SWGIT

Scientific Working Group
Imaging Technology

Disclaimer:

Section 22

Procedure for Testing Digital Camera System Resolution for Latent Print Photography

INTRODUCTION

The purpose of this document is to describe a procedure to ensure that a digital camera system can capture a latent print image at an achievable resolution that enables recording of Level 3 detail.

LIMITATIONS

This procedure is designed to test the ability of a digital camera system to capture the necessary level of detail when viewed on a monitor. This procedure does not address the use of film cameras or output of image data to printed media.

A NOTE ON 1000 ppi STANDARD

Historically, latent prints were photographed so that an image on film, when developed, would be at the exact same dimensions as the latent print itself ("1x" or "1:1"). This would allow for rapid contact printing for comparison against record prints. Digital imaging workflow is not based on the physical size of the capture device (as was the case with film cameras), rather, it is based on the resolution required to capture the necessary detail in the digital image file.

The procedure described in this document is in accordance with current SWGFAST guidelines [Standard for Friction Ridge Digital Imaging (Latent/Tenprint)[1]], as well as National Institute of Standards and Technology (NIST) standard (NIST SPECIAL PUBLICATION 500-271, ANSI/NIST-ITL 1-2007[2]), which specify 1000 pixels per inch (ppi) at 1:1 as the minimum nominal scanning resolution for latent print evidence. This standard appears primarily to be historical and directed towards scanners, rather than cameras, though recent studies suggest that it is suitable for capturing level 3 detail[3].

While the 1000 ppi resolution standard permits the capture of level three detail in latent prints, it does not mean that any image recorded at a lower resolution would necessarily be of no value for comparison purposes. However, there are some latent print impressions that are so degraded or contain such limited quantity of information that at least 1000 ppi resolution is required to conduct an accurate examination. Some automated fingerprint identification systems require 1000 ppi for submission purposes.

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[1] www.swgfast.org/standard_for_friction_ridge_digital_imaging_1.0.pdf Accessed January 12, 2010.
[2] http://fingerprint.nist.gov/standard/ Accessed January 12, 2010.
[3] Jain, A.K., Chen, Y., and Demirkus, M. Pores and Ridges: High-Resolution Fingerprint Matching Using Level 3 Features. IEEE Trans. PAMI 29 (1): 15-27, 2007.

As one commercial testing group notes, the relationship between nominal resolution and achievable resolution (sometimes called "resolving power") can vary greatly by manufacturer:

> …[T]here is … discrepancy between the nominal resolution of a scanner and the actual achievable resolution in the practice. In our film scanner tests we always measure the effective resolution of a scanner, thus the resolution that is achieved in practice… While in practice, [some] top-models achieve approximately 97% of their nominal resolution, in case of some film scanners of [other manufactures], the resulting value is of only 50%. Many times, the flat bed scanners with an integrated transparency unit only achieve 10-20% of their nominal resolution in practice. For the user, the effective resolution is the decisive value and not the nominal resolution…

(ref: Patrick Wagner Purchase of a film scanner, tips and purchase criteria http://www.filmscanner.info/en/FilmscannerKauf.html last accessed 11 Jan 2011.)

As with scanners, camera systems also rarely achieve nominal resolution in practice. One recent study showed that high-resolution black-and-white TMAX film with a nominal resolution of 34.56 Megapixels using a stabilized professional camera under studio conditions was able to achieve a pixel-equivalent resolution of 13.75 Megapixels.

Ref: Herbert Blitzer, Karen Stein-Fergusen, Jeffrey Huang. Understanding Forensic Digital Imaging. Academic Press. 2008 Chapter 17, p 320.

There is a dearth of peer reviewed literature comparing nominal and achieved resolution, but the achieved resolution can be approximated. Jain has demonstrated that sampling at a nominal 1000 ppi can provide level three detail. Zhang, et al. have similar results. By application of the Nyquist theorem, a 1000 ppi nominal resolution can theoretically achieve a maximum resolution of 500 line pairs. In practice, as noted elsewhere, 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 mm.

Ref: Jain 2007 already in footnotes.
Ref: Zhang D, Liu F, Shao Q., Lu G, Luo N. Selecting a reference high resolution for fingerprint recognition using minutiae and pores. IEEE Trans Intrument. Meas. 2010 99:1-9

Equipment/Materials

- Camera system (including tripod, lens, copy lighting, filters)
- Computer hardware to include monitor and image processing software
- Scale
- Resolution test target (e.g., T-90-N-CG "Ultra High Resolution Target")
- Loupe or magnifier

To determine if a camera system 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”, from Applied Image, Inc., Rochester, NY. This target is used as an example only, and its use here should not be construed as an endorsement. Other test targets are available, such as from the International Standards Organization (ISO), which has a standard target for measuring resolution of scanners “ISO-16067-1 Reflective Scanner Test Chart.” ISO also has a test chart for digital and electronic imaging devices (ISO 12233 Test Chart), but this chart does not include explicitly defined regions at the resolution of interest for this procedure. Therefore, its use in this procedure would be problematic.

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 pairs” 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 millimeter (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 mm (1/0.2 = 5).

1000 ppi RESOLUTION AS MEASURED IN CYCLES PER MM

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.

PROCEDURE

This procedure should be repeated for every lens, filter, configuration (aperture, ISO, etc.) and close-up accessory combination used regularly in the capture of latent print images.

Prior to testing for resolution, it is necessary to determine the camera system’s field of view to record at the equivalent of 1000 pixels per inch or more at the target (Part 1). This establishes a starting point for defining the field of view which may be modified based on the results of Part 2.

