SWGDE Guidelines for the Testing and Capture of Latent Impressions Using a Camera or Scanner

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(Note: This document was previously released as SWGIT Section 21 – Procedure for Testing Scanner Resolution for Latent Print Imaging and SWGIT Section 22 – Procedure for Testing Digital Camera System Resolution for Latent Print Photography.)

1. Introduction

The purpose of this document is to describe a procedure to ensure that a digital camera or scanner can capture an image of latent print evidence at an achievable resolution that enables recording of level three detail.

2. Limitations

Resolution references are only for the image being viewed on a monitor or uploaded into an automated fingerprint identification system, and are not for output to printed media.

3. Note on 1000 Pixels per Inch (ppi) Target

There are several references to a 1000 ppi resolution target for latent images [1], [2], [3]. While the 1000 ppi resolution target permits the capture of level three detail, if present, in latent prints, it does not mean that any image recorded at a lower resolution would not necessarily contain level three detail and be of no value for comparison purposes. Latent print images can be captured at lower resolutions and still possess level three detail. Further, latent prints may not possess level three detail and still be acceptable for direct comparison. Currently, there is no quantifiable or minimum numerical resolution standard for use in direct comparison analysis. **The important requirement for determining the needed resolution of latent print images should be a determination made by the latent print comparison experts. This should be based on the resolution necessary to visualize those characteristics necessary for analysis.**

By application of the Nyquist theorem [4], a 1000 ppi nominal resolution can theoretically achieve a maximum resolution of 500 line pairs per inch. In practice, Nyquist sampling is inadequate, and three to four samples are required instead of two, resulting in resolution between 250-330 line pairs per inch, or 9.8-13 cycles per millimeter (mm) [5].

4. Procedure to Test Ability of a Digital Camera to Capture the Necessary Level of Detail

4.1 Additional Needed Equipment

4.1.1 Resolution Test Target Capable of Measuring Between 9.8 to 13 Cycles per Millimeter

(e.g., T-90-N-CG "Ultra High Resolution Target" or similar traceable targets)

To determine if a digital camera is capable of capturing an image at a given resolution, it is necessary to use a test target. The test target used in this procedure is the T-90-N-CG "Ultra High Resolution Target." This target is used as an example only, and its use here should not be construed as an endorsement. Other test targets can be used as long as they possess line pairs in the range of 9.8 to 13 cycles per millimeter.

4.1.2 Description of Resolution Test Targets

Resolution test targets come in a variety of forms and styles. Horizontal and vertical multi-bar test targets are the focus of this procedure. Such multi-bar test targets consist of pairs of dark and light parallel lines ("bars") of equal width ("line pair" or "cycle"), which repeat at a given frequency. The frequency is then defined in terms of cycles per unit distance. On the T-90-N-CG chart, spatial frequencies are reported in cycles per millimeter.

As an example, a set of line pairs in which the width of each individual line is 0.1 mm (i.e., dark line width = 0.1 mm and light line width = 0.1 mm) would have a combined line pair width of 0.2 mm, and would be described as having 5 cycles per millimeter (1/0.2 = 5).

4.1.3 1000 ppi Resolution as Measured in Cycles Per Millimeter

Because a nominal resolution of 1000 ppi corresponds to an achievable resolution of approximately 9.8-13 cycles per millimeter. Any test target within this range would be sufficient; the 12.5 cycle per millimeter region of the T-90-N-CG chart is demonstrated.

4.2 Procedure

In order to consistently and reliably capture images with a digital camera at the required resolution, the camera shall be tested in the configuration(s) commonly used by the agency/organization.

NOTE: *Resampling should not be used within this procedure in order to achieve 1000 ppi.*

Prior to testing for resolution, it is necessary to determine the camera system's field of view to record the test target at the equivalent of 1000 ppi, Part 1 (*see **Section 4.2.1***). This establishes a starting point for defining the field of view, which may be modified based on the results of Part 2 (*see **Section 4.2.2***).

4.2.1 Part 1 – Field of View Determination to Achieve a Minimum of 1000 ppi

The pixel dimensions on the sensor define the area of maximum coverage for 1000 ppi. The reader should refer to the specifications for the camera being tested to determine what values are appropriate. There may be several different sensor settings and file configurations with the ranges of pixels that will allow 1000 ppi. The test needs to be completed using the same settings used during the capture of the latent print.

