Fingerprints – 1000dpi Standard– Fact or Fiction

Optical Resolution

We are consistently told that if a fingerprint is 1000dpi, the quality is suitable for comparison, but is this accurate? And should we use this standard as the only quality control for the photography of fingerprint evidence.

Unfortunately, this guide is both inaccurate and misleading. Often resulting in low quality fingerprints, and the loss of vital crime scene evidence. In some cases, converting an image (especially in colour, due to Bayer interpolation) to 1000dpi, will blur the image. So, what is important?

Firstly, as with all photography, the lighting technique is critical, but that is another topic, so here we will assume that the correct lighting is used, and concentrate on image quality. Remember, real crime scene fingerprints are often distorted, blurred, and lacking detail, with critical minutia almost hidden between the ridges.

In our discussions, we will find that the choice of camera body, sensor, pixel pitch and lens, need to match. A poor lens with a good camera body and high pixel count is a bad choice. In almost every case the pitch of the pixel effects the results.

Optical Resolution – this is more important than dpi. A 200dpi image with high optical resolution will easily out perform a 1000dpi image with poor optical resolution.

Let me explain. We live in an age where everything (especially in sales) is determined by numbers. We are led to believe that the higher the number, (irrespective of anything else) the better the quality of the item in question. So, we have cameras with higher and higher pixel counts. Televisions and monitors have moved from high definition 1080p to 4K and 8K, but is there really any difference, or is it just the 'Emperor's new clothes?'

In both examples, we need to look not at the sales spiel of higher and higher numbers, but what the human eye can actually see. In the case of televisions, your viewing experience is determined by

1. Visual acuity
2. The object you are viewing
3. The angle of view, and the distance from the screen.
4. How fast your gaze is moving.

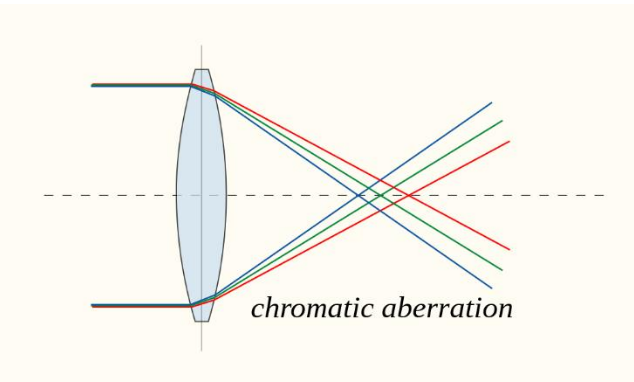
Yes, your eyes can tell the difference between 1080p and 4k, 8k, but you will need a large display, or high visual acuity if you want to see the difference from a normal viewing distance. Fine detail is only seen when sitting very, very close to the screen.

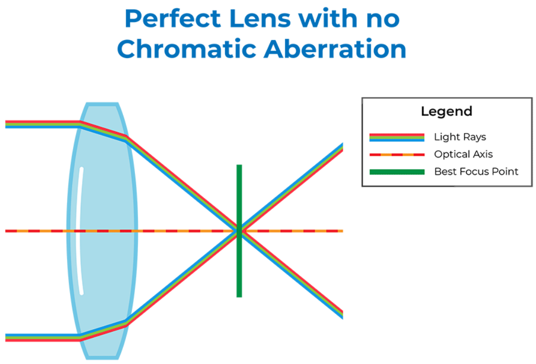
The same principle is true for the macro photography of fingerprints. For fine detail to be viewed, or captured by the camera, the image must fill the frame. This is Optical Resolution. Capturing a large area, and cropping the image to 1000dpi, is not the same, and the fine detail in the cropped image, will be missing. Try viewing a fine art painting from 6 feet, you will just see splashes of colour. View the same painting from 1 foot, and you will see the fine detail of the artist's brush strokes. If you can't see it, neither can the camera. (See the example images at the bottom of this article.)

As optical resolution is so important, so is the quality of the camera lens, especially when used with modern digital camera sensors. The quality of the lens can be broken into four categories:

1. Sharpness
2. Distortion
3. Vignetting
4. Light transmission

Image Sharpness and Light Transmission(MTF/OTF)





When light is outside a vacuum, the wavelengths producing red, green and blue travel at different speeds. To bend these wavelengths to a point of focus, a lens needs many optical components, all from pure glass carefully coated to limit reflection. The transmission factor (the amount of light that reaches the sensor) is dependent on the number of lenses, the quality of the glass and the chemical coatings. Where the glass fails, you will see colour fringing on the edges of your image, this is called chromatic aberration or spherochromatism, and will result in visible imperfections in your image.

