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[Cover photo. Iron Age busyness at Lime Farm, Landbeach, Cambridgeshire. Photo © Rog Palmer, 22 June 2017]
Editorial

Change to AARGnews distribution dates
Your committee decided that, with effect from this issue, AARGnews will be ‘published’ in October and April. The shift of one month will more easily enable us to include invited contributions from the September AARG meetings and information about the next meeting following the February-March committee meeting at the new venue. The original September date was set so that printed copies of AARGnews could be handed out to members at our annual meetings to save postage. Lugging boxes around became more difficult when we moved AARG to mainland Europe and irrelevant when AARGnews became digital. So, the new dates are for the committee’s convenience and your delight.

Cover photo
The site at Lime Farm was first published by Frere and St Joseph in 1983, using a photograph taken by St J in 1976 when features appeared sufficiently spectacular for him to take verticals as well as obliques – all in black and white. In preceding and subsequent years the site was seen only partially as crop rotation blanked off strips of it. At the time of my flight this year the fields were covered in what appeared to be a single crop within which archaeological features were showing clearly and consistently, giving the chance to record it in colour – which makes a small argument in favour of repeat photography.

More information about the aerial photographic history, dating of features, and their later protective covering by Roman plough soil, was given in a note in Antiquity following use of part of the site for a training excavation run by what was then Cambridgeshire County Council Field Archaeological Unit (Connor and Palmer 2000).

For those who like to play with images, the cover picture has been cropped from a wider view and slightly faded using the Gamsat (gamma and saturation) image modifier that comes with the free software XnView. That’s to make the writing show more cleanly.

Another rant about that word ‘cropmarks’
Earlier this year I was asked to review a paper that had been submitted to a journal that deals with prospection in archaeology. The authors, not from an archaeological institution, had taken considerable time and trouble to compare ‘cropmarks’ as identified in county and national HERs with historical SMD tables. They concluded that aerial people were wrong to use SMD data as a guide for flying as the authors’ analytical results showed that ‘cropmarks’ had been visible when SMD values differed significantly from the levels that our accumulated knowledge had shown to produce ‘cropmarks’. This had come about because of the common use of ‘cropmark’ to mean ‘archaeological site identified on an aerial image’ – a use which is probably now too deeply engrained in archaeology to ever eradicate. Perhaps the paper showed too much acceptance by the authors to believe that ‘cropmarks’ as identified in HERs were the same as the ‘crop marks’ discussed by Jones and Evans (1975) when they first showed the value of using SMD to the aerial community. In this case, HER ‘cropmarks’ included earthwork ridge and furrow from 1940s verticals and other ‘cropmarks’ photographed in bare soil in January.

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I, of course, blame you lot – first for making ‘cropmarks’ become one word and therefore something that they are not, and second for continuing to use it (in whatever form) to describe things that had been photographed or interpreted. You’ve heard it all before (I could probably cite Palmer, birth-present) but this is the first time I’ve been aware of it having such an idiotic effect outside the aerial community. We aerial specialists may know what we are talking about (discuss?) but it is part of our responsibility to ensure that those we communicate with are able to clearly understand the words we use. And to continue that theme, if the rest of the world can’t understand what we are talking about, is it any wonder that aerial survey (as we know it) has been subverted by GIS and satellites? This has been the topic of several discussions and private conversations which often ask where we have gone wrong. I suggest that misinformative terminology is a contributor to the decline and fall of what we know to be the most productive means of archaeological survey and discovery yet invented.

Stock enclosures

Flying in Romania at the end of May-early June this year (for which my thanks go to Carmen Miu) gave the chance to grab in passing some shots of stock enclosures in different parts of the country. The first, some 30km WNW of Iasi, is one of many similar enclosures on low-lying pasture. They were often designed as conjoined curvilinear enclosures (below) which can be used for sorting sheep as their gates allow inter-enclosure access and transit to and from the pasture. Unfenced marks in the grass show where other enclosures were located in this year (perhaps) and previously.

A second example (next page), some 70 km west of Constanța, would allow a more selective or staged sorting of stock along the ‘neck’ of the square banjo. However, the only animal in my photographs is a horse for whom the fenced enclosure seems over-elaborate. Google Earth offers no useful hints about other potential users – some (empty) large square areas were visible on earlier dates plus the stain of one enclosure that may have included a ‘neck’ as in the 2017 photograph. Any information from stock-keeping readers will be welcomed.
Neither example shows any hint of the funnel entrances that have been noted in many English prehistoric sites and are thought to be essential for getting livestock through a gate. At these and other photographed sites, wear patterns in the grass and the design of entrance gates suggest that funnel entrances are not needed for herding Romanian sheep who seem able to go through a single gate.

Of relevance to archaeologists is the observation that none of these fenced enclosures would be visible on aerial photographs taken 2000 years later. In Britain and parts of temperate Europe we are used to past features being defined by ditches or stone walls but we need to ask if the objects among those that we suggest were for stock – e.g. banjo enclosures, funnel entrances – are perhaps too elaborate, too much effort, for features that elsewhere (e.g. in modern Romania) are of temporary nature. One reason for the short life of these things may relate to the fact that enclosed animals create a concentration of dung that can fertilise the soil. Whether it is easier to move the dung or the animals is open to debate and also may depend on whether pasture is permanent or temporary. Regardless, things like these stock enclosures may indicate another element of the past that remain unknown blanks in the landscape.

**AARG 2017, Pula**

Enjoyable, rainy, lots of space at the venue, breaks on the terrace, welcome reception in the amphitheatre, conference dinner in an outside restaurant … all really-well organised by Sara Popović and her local helper Davor Bulić. I say ‘all’, because they even managed to give us a rain-free field trip to the island of Brijuni (for some pics of this see the AARG facebook page: https://www.facebook.com/aerialarchaeologyresearchgroup/).
One point to come from conversations was that oblique photographers seem almost to be a species of the past. An extension of that, especially as we now are in a workshop-free period, was a request from a younger delegate that we need to teach people how to take oblique aerial photographs. In some places there may still be a need for oblique photography and the biased means of survey that it accompanies but the greater importance in that request is to show that some of the younger generation are aware that there is more, and different, information than is freely-available on the internet or can be captured using UAVs.

Ralf Hesse and I tried to organise an informal evening session but, other than a tale from Moira Greig, it didn’t work. This is perhaps no surprise in view of the above observation on oblique photographers because the original evening sessions relied on input from photographers and the content ranged from aerial art by Otto Braasch to seat-gripping sets of, “Here’s another ring ditch I photographed this summer” by Anon and his friend. Few of the current attending members remember those evenings which mostly took place when AARG was held in assorted UK universities, and few members now do anything as frivolous as only taking aerial photos. Perhaps this is a good thing and another indication of the changes that Rachel Opitz notes in her final Chairpiece on page 7.

This issue
At the end of this issue is a selection of posters from AARG 2017 as pages at their full size. Posters and presentations at AARG frequently show cutting-edge research projects and give us an idea of how thinking and direction is developing. Among those in this issue is Charles Moriarty’s poster on his uses of multispectral remote sensing for analysing crop stress at a site in Scotland which won our annual competition for the best Student/Young researcher poster or paper. Inclusion of posters in AARGnews has the disadvantage of introducing different page sizes in an issue but has the advantage that posters are not lost after the two-day meeting and that their illustrations can be enlarged and seen at reasonable quality even after compression. Any comments for or against will be noted if we have any future poster inclusions.

References


Outgoing Chair Piece: October 2017

Rachel Opitz

In my new home in Glasgow I met up with Ant Beck, who some of you may remember. Ant last came to AARG circa 2013, and we were chatting about the group, people he remembered, and the character of the organization. Ant, in typical fashion, did not hold back on his thoughts about what needed to change in AARG. Less showing of holiday air photos, get rid of the 'aerial archaeology is flying' attitude, more embracing multiple methods and technologies, more integration with the rest of the discipline. I told him he should come back and see how things are now. Clearly the AARG of his memory is not the AARG we have today. One need only look at the topics of the sessions, papers and posters presented in Pula to recognize an outward looking group, drawing on techniques from satellite imagery to UAV lidar, with applications oriented around the study of specific types of landscape, from karst to 20th c. Poland. In the context of AARG meetings both lidar and hyperspectral imaging are so familiar that we no longer feel obliged to include introductory explanatory slides presenting the basics of the technologies. Ant's DART Project, which ran from 2010 to 2013, was an innovative attempt to get to the heart of the processes behind cropmark formation through a multi-method approach that integrated multi-temporal geophysical survey, regular monitoring of soil and weather conditions, and aerial survey. DART's aims are closely mirrored by current projects within the AARG community, as our collective focus shifts to the ability to plan when and where to apply very high-resolution techniques based on the likelihood of successful collection of different types of data, and to managing and taking advantage of very large data, to which we increasingly have access. For anyone who wants it, DART's data archive is available for further study.

As I hand the leadership of AARG over to the new Chair Steve Davis, I am happy to say that today's AARG is both very different from the group that I joined in 2006 and very much the same. The interests and perspectives are diverse and forward thinking, with members pursuing automation, the implications of open data, the still to be sorted out potential of UAVs, and what we should be teaching to students grappling with our particular mix of practical skills and theoretical frameworks. The character of the group, open, welcoming, ready to hear from young researchers and experienced hands, and eager for real conversations, remains very much the same, and what made me want to come back after my first AARG experience.

I must thank the committee for their support and energy during my tenure as chair. More specifically, I must thank Oscar for teaching me to do the job and telling me I could make it my own, Rog for reminders about what I was meant to be doing when, Moira for silly prizes and taking care of everything, Sara for constant, refreshing honesty about what needed to be done, and Michael who was always reliable, calm, and had the big picture in view. Finally, I must wish my friend Steve the best of luck as he takes over as Chair. I look forward to the next few years.

Rachel

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Incoming Chairman’s piece

Steve Davis

As incoming Chairman of AARG I would like to take this opportunity to thank Rachel for her work over the last few years, and also Oscar, both as Chairman and Vice-Chairman. Both Rachel and Oscar have recently moved jobs, cities and countries, so these are no doubt exciting (and possibly stressful!) times for them both. Also to Sara, for her work in organising the 2017 conference in Pula which I felt went really well.

Rachel’s commentary on meeting up with Ant Beck is interesting. I have been coming to AARG since 2011 – compared to some of our membership this makes me a newcomer – but while elements of Ant’s recollection ring true, I think there is an element of seeing things through whatever the opposite of ‘rose-tinted glasses’ are. There are always papers that have an element of ‘these are my flying from last summer’ in them – this is part of AARG and especially in bringing aerial archaeology to areas where it has traditionally not been strong. Such papers are valuable both for us the audience and often for the practitioner who has the benefit of the opinions of some of the most experienced aerial archaeologists to be found anywhere. However, I’m not sure in my brief AARG career that I can remember a conference where those sorts of papers have dominated proceedings.

I entirely agree with Rachel’s sentiment that the diversity of papers that we see now is really exciting. We have in the last few years seen a democratization of method – the amount of high-quality aerial imagery and data that are available to *everyone* now is staggering, from the satellites of Google and Bing, to digitised collections of oblique APs (at least part of CUCAP, Leo Swan collection here in Ireland) and increasingly open-source lidar data, and the tools to visualise it (e.g. RVT; LiVT). A few years ago, having a drone was the equivalent of having a mobile telephone in the 1980s – a rare and wonderful thing. By 2015 drones were described as ‘the Christmas present du jour for kids, teenagers, and grown ups’ by the Irish Examiner, although this is not necessarily any great seal of approval.

While there is work to be done around educating new users of some of these data as to what they are, how best to use them and what they can and cannot do, the value of aerial methods is probably more appreciated now than at any time in the history of archaeology. From my own perspective one of the advantages of the open availability of data and methods is that as a group we have more time to think about the archaeology, the landscape and how the methods we use add to the story, rather than the methods *being* the story. Perhaps this is the change Ant wanted to see? If so, I think we are well on the way.