1. Choose the sensor setting and file configuration with the range of pixels that will allow 1000 ppi. It is recommended to capture using no compression, or lossless compression (RAW or TIFF). However, the use of lossy compression (JPEG, high quality setting) on these images does not preclude them from being analyzed if the pertinent features are retained. Refer to *SWGDE Digital Image Compression and File Format Guidelines* for more information [6].
2. Determine the number of effective pixels for the camera. See the manufacturer's specification sheet for this value.
3. Divide the pixel resolution by 1000. The camera used in this example has a pixel dimension of 3872 x 2592 pixels. Dividing these pixel dimensions by 1000 ppi results in 3.872 x 2.592 inches (3-3/4 inches x 2-1/2 inches). To convert inches to millimeters, multiply inches by 25.4. This represents the area of coverage in which the camera should be capable of capturing at 1000 ppi.

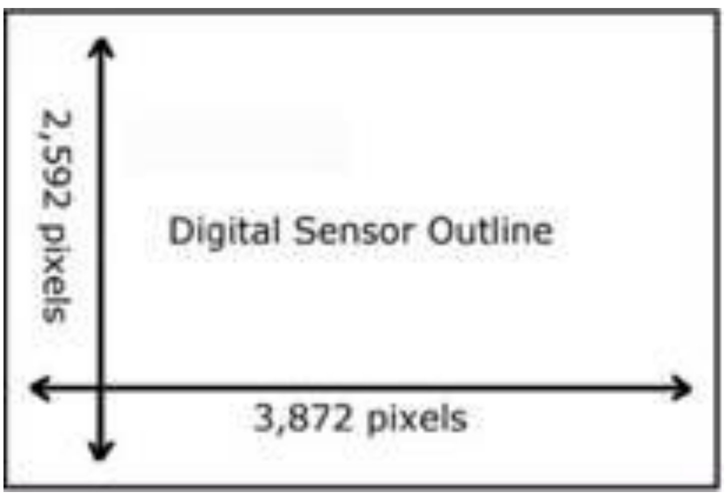

Figure 1. Area of coverage

4. Make a template (or frame) to the exact dimensions of this area of coverage (3-3/4 x 2-1/2 inches). *See **Figure 1***.
5. Place template on a flat surface.
6. Insert a flat scale inside the area bounded by the template.
7. Mount the camera on a tripod, or copy stand, above the flat surface on which the template rests. Ensure the camera focal plane is parallel with flat surface.

8. If using a fixed focal length lens, proceed to step 9. If using a zoom lens, proceed to step 10.
9. While looking through the viewfinder, adjust the height of the camera to fill the frame with the template, while keeping the image in sharp focus with the camera, set to manual focus and manual exposure. If focus cannot be accomplished for this lens, then the 1000 ppi target cannot be met and the test should be terminated for that lens. Otherwise, go to step 11.

NOTE: *Not all camera viewfinders cover 100% of the capture area. Take a test image of scales across the vertical and horizontal axis to determine coverage of the viewfinder.*

10. When using a zoom lens, repeat step 9 for each of the zoom settings that will be used for photographing latent prints. This will result in different camera heights for different zoom settings. If focus cannot be accomplished for some zoom settings, then the 1000 ppi target cannot be met for those settings. If focus cannot be accomplished for this lens at all, then the 1000 ppi target cannot be met and the test should be terminated. Otherwise, go to step 11.
11. Record the height determined in step 9 or 10. This height is the maximum camera-to-subject distance to provide 1000 ppi resolution.
12. The camera setup is ready to replace the template with the resolution test target and proceed to ***Part 2 – Camera Setup***.

