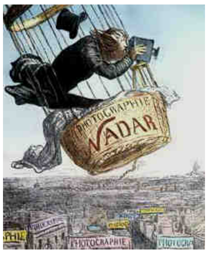


A Digital Solution

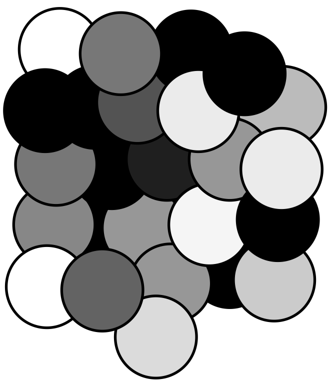
The process required to produce a photographic print is no stranger to technological developments. In Fox Talbots day cameras were extremely large and cumbersome pieces of equipment. The idea of taking a photograph from a moving balloon was not an option. Exposure times were at least 2 minutes in length, hence any movement by the subject or camera would prevent the successful capture of a photographic image.

Today we use cameras that are just a fraction of the size. Cameras are even specialised to use for medical imaging and deep space exploration. We even use disposable cameras that children can operate, certainly Fox Talbot would be amazed at the effect his early research has made in today's modern society.

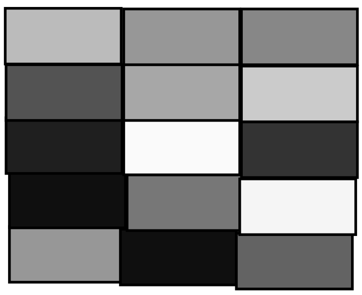
But the cameras themselves were not the only part of the photographic process to develop with new scientific research. The film that we use has also witnessed a considerable change. Early photographers used the wet collodian plate process. This required the application of a light sensitive solution of silver nitrate on a glass plate. Once the plate had been treated, the photographer would need to photograph his image and process it before the plate dried out, if the chemical compounds dried the plate would have virtually no light sensitivity whatsoever. The introduction of dry plate photography was indeed a technological development of the utmost importance. The eventual introduction of photographic film further advanced the development of the photographic process. Early black and white films were only sensitive to the blue section of the visible spectrum, later films were orthochromatic (red/blue sensitive), and eventually panchromatic films (red, green and blue) became the standard. But there was yet another technological development to come, this was the introduction of colour film.

THE DIGITAL ALTERNATIVE

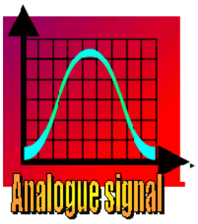
Today we are witnessing yet another development within the photographic industry, the digital image. Film is finally being replaced with a digital alternative, no more darkrooms, or chemistry to worry about, photographic prints can be produced at the click of a button. So what exactly is this digital technology and what are the implications for the crime examiner and the Judicial system.

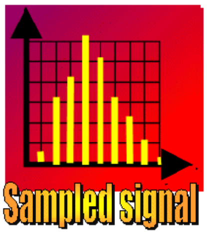


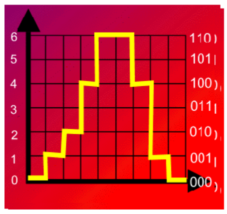
Silver Halide crystals in conventional photographic film.



Picture Elements (PIXELS) in a digital image







0	000
1	001
2	010
3	011
4	100
5	101
6	110

The digital signal is 0,1,2,4,6,6,6,4,1,0

The binary representation is :

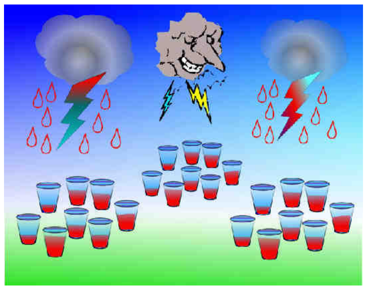
000,001,010,100,110, 110,110,100,001,000

Conventional Photography-The Silver Halide

Photographic film has a light sensitive layer of gelatine which holds in place tiny crystals of silver halide (silver combined with chlorine, bromine and iodine.) When a lens projects an image onto the film, some of the crystals are exposed to the light. This exposure changes the crystals at an atomic level, turning the silver halides into metallic silver. The amount of silver formed is far too small to be visible; the silver just forms tiny specks at the most light sensitive points on the crystal. The development process changes the affected crystals to metallic silver. The appearance of these crystals in the final print is referred to as grain (which is viewed as tiny circles) and the size of the grain is determined by the light sensitivity or speed of the film. The more light sensitive the film(I. E. 400ASA), the larger the garin, the less sensitive the film (I. E 50ASA) the finer or smaller the grain.