In film photography, closing down a lens aperture, would (to a certain extent) increase sharpness (forcibly bending the colours to a central point of focus). However, in a digital camera, the closing of the aperture causes the airy disc of light to overlap the pitch of the pixel (the smaller the pixel pitch, the faster this occurs). These overlapping wavelengths interfere with each other by cancelling out visual wavelengths. This is lens diffraction, resulting in the blurring of the image.

Digital cameras require exceptionally high quality, or fast lenses. These lenses can produce sharp images at wide apertures such as F2. Digital post processing can help, but if the captured image is not in focus, the missing detail can never be accurately recovered, and the minutiae of the fingerprint is lost forever. Digital sharpening, when applied too much, creates digital artefacts, interfering with ridge detail.

Optical Transfer function (OTF), also referred to as Modulation Transfer Function (mtf) (slightly different as mtf neglects phase effects), is a method of measuring how a lens transmits wavelengths onto the photographic media or digital sensor. Put simply, a lens with good mtf will be free of lens aberrations resulting in good contrast and clarity.

The Perceptual Megapixel.

(P-Mpix): The “equivalent” number of megapixels when using a particular lens.

A new benchmark from DXOMARK https://www.dxomark.com. You can search the website for camera/lens combinations and their performances.

The focal length of the lens varies depending on the size of the sensor. A cropped sensor(apsc) may have a multiplication factor of x1.5, x1.6 etc. So, on a cropped sensor a 50mm lens may be 75mm. On a full Frame sensor, a 50mm lens is 50mm. Remember, the choice of lens affects image distortion. Wide angle lenses will distort the distances between objects making them appear further away than they actually are.

So, just as the lens effects focal length, sensors have different equivalent megapixels when paired with lenses of various optical qualities.

A poor-quality lens on a high megapixel camera, will produce an image with a high pixel size, but the sharpness is equivalent to the sharpness of a photo taken with a smaller sensor, with a perfectly matched lens. For example, say you’re shooting with a 24-megapixel camera, but are using a lens rated at 18 P-MPix. This means that the resulting photos are equal in sharpness to an 18-megapixel camera shooting with an optically perfect lens.

Distortion

A perfect lens would render straight lines correctly, no matter where they occur. However, most lenses bend lines outwards (barrel distortion) or inwards (pincushion distortion). The edges of most lenses show this curve, hence fingerprints should always be in the middle of the frame, not along the edges where distortion usually occurs. For imaging at 1:1, most images are correct in the middle, but depending on the distance from the fingerprint will not be 1:1 around the edges.

Wide-angle lenses and wide-range zoom lenses are badly affected, and should never be used for fingerprints or crime scene.

Camera lens distortion is the degree to which a lens cannot render straight lines in a scene as straight lines in the final image.

Vignetting

Vignetting (or light shading) consists of the attenuation of light as you move away from the image centre. It’s caused by the fact that not all rays from an off-axis element that go through the stop of the lens (the hole) will reach the sensor.

Some of them will be blocked by mechanical elements inside the lens.

Conclusion

For fingerprints, a high-quality macro lens is essential. If the lens performance is not good, not even the most expensive camera body can compensate. The final image will always reflect the quality of the lens. A macro lens will give 1:1 magnification. Standard lenses with extension tubes will allow close imaging, although not 1:1, but the images will be blurry, especially at the edges. Extension tubes can be added to macro lenses to allow closer imaging, but only use when required. An extension tube can never replace the performance of a quality macro lens.

Use recognised professional manufacturers such as Zeiss, Nikon, Canon etc. The lens must be compatible with the camera sensor (Full frame or cropped). A cropped sensor lens on a full frame camera will cause vignetting on the corners. Lenses designed for digital cameras (not film) have special coatings to remove ultra violet light (digital cameras are very sensitive to UV.) UV light will blur the image. Pro UV filters can be attached to the lens to further reduce UV light. Lenses designed for digital sensors have a wider barrel to allow higher light transmission. Digital cameras require more light than film, as film had a greater sensitivity. A typical 35mm film camera lens was 52mm, most digital cameras are at least 67mm. Whilst old film lenses will work on full frame digital sensors, they are not optimised for digital, and will not give the same performance.

When using the lens, don’t close the aperture beyond the point of diffraction. An aperture of about F8 will usually give the best images. Camera sensors with small pixel pitches will diffract much earlier. If greater depth of field is required, consider a shift and tilt lens, or use focus stacking in software to compile a series of images with different points of focus.

For more information on pixel resolution and camera sensors, see the next article.

This photograph from an original oil painting clearly shows the individual brush strokes.

This image on the left, is still with a macro lens, but is from further away. Already the fine detail is turning to blocks of colour with no fine detail.

The final image shown below is taken from further away and cropped. It still has a high pixel count, but the detail is blurred, we just see blocks of colour.

<u>To photograph fine detail, the fingerprint must fill the centre of the frame.</u>