I suppose the question in this is the same one we have been asking ourselves for as long as I have been coming to AARG – what is AARG’s place in all of this? I think it is fair to say we have no ambitions to be a massive organisation – the thought of an AARG conference with hundreds of delegates is an anathema. That said, to use a much reviled phrase we need a ‘strong and stable’ organisation: we need to encourage first time attendees and, perhaps more difficult, we need to keep them coming back and build a new generation.

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There are *a lot* of conferences now with a focus on remote sensing and digital approaches. In each of those there would be a cross section of papers that would be quite at home at AARG, methodological papers, landscape studies using aerial approaches. We as an organisation need to be better at self-promotion. This can be difficult, especially given AARG’s usual calendar slot in the whirlwind of early September conference season – in 2018 we will be sandwiched between EAA in Barcelona and Landscape Archaeology Conference in Newcastle. I would hope that the AARG flag will be flown at both of those to some extent, but purely financially the number of delegates who will attend all three conferences is probably relatively low.

For myself, I will definitely be at AARG 2018 – and would be even if I wasn’t the Chair! This probably sounds clichéd, but AARG is more than just another conference – since the first time I attended it has been the one conference which remains in my calendar as a ‘must attend’. I am honoured to be the Chairman and to have the opportunity over the next few years to work with a committee of friends and colleagues. I hope to see you all in Venice!
Preliminary notice:

AARG 2018

12-14 September 2018, Venice

Further details will be circulated to members in March 2018

STUDENT/YOUNG RESEARCHERS’ SCHOLARSHIPS FOR AARG 2018

These scholarships are intended to support bona fide students and young researchers who are interested in aerial archaeology and wish to attend the conference. There is no application form. Please provide the following information in an emailed headed with “Student/Young Researcher Scholarship”: Your interests in archaeology and aerial archaeology; place of study; the name and contact details of a supervisor or employer (email) who can provide a reference; why you would benefit from attending the conference; and an estimate of travel costs to attend. Furthermore, you should also be willing to provide a poster, or for exceptional work provide an abstract for a paper (20 mins) under one of the conference session themes listed above.

Applications should be addressed to Steve Davis at aargchair@gmail.com. In addition, there will be a competition for the best Student/Young researcher poster or paper, judged by the Chairman and Vice-Chairman. The prize will be a free 2019 conference package (registration fee, dinner and field trip). All entries for the competition must apply for the Student/Young Researchers Scholarships to be eligible. The closing date for applications is the 1st June 2018.

More information may be found at the Aerial Archaeology Research Group website:

http://www.univie.ac.at/aarg/
AARG notices

The Derrick Riley Bursary

The Derrick Riley Bursary still exists. It is £500 a year, usually a single award, but sometimes is split and given to two people.

There should be an application form on the Sheffield Archaeology Department website and a Riley Bursary page on the Sheffield website where potential applicants will be able to find information and download the application form.

Finding the relevant page represents the first challenge, but if you can’t please contact Bob Johnston (r.johnston@sheffield.ac.uk) who administers the bursary.

Please apply for this even though it is not used only for conference attendance. AARG has limited funding and access to the Riley Bursary extends this amount to something more useful. No whinging about lack of money if you don’t apply.

ISAP Fund

In August 2015, ISAP announced establishment of a fund to provide support of up to £1000 to assist with members’ projects [membership costs less per year than AARG does] that ‘further the objectives of the Society’.

Guidelines and application form from the ISAP web site: http://www.archprospection.org/isap-fund

Information for AARGnews contributors

AARGnews is published at six-monthly intervals. Copy for AARGnews 56 (April 2018) needs to be with me no later than March 25, 2018. Editorial policy (for want of a better word) tends to be that if I am sent interesting contributions they go in unless there’s a danger of an issue overflowing. Instructions for contributors are no longer on the AARG website, but this issue and a page that can be sent on request may guide.

Please do not use any ‘clever’ formatting and avoid footnotes.

Good-quality jpegs are suitable for illustrations. Tiffs are for archives.

Address for contributions: rog.palmer@ntlworld.com
Several months ago Geert Verhoeven asked if AARGnews would be interested in a series of technical contributions, to which my reply was “Yes please”. The text below is his introduction explaining his aims for the series and its contents.

If any readers want a more technical version, it can be found as part of Geert’s paper in Stylianidis, E and Remondino, F., 2016. 3D Recording, Documentation and Management of Cultural Heritage. Whittles Publishing: Dunbeith.

Geert’s aerial pixel corner

In this “corner”, I will try to share some insights about the rather technical world of remote sensing. The idea of this column is to unveil some of the most useful principles of digital imaging and provide easy-to-understand explanations of abstract but archaeologically-relevant image processing concepts. That is why I will try to keep an informal style while using ample illustrations. I sincerely hope that the reader gets a better understanding of the topics at hand, which might in turn help them to recognise and solve their own digital image processing needs.

The first article will address the nature of electromagnetic radiation and explain how its various ways of reflection determine image creation. In the next contribution, I will address the fundamental building block of all digital imagery: the pixel. What is this concept we call “pixel”? Why is it often explained wrongly to be a square and how can a more accurate description improve our general understanding of images?

In future volumes of AARGnews, we will draw upon both these concepts and explain how a monochromatic, two-band, three-band, multi- and hyperspectral pixel stores some form of spectral reflectance data. These concepts will prove helpful in debunking some major myths about spatial, radiometric and spectral image resolution, while also aiding a low-tech explanation of image sharpening and deblurring algorithms.

Afterwards, I plan to explain two abundantly used but ill-understood image processing techniques: principal component analysis and the computation of vegetation indices. It goes without saying that I remain open for any suggestion about future topics and that I welcome any addition, doubt or criticism you might have on these scribbles.

Happy reading.

Geert
The reflection of two fields –
Electromagnetic radiation and its role in (aerial) imaging

Geert Verhoeven¹

Since air- or spaceborne imaging usually records how an object or a scene interacts with solar radiant energy (among many other interactions such as those taking place in the atmosphere and inside the camera), it is advisable to start our journey with a concise exploration of the world of electromagnetic energy. This entry will give some highly simplified insights into the properties of electromagnetic radiation and explain how they are harnessed when creating a digital image from a terrestrial or aloft platform. These insights should serve as essential building blocks for future entries. Since the latter will focus on the imaging pipeline of a digital camera and tackle related concepts such as spatial, spectral and radiometric resolution, they will build upon the concepts introduced here.

1 What is light?
1.1 Light is fast
Everybody knows the expression “the speed of light” and some people might even remember that it is about 300 000 km per second. Well, to be accurate, this “speed of light” should be denoted “the speed of light in vacuum” because the velocity of light will decrease when travelling in air, glass, water or other transparent substances. Moreover, this speed is not exclusively related to light. Any massless particle will always travel at this velocity in a vacuum. If scientists did not discover gravitation waves in 2016 but already two centuries before, this speed might nowadays be denoted “the gravitational wave velocity”. However, since light was the only massless physical entity that was known in the 1800s, this velocity is currently known as the speed of light and symbolised by c. Moreover, c is exactly 299,792,458 m/s. Why exactly? Because this is the number that physicists agreed upon to be the vacuum speed of light. This fixed quantity has also been used to redefine a “metre”. Today, the official definition of one meter is 1 / 299,792,458th of the distance travelled by light in a vacuum in 1 second. As a consequence, one cannot remeasure and redefine the speed of light in vacuum, since one must use the definition of a meter to measure it, but the latter definition relies on the speed of light in vacuum.

This speed of light in vacuum is very special. Everybody will observe anything massless travelling at this speed irrespective of their motion. For example, if one would be in a high-speed rocket flying along a green laser beam, one would come up with the same velocity of that light beam as when standing still on Earth. This vacuum speed of light is, therefore, said to be invariant for any possible observer and as such also known as the invariant speed of relativity theory.

Finally, it is also wrong to state that the speed of light in a vacuum is the fastest observable phenomenon. If one would quickly sweep an Earth-bounded laser beam across the moon, the velocity of the laser spot could easily exceed the vacuum speed of light. In addition, some physicists also hypothesise about tachyons: particles that, at least in theory, travel faster than light in vacuum.

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Although relativity theory does not forbid their existence, they are highly debatable since they could violate causality by sending signals to the past.

1.2 Light is wave-like and part of a wider spectrum

However, what exactly is light? Light is a tiny part of the phenomenon we call electromagnetic radiation. It bears that name because electricity and magnetism are intimately related. Moving a magnet around an electric wire “pushes” electrons in the wire and creates an electric current. The reverse relationship also holds. Just as a moving magnetic field generates an electric field, a moving electric field will produce a magnetic field. Since both “fields” create each other, they oscillate together and create a so-called electromagnetic wave (Figure 1). The Scottish physicist James Clerk Maxwell (1831-1879) found out that this is the very nature of light. He was the first to accurately describe the relationship between these magnetic and electric fields in a famous set of equations.

![Figure 1 – An electromagnetic wave consisting of electric and magnetic oscillating fields. In this example, the oscillating electric field vectors are indicated in red, while the blue lines represent the magnetic field vectors.](image)

Being a wave-like phenomenon, electromagnetic radiation can be distinguished by the length of its waves, called the wavelength (λ). Electromagnetic radiation with a wavelength between 400 nm (400 * 10⁻⁹ m) to 700 nm (700 * 10⁻⁹ m) is called visible light or simply light. Light is thus only a very narrow spectral band out of all possible electromagnetic radiation and the only wavelengths to which human eyes respond with a visual sensation.

In the visible wavelength range, each wavelength of light correlates with a sensory impression of a particular colour (or more technically correct “hue”, but that is for another time). Even though colour is thus not a physical property of the electromagnetic radiation itself, the light spectrum may be divided roughly as indicated in Figure 2. The latter shows that the light spectrum contains all hues that are visible in a rainbow: varying from Red on the long-wavelength side over Orange, Yellow, Green and Blue to Violet on the short-wavelength side. For the sake of simplicity, the visible spectrum is usually considered to consist of only three bands: Blue (400 nm – 500 nm), Green (500 nm – 600 nm) and Red (600 nm – 700 nm). Although a coarse approximation, many image-related devices such as digital cameras and monitors base their physical working principles on this subdivision.
Nonetheless, the complete electromagnetic spectrum consists of far more particular wavebands with characteristic wavelengths that are not perceivable by the unaided normal human eye. As an example, radio waves are also electromagnetic radiation. However, we have to build specific sensors (e.g. ground-penetrating radars) to utilise those wavelengths, since they are useless for the human eye. To both sides of the visible band resides radiation that does not produce a visual sensation: gamma rays, X-rays and ultraviolet radiation with shorter-than-visible wavelengths, while the long-wavelength region encompasses infrared radiation, microwaves and radiowaves (Figure 2).

1.3 Light is particle-like

In addition to the wave properties mentioned above, electromagnetic radiant energy is known to exhibit particle-like behaviour. The latter leads many to write that one can conceptualise electromagnetic radiation also as a travelling bundle of indivisible particles or photons. These photons are discrete energy packets with energy levels that differ according to the wavelength. In this sense, electromagnetic radiation can be considered a vehicle for transporting energy from the radiation source to a destination, photons or quanta being the particles of the radiant energy. Since all photons travel at the vacuum speed of light and nothing with mass can ever attain that speed according to Einstein’s special theory of relativity, photons must be massless.

Creating a more intense beam of radiant energy while keeping the wavelength the same means a tighter packing of the photons in that beam so that the radiant flux (i.e. the amount of photons passing a given point in a given time) increases. Even so, each photon in the more intense beam has the equal amount of energy as those in the less intense beam. Due to this quantization, a visible photon with a wavelength of 650 nm will always have 1.9 eV of energy, while photons with quantum energies of 3.6 eV characterise 345 nm ultraviolet radiation. From these numbers, it is evident that shorter wavelengths have higher radiative energies (see also Figure 2). This also explains why highly energetic ultraviolet radiation causes sunburns.