Digital Photography-The PIXEL

The first step is convert the analogue signal into a series of numbers. This process occurs in two steps, firstly the image is sampled, it is then quantised into series of discrete steps. Each step has a recognised numerical value. This value is subsequently converted into it's binary equivalent of 0 and 1 values. It can now be stored on a storage medium such as a computer hard drive or a compact disc where it is represented as either a 'pit' or 'land'.



Most digital images are captured using an electronic chip called a Charge Coupled Device (CCD) some systems are using CMOS technology and this is starting to be viewed as a viable alterative to the CCD, an example is the new Kodak DCS Pro 14N. The CCD is an electronic imaging system where the process of light capture, is performed by photo diodes. Here each incident photon frees up an electron, which can be stored for a subsequent readout, the charge is then temporarily transferred via a gate from the photo diode to the charge coupled device. The CCD acts like a bucket holding the electrons.

The CCD's can be cascaded into arrays in which the electrons can be efficiently moved from one cell to another over long distances to a final readout destination. The reading, which is taken from each array, is directly proportional to the light intensity at that point in the captured image. So just as in conventional photography where, silver halide crystals record the level of light intensity. In a digital system the photo diode performs the same operation.

The intensity value from the CCD is subsequently stored, as a value, which relates to the grey scale value at that point within the image.

The subsequent image is finally composed of a series of square picture elements (PIXELS) each with it's own numerical value. We now have an image that is essentially composed of a series of numbers in square blocks, rather than silver halide crystals.

Image Enhancement

The goal of image enhancement is to improve the usefulness of an image for a given task, such as providing a more subjectively pleasing image for human viewing.'

One of the greatest benefits of digital technology is the availability of image enhancement tools. When used in a controlled environment these facilities offer considerable benefits to the crime examiner.

DIGITAL **1/9**

1	1	1
1	1	1
1	1	1

1/20

2	2	2
2	4	2
2	2	2

FILTERS

Bit depth-Image class

Each pixel also has a bit depth which dictates the number of tonal values that are available to create the image. For black and white images we use the following values :
-
1. A pixel bit depth of 8 bits (256 tonal variations)
2. A pixel bit depth 10 bit (1022 tonal variations)
3. A pixel bit depth or 12 bit (4096 tonal variations).

Most cameras capture images using an 8 bit pixel depth. For fingerprint photography it is preferable to use a 12 bit pixel depth giving us 4096 levels of grey scale. The DCS 121 not only captures in 12 bit, but the software also has the capability to convert images to 16 bit and floating point. A floating point image would have a numerical value of 1.234 or 3.678 or 6.789 etc., whereas a normal bit depth would have an integer value of 6 or 7 or 255 etc.

Digital Filters

As we have now converted our photograph to a series of numerical values we can use mathematical algorithms to change the values and so improve the quality of our final images.

The simplest example of this type of image enhancement is the digital filter also known as a kernel mask or window. It is a two dimensional array of numbers that can be used to alter an image in order to achieve a desired effect such as smoothing or sharpening. The filter components are also referred to as filter taps or weights.
The images above are an examples of simple 3 x 3 digital filters, a filter is applied in the following manner :-

1. The centre filter weight is placed on the target pixel.
2. Each filter tap is multiplied by it's corresponding pixel value.
3. The result is summed together.

The number of operations needed to filter each pixel of an image is proportional to the number of filter taps. For small size filters such as the 3 x 3 in the chart the filtering operation is very fast and almost real time.

For larger filter sizes the filtering operation can be substantially longer.

