The Use of 1000 ppi

INDUSTRY PAPER

CROSSMATCH® TECHNOLOGIES

The Importance of Using 1000 ppi in Law Enforcement

June 2010

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The Importance of Using 1000 ppi in Law Enforcement

In 2005, Superintendent William Casey from the Boston Police Department and member of the FBI Image Quality Task Force stated that, “Latent examiners want Level 3 fingerprint image detail to make identifications. There is zero tolerance for friction ridge identification error in forensic science and the fact that every impression varies makes it critical to capture the clearest images with the most data every time.”[1] In the same year, the FBI Electronic Fingerprint Transmission Specification (EFTS) was extended to support images with 1000 ppi resolution. Today, although there is no AFIS available yet that uses Level 3 features for automatic matching, the majority of fingerprint examiners are using Level 3 details for their manual comparison and evaluation processes.[2]

This document provides insight into:

- The technical differences between 500 ppi and 1000 ppi
- The benefits of using 1000 ppi images not only for law enforcement applications
- The technical prerequisites to tap the full potential of 1000 ppi images

1. What is 1000 ppi resolution?

The definition of 1000 ppi is 1000 pixels per inch horizontally and vertically. Compared to 500 ppi, 1000 ppi images have four times higher resolution (Figure 1). Achieving four times higher resolution is a technical challenge, although today the perception is that it is easy to accomplish. Let’s take an analogy from the consumer market: at present, consumer digital cameras do have image sensors with a resolution of about 10 - 15 megapixels (Mpx). Four times higher resolution results in 40 - 60 Mpx and consequently, prices for such high-resolution image sensors are not suitable for the consumer market. In addition sensors used in today’s digital cameras are optimized for small pixel size, color and still images. Due to the high image quality requirements defined in the FBI Image quality standard, only very special sensors can be used for livescan devices.

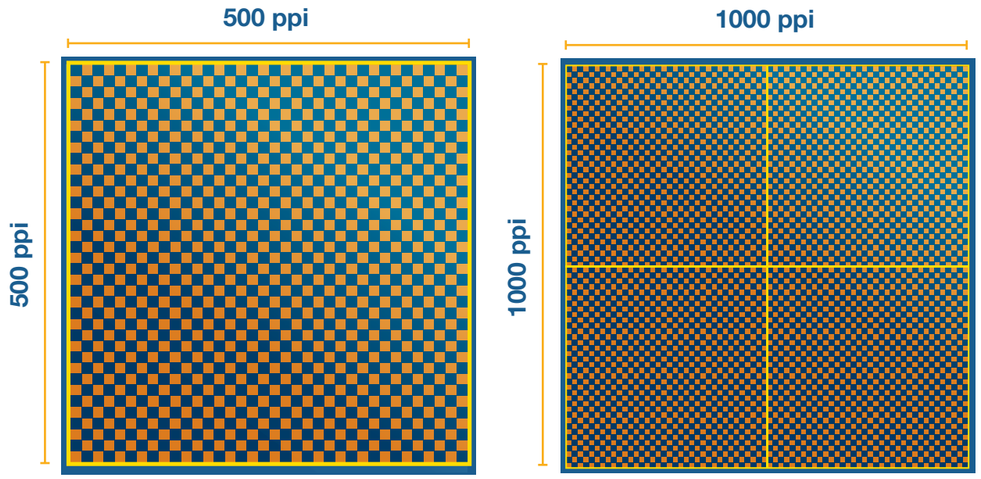


Figure1: Number of pixels for 500 ppi and 1000 ppi resolution

[1] W. Casey, Perspectives on Livescan Imaging and Image Quality, Law enforcement technology, April 2005

[2] A. Anthonioz et al., Journal of Forensic Identification, 2008

4. How are 1000 ppi images being used in modern law enforcement systems today?

Starting in 2005, law enforcement agencies worldwide began using 1000 ppi live scanners in their routine operations. Cross Match scanners are used by police forces in the U.S., Germany, Finland, Romania, Australia, Norway, Canada and elsewhere. In Figure 6, the process from capturing to comparison is demonstrated. After capturing the fingerprint / palm print images with 1000 ppi resolution, these images are stored in a separate image database. For automatic matching of fingerprint / palm print images, a downscaling to 500 ppi resolution is done either prior to submitting to AFIS or in the AFIS system prior to matching. Once candidates are provided by AFIS, these candidates are linked to the separate image database containing the 1000 ppi images. Subsequently, for manual comparison and identification process, the 1000 ppi images are much more detailed than the 500 ppi images.