1.4 Is light now a wave or a particle?

None of the wave-like and particle-like descriptions of electromagnetic radiation is complete by itself, but each of them a valid description of some aspects of its behaviour. This wave-particle duality is still
one of the key concepts in quantum mechanics, which states that all things are both waves and particles at the same time and that nothing can be predicted or known with absolute certainty. Despite being mind-blowing, one could as well forget about this wave-particle duality if in need for absolute physical accuracy. In essence, there are no waves and no particles, just quantised fields with discrete excitations. That is also the reason why quantum field theory is the theoretical framework behind the standard model of particle physics. However, to understand how solar radiant energy contributes to the imaging process, this naïve interpretation of electromagnetic radiation as both “waves” and “particles” is satisfying enough.

2 Remotely imaging optical radiation

2.1 Remote sensing

Remote sensing is the collection of data about a scene or object without having direct physical contact with it. In archaeology, remote sensing is a general name given to all techniques that use propagated signals to observe the Earth’s surface from above. Based on their specific characteristics, remote sensing techniques can be classified in different ways: imaging versus non-imaging, passive versus active, optical versus non-optical, airborne versus spaceborne. Whereas passive remote sensing systems capture naturally occurring radiation, active systems produce their own radiation. Airborne systems operate from within the Earth’s atmosphere, while spaceborne systems deploy a sensor mounted onboard a spacecraft (often a satellite) that orbits the Earth. When dealing with an imaging system, the output is an image, whereas non-imaging systems can deliver sounding data or emission spectra.

2.2 Optical remote imaging

Although exceptions exist, archaeological air- and spaceborne imaging generally refers to the amalgam of passive remote sensing techniques that capture a specific part of the Earth’s reflected solar energy or self-emitted thermal energy and turn that into a (digital) image. In addition, these remote imagers only operate in the optical electromagnetic spectrum (Figure 3), which conventionally incorporates the complete ultraviolet to infrared bandwidth, comprising radiation with wavelengths between 10 nm (0.01 μm) to 1 mm (1000 μm). However, remotely-sensed imaging in the optical range usually begins at the visible waveband (i.e. 400 nm–700 nm). Together with the near-infrared (NIR; 700 nm–1100 nm) and short wavelength infrared (SWIR; 1.1 μm–3 μm), this waveband is known as the solar-reflective spectral range because reflected solar energy predominantly generates the imagery.

The neighbouring mid wavelength infrared (MWIR; 3 μm – 6 μm) range is considered an optical transition zone, as the solar-reflective behaviour slowly shifts in favour of self-emitted thermal radiation. In both the long wavelength infrared (LWIR; 6 μm to 15 μm) and far/extreme-infrared (FIR; 15 μm to 1 mm), thermal electromagnetic radiation emitted by the scene objects themselves almost uniquely governs the imaging process. As a result, the MWIR to FIR optical region is commonly denoted the thermal region.
### Figure 3 – The divisions of the optical electromagnetic radiation (*VUV does not perfectly correspond to UV-D. While VUV runs from 10 nm to 200 nm and FUV from 200 nm to 280 nm, UV-D encompasses the 10 nm to 100 nm region and UV-C the 100 nm to 280 nm zone).

<table>
<thead>
<tr>
<th>Division</th>
<th>Subdivision</th>
<th>Abbreviation</th>
<th>Cut-on (nm)</th>
<th>Cut-off (nm)</th>
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</thead>
<tbody>
<tr>
<td><strong>UltraViolet (UV)</strong></td>
<td>Vacuum UV</td>
<td>VUV / UV-D*</td>
<td>10</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>Far UV</td>
<td>FUV / UV-C*</td>
<td>200</td>
<td>280</td>
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<tr>
<td></td>
<td>Middle-UV</td>
<td>MUV / UV-B</td>
<td>280</td>
<td>315</td>
</tr>
<tr>
<td></td>
<td>Near-UV</td>
<td>NUV / UV-A</td>
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<td>400</td>
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<td>NIR</td>
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<td>Short Wavelength IR</td>
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<td>Mid Wavelength IR</td>
<td>MWIR</td>
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<td>Long Wavelength IR</td>
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<td>Far/Extreme-IR</td>
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### 2.3 General principle of imaging

At the very origin of any imaging chain lies the interaction of electromagnetic radiation with the scene or object to be photographed. This interaction determines which portion and quantity of electromagnetic radiation the digital imaging sensor will detect, integrate and digitise. To better grasp this process, it is useful to understand that almost any form of optical imaging is the outcome of a three-variable process (see figure 4):

- electromagnetic radiation of a specific radiation source (such as the Sun) falls onto the object. This so-called spectral irradiance \( E(\lambda) \) is partly absorbed, transmitted and reflected by the object;
- in addition to the particular chemical and physical structure of the object, this interaction and the specific ratio of the three processes is wavelength dependent. The combination of both incoming energy \( E(\lambda) \) and the object’s unique reflection \( R(\lambda) \) creates a spectral radiance distribution \( L(\lambda) \) [i.e. \( L(\lambda) = E(\lambda) \times R(\lambda) \)] that is sampled by an imaging sensor such as an airborne digital camera or a human eye;
- this imager also has its own spectral response(s). It will detect and integrate the incoming electromagnetic radiance in specific spectral regions. Digitising this integrated response yields a pixel with as many values as are there are spectral bands in the imager. For a standard digital photographic camera (as displayed in Figure 4), this means three values: one for the Blue, one for the Green and one for the Red spectral channel (hence denoted RGB values). In the entry about spectral resolution, we will delve deeper into their properties.
When observing a hot object, the imaging process is ideally governed by just two variables since the thermal electromagnetic radiation emitted by the object itself should be the only radiation source. The principles of fluorescence imaging are similar to those of thermal imaging. In contrast to reflected or direct imaging, fluorescence imaging uses a radiation source to excite electromagnetic radiation of a wavelength longer than the incident wavelengths. Subsequently, only the emitted portion of the electromagnetic radiation is recorded.

To make things even more complicated, highly anisotropic reflectors of solar energy such as soils or vegetation have a spectral reflectance that is directionally non-uniform. This means that the soil and vegetation pixel values also depend on both the camera’s angle of observation and the illumination geometry (i.e. the Sun’s zenith and azimuth angle). As a result, the rendering of vegetation and soil marks varies both in our brain as well as in our digital cameras as we circle them.

Finally, also an atmosphere strongly interacts with both the irradiance and radiance signals. Since the amount of interaction depends on the thickness of this atmospheric layer, it influences spaceborne pixel values even more than their airborne counterparts (e.g. the contrast in spaceborne images can become very low). The next entry will tackle the actual nature of these pixels and debunk many of the misconceptions that surround them.
Developing an approach to national mapping – preliminary work on Scotland in miniature

Dave Cowley¹ and Adara López-López²

Introduction

This paper presents the preliminary results of a survey project to create an archaeological map of Arran, an island 432 km² in extent in the west of Scotland (Figure 1). Beyond mapping the archaeological remains of Arran that are preserved as topographic features, the project also aims to develop an approach to national scale mapping that draws primarily on remote sensed data with an ambition to achieve rapid large-area coverage. Much of the work reported on here was undertaken during a three-month internship (AL-L) with Historic Environment Scotland in May, June and July 2017, within the Survey and Recording Group of the Heritage Directorate.

Background

Historic Environment Scotland (HES) is the lead public body established to investigate, care for, promote and understand Scotland’s Historic Environment. It fulfils this function in many ways, but in part through the activities of the Survey and Recording Group, which includes the aerial and field archaeological survey teams. A primary function of these teams is to explore the archaeological landscape, placing previously unknown monuments on record and documenting known ones, producing a sound knowledge-base to support management and research. The ways in which this objective has been progressed have varied greatly over the last century, from published lists and inventories of ancient monuments, though narrative publications, and a continuing focus on the creation of the National Record of the Historic Environment (NRHE), which is available online through the Canmore website³.

Archaeological survey in Scotland – tensions, challenges and potential

Scotland’s landscape presents a tension for archaeological prospection. When publicly funded archaeological survey was established in 1908 there was an aspiration to cover the country completely, publishing the results in a series of books⁴. Many things have changed over the last century, including the character of archaeological remains that are considered worthwhile recording and methods of survey. However, coverage of the country by systematic survey to modern standards remains very partial, amounting to approximately 8200 km², or a little over 10% of the 80077 km² of the total land mass (Figure 1). The challenge lies in the knowledge that wherever such systematic survey is undertaken, the process increases the number of known monuments by up to 200%. And this highlights a problem that the established approach to archaeological prospection is not scalable to cover the entirety of the country, even over many lifetimes, without massive injection of resources. Moreover there is the certain knowledge that there are many hundreds of thousands of unknown sites in the Scottish landscape, which without survey are more vulnerable to destruction and cannot enrich our understanding of the past.

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⁴ These are available as PDFs through the Canmore website: https://canmore.org.uk/collection/1296798
Figure 1. Left: The areas of systematic archaeological survey by HES (and its precursor the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS)) since the mid 1980s amount to a little over 10% of the land mass. Right: The Walls survey on Shetland demonstrates the impact that systematic survey can have, contrasting with the adjacent areas where archaeological records have been created piecemeal. © Historic Environment Scotland

The 21st century has seen significant increase in data sources, including metrically accurate orthophotos and Airborne Laser Scanning (ALS). Today, Scotland has multi-temporal coverage of orthophotos obtained since the early 2000s, and while ALS coverage is partial, at present (2017) the Scottish Government is planning how total coverage can be acquired. These sources of information add to the considerable body of aerial photographs dating back to the mid-1940s, a resource which has never been fully explored for archaeological mapping. This multiplicity of sources clearly has massive potential, but the volume of data is a challenge as the requisite human resources to explore these datasets are not available.

Therein lies a challenge for archaeological prospection in Scotland – while large increases in the numbers of sites can be expected in any given area as a result of systematic survey, the limited human resource restricts the capacity to cover large areas by ground-based survey. Equally, the increasing volume of remote sensed data has already outstripped the capacity of (manual) observer-based identification processes, and so does not contribute its full potential to archaeological mapping. A key question for the Arran survey is therefore how to develop approaches to archaeological prospection at a national scale that are better placed to exploit the proliferating remote sensed data.

Towards national mapping – getting to work on ‘Scotland in miniature’

The discussion above has laid out the background to the issues that HES is exploring through the Arran project, using it as a laboratory to explore approaches that are scalable and address the challenges of national mapping. Arran is colloquially known as ‘Scotland in miniature’,
reflecting the range of topography and land use on the island. It has a great diversity of archaeological remains typical of many parts of Scotland, ranging from Neolithic standing stones, to prehistoric round houses and forts, and medieval and post-medieval farmsteads and land use. Moreover, there is total coverage of 0.5m resolution ALS and complete orthophoto coverage, as well as a range of other sources. This combination of factors makes it an ideal area to test approaches to rapid national mapping.

Preparing the ground
Adara López-López’s internship during May-July 2017 provided additional human resource to prepare the ALS data for use, and to consolidate existing information to a common standard. One of the first tasks was to ensure the spatial accuracy of approximately 700 known archaeological sites in the NRHE, many of which might only have a location accurate to within 100m (Figure 2, left). Polygons of site extents were also created, using a range of sources including ALS-derived visualisations, current maps, 19th and 20th century Ordnance Survey maps, and oblique aerial photographs and orthophotographs. Of these the ALS visualisations proved the most useful, rendering the ground surface consistently across the overgrown heather vegetation, rushes and low-to-ground shrubs that characterise much of Arran. Some 102 site records, whose spatial information was poor, were improved to a locational accuracy of either 10m or 1m. These coordinates are important because they are a primary index in the HES online database Canmore. In addition, 670 polygons defining the extents of remains were created (Figure 2, right; Figure 3). As observed above, the archaeological record for Scotland has been built up piecemeal from many sources over more than a century and the lack of consistently accurate site locations is one manifestation of this. By itself the upgrade of the spatial data for the known sites is a significant enhancement of the NRHE, standardising the metrical accuracy of the archaeological records and defining site extents.