Digital filters perform many different types of functions depending on their values.

We can use low pass filtering to create a smoother image and reduce image noise. We can use it for anti aliasing and special effects.

High pass filtering will create a sharper image
Filters can also be used for point, line or edge detection for image segmentation and analysis.

The numerical values or taps in the filter have different effects on the image. If the filter values are positive the resulting image will contain mainly low frequencies therefore generating a smoother softer image. Filters with these values are called low pass filters. The larger the filter, the flatter the filter weights, the smoother the resulting image.
To sharpen the image we need to use different filter values. If we place a positive value at the centre of the filter and put some negative taps in the adjacent spaces when we use the filter it will sharpen the image. This is a high pass filtering operation. The larger the contribution of the negative taps, the sharper the resulting image. The more an image is sharpened the more the noise in the image will be amplified, but used with care this type of filter can be very effective especially on smudged Ninhydrin fingerprint impressions.

Sharpen a smudged Ninhydrin fingerprint

The larger the filter the greater the effect on the image, therefore if you have a smudged fingerprint try applying a 3 x 3 sharpening filter followed by a 5 x 5 sharpening filter followed by a 7 x 7 sharpening filter, finally smooth the amplified digital noise by applying a 3 x 3 median filter.

Try creating a few of your own and let me know how you get on. To get started with image processing I suggest you down load a copy of NIH image from http://www.Scioncorp.Com.

Other Digital Enhancement Techniques

The fingerprint on the far left has been developed with Ninhydrin on a piece of paper, unfortunately one side of the mark is much darker than the other. To compensate for this I have applied a Flatten filter the result of which is shown on the immediate left.
This type of filter is also very useful for florescent fingerprints and cyanoacrylate fumed prints. Cyanoacrylate can leave a heavy white deposit in one area of the mark , and a lighter one elsewhere, look at the example below :-

The fingerprint on the left has been chemically developed but as can see it has over developed on one side obscuring a large amount of fingerprint data. The fingerprint on the right has been enhanced with the use of the Flatten filter, the fingerprint now contains enough information for a possible identification. It is also worth noting that I have already reversed the colour of the fingerprint ridges. (Fingerprint developed with cyanoacrylate have white ridges, but the final photograph should depict black ridges.) To obtain this type of image with conventional photography is very labour intensive, however with the DCS 121 all that is required is the click of a button.

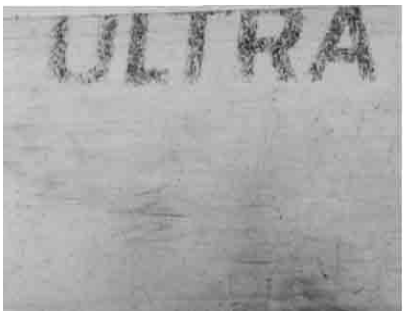
White Ridges

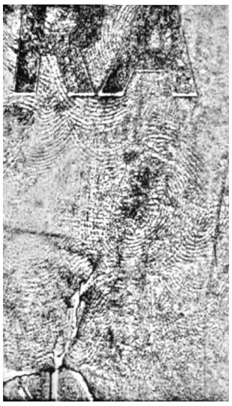
Black Ridges

The fingerprint on the left has white ridges and the fingerprint on the right has been reversed to show black ridges.

The next fingerprint is located on the interior surface of a vehicle cowling. It has been developed with cyanoacrylate fuming and stained with a florescent dye. The image on the left is before digital enhancement, and the image on the right has been subjected to digital enhancement. The ridges have been reversed and a flatten filter has been applied.

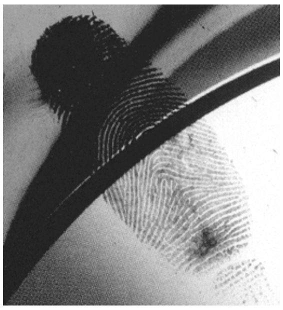
The Flatten filter can also be very effective on Fingerprint lifts. The example shown below is a very faint black powder fingerprint lift. The photograph on the left is the result we obtained using the conventional photographic process. Unfortunately this print does not show any fingerprint detail whatsoever. As a result I used the DCS 121 to photograph the lift, apply a flatten filter and perform some contrast adjustment. The result of which is shown on the right hand side. It's difficult to show the effect on an image compressed for the web, but it should give you an idea of the effectiveness of digital capture and enhancement of fingerprint lifts.