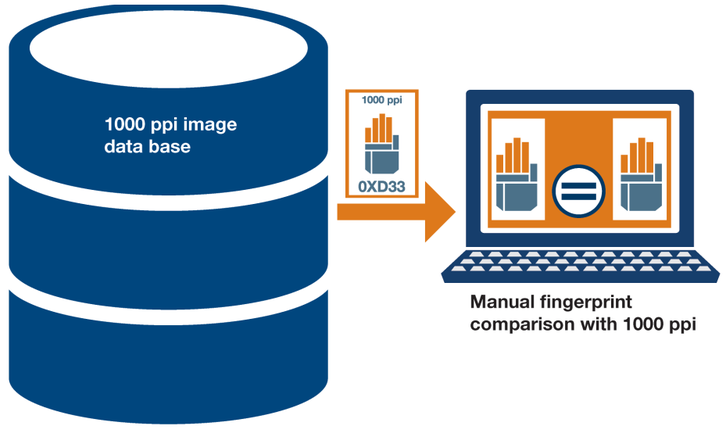


Figure 6: Using 1000 ppi in criminal forensic routine

2. There is more than image resolution

Although the performance of a digital imaging system is primarily defined by its resolution, there is much more to consider in order to meet the high quality requirements defined by the FBI standard. According to the FBI standard, six parameters are defined for testing the performance of an optical system (Table 1). Not only from a technical perspective but also from a user's point of view, the most important function is the modular transfer function (MTF). The MTF measures the contrast as a function of coarse and fine image detail or in other words provides a parameter for the sharpness of the image (Figure 2). As shown, using 1000 ppi enables users to visualize much sharper details than 500 ppi.

Image parameters of the FBI EBTS standard (Appendix F)

Parameter of the FBI EBTS Appendix F	What does it mean?
Geometric image accuracy	Describes the accuracy of each point on the entire platen. Verifies if a point on the platen corresponds to a point in the final image.
Modulation transfer function	Describes the contrast of the final image and the details that will be visible in the final image.
Signal to noise ratio	Describes how much the signal is above the noise level, both white noise and black noise.
Gray-scale range of the image	Describes the total amount of gray levels in the image. The higher the number of gray levels the higher the contrast of the image.
Gray-scale linearity	Ensures that the complete system always has a linear signal response. This is a strong requirement for comparing final images from different devices.
Output gray level uniformity	Ensures that all gray-levels are consistently distributed across the entire image area.

Table 1: Image parameters of the FBI EBTS standard (Appendix F)

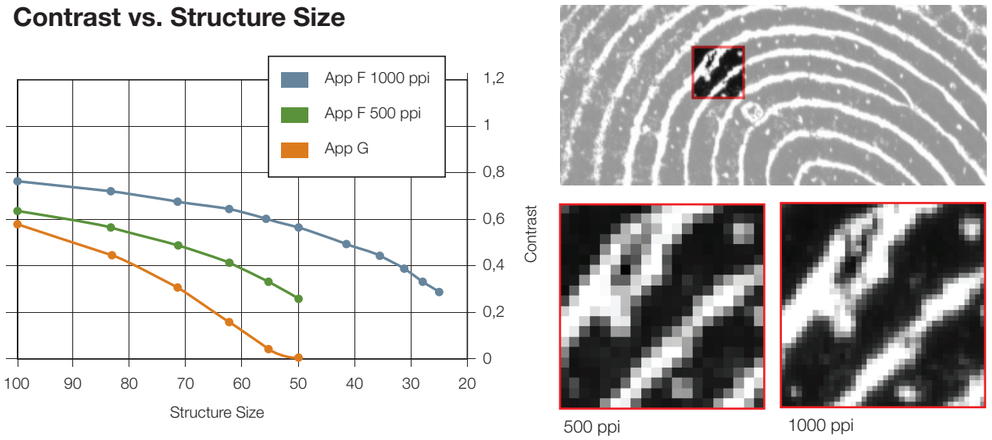


Figure 2: Contrast in correlation to structured size and resulting images of 500 ppi and 1000 ppi scanners