Figure 2. ALS visualisations were used as the primary source to upgrade the central coordinates of the known sites on Arran (left) and were fundamental to the creation of site area polygons defining monument extents (right). © Historic Environment Scotland
Assessing ALS visualisations
A further objective during this phase of the project was to assess the value of different ALS visualisations for mapping the archaeology of Arran. The basic 0.5m DTM was visualised in six ways: hill shading, Sky View Factor (SVF), Local Dominance (LD), positive and negative Openness, and slope. An entirely subjective assessment is that SVF was a highly effective general purpose visualisation, dealing with detail well and more immediately highlighting the majority of identified structures (Figure 4). To this general observation can be added the utility of LD for areas of plough-smoothed ground, especially in highlighting aspects of the palaeo-drainage patterns, as well as the enduring easy readability of hill shading.

Figure 3. An old paper record map with pecked site area extents overlain by the pink polygon created with reference to the ALS visualisations in the background – the improvements in metrical accuracy are clear. ALS Fugro, © Historic Environment Scotland

Figure 4. The range of archaeological remains at Tormore on the west coast of Arran include the footings of round houses, clearance cairns, field banks and hollow trackways. ALS Fugro, © Historic Environment Scotland
The assessment of the visualisations was informed by a field trip during July 2017 to selected areas and sites, representative of different types of landscapes, remains and land cover. The field visits demonstrated the effectiveness of the ALS data in capturing many aspects of the island’s archaeological remains. While the vegetation in July was not well suited to field observation, it was clear that the visualisations dealt well with the variety of land cover and vegetation types (Figure 5). Indeed, it is worth noting that despite the very uneven ground surface and vegetation cover on Arran, the ALS data appears to have produced a remarkably good record of the archaeological earthworks. In this area, overgrown heather vegetation, rushes and low-to-ground shrubs could all have conspired to compromise the effectiveness of the ALS, but this has not proved to be the case.

**Figure 5.** Visiting sites on the ground allowed an assessment of the effectiveness of the ALS in documenting archaeological remains. Despite the often very uneven vegetation, the ALS captured most remains very effectively. Two of the features marked above are the low footings of prehistoric round houses in an area with lots of very dense low to ground shrubs and trees that are visible in the visualisation. ALS Fugro, © Historic Environment Scotland

**Exploring the potential**

Finally, having consolidated the spatial data for most of the known archaeological sites, two days were spent rapidly scanning the visualisations to explore the potential for previously unknown monuments on Arran. This made use of hill shade and SVF visualisations as the main sources, examined at scales of 1:2,000 to 1:1,250, and identified at least 140 previously unknown sites (Figure 6). These include prehistoric round houses and agricultural remains (mainly field clearance cairns), enclosures of unknown date, and large numbers of medieval and post-medieval remains, including field banks, large areas of rig and furrow and lazy beds, and numerous groups of shieling huts. These discoveries include sites in what today are remote locations, such as the tops of valleys, but also in areas of dense known site distributions. This reflects the lack of previous systematic archaeological prospection on Arran, and demonstrates the value of the ALS data and its potential to produce even more discoveries with systematic inspection of the visualisations.
Figure 6. Rapid inspection of the ALS data revealed at least 140 previously unknown monuments, the site areas for which are indicated as blue polygons on the map (with previously known sites in pink). Examples of new discoveries are shown on the right (Top: prehistoric round houses and cultivation remains; Middle: medieval or post-medieval shieling (transhumant) huts; Bottom: post-medieval hand-dug cultivation ridges. ALS Fugro, © Historic Environment Scotland

Initial outcomes and next steps
The work described above has demonstrated the effectiveness of the ALS data not only for enhancing spatial information in the NRHE, but also in identifying large numbers of previously unknown sites. The lack of previous systematic landscape survey and the impact that this has on the reliability of our knowledge-base is also clear. This is compounded by the fact that the NRHE does not document and explain the factors that structure distributions of sites and monuments. As a result users are missing the information needed to better understand the characteristics of the datasets and avoid uncritical use of that information in management and research. Assessment of the representativeness of heritage datasets is rare\(^5\), although this is fundamental to assessments of reliability. Confidence statements on the reliability of remote sensing outputs are also not common. However, this has been identified

as an aspiration to develop as a commentary for users on factors that condition the reliability of the information created through survey work.

The early stages of defining the parameters of the Arran survey project, especially as they relate to rapid mapping, has also raised issues that will require management within ongoing project work. Foregrounding the remote sensed data as the primary source of information requires methods for assessing confidence in identifications, which have otherwise usually been expressed through the eyes of an observer in the field. This will include dealing with what constitutes a ‘site’ and how ‘possible’ or ‘potential’ identifications are managed. In part this relates to how an archaeological record is perceived, and how different types of information are managed in a national database. There is also an issue of clarity about the representativeness of archaeological records, as, certainly within heritage databases, they are usually presented with little, if any, commentary on the many processes that lie behind the creation of the data, and the reasons for presence or absence in the landscape. There is also a requirement to consider the intensity or level of survey, and what comprises an adequate minimum useful archaeological record for a national mapping programme (i.e. how much beyond ‘where is it’ and ‘what is it’ are required?).

**Automating Arran**

A final component of the work underway at present is a proof of concept module to test heavily automated analysis of digital topographic data to extract archaeological information. This approach draws on developments in computer vision to fundamentally recast the capacity of archaeological prospection and survey to cover large areas and deal with mass data, ultimately, to a large extent breaking a dependency on human resource. Without such developments the potential of the vast amount of archaeological information embedded in large topographic and image-based datasets cannot be realised to inform our knowledge and understanding of Scotland’s Historic Environment. This approach is being developed in the belief that heavily automated computational tools and the increasing availability of large datasets put the creation of systematic national scale archaeological mapping of Scotland within reach. The proof of concept for Arran draws on the Convolutional Neural Network (CNN) developed in pioneering work by the Norwegian Computing Center. At the time of writing the Arran height data is being worked on, using learning sets for round houses, cairns and shieling huts manually generated from the ALS data through visual inspection. This is a work in progress, but is driven by the hope that heavily automated processing and analytical routines will be a fundamental element of up-scaling rates of coverage in pursuit of more comprehensive national databases, recognising that the proliferation of data has outstripped the capacity to deal with it by current methods of archaeological prospection.

**Acknowledgments**

We are grateful to Ziga Kokalj, Slovenian Academy of Sciences and Arts, for processing the ALS from the RAW files to generate a 0.5m DTM, for advice on visualisations and for company in the field. The three-month internship undertaken by Adara López-López was funded by a grant from University of Alcalá (Madrid, Spain). Our thanks to Angela Gannon, Piers Dixon and Robin Turner for comments on the text.

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6 [https://www.nr.no/nb/node/849](https://www.nr.no/nb/node/849)
Cropmarks
Harvested by Rog Palmer

(web links were accessed on various dates between March and mid-October 2017)

Aerial survey in Iraq
Under the headline Pioneering program makes aerial survey of Iraqi antiquities is an article noting that comprehensive aerial survey will be used to assist UNESCO and Iraqi archaeologists restore some of the archaeological sites destroyed by IS. Not one of the people named is, to my knowledge, familiar with using aerial images, but they seem keen as is evidenced in the concluding remark by the Undersecretary of Tourism and Antiquities, “It is high time aerial survey techniques were used in archaeological sites because they can scan large stretches of land and detect the buried sites, whereas old methods of excavation require time and effort, but can be inaccurate.”

[I remain uncertain about the merit of restoring damaged sites as decay and destruction (by whatever means) seems to be a valid part of their ‘afterlife’. Will tourists be happier seeing a modern reconstruction, however well finished, to a genuine heap of old stones?]


Pretty aerial photos
I may have mentioned this site before but was reminded of it by an announcement of their annual prize winners. If you like pretty APs and have some time to spare:

http://www.dronetagram.com/

ALS for drones
A survey of the ‘best ten’ sensors which may be out of date before you read it. Possibly of interest as may be the rest of the website. Can we point these things out of a Cessna window?


(thanks to John Wells)

Camera GPS
Changing cameras a few years ago meant that I needed a different camera GPS for aerial work. I initially tried Dawntech’s tiny Eco Professional M that screws into the 10-pin port on a Nikon if you have small enough fingers to get into miniscule spaces. After struggling with that, I asked Geert if he had any recommendations and was directed to the Solmeta website and their GMAX which I’ve used for only two flights in 2017 and it achieved a very high hit rate of coordinates. One of Geert’s major selling points (for me) was that Michael Doneus also uses one. Dawntech’s GPS seems to be for Nikon only, Solmeta for Nikon and Canon.

http://dawntech.hk/shop/
http://www.solmeta.com/Index/index

1 rog.palmer@ntlworld.com
Advice for aerial photographers
Any of you thinking of splashing out on a PhaseOne camera may also like to download a free book on using it to take aerial photographs written by ‘…renowned photographer Joshua Jensen-Nagle.’ No, I haven’t heard of him either.


Hasselblad aerial camera
Or you may prefer the new A6D-100c camera produced by Hasselblad specifically for aerial work. It seems to have been designed to be used with the DJI M600 drone as pics of it show no handles or useful things to hold if operating from an aircraft. The cost is not yet announced, but their equivalent non-aerial camera costs about €30,000. Plus lenses.

http://www.hasselblad.com/industrial-products/a6d-100c

Borgring, Denmark, ring fort
Visualisation and interpretation of ALS led to the identification of a rare kind of 10th century AD earthwork. See also Books of Interest.

http://www.ibtimes.co.uk/1000-year-old-massive-perfectly-circular-viking-fortress-discovered-denmark-1634131

Anti-virus software
Not aerial but something we all need on the ground.
Sophos offer ‘business-grade security for your home Macs and PCs’ that can be installed freely on up to 10 machines. Reviews are good and it is based on a product that is widely used commercially so it seems worth trying.

https://home.sophos.com/

(thanks to Irwin Scollar)

Assorted drone laws
A map has been compiled (and will perhaps be kept up-to-date) listing the laws for operating drones in each country and/or state. Perhaps of use to those of you who travel around and don’t want to get arrested.

https://www.google.com/maps/d/viewer?mid=1OkEtyCaGNIkJhLeMr6L2lU/975SP8&ll=3.81666561775622e-14%2C128.3128787500001&z=2

Finally, a ‘UK’ geoportal site
Just as we are destined to leave the EU, the UK government has finally responded to the EU’s Inspire directive and produced an informative geoportal, even if it does seem complicated to navigate through. Users will also find that, as so often, ‘UK’ means ‘England’ although there is some information for other parts of this Ununited Kingdom (see below for Scotland).

The basic site from which you can get ALS, woodland, and other useful bits is at:

https://data.gov.uk/data/search

A whole lot more, with bells, whistles and a lot of fish (+ SAM) is at:

https://data.gov.uk/data/map-Preview?url=http%3A%2F%2Fwww.geostore.com%2FOGC%2FOGCInterface%3FSERVICE%3DWMSS%26UID%3DUDATAGOV2011%26PASSWORD%3Ddatagov2011%26INTERFACE%3DENVIRONMENT%26LC%3D1000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000&n=55.816&w=-6.236&e=2.072&map=49.943

(thanks to Mikolaj Kostyrko via Lidka Żuk)
Scottish remote sensing site
Another useful store of information holds ALS data for parts of Scotland which is available to freely download.

https://remotesensingdata.gov.scot/

… and a bit of a rave review of the site:

https://rapidlasso.com/2017/10/03/scotlands-lidar-goes-open-data-too/

SfM and 3D models
Nothing aerial, but a demonstration of different levels of detail achieved using Agisoft Photoscan Pro. The target was one hold in the wreck of SS Thistlegorm containing vehicles that had been stored in an underwater hold.