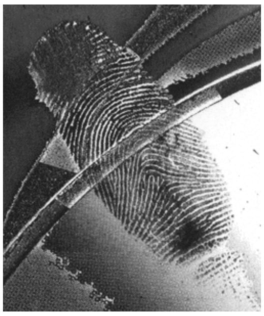




Area of interest

Many of the chemically developed fingerprints are located on coloured and varied surfaces. To compensate for this with the conventional photographic process the photographer is required to hand print the marks manually dodging and burning as required. The digital process is much easier, the photographer simply selects the specific area that needs altering and adjusts it accordingly. The example below is a fingerprint developed with cyanoacrylate and florescent stained on a number plate. The yellow and black lettering on the number plate create significantly different backgrounds. The fingerprint on the left is the original mark and the fingerprint on the right is after enhancement. The other fingerprint has been developed with cyanoacrylate on shiny cardboard. It has many different colours in the background, but digital enhancement has made produced a clear well defined fingerprint impression.



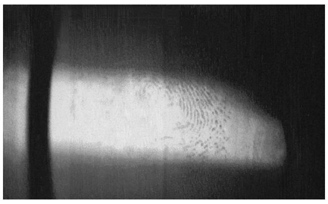


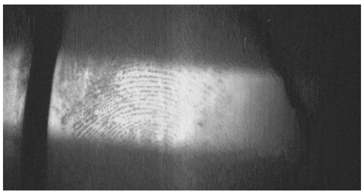
Number Plate

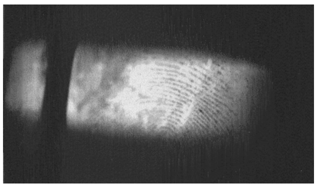
Shiny Cardboard

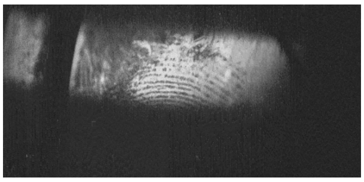
Angled and Curved surfaces

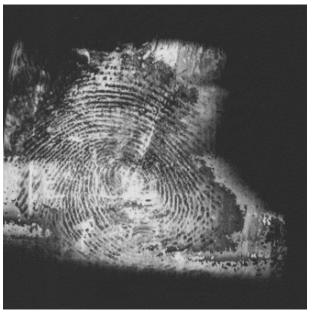
One of the problems afforded the fingerprint photographer is the location of fingerprint impressions. Although many fingerprints are located on flat even exhibits, a number of marks are developed on curved or angled surfaces. The only option open with conventional photography is either to use a large format camera and use camera movements, or to photograph the image in sections and give the Fingerprint bureau a selection of prints.
However thanks to the DCS 121 we can now capture our selection of digital images each showing a different point of focus (Each image is authenticated with Veridata, enabling each individual image to be presented at court if required.)
The images can then be uploaded into the Synoptics Auto-Montage software.
The software will put all the points of focus together to produce a final image that can be used for identification. Look at the example below:-











The fingerprint demonstrated above was developed with cyanoacrylate on a white plastic spray can lid. The chemical process developed a white fingerprint, it therefore very difficult to distinguish between the back-ground and the developed fingerprint impression. To further complicate matters, the fingerprint is on a curved surface, as a result only a small section of the fingerprint is in focus at any one time. Although I would generally apply black powder to the mark, for the purposes of trialing the software I have chosen to leave it as a white fingerprint impression.
The first four images illustrate what could be seen and subsequently photographed at any one time. Image five is the result obtained through Auto-Montage. To achieve this I took 12 individual photographs of the fingerprint, the Auto-Montage software put the images together, the result I think speaks for it's self.
It is important to note that it is not always necessary to capture this many marks, in most instances four to five photographs are sufficient.