Thoughts on the suitability of digital photography for archaeological recording

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Photography has been fundamental to archaeology since at least the late nineteenth century and it is still one of our principal means of primary data gathering. Indeed, in certain branches of archaeology, such as aerial work, the photographic record can represent the dominant, or even sole, source of data. Its value often lies in the fact that it produces, in as much as is possible, an objective pictorial record, whereas secondary illustrative techniques, such as plan and section drawings, at best involve an element of (possibly mistaken) interpretation and, at worst, are open to subconscious or even deliberate falsification.

For most of its history photography has been a photochemical process which exploited the readiness of silver-halide salts to break down when exposed to light. The result was an image composed of metallic silver particles, which could itself be replaced by dyes in the case of colour and chromogenic (C41 colour process compatible) B&W films. In recent years, however, we have seen the rapid rise of photoelectric processes, which use CCD (Charge Coupled Device), or similar technologies to produce digital pictures. Digital imaging is hardly new. The writer's own career began as an archaeological photographer in the early 1980s and it was starting to appear even then. We have been using scanners for around twenty years but, although digital cameras have been available for a similar period, it is only in the last few years that they have really started to come of age. Now, however, we are starting to see many archaeologists, including a number of aerial workers, making the transfer to digital. But some of the reasons given make one wonder whether this has always been done with proper consideration of the potential ramifications. Indeed, one is sometimes left with a feeling that the process is being, at least partly, driven by fashion. In other words, digital photography and digital cameras are currently, to use the vernacular, ‘cool’, and it is tempting to wonder whether some archaeologists are adopting them so as not to be seen as old fashioned, rather than because they have decided, after due reflection, that they do the job of archaeological recording better than traditional technology.

Of course digital photography has a number of clear advantages and no one could object to its use in archaeology. In particular, the images are obtained instantly. This allows technical aspects such as focus and exposure to be checked on the spot so that failed pictures can be re-shot, something which might no longer be possible after the delay imposed by film processing. Less obviously, though, it can also permit instant access to data which might help to guide the progress of an excavation. For example, I have long used a technique of elevated photography in which a camera, fired by its self timer, is used to shoot vertically downwards into a trench from the end of a long telescopic pole (Woolliscroft 1989). For the most part, this is just an economical way of producing more helpful plan view images, but it occasionally reveals subtle features before they had been noticed on the ground, so that the ability to view the pictures immediately, on site, allows such features to be more fully investigated. Modern communications technology also allows digital pictures to be transmitted to and from site which can be useful in consulting finds and conservation specialists and in communicating quickly with heritage bodies, other scholars and the media. The fact that digital photography is archaeologically useful is, however, a very long way from meaning that it should be relied on as our prime (let alone only) means of photographic recording. Indeed, given the current state of the technology, there are powerful reasons why this is not the case, and is not likely to become so in the immediate future. The first is the question of resolution.

Archaeological records should, of course, be as comprehensive as possible, which means that features should be photographed at all stages of excavation and in such a way as to bring out maximum detail. Yet for the last few decades, much of archaeology has already seen something of a retrograde slide in this area. Cookson, in his classic 1954 book *Photography for Archaeologists* (chapters 2 & 3), took it almost for granted (albeit not entirely realistically) that archaeologists would seek to use large format cameras whenever possible; with medium format, and especially 35mm, being useful only as a poor second best when nothing else was available. It is true that film has improved a good deal since that time, but not to the extent that a modern 35mm negative can even begin to compete with the resolution of Cookson's full plate work. Nevertheless, 35mm is now the default photographic medium on most archaeological sites including, I admit, my own. Likewise, much early aerial photography was

conducted using large format film. For example, much of the late Prof JK St.Joseph's work used 12cm square negatives. Some of his pictures are now almost sixty years old and yet their quality can still beat air photographs taken today, despite our better films and lenses, simply because most workers now use 35mm or, at best, 6cm film.