4.2.2 Part 2 – Camera Setup

1. Locate the portion of the test chart that depicts 12.5 cycles per millimeter (*see* ***Figure 2***).

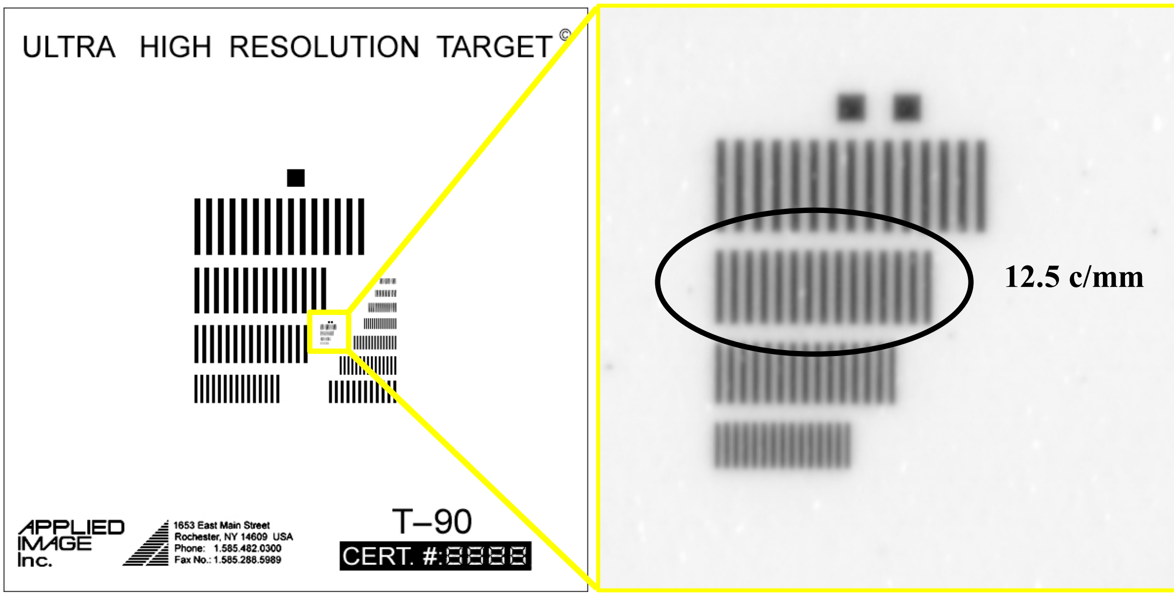

Figure 2. Area of chart depicting 12.5 cycles per millimeter

2. Visually verify (count) the number of dark and light lines, and record each (i.e., 15 light and 14 dark, *see* ***Figure 3***). It is recommended that a magnifier or loupe be used in the counting process.

Figure 3. 15 light and 14 dark lines

3. Place test chart on flat surface below camera so the test bars are in a vertical orientation (*see **Figure 3***). The camera back must be parallel to this surface.
4. Set the camera using manual focus and manual exposure controls.
5. Select camera settings to capture image file using normal file format used for latent print image capture.
6. Capture an image file with the camera.
7. Open the file in an image processing application. It should be viewed at 100%, or a multiple of 100% (e.g. 200%, 300%), to prevent interpolation.
8. View the region that depicts 12.5 cycles per millimeter.
9. Zoom in on the image so that individual pixels are visible. If the camera has accurately captured 12.5 cycles per millimeter, then it should be possible to distinguish the dark and light line pairs in this region. Do not use image post-processing to improve the visibility of the line pairs.
10. To verify an accurate capture, it is necessary to verify that the correct number of dark and light line pairs per millimeter have been recorded by counting them and checking this number against the number recorded in step 2 (i.e., 15 light and 14 dark).
11. If the number counted in step 10 matches the number counted in step 2, then you have verified that this camera system configuration can sample at 12.5 cycles per millimeter in the horizontal direction and meets or exceeds the 1000 ppi target. If not, then this camera system configuration does not meet the 1000 ppi target. Resolution may be increased by decreasing the field of view (zoom in or get closer); some cameras may allow other types of resolution adjustments.
12. Rotate the chart 90-degrees and repeat steps 3 through 11 to measure vertical resolution. In some cases, the resolving power of the camera may be lower in the horizontal or vertical direction. Therefore, the shorter of the two distances determined should be recorded and used.
13. If resolution was modified by changing the field of view, the final distance from the target should be recorded for future use. This can be implemented in several ways, such as, but not limited to, a string of the known length used to measure the maximum camera-to-subject distance or a template to determine the maximum field of view.

It is recommended that this process be documented in accordance with organizational policy.

It is further recommended that this procedure be repeated in accordance with organizational quality assurance and quality control practices. Likewise, if the camera or lens was repaired or replaced, then this procedure should be performed prior to use in casework.

5. Procedure for the Proper Capture of Latent Print Evidence Using a Camera

1. Verify the camera's settings are those that passed the testing referenced above in ***Section 4***. Verify the camera's date/time settings are correct.
2. The camera must be used at a 90-degree angle (camera sensor parallel) to the impression. Mounting a camera on the tripod, or other firm mount, will maximize the quality of the image.
3. Place a scale on the same plane and as close as possible to the impression without obscuring any detail. Fill the frame, but do not exceed the maximum field of view established in the successful testing procedures above. See ***Figure 4***.

