional axes, horizons and vanishing points.

7.5.1.2 Measure the uncertainty derived from the angle of measurement, and the position of the subject.

7.5.1.3 After performing the chosen methodology and documenting results determine whether the data collected during the examination process is of sufficient quality to support further analysis.

8. Interpretation of Results

8.1 A series of observations and/or measurements recorded using the enacted methodology will require the examiner to interpret results.

8.2 Measured results require interpretation by the examiner based on the identified sources of uncertainty (and potential error). Sources of measurement uncertainty may include limitations of the:

8.2.1 Original and controlled capture systems (e.g. camera height and position will influence the geometric calculation of the measurement; image resolution will limit the precision of the measurement)

8.2.2 Measuring device (e.g. accuracy of placement will influence the geometric calculation; precision of the scale will influence the uncertainty)

8.2.3 Employed software and hardware (e.g. inherent software limitations will influence the precision, such as the calculation of vanishing points and the numerical precision of data types)

8.2.4 Factors involving the original subject (e.g. posture, contrast, location, movement) 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 person of interest can be excluded from or included in the group of suspects based on the range of estimated height.

8.3 Based on the observations and measurements, a result should be reached. This may or may not be in the form of a numerical value.

8.4 Report results in response to the requested analysis. The basis for, and uncertainty of, any results shall be documented and reported. An examiner should consider factors that influence the uncertainty of measurement, including the limitations of the measured results.

8.5 The results of the examination should undergo independent review by a qualified individual.

8.5.1 If disputes arise during review, a means for resolution of issues should be in place.

8.5.2 Additionally, if the examiner and reviewer reach different opinions, then both opinions and how the inconsistency was resolved must be documented.

8.6 To reduce potentially biasing effects, an examiner should not be exposed to task-irrelevant contextual information, such as the measured height of a suspect.

8.6.1 Any contextual information provided to the examiner shall be documented.

8.6.2 Similarly, a technical reviewer should not be exposed to task-irrelevant contextual information or to the examiner's conclusions.

9. Guidelines for Photogrammetry Standard Operating Procedures

9.1 The purpose of forensic photogrammetric analysis is to apply knowledge of image processing techniques, measurements, and analysis to answer specific questions, as discussed in Appendix 3. Regardless of the methodology employed, standard operating procedures should be developed and followed. For more information on developing an SOP, see the SWGDE/SWGIT document, "Recommended Guidelines for Developing Standard Operating Procedures". For more information on image processing, see E2825.

9.2 Equipment—The laboratory standard operating procedure (SOP) should define minimum hardware and software equipment requirements including, but not limited to:

9.2.1 Hardware

9.2.1.1 Input/capture device,

9.2.1.2 Measuring device,

9.2.1.3 Image-processing systems,

9.2.1.4 Output devices, and

9.2.1.5 Storage/archive.

9.2.2 Software:

9.2.2.1 Image management, and

9.2.2.2 Image processing.

9.3 Procedures—Laboratories should establish specific step-by-step procedures for forensic photogrammetry and image processing according to published guidelines. Each utilized methodology for photogrammetric analysis (including, but limited to, reverse projection, analytical photogrammetry, and dimensional scanning) should have separate procedures. These procedures should address the following as a minimum:

9.3.1 Documentation,

9.3.2 Capture,

9.3.3 Image processing,

9.3.4 Storage and archiving,

9.3.5 Image management

9.3.6 Data security

9.3.7 Photogrammetric Methodology

9.3.8 Interpretation of results, and

9.3.9 Reporting

9.4 Calibration—Laboratories should develop SOPs for calibrating all equipment that produces test results. These procedures should be consistent with the manufacturer's recommendations.

9.5 Limitations—Laboratories should document the limitations of their processes and equipment in their SOPs.

9.6 Safety—Laboratories should develop safety procedures specific to their needs.

9.7 References—Laboratories should maintain their laboratory specific documentation, manufacturers' manuals, and published guidelines.

9.8 Training—Laboratories should define the level of training necessary to perform the procedure. Refer to the SWGDE "Training Guidelines for Video Analysis, Image Analysis and Photography".

10. Keywords

10.1 criminal justice system; image processing; digital image processing; forensic photogrammetry

APPENDIX

(Nonmandatory Information)

X1. APPENDIX 1: CONSIDERATIONS WHEN REPORTING THROUGH QUALITATIVE MEANS

X.1.1 Purpose

X1.1.1 This guide sets forth key points that should be considered when reporting quantitative photogrammetric analysis results.