This much might be bad enough, but digital photographs usually represent a further marked diminution in quality. The two technologies are not directly comparable, but the resolution of a 35mm frame is thought to equate to that of a digital image of somewhere in the region of 12-20 megapixels, depending on the grain size and sharpness of the film being used, and the ISO setting of the digital camera (which effects its signal to noise ratio). On the other hand, most current generation digital SLR (single lens reflex) cameras have resolutions of only around 6 - 8MP: just half that of an average 35mm film, and poorer still when compared to medium format. In fairness, there are many applications where this tends to matter less than one might expect. For example, the difference is barely noticeable on a standard 6" x 4" imprint and most published archaeological photographs are reproduced at this size or smaller using half tone printing technology which, even at its best, will further lower resolution. Nevertheless, archaeological archive photographs (especially air photographs) are often used under high magnification, where their full resolving power can be exploited and we would thus seem duty bound to ensure that this should be as high as possible. In particular, archaeological features are sometimes visible only as slight changes in soil texture, rather than colour, and very high resolutions are often needed to record such changes.

Of course, there are a few digital cameras that can now match at least 35mm resolution. At the time of writing Canon make a well thought of 16MP SLR, whilst a 22MP digital back is available to fit certain medium format cameras. These are, however, frighteningly expensive (at present £6000 and almost £20,000 respectively) and although costs will no doubt fall in the future, they remain out of reach of most archaeologists. They also represent a great deal to invest simply to be able to do something by another means that we have anyway been doing for decades. After all, most archaeologists already have access to high quality film based equipment and so, unless there are compelling reasons to the contrary, the money might be better spent elsewhere. Moreover, simple angular resolution is not the end of the story. Archaeological recording is heavily dependant on the ability to distinguish very subtle colour/tone changes, be they in soils, crops or artefacts. Yet digital cameras are inherently limited in this respect, since they record tones as a fixed series of (albeit fine) discrete steps. Traditional film, with its infinitely variable tonal rendition is thus again a potentially superior medium.

In addition to their poorer average resolution, most digital cameras also have poorer exposure latitude than film (especially negative film). In other words the range between the darkest and lightest parts of a single picture in which they can still record detail is lower. At the very least this tends to make setting exposure values more critical with digital, but it can also make it harder, if not impossible, to record unevenly lit subjects such as feature sections and building interiors without extensive use of bracketing (taking repeated versions of the same picture at a range of exposure values) or artificial lighting.

Another issue is what is sometimes called "total cost of ownership". The price of professional quality digital cameras may be high, but it is often argued that digital running costs are lower, since there is no expenditure on film and processing, and only those images deemed necessary need be printed. In practice, however, a good site or aerial archive should contain at least imprint sized versions of all the pictures taken and, on this basis, digital costs can actually be higher than film.

True objectivity in archaeological recording, although perhaps not a completely attainable goal, has always been an ideal to strive for, and here again there are advantages with film. No one who has worked in a dark room could accept without reservation the old adage that "The camera never lies", but it is certainly a great deal more difficult to falsify a traditional negative than it is a digital file. More seriously, digital imaging can produce visible noise and processing artefacts which might accidentally falsify data or be misinterpreted as archaeological data by the unwary. In fairness, negative faults can be similarly misleading, but they do, at least, tend to be relatively large and highly localised and are thus easier to spot and discount.

Next, come a number of issues which, although not necessarily inherent to digital photography do raise questions over the suitability of current equipment. The first is the fact that most digital SLR's are based on the latest generation of autofocus film cameras, which are themselves not particularly well

suited to archaeological work. Fast reacting autofocus systems have been a godsend to sports photographers and to parents trying to photograph energetic children at play. For the archaeologist, however, autofocus is just one more thing to go wrong with delicate equipment under tough field conditions. At best it is largely valueless and at worst it becomes an active nuisance. On excavations, for example, depth of field (the distance between the closest and furthest point to appear in focus at a given lens setting) is usually far more important than any specific point of focus, since we generally want entire features or trenches to be rendered sharp. Here, so called "hyperfocal" focusing becomes crucial, with the aperture and depth of field scale being used together to produce the desired result. Sadly, few autofocus lenses have depth of field scales, which means that, although some control is possible, it is largely a matter of guesswork, and precision is hard to obtain. Likewise, autofocus can be a major problem in the air as it has an irritating tendency to lock onto to any part of the aircraft that comes into shot, leaving the ground as a distant blur. There are also times when critical point focusing is vital in situations where autofocus might not be reliable in its target selection: particularly in macro and finds photography. Yet, although many autofocus cameras do allow manual focusing, few have the precision viewfinder aids (split prism rangefinders etc) needed to exploit this facility properly. Furthermore, digital and autofocus film cameras are completely battery dependant, whereas many older film cameras only need power (if at all) for their light meters. This can be a major issue on remote sites and digital cameras suffer particularly badly because most run on rechargeable batteries with only enough power for a few hours use. This is obviously more economical under normal circumstances, but it leaves them totally dependant on ready access to the mains and, although additional batteries are available, they are usually very expensive.