Note: *Your agency/organization's standard operating procedures may also require you to capture an overall view of the impression area without a scale, or include information about the image on the scale.*

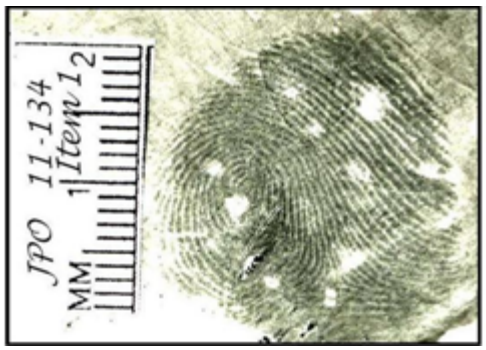

Figure 4. Example of scale placement and filling the frame

4. Photograph the impression and make sure it was recorded with suitable quality.

6. Testing Scanner Resolution

For information on additional equipment, description of resolution test targets, and 1000 ppi resolution, as measured in cycles per millimeter, please reference ***Section 4*** above.

1. Locate the portion of the test chart that depicts 12.5 cycles per millimeter (see ***Figure 2***.)
2. Visually verify (count) the number of dark and light lines and record each (i.e., 15 light and 14 dark, see ***Figure 3***).
3. Set scanner's nominal resolution to 1000 ppi.
4. Place the test chart on scanner plate with top of chart at top of scanning region. This will allow the user to measure the resolution in the horizontal aspect (as depicted in the figures above).
5. Save file using either lossless compression or no compression (such as TIFF or Bitmap).
6. Open file in an image processing application. The image should be viewed at 100%, or a multiple of 100% (e.g., 200%, 300%), to prevent interpolation.
7. View the region that depicts 12.5 cycles per millimeter.
8. If the scanner has accurately captured 12.5 cycles per millimeter, then it should be possible to distinguish the dark and light line pairs in this region. Do not use image post-processing to improve the visibility of the line pairs.
9. To confirm accurate capture, it is necessary to verify that the correct number of dark and light line pairs per millimeter have been recorded by counting them and checking this number against the number recorded in step 2 (i.e., 15 light and 14 dark).
10. If the number counted in step 9 matches the number counted in Step 2, then you have verified that your scanner can sample at 12.5 cycles per millimeter in the horizontal direction. If not, then your scanner does not meet the necessary resolving power at the 1000 ppi setting.
    a. The scanner should be set to a higher nominal resolution (up to the limits of the scanner's optical or machine resolution) and retested (step 4).

    Note: *Some scanners exhibit higher achievable resolution in the center of the scan area. Thus, it may be appropriate to retest at different locations on the scanner.*
11. Rotate the chart 90-degrees and repeat steps 4 through 10 to measure the vertical resolution.

It is recommended that this process be documented in accordance with organizational policy.

It is further recommended that this procedure be repeated in accordance with organizational quality assurance and quality control practices. Due to the internal mechanics of a scanner, as scanners age or are used frequently, it may be necessary to retest on a more frequent basis. Likewise, if the scanner was repaired, then this procedure should be performed prior to use in casework.

7. Procedure for the Proper Capture of Latent Print Evidence Using a Scanner

1. Verify scanner settings are those that passed the testing referenced above.
2. Scan the impression and make sure it was recorded with suitable quality.

8. References

[1] Scientific Working Group on Friction Ridge Analysis, Study and Technology, "Standard for Friction Ridge Impression Digital Imaging". [Online]. http://www.swgfast.org/Documents.html

[2] ANSI/NIST-ITL 1-2007, "Data Format for the Interchange of Fingerprint, Facial, & Other Biometric Information – Part 1," *NIST Special Publication 500-271*, May 2007. [Online]. https://www.nist.gov/sites/default/files/documents/itl/ansi/Approved-Std-20070427-2.pdf

[3] A.K. Jain, Y. Chen, and M. Demirkus, "Pores and Ridges: High-Resolution Fingerprint Matching Using Level 3 Features," *IEEE Transactions on Pattern Analysis & Machine Intelligence*, vol. 29, pp. 15-27, January 2007.

[4] B. Olshausen. "Aliasing" (Handout), PSC 129 - Sensory Processes. Bruno Olshausen Homepage, Professor, Redwood Center for Theoretical Neuroscience (University of California, Berkeley). October 10, 2000. [Online]. http://redwood.berkeley.edu/bruno/npb261/aliasing.pdf

[5] D. Zhang, F. Liu, Q. Zhao, G. Lu, and N. Luo, "Selecting a Reference High Resolution for Fingerprint Recognition Using," *IEEE Transactions On Instrumentation And Measurement*, vol. 60, no. 3, pp. 863-871, March 2011.

[6] Scientific Working Group on Digital Evidence, "SWGDE Digital Image Compression and File Formats Guidelines,". [Online]. https://www.swgde.org/documents/documents

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History

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1.0 DRAFT	2016-10-08	All	Formatting and technical edit performed for release as a Draft for Public Comment.
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