The main deep3d website specialises in underwater photogrammetry.

http://deep3d.co.uk/2017/10/10/can-take-closer-look/

Weird stuff in Saudi Arabia
More from the eye of David Kennedy, this time they’re structures he calls ‘gates’ in the Harrat Khaybar region of Saudi Arabia (GE will fly you there). These are stone built linear features, cursus like or sometimes double cursus (ie with three parallel walls). Those illustrated in the NY Times article below have squared ends, but during a quick look on GE, most of those I found had one rounded end, the other open, with internal small (5-10m) oval walled features near the rounded end. Needless to say, no one is sure of the date (other than perhaps very early, pre-kite) or purpose of these things.


Which refers to the November issue of Arabian Archaeology and Epigraphy (which I could not find on Wiley online on 20 October 2017 – the link below is to the May 2017 issue):


Hedgehenge in Russia
A recent series of programmes on BBC, Russia with Simon Reeve, included a visit to a cult community run by a reincarnation of Jesus. The village included a circular feature – my Hedgehenge – where locals gathered to sing to JesusII and which I wanted to find on GE. The BBC told me where they thought it was (it wasn’t: have I uncovered an expenses fiddle?) but I tracked it down eventually. GE shows not only Hedgehenge but that it is the focal point for the layout of the cult village with roads radiating with respect to the henge centre. I bring this to your attention because Hedgehenge is another form of feature (see Editorial) that is unlikely to show on aerial photographs 2000 years after its abandonment. There isn’t room for a picture here, but the coordinates are: 53.866138°N, 94.076123°E. To read about the cult and get a message from JesusII go to:

http://vissarion.eu/en/
Books and papers of interest?

Rog Palmer

Recent volumes of Antiquity have two papers based on ALS interpretations (August) and another two on ‘new’ methods (October):


ALS, plus selected excavation, confirmed that two moats surrounding Lovea were elements of the water-management network that culminated in the vast system of the Angkor society.


A massive ring fortress was recently identified at Borgring, south of Copenhagen in Denmark. The combination of high-resolution ALS visualisation, geophysical survey and targeted small-scale excavation demonstrated that the site is a Trelleborg-type ring fortress (AD 975–980) of which only five others are known. There have been other notes based on the Antiquity paper one of which (http://www.ibtimes.co.uk/1000-year-old-massive-perfectly-circular-viking-fortress-discovered-denmark-1634131) includes larger graphics than I was able to download from Antiquity.


Use of PCA on high-resolution satellite images to identify looting pits at a small sample of sites. This paper has me wondering if anything useful has been achieved as the computer games seem to have offered no advantages to basic ‘looking’ – although I’m willing to be corrected on this. Other things, such as this sentence, ‘Individual pits and disturbances are clearly visible on panchromatic WorldView-2 images, especially after pansharpening.’ (1347), make me wonder if the authors know what they are doing – can you pan-sharpen panchromatic images?. Also, I get the impression that the main image (Fig 1) is upside down which presumably is because the authors and editor continue this stupid ‘North to the top’ ritual.


Application of many methods of non-invasive prospection to a sample area identified a wide range of archaeological features and information where previously little was known.

1 rog.palmer@ntlworld.com
A useful guide to the range of visualisation techniques for high-resolution ALS DEMs that includes descriptions of each, including what goes on in the background and reasons for ‘uncertainties’. Different techniques have been used on the same data to enable comparison of some of the visualisations and to help the user choose appropriate ones for their questions. Eleven case studies demonstrate widespread applications of ALS visualisations and include archaeological, geological and geomorphological examples, plus one of a lake bed and another of high-rise buildings.


Pécs should be a key place for AARG as the first (and most successful in terms of continuity) of our training schools was organised in 1996 by Zsolt Visy who was then at the Janus Pannonius University at Pécs where he had already established what later was named the Aerial Archaeological Archive of Pécs – to which were added the 8288 colour slides taken during the school.

After a historical and methodological first part – up to date with sections on drones and 3D modelling – the author uses that archive to illustrate what he calls ‘episodes’ in the chronology of their occurrence at Pécs. This begins with Zsolt Visy’s work on Roman limes and temporary camps – some of which had been published by 1996 – before moving on to Neolithic enclosures … and so on. Each of these episodes/chapters includes illustrations with informative captions, text that explains the archaeological relevance of the types of feature and a short bibliography. Problems of seeing and photographing some of the features is also discussed, so the book offers a level of training for any future observer-photographers.

Towards the end of the book are chapters that deal with the recent past and present – times when our archaeological heritage has been more effectively destroyed or damaged by development than ever before. In one chapter (234-243), the author’s frustration about the neglected role of aerial assessments prior to Hungarian construction projects is evident, especially when aerial photography is more often used to record excavations than to identify where they may usefully be located prior to development. The point made – that assessment of aerial photographs prior to development can identify some of the sites along (for example) a road corridor and provide archaeological and natural context for the excavated parts – needs emphasising again and again to whoever are responsible for planning these archaeological evaluations. Chris Cox and I spent quite a lot on beer to make just these points in the early days of commercial archaeology in the UK – and it worked. Two following chapters tend to mull over the problems that all interpreters face when trying to understand if a feature is ancient, recent, natural or farmer-created. Into this is woven the need to understand and identify natural features that may have been of relevance to past occupants of the land and that can usefully become part of a narrative or map.
The book contains more than 340 illustrations, mostly aerial photographs taken by Otto Braasch and the author. Otto was responsible for opening the skies of Hungary and other parts of central Europe and played a major part in the first training school and Máté continues the aerial tradition and (presumably) teaches aspects of aerial work to his students at Pécs.

For me, the writing style in English is perfect. No long words or jargon-filled sentences and a paring down of the text to what we really need to be told – something that has become an almost lost art in this era of digital writing and cubical books. If I had a book of the month, this would be it.

*NASA’s website recently added the following ‘history’:*

Pola Lem, 2017. Peering through the Sands of Time: Searching for the Origins of Space Archaeology

A journalistic stroll through the recent past and some early archaeological use of satellite images by NASA and its compatriots. It makes no mention of people I thought were key players (eg Jason Ur) and omits one who thinks she invented it all herself.

[https://earthobservatory.nasa.gov/Features/SpaceArchaeology/?src=eorss-features](https://earthobservatory.nasa.gov/Features/SpaceArchaeology/?src=eorss-features)


*AARGnews* readers will remember a note a few issues ago on the 450(+-) geoglyphs that have been identified in the Acre region of Brazil. This paper explains the ways the authors have studied those sites and their deductions – summarised in the paper’s abstract as:

> Our aim is to explore earthwork iconography through the lens of Amerindian visual arts and movement. Combining ethnographic and archaeological data from the Upper Purus, Brazil, the article shows how ancient history and socio-cosmology are deeply “written” onto the landscape in the form of geometric earthworks carved out of the soil, which materialize interactions between nonhuman and human actors.

The earthworks were constructed and used between 3000 and 1000 BP with individual sites being in use for periods of 200-500 years. The earthwork ditches form geometric patterns, such as squares, circles, U-forms, ellipses and octagons. They can be several metres deep and enclose areas of various sizes.

The authors’ analysis of the site goes beyond shape and size and proposes that the sites were used to make contact with ancestor spirits and other non-human beings. Apparently, this continues today, with the sites being revered and respected by locals. Maybe the rest of us need to re-evaluate our understanding of European landscapes..?

This seemed to be a fairly standard survey, mixing images from GE and UAV with ‘pedestrian survey’, but became more interesting through the authors’ use of supervised classification of aerial imagery to identify terrace fields and to supplement the ‘eyeball’ GE study. In this case, training was done using a set of gravel mulch fields that had been identified on GE images and checked on the ground. Supervised classification used the red, blue, and green bands from 1-metre resolution aerial imagery that was distributed as part of the National Agricultural Imagery Program. Results identify the numbers and areas of fields identified by different methods and uses these, and figures for land capacity, to discuss possible population numbers.


This book, published in conjunction with an exhibition of aerial photographs, includes 30 views from Lindbergh’s 1927 aerial survey of the Four Corners and Upper Rio Grande and, for comparison, the same views taken ‘ninety years’ later by Adriel Heisey.

The exhibition is for hire, currently (September 2017) with no takers until August 2019: http://www.guestcurator.com/oblique-views-archaeology-photography-and-time/


The abstract includes:

This paper provides an overview of the theory behind aerial thermography in archaeology, as well as a discussion of an emerging set of methods developed by the authors for undertaking successful surveys. Summarizing investigations at archaeological sites in North America, the Mediterranean, and the Near East, our results illustrate some contexts in which aerial thermography is very effective, as well as cases in which ground cover, soil composition, or the depth and character of archaeological features present challenges.


The author is one of the many student/young researchers who has travelled with a drone in many countries. This publication describes work on 4 sites in the Orkney Islands and advocates use of this method of survey in ‘inhospitable’ areas. The results – orthophotos and
DEM’s – provide a way of looking at the areas and enabled the author to propose a level of interpretation of sequence or relative chronology. However, I feel slightly uncomfortable with the implication that these types of ‘views’ are what archaeologists need to understand processes and change in landscapes. I also wondered about the cost effectiveness of this exercise and whether it was cheaper to send one or two people from Poland for a few days, or to hire a light aircraft from Kirkwall, or ask Dave Cowley to put a long lens on his camera and take some overlapping shots next time he’s in the area. One may also wonder whether, in an area where moving grass was a problem (as noted by the author although it probably will affect all methods of remote survey in Orkney), results may have been better defined if a UAV + ALS was used instead? I’m assuming that grass would be a first return and could be removed from the final model, but I’m not sure.

But regardless, consider this paper as one of many which are exploring ways in which survey from UAV’s can help archaeology, or archaeologists.


This paper compares the information on targeted oblique photographs with that derived from ALS and demonstrates that they complement one another. The examples used highlight the danger of complacency that assumes that sites in forests may be undamaged – this is not always the case. ALS also showed the degree of damage to sites in arable land and its ability, sometimes, to show minimal height information that may not be seen by an experienced field surveyor.


Bidirectional Reflectance Distribution Function is a measure of reflectance from crop canopies and its effect on the visibility of archaeological and other features on aerial images. The conclusion, based on theory and practice, is that the nadir view achieved in vertical photography may surpass that from oblique images that may be affected by light scattering.


Interesting use of relief-enhancing visualisation techniques to enable the height of crops to be combined with colour differences to ‘add new depth to interpretative mapping. The method is more technical that that sentence suggests but may be a useful approach in those cases where visual (colour) information by itself provides a poor record. Tests were conducted using archival oblique images (taken without the needs of 3D modelling in mind) which gave successful results.
The Aerial Archaeology Research Group

AARG sees the aerial perspective as integral to the pursuit of key questions in archaeology and heritage, including landscape character, long term landscape change, human ecodynamics, and the experience of place. We are a community of heritage professionals, researchers, students and independent scholars dedicated to education, research and outreach initiatives involving the acquisition and application of data from airborne platforms. AARG provides opportunities for networking, mentorship, and exchanges of ideas on theories, methods and technologies related to aerial archaeology. The organization supports an annual conference, workshops, training schools, and publications.

Membership is open to all who have an interest or practical involvement in aerial archaeology, remote sensing and landscape studies.

AARG is a registered charity: number SC 023162.

AARG homepage.  http://aarg.univie.ac.at/

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Student scholarships. AARG has a limited number of student scholarships for attendance at its annual meeting. These are aimed at supporting bona fide students who are interested in aerial topics and may wish to attend.