With a few exceptions, the sensors used by current digital cameras tend to be markedly smaller than a full frame 35mm negative. This tends to make them electronically noisy, since the minute signals from their tiny individual light gathering sites require greater amplification, but it can also have serious consequences in a discipline like archaeology which relies heavily on wide angle lenses. For the smaller the sensor, the smaller the angle of coverage of the pictures becomes, which means that digital cameras tend to decrease the angle of view of the lenses used. Digital SLR's are generally designed to use the manufacturers' normal 35mm system lenses. This may seem to save money for users of existing systems, but the lenses will most emphatically not behave in the way that they did with film. Digital cameras usually quote a lens correction factor, a focal length multiplier which will typically lie between 1.4 and 2 and what this means is that a typical 28mm wide angle lens will only have the coverage of more standard 40-55mm lenses when used with digital. Admittedly, this can be corrected by moving to still shorter focal lengths. For example, given a correction factor of 1.5, the normal effect of a 28mm can be gained with an 18mm lens, but lens prices tend to increase exponentially with falling focal length, bringing substantial extra costs to already very expensive equipment. Very wide angle lenses also tend to vignette (darken towards the image corners) markedly on digital cameras because the light they project towards the edges of the sensor arrives at an oblique angle. This makes little difference with film, but digital sensors become significantly less efficient at registering light, the further its angle of incidence diverges from the perpendicular. To some extent this effect can be compensated for later by computer processing, but the inherently narrow exposure latitude of digital cameras imposes strict limits.

Archaeological sites are, almost by definition, dirty places where delicate cameras have always faced fairly hard lives. For sealed (compact style) digital cameras this is probably no more of a problem than it is for film based equipment, but most serious work is done using interchangeable lens cameras, predominantly SLRs. Here digital cameras face another major problem, because removing the lens, however briefly, exposes the interior to dust, which can then work its way onto the sensor. With a traditional camera, a speck of dust on the film will affect one frame only, but as a digital camera uses the same sensor for every picture, dust spots can become permanent features. Worse still, because most digital sensors are so small, the same specks will appear more highly magnified on the final pictures and will, thus, be more obtrusive. This has already become such an issue that one manufacturer, Olympus, has begun to install ultrasonic vibrators on the sensors of some of its higher end cameras to shake them clean during use, but for most cameras sensor cleaning is a delicate job which manufacturers recommend be left to a skilled (and so expensive) repair specialist and which will thus take vital equipment out of commission while the work takes place. This is a serious enough problem in western

Europe, but it is likely to be still more so in dryer regions where airborne dust is endemic and where camera repairers are often much thinner on the ground.