X.1.2 Estimation of error in analysis

X1.2.1 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 documented in the final report.

X1.2.2 Example: As in the workflow example, the practitioner is requested to complete a photogrammetric examination of a bank robber depicted in DCCTV surveillance video. The police have two different suspects and would like to determine if either can be eliminated based on height.

X.1.3 Incorporation of uncertainty in reporting of results

X1.3.1 The practitioner elects to use the recommended workflow for photogrammetry, incorporating reverse projection as the analytical method. 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.

X1.3.2 However, multiple areas of uncertainty can be calculated, and multiple limitations in this measurement should be noted in the analytical report.

X1.3.2.1 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 increase, 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.

X1.3.2.2 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.

X1.3.2.3 In subject height analysis, the measurement is captured at only a single moment of 262 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.

X1.3.2.4 In the case of a velocity analysis, the calculated value for velocity relies upon a known time interval, and the distance traveled by an object, between two images. The uncertainty in the calculated velocity should be examined based on principles of video engineering and image analysis and recognizing the errors in time and distance measurements.

APPENDIX

(Nonmandatory Information)

X2. APPENDIX 2: WORKFLOW EXAMPLES

X.2.1 Scenario 1:

X2.1.1 A local police agency asks the crime laboratory 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 laboratory to determine if either can be excluded on this basis.

X2.1.2 The practitioner proceeds as follows, while documenting the process, analyses, and results:

X2.1.2.1 The practitioner determines that the imagery is the original video, not a transcoded copy.

X2.1.2.2 The practitioner reviews the material and determines if images exist suitable to an accurate photogrammetric examination.

X2.1.2.3 The practitioner determines if more than one examination is appropriate to complete the request.

X2.1.2.4 The practitioner transfers the contents of the video file to a working file. X2.1.2.5 The practitioner processes the video files.

X2.1.2.5.1 Still images are output from the video files, and images suitable to an accurate photogrammetric analysis are selected.

X2.1.2.5.2 Standard image processing techniques, such as brightness and contrast adjustments, are applied to the working images.

X2.1.2.6 The practitioner imports the images into an application suitable for photogrammetry and conducts the 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 output. This step should be documented and the limits of the results obtained should be clearly identified.

X2.1.2.7 The practitioner writes the report. Per the crime laboratory's standard operating procedures, the report includes a review of the materials received, the request, the methods used, the observations noted, the basis for the interpretations, the results, and an estimate of the accuracy and precision.

X2.1.2.8 The report is administratively and technically reviewed prior to release. X.2.2 Scenario 2:

X2.2.1 A local police agency asks the crime laboratory 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.

X2.2.2 The practitioner proceeds as follows, while documenting the process, analyses, and results:

X2.2.2.1 Determines that the imagery is the original video, not a transcoded copy.

X2.2.2.2 Reviews the material and determines if images exist suitable to an accurate photogrammetric examination.

X2.2.2.3 Determines if more than one examination is appropriate to complete the request;

X2.2.2.4 Transfers the contents of the video file to a working file.

X2.2.2.5 Processes the video files.

X2.2.2.5.1 Still images are output from the video files, and images suitable to an accurate photogrammetric analysis are selected, considering the known time elapsed between the images.

X2.2.2.5.2 Standard image processing techniques, such as brightness and contrast adjustments, are applied to the working images.

X2.2.2.6 Imports the images into an application suitable for photogrammetry and conducts the 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 output.

X2.2.2.7 Writes the report. Per the crime laboratory's standard operating procedures, the report includes a review of the materials received, the request, the methods used, the observations noted, results obtained, the basis for the interpretations, the results, and an estimate of the accuracy and precision.

X2.2.3 The reviewer completes an administrative and technical review of the analysis and report. The technical review shall include verification of the results.

X3. APPENDIX 3: SAMPLES QUESTIONS ASKED IN FORENSIC PHOTOGRAMMETRY

X.3.1 How tall is the individual?

X.3.2 How fast was the vehicle/person/object travelling?

X.3.3 What time of day was the photograph taken?

X.3.4 Where is the scene depicted in the image?

X.3.5 What are the dimensions of an object?

X.3.6 Where was the camera at the time this photograph was taken?

X.3.7 Can you determine the location of the object(s) within the scene?