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.

1. Determine the number of effective pixels for the camera. See the manufacturer's specification sheet for this value. For this procedure, a 12-megapixel camera with 4288 x 2848 effective pixels is used as an example.

2. Divide the pixel resolution by 1000. In this example, 4288 x 2848 pixels divided by 1000 pixels per inch results in 4.288 x 2.848 inches (4-1/4 x 2-13/16 inches). This represents the area of coverage in which the camera should be capable of capturing at 1000 ppi.

3. Make a template (or frame) to the exact dimension of this area of coverage (4-1/4 x 2-13/16 inches).

4. Place template on a flat surface.

5. Insert a flat scale inside the area bounded by the template.

6. Mount camera on tripod or copy stand above the flat surface on which the template rests. Ensure the camera focal plane is parallel with flat surface.

7. If using a fixed focal length lens, proceed to step 8. If using a zoom lens, proceed to step 9.

8. 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 standard cannot be met and the test should be terminated for that lens. Otherwise, go to step 10.

9. When using a zoom lens, repeat step 8 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 standard cannot be met for those settings. If focus cannot be accomplished for this lens at all, then the 1000 ppi standard cannot be met and the test should be terminated. Otherwise, go to step 10.

10. Record the height determined in step 8 or 9. This height is the maximum camera-to-subject distance to provide 1000 ppi resolution.

11. The camera setup is ready to replace the template with the resolution test target and proceed to Part 2.

Part 2: Camera setup for latent print photography

1. Locate the portion of the test chart which depicts 12.5 cycles per millimeter (See Figure 1.)

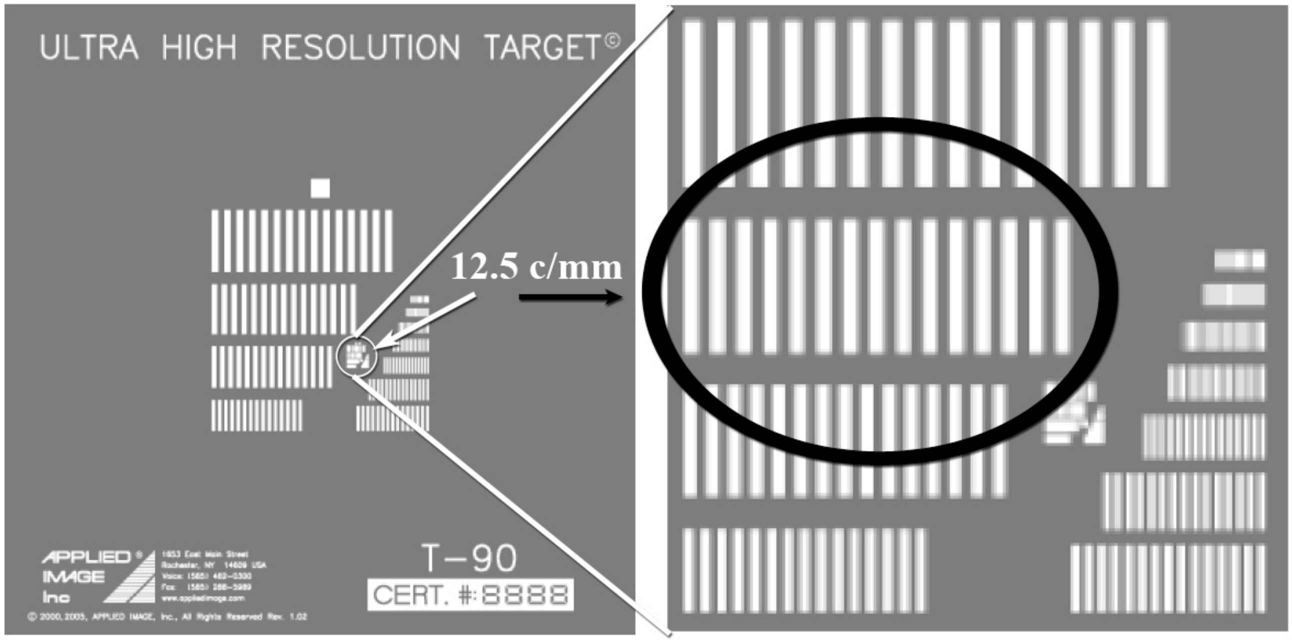

Figure 1.

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

Figure 2.

3. Place test chart on flat surface below camera so the test bars are in a vertical orientation (see Figure 2 above). 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. NOTE: SWGIT recommends the use of lossless file formats such as RAW or TIFF when capturing latent print images. The use of file formats that utilize lossy compression can introduce artifacts which may invalidate the test results.

6. Capture an image file with the camera.

7. Open file in image processing application.

8. View region which depicts 12.5 cycles per mm using the workstation monitor.

9. Zoom image so that individual pixels are visible. If the camera has accurately captured 12.5 cycles per mm, then it should be possible to distinguish the dark and light line pairs in this region. It should not be necessary to use image post processing to improve the visibility of the line pairs.

10. To verify accurate capture, it is necessary to verify that the correct number of dark and light line pairs per mm 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 standard. If not, then this camera system configuration does not meet the 1000 ppi standard. 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° either to the right or left 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 agency policy.

It is further recommended that this procedure be repeated on a regular basis (e.g., annually) in accordance with agency quality assurance and quality control practices. Likewise, if the camera requires repairs, then this procedure should be performed prior to use in case work.