Anyone wishing to apply should write to AARG’s Chairman (aargchair@gmail.com) with information about their interests in archaeology and aerial archaeology, as well as their place of study. The annual closing date for applications to the annual AARG conference is 1 June. Other meetings for which scholarships may be available will be advertised on an ad hoc basis. Support for conference attendance may also come from the Riley Fund (see elsewhere, this issue).
Digital Elevation Modelling and Geophysical Surveys at the Roman Camps of Ardoch (Scotland)

Dr. Manuel Fernández-Götz, Prof. Felix Teichner and Christoph Salzmann

The Roman military complex of Ardoch (Braco, Perth & Kinross) is one of the most important archaeological sites for the study of Rome’s military expansion in northern Britain. It comprises the remains of a main fort with a rectangular area of around two hectares, and at least five, partly overlapping marching camps dating between the 1st and 3rd centuries AD. Ardoch was part of the so-called Gask Ridge frontier, a chain of forts and watchtowers established by the Romans in the 80s AD with the aim of separating the Highland massif from Fife.

During the course of a fieldwork campaign carried out in March 2016, a geomagnetic plan of the entire main fort was completed, providing new insights into the internal organisation and the defences. Some selected areas were also analysed by means of geoelectric. This research was complemented with a drone flight of the main fort and some adjacent areas, producing a high-resolution digital elevation model of the archaeological site. The project was the result of a collaboration between members of the archaeology departments from the University of Edinburgh and the Philipps-Universität Marburg.

The aerial images provide an overall plan of all fortification structures, thus representing a significant advance compared to older plans where only parts of selected sections are usually shown. The conservation state of the monument during spring 2016 is exactly documented in a 3D-Modell. The large-scale combination of drone flight and geophysical surveys represents an innovative research project in the archaeology of the Gask Ridge Frontier.

While large-scale magnetometry offers a general view of the inner area of the fort, the resistivity prospection was able to focus on details, especially on stone structures. Within the main Roman fort, it was possible to obtain new information about the fortification system (ditches and rampart) on the south-eastern side. A Roman stone building identified during the course of the old excavations could also be clearly recognized, but also further rectangular structures west and east of the medieval chapel. Moreover, outside the main fort the possible corner of a fortification could be observed, possibly belonging to a semi-permanent Roman camp.
The exploitation and integration of various types of geospatial-data in the domains of archaeology and built heritage sites is by now a well established sub-discipline, that continues to develop and benefit from incessant technological improvements. Geo-datasets can be exploited for the improvement of the final interpretation of sites of archaeological interest, while at the same time they can help to enhance and redefine other, more traditional types of archaeological information.

This study is part of a post-doctoral project under the acronym SpAce (A contemporary approach of the ancient necropolis of Nea Paphos: GIS application in Archaeology), which is funded by the University of Cyprus (Archaeological Research Unit) and deals with the aerial investigation of a very important ancient cemetery of Nea Paphos, known as the Eastern necropolis of the Hellenistic-Roman capital of Cyprus. This funerary landscape, extramural itself, lies to the east of the city of Nea Paphos on a relatively plain land. The Eastern necropolis has been excavated mainly during the 1980's as a result of large scale rescue excavations, due to the urgent development and expansion of Paphos at that time. After the lapse of many years since then, this is a first attempt to study the necropolis from the view of landscape archaeology. This poster will deal with the integration of various types of geospatial datasets, such as satellite and aerial images, both archival and more recent, as well as historical cartography, to complement the up to date knowledge and to supplement the available archaeological information of the site.

Additionally, a diachronic investigation of the landscape, employing traditional topographic sources (i.e. cartography), modern aerial information (i.e. archival aerial photographs of the area for the years 1945, 1963, 1993, 2014), and contemporary geographic informants (i.e. high resolution satellite imagery and CORONA data) will also be undertaken. This investigation will provide some insights concerning the usage of the archeo-landscape, which does not seem to have changed much in terms of the exploitation of the topography over time.

**Abstract**

**Introduction**

The greater part of the Eastern necropolis of Nea Paphos has been excavated during the 1980’s, the decade of the construction boom of the modern city of Paphos city in the south-western part of Cyprus, which has inevitably affected the monuments (Lyssandrou et al. 2015). Within the last decade, several studies discussed and presented the utility of geo-spatial analysis in the study ancient landscapes. Few of them, however, were exclusively dedicated to the ancient funerary sites (Déderix 2014). The Hellenistic and Roman tombs excavated in Cyprus are almost exclusively underground structures, formed within the natural bedrock and thus completely integrated to the surrounding landscape. Of particular spatial value are specific features of Hellenistic and Roman funerary landscapes, such as tomb markers, delimited areas within a necropolis defining a group of tombs, etc. Therefore, topography was fundamental for the development of ancient cemeteries, as it was for the cities. A landscape oriented approach of ancient cemeteries could shed some light on the interconnection between the ‘city of the dead’ to the ‘city of the living’.

Such a landscape approach could be ideally enhanced once traditional archaeological information is integrated to spatial datasets.

**Aerial data**

The SPAce project offered the possibility to create a repository of aerial and satellite imagery of the Eastern necropolis of Nea Paphos. Table 1 displays the most significant data gathered and highlights important characteristics, such as their provenance and year of capture. As shown in table 1, the quality of the data varies, mainly according to the means employed for their acquisition. Data numbers 1 to 5 were produced by means of analogue air photogrammetric acquisition, and were subsequently transformed in digital form from traditional tape film, hence the low quality in terms of resolution. In some instances, great noise in the image resulted in low quality and thus in poor interpretation. The more recent are of better quality, since they have been captured through digital means. Another factor that defines the quality of the data is the spatial resolution of the pixel size. The pixel size of the digital data has greatly decreased over the years, thus permitting a more detailed capture of the sites. This high spatial resolution facilitates the extraction of information, as well as the final interpretation.

**Preliminary results and future research**

The preliminary results from the investigation of the aerial data of the Eastern necropolis of Paphos have already provided some very interesting insights regarding the funerary landscape. Rectangular shapes of specific geometry and size recalling tomb structures were spotted on the aerial image of the 1968 (from the National Collection of Aerial Photography), above the area of the Eastern necropolis. Many individual tombs were geometrically and geographically associated with the detected spots. These ‘tomb-shaped marks’ have been finally confirmed as tombs upon georeferencing and digitization of the plans of Hellenistic and Roman tombs (excavated during the 1980’s) on the rectified image (Figure 4) Other identified features could be also associated with tombs, based on their geometry and geospatial distribution, and deserve further investigation. The yellow circle in Figure 4 shows the unknown western part of a tomb cluster. Many of the tombs detected in this area have never been excavated or documented, since they are not traceable in the excavation records or elsewhere (perhaps they have been destroyed during the development of the area). Future research will also discuss issues, such as the Roman roads network (Bekker-Nielsen 2004), an important topographical feature of a twofold function, that of defining the urban limits of the city of Nea Paphos, and of the boundaries of the surrounding cemeteries.

**Table 1. Aerial and satellite data**

<table>
<thead>
<tr>
<th>Type of Data</th>
<th>Resource</th>
<th>Country</th>
<th>Capture Date</th>
<th>Spatial Resolution (Pixel Size)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Aerial image</td>
<td>Instituto Geografico Military</td>
<td>Italy</td>
<td>1937</td>
<td>Few meters (scale 1:25000)</td>
</tr>
<tr>
<td>2. Aerial image</td>
<td>Royal Air Force Cyprus</td>
<td>United Kingdom</td>
<td>1940s</td>
<td>Few meters (scale 1:20000)</td>
</tr>
<tr>
<td>3. Aerial image</td>
<td>Department of Land and Surveyors</td>
<td>Cyprus</td>
<td>1963</td>
<td>1 m</td>
</tr>
<tr>
<td>4. Aerial image</td>
<td>Department of Land and Surveyors</td>
<td>Cyprus</td>
<td>1957</td>
<td>1 m</td>
</tr>
<tr>
<td>5. Aerial image</td>
<td>National Collection of Aerial Photography</td>
<td>Scotland</td>
<td>1968</td>
<td>Few meters (scale 1:20000)</td>
</tr>
<tr>
<td>6. Aerial image</td>
<td>Department of Land and Surveyors</td>
<td>Cyprus</td>
<td>1993</td>
<td>0.5 m</td>
</tr>
<tr>
<td>7. Aerial image</td>
<td>Department of Land and Surveyors</td>
<td>Cyprus</td>
<td>2008</td>
<td>0.5 m</td>
</tr>
<tr>
<td>8. Aerial image</td>
<td>Department of Land and Surveyors</td>
<td>Cyprus</td>
<td>2014</td>
<td>0.2 m</td>
</tr>
<tr>
<td>9. Satellite images</td>
<td>CORONA</td>
<td>USA</td>
<td>1962</td>
<td>10-30 feet</td>
</tr>
<tr>
<td>10. Satellite images</td>
<td>Quickbird</td>
<td>Digital Globe</td>
<td>2004</td>
<td>0.6 m</td>
</tr>
<tr>
<td>11. Satellite images</td>
<td>IKONOS</td>
<td>Digital Globe</td>
<td>2008</td>
<td>1.0 m</td>
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</tbody>
</table>

**Figure 4. Aerial image (NCAP/ncap.org).**

**References**


The Role of Agriculture and Pastoralism for the Cultural Formation of the Mountainous Landscape of Siteia Area, Crete (Greece): a view from the sky

The present paper is part of a larger project on the Mountains of Crete named “High-above-the-mountains. Fossil Built Landscapes on Cretan Mountainous Uplands from the Sky”. The research presented here, focuses on the understanding of variability of human interference on the low mountain-range of West Siteia/Thrypot Mttns (1476m. a.s.l.), which is situated on the NE of Crete [Fig. 1].

**Terrace walls**

Series of terrace walls are built along and/or at the exit of natural passages [Fig. 2] for the extension of cultivated land and the augmentation of soil humidity levels. Because of their localization (passages between slopes) they could work also as dams for the flowing water, as retaining walls against the degradation of soil during certain periods of the year and as footbridges for connecting slopes.

**Small Plateaus**

At the small plateaus, threshing floors, clearings, small single room buildings and circular cisterns are frequently located [Fig. 283] and normally they are all relevant to the plateau’s cultivation. The existence of numerous cisterns has been always important because of the low levels of rainfall and the low number of streams and springs on eastern Crete.

Three semi-destroyed circular constructions [Fig. 4] at about 1100 m. a.s.l., which must have been cisterns too, are now largely damaged by weathering and abandonment. There is no memory of their use or of cultivation of the plateau in which they are situated, that is possibly why locals want to consider them as “Minoan royal tombs”. Elements such as reservoirs and terraces in combination with dry farming allowed sufficient production of cereals and other agricultural products. The cultivation of wheat, barley and oat oil highlands disappeared almost completely during 1950’s, partly because of the development of tourism and olive oil production (both in low altitudes), the decrease of highland population and the difficulties, the costs and the effort required for such cultivations on high lands.

**Enclosures**

The enclosed fields [Fig. 5 left] are also characteristic structures for agricultural and pastoral activities. The surrounding circular wall was protecting fields and gardens from the roaming animals (caprines and maybe wild goats) or sensitive cultivated plants from the wind. Numerous enclosed fields are part of complex built structures [Fig. 5 right], which include numerous closed (seasonal houses? storing places?) and open spaces (gardens, fields, bee-gardens and corrals).

The enclosed fields are still in use, even if small and not frequently exploited for agricultural purposes. Usually far from plateaus, double or single-spaced enclosures with a narrow entrance/exit and no corners are recognizable [Fig. 6]. Old shepherds say that the form is ideal for milking activity because the animals don’t stick in corners and cannot escape because of the narrow exit.

**Fig. 1:** President of the Research team, Dr. Stefania Michalopoulou.

**Fig. 2:** Double-spaced corral for animals, south slope of Kyparissia vector [DINS / Airbus, DigitalGlobe, European Space Imaging].

**Fig. 3:** Terraced fields with four circular enclosures (eastern side) at about 1100 m. a.s.l., DINS / Airbus, DigitalGlobe.