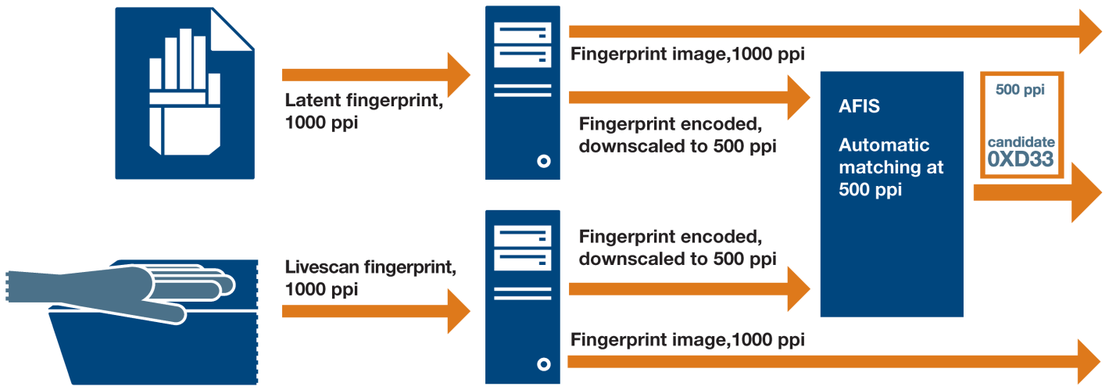
3. Prerequisites for using 1000 ppi images

In order to use and benefit from 1000 ppi images the availability of 1000 ppi livescan units is essential but certainly not the only component required. The workflow as well as the training and expertise of the examiners have a large impact on the successful implementation of 1000 ppi images in law enforcement. In Table 2, all elements necessary for capturing, processing and evaluating 1000 ppi images in a law enforcement environment are shown. In recent years, PC performance has increased significantly and today a 1000 ppi palm scanner can be run with a COTS computer. On the other hand, costs for storage capacity and bandwidth have decreased considerably, which allows much broader use of modern livescan systems. With software for quality and sequence checks, image compression as well as AFIS systems that accept 1000 ppi images, the industry provides all the components—from the frontend to the backend—in order to tap the full potential of 1000 ppi image resolution.

Technical requirements for using 1000 ppi images

Component	Availability	Example
Livescan System	✓	L SCAN 1000PX, L SCAN 1000T
Algorithms + software	✓	Aware Sequence and Quality Check
Bandwidth	✓	High bandwidth is broadly available
PC performance and storage capacity	✓	COTS PC with dual core 2,4 GHZ processor and 2 GByte RAM can run 1000 ppi scanners
AFIS systems that accept 1000 ppi	✓	MORPHO, NEC

Table 2: Technical requirements for using 1000 ppi images



What does it take to achieve this level of performance?

Obviously more than a high-resolution image sensor is needed. The optical principle used in modern livescan palm scanners is called Frustrated Total Internal Reflection, FTIR (Figure 3).

As long as there is not a finger on the platen, the light beam is totally reflected. When a finger is placed on the platen, light rays are scattered. The reflection is no longer total at these contact points, i.e. the reflection is frustrated.

The change in the reflection is detected by the image sensor and the fingerprint image is generated.

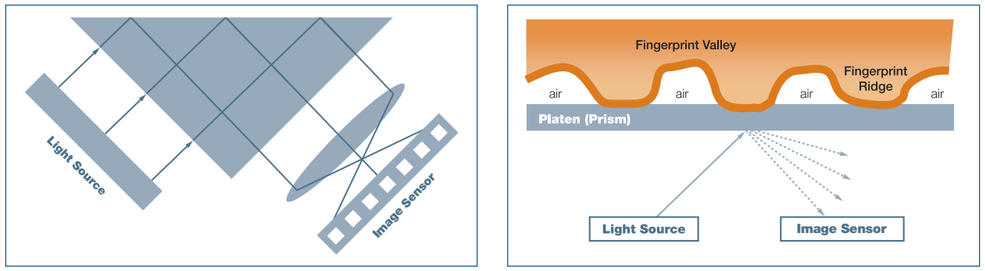


Figure 3: Optical principle of Frustrated Total Internal Reflection

This optical principle has high requirements to maintain sharpness, aberration, distortion and diffraction. Besides the optical components used, such as mirrors and lenses, the electrical components have to be selected very carefully for enabling a high signal to noise ratio. Consequently the performance of a livescan system is determined by the image sensor and the complete system. That means that all components of 1000 ppi systems are calculated in order to fulfill the high image quality requirements. Compared to a system that works with 500 ppi only, 1000 ppi systems will always have a much higher performance, even if used at the 500 ppi resolution setting. Figure 4 shows the MTF function of a 500 ppi scanner and a 1000 ppi scanner used with 500 ppi as well as demonstrates how the higher performance results in a much greater level of detail.