Perhaps the most serious question facing digital photography, however, is the likely longevity of the images. Excavation is, after all, a process of controlled destruction, so that at the end of a dig the records are all that survive to enable us to interpret (or reinterpret) the results. Finds photographed in situ can disintegrate later and recent events in Iraq have reminded us that even well conserved museum collections can be looted or destroyed. Likewise air photographic indications, such as cropmarks, never seem to show exactly the same information twice and many aerial discoveries and, indeed, surface monuments, have since been ploughed out, demolished or built over so that again the photographic record can be all that survives. Consequently, as archaeologists, we are rightly expected to produce records which are as near as is practical to true archival permanence. With the possible exception of early twentieth-century nitrated cellulose films, traditional photography has given us just that because, although it is true that dye based colour and chromogenic B&W images tend to fade slowly over time, even when properly stored, the metallic silver image of a normal black and white negative is to all intents and purposes eternal. It is still perfectly easy to print nineteenth-century glass plate excavation pictures and, as I write, I have just finished printing a newly found and very useful series of pictures taken by a volunteer on the late IA Richmond's 1930s excavations at the Roman fort of Fendoch. Indeed vintage negatives will often produce better images now than they would at the time, thanks to improved enlarger lenses and (arguably) printing papers. This is a proven track record of considerable distinction and as yet we have no idea whether digital storage will prove able to match it. In principle, there is probably no reason why it should not. Indeed, the ease with which truly identical copies can be made quickly and cheaply from digital files might even enhance the survival of digital work, by allowing multiple copies to be kept at different locations, thus lessening the risk of destruction by fire, war or other types of disaster. Nevertheless, the preservation of all types of digitally archived material is becoming an area of great concern in many areas of academe, commerce and government and we may find that it will take a great deal more active management than traditional media: something which much of archaeology is currently ill equipped and ill funded to support.

Computers are now so ubiquitous that it is difficult for younger scholars to remember how very new they are. Routine use only dates back to the 1980s with the introduction of machines such as the original DOS based IBM PC and the CPM based Amstrad PCW. At that time hard discs were still rare esoteric equipment and most users saved their files to either the then standard 5¼" floppy discs or Amstrad's proprietary (and higher capacity) 3" floppies. Some machines even used audio cassette tapes for storage. Given the meagre power then available most computers were used almost exclusively for word processing and, to a lesser extent database and spread sheet work and the standard word processor packages were "Wordstar" or "Word Perfect" on the PC and "Locoscript" on the PCW. Many of us who date back to that era still have discs and tapes full of data which has never been transferred to any other media. But magnetic storage is notoriously ephemeral and these discs and tapes may well no longer be readable. In practice, however, few of us will ever be able to find out, since drives capable of dealing with them are now all but unobtainable and few modern software packages could, anyway, open the files. Technology continues to move on apace and we now have optically recordable CD and DVD, new data file formats and new software, but these are just as vulnerable to the onward march of time. CD is already bordering on obsolescence and, although DVD drives will probably continue to be able to read them, they too will eventually fade away. Likewise, for both these formats, the recordable discs may only have a reliable storage life of around ten years and, again, even if the media survive, the file formats may well go out of use. Online hard disc storage (suitably backed up to protect against virus attack, disc failure, accidental/malicious erasure etc) might seem safer, as the files can be monitored and periodically converted to new formats. But even given recent exponential increases in hard disc storage capacities, this will often prove impractical. High resolution digital photographic archives can grow rapidly to consume multiple terabytes of space, which means that they can only be kept on large and expensive servers. For example, I take around 3000 archaeological pictures a year which at 16MP resolution would equate to around 250Gb of storage in full resolution RAW format. Indeed the very size of digital images might be a further enemy of resolution since it inevitably raises the temptation to use lossy compression techniques, such as JPEG, to save space.

If the price of freedom is constant vigilance, the price of digital archiving will be constant maintenance. Some archiving organisations, such as the British Royal Commissions for Ancient and Historical Monuments, are by nature well suited to addressing these issues and will no doubt deal with them efficiently, but a high proportion of university and independent archaeology continues to run on what might be called ‘box file technology’ where material is kept, often very neatly, in files, and only makes its way to a central archive decades later after its creator's retirement or death. This has worked perfectly well in the past and properly kept negatives, hopefully stored with their original records, will survive perfectly unscathed. Increasingly, however, our box files also contain computer discs and if these are not regularly checked and updated, the result is likely to be tears. By no means all archaeologists or academic institutions even make regular backups of online computer data, let alone CD/floppy archived material, and still fewer routinely check their backups to ensure that they can indeed be properly restored. Thanks to 'PictBridge' technology, others have got into the habit of printing out digital photographs direct from the camera and then clearing the memory card without downloading the digital record, despite the fact that ink jet prints can be even more ephemeral than ill maintained computer data. This is far from best practice, but it is common nevertheless and it is likely to result in disasters from which there can be no recovery unless data is also recorded on more time robust, if old fashioned, media such as paper and film.