**Fig. 4:** Three semi-destroyed circular constructions [Fig. 4] at about 1100 m. a.s.l., which must have been cisterns too, are now largely damaged by weathering and abandonment.

**Animal-made landscape**

Finally, animal-made landscape transformations, both short and long term, are recognizable form the sky in shapes of paths, which are considered by shepherds as the safest passages, and pit-like formations [Fig. 8] stripped from vegetation, created when the lambs learn how to walk and play.

**Conclusions**

The built-structures on Siteia Mtns imply a mixed agro-pastoral exploitation (without excluding other ways that leave scarce or no traces visible from the air as lumbering, herb gathering and honey production), which matches –at least for the 20th century situation- with the interviews of old local inhabitants. According to historical documents of Venetian and Ottoman periods, the region was famous for its dairy products. This fact is supported by the information that about 43.5% of the land belonging to settlements around Orno (one of the mountains of the range) was not cultivated at the beginning of Ottoman period (second half of 17th century), proposing an intensive pastoral activity in connection with the mountain and the areas around it (Koloá 2010). Another interesting and relevant element is the name of one of the tops of Orno that is called “Korphokafala”, which means a mountain-top full of manure. The Siteia Mtns area has not been surveyed archaeologically so far. Hopefully, future field surveys, excavations and more ethnological expeditions could help to the chronology and the deeper understanding of landscape exploitation. Based on the better surveyed surrounding area (Beckmann 2012; Nowicki 2014; (Agiadós & Zographou 2015), it seems that on the mountainous volumes of Lasithi prefecture a mixed agro-pastoral system of exploitation and production was prevailing too at the end of Final Neolithic period (16th mil. B.C.), during the Middle-Minoan (2100-1550 B.C.) period, the transition period from Bronze to Iron Age (~1150-1050 B.C.), the Airchae period (770-480 B.C.) and the last two centuries of our era (before the great twist during 1950’s that was already mentioned).

Acknowledgments: G. and M. Gadanakis, N. Spafianakis, M. Kafidori, A. Paraskevopoulos and G. Cappo, RCH (for the funding granted to the project) and AARG (for the fellowship to participate to the AARG meeting).

Selected bibliography


Deploying multispectral remote sensing for multitemporal analysis of archaeological crop stress at Ravenshall, Fife, Scotland

Charles Moriarty

Introduction and Objectives

Advancements in remote sensing for precision agriculture have widened the availability of lightweight, low-cost sensors that can be mounted on Unmanned Aerial Vehicles (UAVs). These include multi- and hyperspectral sensors that are sensitive to light across a number of broad or narrow wavelength bands both including and outside the visible spectrum, which can be used to detect reflectance changes beyond the spectral and temporal observing windows of RGB photography (Aguas et al., 2012; Beck, 2011; Berni et al., 2009; Doneus et al., 2014; Morgan et al., 2010; Verhoeven and Doneus, 2011). This study aims to assess the potential of UAV-mounted multispectral imagery for detecting vegetation change across archaeological features over time in comparison to RGB photography.

Research Questions:

• Can a near-ground multispectral sensor designed for agricultural applications be utilised for effective detection of crop marks?
• How do multispectral observations compare to RGB observations for the detection of reflectance changes due to underlying archaeology?
• How different combinations of spectral bands perform for the detection of features over time?
• How do local and regional soil moisture deficits relate to the detectable presence of crop marks?

Methods

Multispectral Data Collection

Three multispectral surveys were conducted utilising a Parrot Sequoia, a four-band sensor designed for precision agriculture, mounted on a Tarot 680Pro custom-built hexacopter.

- Illumination conditions at the time of flight were recorded by the Sequoia’s ‘Sunshine’ sensor, attached to the top of the UAV, and calibrated McSense reflectance panels were photographed before and after each flight to support radiometric correction.

- Images were georeferenced using both the built Sequoia GPS and ground control points installed around the field perimeter and measured to centimetre accuracy using a Trimble GNSS kit.

- Pix4Dmapper Pro was utilised to build digital surface maps (DSMs) through Structure from Motion and create radiometrically corrected orthomosaics and vegetation index (VI) maps from the multispectral images.

RGB Data Collection

Seven surveys were conducted using a Nikon D800E digital camera, from light aircraft sorties.

- These photographs were processed into DMSs and orthomosaics using Agisoft Photoscan.

Analysis

Sample areas were defined as ‘object’ and ‘field’ based on pre-existing archaeological interpretation of the site.

- Differences in values between the two sample regions were studied through equations for histogram separability (M Distance for single band sensor and Matusita Distance for multispectral imagery to enhance archaeologically sensitive to light across a number of broad or narrow wavelength bands both including and outside the visible spectrum, which can be used to detect reflectance changes beyond the spectral and temporal observing windows of RGB photography (Aguas et al., 2012; Beck, 2011; Berni et al., 2009; Doneus et al., 2014; Morgan et al., 2010; Verhoeven and Doneus, 2011). This study aims to assess the potential of UAV-mounted multispectral imagery for detecting vegetation change across archaeological features over time in comparison to RGB photography.

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References


Acknowledgements

Many thanks to my supervisor Dr Caroline Nicholl for her support and advice; Tom Wade, PhD for the University of Edinburgh School of GeoSciences for LiDAR piloting and support; and Dave Cowley and Adara Lopez from Historic Environment Scotland for provision of aerial data and expertise. Additional thanks to Raesuck Farm for their accommodation of the study.
The Iron Age hillfort settlement of Vix – Comparing historical DEMs

Gerald Raab1,2 and Ronny Weßling1,2
1 Crazy Eye – Geoinformatics and Digital Archaeology
2 University of Vienna, Department of Prehistoric and Historical Archaeology

Introduction

The site of Vix, located in northern Burgundy, France is an important prehistoric complex from the Late Hallstatt period, comprising a fortified settlement and several burial mounds. The most famous tumulus is the grave of the Lady of Vix, including a great deal of jewelry and the Vix krater. Archaeological research has been carried out since the early 20th century, mostly concentrating on excavations and field surveys. To gain new insight into Vix and its surrounding historical aerial photos and airborne laser scan data are analyzed by comparing their three-dimensional information. This helps to understand the surface as an evolving factor and to recognize why certain archaeological features are still visible or already vanished.

Methods

The historical aerial images were preprocessed using different denoising filters and image enhancement techniques. Afterwards Structure from Motion and Multi View Stereo algorithms of Agisoft PhotoScan were applied on the geo-referenced photos (GCP derived from french webgis) to calculate point clouds which were coregistered to the reference point cloud derived from the 2006 dataset. The coregistration was done in CloudCompare and enables for the calculation of difference models. The reclassified clouds were meshed in CloudCompare, imported to Agisoft PhotoScan and rasterized to (historical) DEMs.

Results

The aerial images used are generally suitable to calculate detailed DEMs, but the low registration accuracy does not allow an exact quantification of surface changes. For demonstration difference models were calculated as they are an ideal tool for the detection of surface variations. The reclassified difference model presented here (DEM 2006 minus DEM 1948) indicates changes mainly generated by different vegetation cover. Areas with a gain or loss between -2 m and 2 m have to be considered unchanged because of several uncertainties, mainly regarding the referencing and coregistration process but also due to poor image overlap and 3D-reconstruction. This means that the vertical accuracy of the difference model is too low to detect smaller soil displacements, including most archaeological field work activities. The increased vegetation in many sensitive areas is compounding this effect even more.

Nevertheless the proposed workflow allows for a deeper understanding of the intensity and direction of landscape development.

Summary

The available historical aerial images are very well suited for the generation of meaningful elevation models, particularly for historic landscape visualisation and large scale spatial analysis. Historical DEMs also help to realize how human activities like changes of land use may affect the perception of archaeological remains and the landscape in its entirety.

The application of well distributed and highly accurate ground control points as well as a better estimation of intrinsic camera parameters, calculated from known EXIF data and fiducial markers, will surely increase the accuracy of hDEMts to an extend that a reliable detection and quantification of smaller geomorphological changes can be achieved.

Historical DEMs for multitemporal landscape analysis

While the extraction of high resolution topographic data from aerial images is a well known method in the field of archaeology it is mostly applied to digital datasets. Recent research led to successful applications of historical aerial photographs for the calculation of accurate and detailed digital elevation models [1]. Below a comparison of a hDEM from 1948 and ALS data from 2007 can be seen.

Land use change at Mont Lassois

Since the discovery of the grave of the Lady of Vix in 1953 the land use at the flanks of the hillfort settlement rapidly changed from pasture with scattered bushes towards woodland with high trees. The plateau itself kept its vegetation cover due to heritage protection and has intensively been excavated since 1991 when Bruno Chaume together with several international teams started to focus on the hilltop settlement. During this time period the forest density decreased slightly.

Remote sensing data from Vix

For this study five freely online available vertical datasets [2] from 1948 to 2006 were used as well as an airborne laser scan [3]. The following table shows more details. As the scans of the aerial photos already existed no EXIF information were on hand and the image and pixel size relate to the scanned images. The aerial photography missions usually cover a large area but for the aim of this study the focus was put on Mont Lassois to evaluate the data quality. The available ALS data however only covers an area of 12 km².

Cross Section

Reference


Contact: Gerald.Raab@crazeye.at
Ronny.Wessling@crazeye.at

CRAZY EYE
Aerial Archaeology at Sasamón (Burgos, Spain): Iron Age Hillfort and Roman Camps

Dr. Manuel Fernández-Götz, Dr. Jesús García Sánchez, Dr. José Costa García, Dr. Joao Fonte and Prof. Felix Teichner

The area of Sasamón (Burgos, Spain) is mentioned in ancient written sources as the location of the headquarters of Emperor Augustus during the Cantabrian Wars (29-19 BC). Through these military campaigns, the last independent populations of the Iberian Peninsula were forcibly incorporated into the Roman Empire. This poster presents the first results of a research project that aims to gain a better understanding of the Roman military infrastructure and the impact on the local population of the Odra-Pisuerga region.

One of the main aims of the archaeological campaign carried out in August 2017 has been the study of a Roman military camp of ca. 8 ha, originally identified from aerial photography as cropmarks. The project included a combination of micro-relief analysis, pedestrian surveys, geomagnetics, and exploratory metal detecting in selected transects. The long-term use of the land for agricultural purposes and the supposed short-term use of the military complex makes identification of structures on the ground difficult, but some of the recovered finds can be related with Roman military activity.

The Late Iron Age oppidum of Castarreño is of interest for understanding of the relationships between the Roman military and indigenous populations. Located on a prominent hilltop plateau that overlooks the area, Castarreño belongs to a number of large fortified sites in the area of Burgos and Palencia such as Dessobriga, La Ulaña, and Monte Bernorio. Pedestrian surveys show an occupation of the ca. 20 ha plateau between the 4th-1st centuries BC. During the fieldwork a drone survey of the oppidum was undertaken and some transects surveyed using geomagnetics. The latter have allowed for the identification of a defensive system with wall and ditch, as well as several structures within the fortified space.

Looking ahead, the area of Sasamón presents a huge potential for the development of an interdisciplinary research project. The investigation of the oppidum of Castarreño is still in an embryonic state but offers promising perspectives as shown by the geomagnetic results. The systematic study of airborne LIDAR images and aerial photography can lead to the identification of further military camps which can then be researched with a combined survey methodology. Finally, the development of the town of Segisama, established after the Roman conquest, can be explored using geophysics and targeted excavation trenches.
A semi-automatic workflow for the supervised detection of anthropogenic objects in archaeological analysis using GIS APIs and R

Agnes Schneider, graduate student, Vorgeschichtliches Seminar, Philipps-Universität Marburg, Germany

The aim of this project (R-CHAOLOGY) is to utilize ‘semi-automated’ image analysis methods and data analysis techniques on remote sensing data to predict anthropogenic objects for the benefit of archaeological research. A semi-automated workflow has been applied on LiDAR data from the Cultural Heritage Management of Hessen, which was implemented in R calling up various APIs like GRASS GIS, SAGA and OTB. At the moment the ever evolving workflow and some preliminary results are presented and confronted.