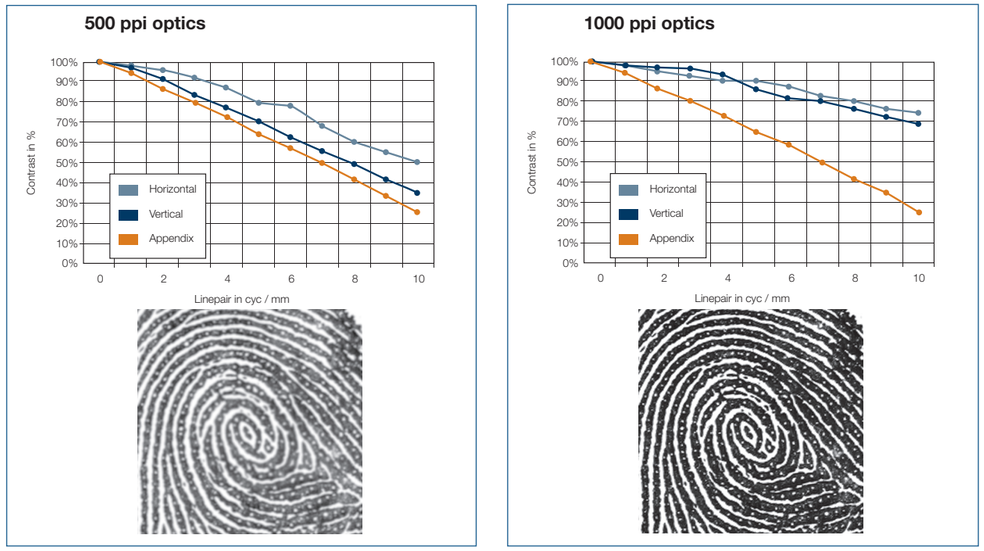


Figure 4: Contrast (MTF) of 500 ppi and 1000 ppi livescan systems (both used at 500 ppi) and resulting images

It is quite obvious that the higher the performance of the optical system, the greater the level of visible details.

Today, there is no doubt about the need for 1000 ppi for comparing Level 3 details, such as pores, edges and shape of the ridges and ridge/valley width, scars, warts, creases and deformations (Figure 5). Furthermore, scanning with 1000 ppi also helps to scan images from fingers or palms with very thin ridges, which is common among children or people of Asian descent.

However as explained above, even using a 1000 ppi system at 500 ppi resolution for capturing the image will result in higher quality of the image compared to a pure 500 ppi system. Given that “we move toward the deployment of livescan for broader homeland security uses, there will be a huge premium placed on improved image quality because of the implications of running a system designed for 200 million or more enrollees, the need for faster throughput and the minimizing of incidences where operators have to look further down the candidate list for a match.”[3] The more fingerprint systems are used outside law enforcement, (e.g. for enrollment in ID card or passport programs, visa or voter registration), the more important the image quality is in order to ensure that these fingerprints can be used in very large databases and automatic verification procedures.

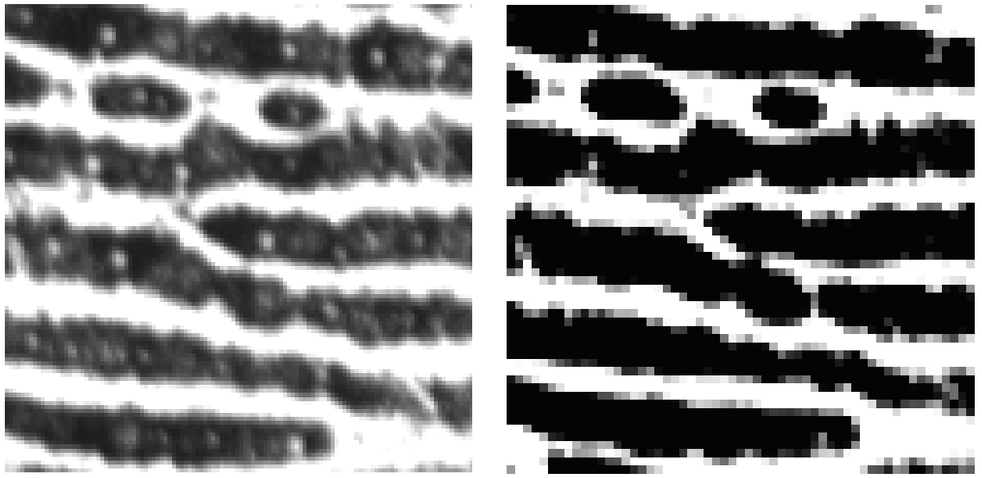


Figure 5: Difference of the same image captured with a live scanner at 1000 ppi (left) and 500 ppi (right)

[3] W. Casey, Perspectives on Livescan Imaging and Image Quality, Law enforcement technology, April 2005