A particularly insidious problem with photographic data is the current chaos over the so called RAW format. In theory, this represents the camera's raw, unprocessed and uncompressed sensor data. It generally has a wider tonal/dynamic range (12 as opposed to 8 bits per colour channel) and is the nearest thing digital photography has to a traditional negative. Ideally, all archaeological digital pictures would initially be saved this format and kept unaltered however else the images might then be processed and re-saved. After all, film images can also be subjected to considerable reprocessing, either digitally or in the darkroom, but the original negative will always stand to act as a reference, and RAW files are supposed to serve the same function. They should thus allow future scholars to gain the very last ounce of data from our photographic records and ought surely to be a standardised, scalable format which can continue to be read for all time. In practice, however, this is very far from the case. Many manufacturers impose differing degrees of in-camera processing on the raw data before the image is saved, the details of which are often kept as closely guarded commercial secrets (Fearon, 2005). The result is that RAW is not really a format at all, but a whole galaxy of often mutually incompatible formats of which many variants are maker or even camera specific. Indeed, some cameras cannot save in RAW format at all. Camera manufacturers seem highly defensive of this practice, but the inevitable result is that it will be extremely difficult to archive these digital 'negatives' in a usable form without also archiving the driver software for a huge variety of individual cameras (and the operating systems under which they run) or, at best, multi-camera plug in software such as that available for Adobe Photoshop. Indeed, even this may not be enough, since most software is itself hardware specific and we cannot even rely on the current "WINTEL" standard persisting over the longer term. In practice, therefore, we will probably be forced to save digital files in more widely usable formats, thus sabotaging their quality (in however small a degree) and destroying their status as 'originals'.

This paper is not intended as either luddism or a nostalgic lament for an obsolescent technology. I would not for one moment question the value of digital imaging or, more narrowly, of digital photography in archaeology. In addition to the advantages already mentioned, it can be invaluable to be able to carry large photo collections into the field on a laptop. Many publishers now require all images to be submitted in digital form and, of course, there is no other means of posting pictures to the Internet. I would, however, seriously question the wisdom of using digital technology as the sole means of photographic recording for any archaeological work where the pictures cannot be readily re-shot. In particular, it would currently seem to be folly, bordering on irresponsibility, for any worker to fail to produce a silver negative (ie non chromogenic) black and white record. For this is the recording medium with by far the best proven track record for archival permanence and should probably be seen as an irreducible minimum for at least the foreseeable future. Film does not, after all, in any way preclude the use of digital imaging. Very high quality dedicated film scanners are now available at a fraction of the price of the best digital SLRs, and are usually capable of significantly higher resolutions. Indeed most labs will now scan films to CD as they are processed. Likewise, there can be no objection to the use of digital photography as a supplement to film based site photography and it may even be able to replace

some field photographs. For example, almost all of my own excavation photographs are taken with three cameras, using black and white, colour negative and colour slide films. This is partly a means of ensuring an effective fail-safe should any one film be incorrectly processed, but it also reflects the fact that different film types are best suited to different uses. The black and white work is the ultimate archival record and goes more or less straight into storage. The colour prints are most useful during report writing and the slides are best suited for lecturing and for those publishers who have not yet turned digital. The academic value of slide images is currently falling, however, despite the film's technical superiority, as demand from publishers has all but vanished and digital projectors take over in lecturing. Moreover, slides can easily be made from prints if needs be. Indeed, as they can be made by copying prints from larger format negatives onto slower, higher quality film than is usually practical in the field, such copies might even be superior to original field shots. I am thus considering using a digital camera instead of slide film in future, whilst still maintaining a three format approach. Nevertheless, the use of digital to replace film altogether would be an entirely different matter and archaeologists, both amateur and professional, should consider very carefully what real (rather than fashion) advantage they might be gaining and what risks they are taking with the future usability of their records before taking such a step.

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Information on digital archiving best practice can be obtained on-line from the Technical Advisory Service for Images: http://www.tasi.ac.uk/