The input data

A LRM is the fundament of the raster-derivations, which are on the other hand the fundament of the segmentation which was rasterized, as was the shape-file ion, containing the contrast-dataset. The derivatives were stacked together (in different ways) to serve as a reference for the model and the prediction.

The supervised classification method

The random forest algorithm has been chosen as training/classification method for it takes random subsets of the training dataset and builds classification trees which consist of branches and leaves. Branches represent thresholds and the leaves the class labels. To control the validity of the model, the k-fold cross-validation was chosen as train control method. The resulting model was then predicted on the whole raster.

Results: Three predictions are compared as a preliminary result of the project: the models, on which they were built on differ in the layers of the predictorbrick: the preliminary result is only the first step. The workflow has to be refined and developed further.
Climate, Heritage and Environments of Reefs, Islands and Headlands

The reefs, islands and headlands of the Irish Sea have a rich cultural heritage. These are iconic locations in the coastal and maritime culture of both nations, and home to a number of designated heritage assets. Yet they remain largely unexplored, inadequately mapped and their environmental context poorly understood.

CHERISH will increase cross-border knowledge and understanding of the impacts (past, present and near-future) of climate change, storminess and extreme weather events on the cultural heritage of reefs, islands and headlands of the Irish Sea. The operation will target data and management knowledge gaps, employing innovative techniques to discover, assess, map and monitor heritage assets on land and beneath the sea.

CHERISH will raise awareness about the impacts of climate change on heritage, train the citizen scientist and widely disseminate the results. It will develop best practice and guidance, making recommendations for future adaptation.

This is an unparalleled opportunity for both nations to gather shared data and new cultural heritage information across the Programme area.

Koen Verbruggen

Executive Summary

Objective 1:
Adaptation of the Irish Sea and Coastal Communities to Climate Change

Objective 2:
To increase capacity and knowledge of climate change adaptation for the Irish Sea and coastal communities

4 Partners
8 Ultimate Changes across
9 Initiatives
5 Year Operation (2017-2021)

Supported by: Aberystwyth University, Coastal Geodiversity and Climate Change

Geophysical survey at Drumanagh, Co. Dublin
INFOMAR coastal bathymetry
A team from Aberystwyth University coring at North Pond Skokholm, in south-west Wales
1. COASTAL ZONE MAPPING

UAVs/SUA/RPAS or drones represent a disruptive and emerging technology with high potential for coastal zone monitoring. Accurate three dimensional surfaces can be readily produced from RGB image data acquired using UAVs as a platform. The emergence of UAVs capable of direct geo-referencing using RTK or PPK techniques mean that it is feasible to safely carry out mapping operations in the coastal environment over large areas without the need for deploying extensive ground-control points. Since 2016 Geological Survey Ireland has developed capacity in the field of carrying out high precision airborne topographic surveys on the coast and within the intertidal zone in support of the INFOMAR seabed mapping programme and more recently the CHERISH programme. Operational methodologies, data processing and value added product development have all been investigated and optimised during this time and early results indicate that in terms of data quality, cost and system availability the technology shows high potential. The team at GSI is currently working on the production of large scale outputs mapping at strategic locations along the Irish coast.

2. MANAGING THE DATA GAPS: Commissioning new lidar

The CHERISH project seeks to fill gaps in both data and knowledge for the coastal regions of Ireland and Wales, to develop a greater understanding of climate change impacts on fragile coastal heritage sites and to establish new metrical precision for the rural, coastal landscapes under study.

Existing lidar coverage for the more remote stretches of the Welsh coastline and islands has been poor, or non-existent, meaning that significant archaeological landscapes lacked any accurate 3D geomatic data. At the start of the 5-year CHERISH project the Royal Commission tasked Bluesky International Ltd to fly 25cm ‘leaves off’ lidar of 6 Welsh islands at low tide. Improvements in technology and delivery meant that 25cm data was no more expensive than 50cm data.

The new lidar offers unparalleled views of the archaeological landscapes of these key Welsh islands. Processing using the Relief Visualisation Toolbox (RVT) has allowed deeper interrogation of the data, and revealed new monuments. During autumn 2017 work will start on compiling new maps of the archaeology. In 2018 lidar will be combined with drone photogrammetry and detailed DGPS ground surveying to provide an absolute fix on eroding island coastlines for the purposes of future climate change modelling.

3. BASELINE MONITORING: Oblique photography

At the start of the 5-year CHERISH project a series of baseline coastal monitoring flights of Welsh coastal study areas was carried out, establishing a library of oblique aerial photographs showing the current erosional conditions of key archaeological sites. The aim is to repeat the process in 4 years time, allowing rapid visual comparison of change for long-term heritage monitoring. Images will be securely archived as part of the National Monuments Record of Wales, and available for consultation online.

As well as stereo oblique cover, aerial photographs were also routinely taken in orbit around the coastal sites to provide a library of images suitable for 3D modelling in Agisoft PhotoScan where drone photogrammetry may prove difficult. Resulting 3D point-clouds can also be compared following 4 years of change. During autumn 2017 the process will be repeated for coastal study areas of Ireland, establishing a programme of systematic archaeological aerial monitoring of the coastline.

4. BASELINE MONITORING: UAV survey

Dunbeg Fort (An Dúin Beag), an Iron Age promontory fort on the Dingle Peninsula, is an example of the issues and challenges facing the CHERISH project. It is located in an area of active coastal erosion, most recently and dramatically in 2014 when a large part of the western wall fell into the sea during a winter storm.

Surveying and monitoring such a site is best achieved by the use of terrestrial laser scanning, UAV mapping or a combination of the two. 3D modelling from these sources allows a baseline surface model to be created against which any future change can be measured through regular re-survey. It is hoped to include Dunbeg in our programme of monitoring.

CHERISH has enabled The Discovery Programme to invest in new equipment, including a DJI Matrice 600 enabling DSLR photography, and improved modelling quality.

SMI photogrammetry also offers the potential to use historic aerial imagery to model the landscape at the date of image capture. This is planned for Dunbeg, allowing assessment of change and damage over the recent past.
1. SKELLIG MICHAEL

The Discovery Programme has been working with the Office of Public Works (OPW) to develop a monitoring strategy for the built heritage of Skellig Michael World Heritage Site. Elements of the fragile 6th century dry stone structures of the monastery sites at both the Monastery and South Peak of the island have shown cause for concern, with visual signs of deterioration and potential structural movement. The aim of the project was to establish a rigorous network of physical control points to enable regular monitoring by total station observations to ascertain the stability of the structures. In conjunction, a parallel assessment of terrestrial laser scanning as a monitoring tool was undertaken, examining the potential of this rapid non-contact technique as an alternative, more flexible option, giving potentially greater levels of information on the nature of any deformations taking place.

2. TOTAL STATION SURVEY

The OPW are concerned that the stone-built heritage sites on Skellig Michael may be subject to movement and have the potential, in extreme scenarios, to collapse in the future. For this reason a programme of precise monitoring has been put in place at three strategically selected locations around the monastery, at the North of the island. The objective of the survey was to establish the precise 3D coordinates of brass survey markers placed in drilled holes and filled by adhesive. The survey network at the three locations comprised a resection framework of four markers in the bedrock to provide fixed station locations, and a selection of markers in the stonework of the structures themselves.

SURVEY OBSERVATIONS

The survey points were observed over two seasons (2015/2016) using a calibrated Trimble VX total station. This instrument is a geometrically-robust total station appropriate for a monitoring project where high precision and accuracy are a requirement. For each survey location multiple observations were taken over each survey resulting in three or more readings for each of the monitoring points each year.

COMPARISON 2015 / 2016

The re-observation in 2016 allowed a comparison to be made with the previous set of computed calculations taken in 2015, and some evaluation of the differences can be made. Figure 4 presents the vector shift between the 2015 and 2016 positions. The values range from no change to a maximum of 6.4mm difference, with a mean shift of 2.9mm.

In 2015 we considered the parameters and variables associated with the observation approach and concluded that with an instrument RMS of 2mm + 2ppm a difference of in excess of 5mm would have to be measured before we could say, with confidence, that any movement in the structure had been detected. Six out of 26 observed points are measuring 5mm or more, but as only one of these exceeds 6mm it is not unreasonable to claim the monitoring survey 2016 observed no significant movement. However, these 3D vector shifts do not sign a shift is also significant. These have been calculated and visualised as arrows (opposite). They reveal generally random directions at sites one and three, the blue and orange arrows respectively, as might be expected. However, a much stronger trend across the points at site two is observed, generally downward and forward, the most likely direction of any structural slumping. Given the small overall size of these vectors, mean value 4.1mm, it is too early to say whether this is a significant change, a further set of observations in 2017 is critical to provide definitive evidence to support this.

3. TERRESTRIAL LASER SCANNING

During several seasons (2013, 2015, 2016) the main monastic complex of Skellig Michael was recorded utilizing a Faro Focus 3D terrestrial laser scanner. The initial survey season (2013) aimed to capture as much of the monument as possible and act as a baseline for future comparison. In the following seasons (2015, 2016) specific areas of interest where selected but the OPW where suspected movement of the monument has occurred. The results of these surveys would go to reinforce the total station survey findings from the total station survey.

For each area of interest, a single scan was recorded each year (2015, 2016) from a position similar to the total station survey with the instrument programmed to record a higher density of point spacing than usual (3.068mm @ 10m) ensuring high quality clean data. The resultant point clouds were compared utilizing GeoMagic Studio software to identify where the two surveys deviated from each other, highlighting areas of movement and also loss and accumulation areas. This approach offers the ability of revealing more detailed information on the overall deformations which may occur.

4. RPAS/UAV AERIAL SURVEY

Many areas of Skellig Michael including cliff edges, shorelines and high relief areas are inaccessible and serve the use of terrestrial survey instruments (laser scanner, GPS, total station). These areas require survey to identify potential instability and rock fall, but also to identify and survey newly discovered anthropogenic structures including rock cut steps and alternative routes to the monastic summit. RPAS/UAV technology (DJI Phantom 2) with attached imaging device has been utilized to inspect these areas but also to capture overlapping imagery to enable the construction of accurate 3D models through the use of Structure from Motion (SfM) software processing (Agisoft Photoscan).
INTERACTIVE MAP OF THE HISTORICAL HERITAGE OF MOSUL

Lenka Starková - Karel Nováček - Miroslav Melčák

In reaction to serious threats to the Mosul architectural sites from ISIS (Daesh), a team of Czech scientists under the auspices of the Oriental Institute of the Czech Academy of Sciences in Prague, has launched the project Monuments of Mosul in Danger (duration: 2015-2018).

One of the main aims of the project Monuments of Mosul in Danger is to collect all possible data and documents for the reconstruction of destroyed architecture and the protection of endangered historical buildings in the city of Mosul. The standard procedure, where the reconstruction project is based on plan and drawing documentation, photographs, and structural-historical research of individual architecture, cannot be used in the case of Mosul. Documentation for individual ruined monuments, as well as for entire urban blocks of the historical centre, is inaccessible today and, for most of the monuments, probably doesn’t even exist.

In order to locate building, satellite images were used in combination with several urban development plans starting from the early 20th century. However, these are insufficient for the reconstruction of buildings. Therefore, we decided to use another method which makes it possible, in a relatively simple way, to create virtual 3D models through the use of photographic collections.

The principle of reconstruction models:

- The virtual model is a duplicate of a 3D object. There are no surfaces in this type of model. It is composed only of points, lines, and curves, which describe the edges of the object.
- The surface model 3D model with the edges of the 3D object, with the surface described. In this method, each point of the object is described as a collection of THIGS (photographs taken during the last 2010-2018).
- The final step of the MosulAFilM 3D reconstruction is a combination of 3D models by adjusting the location and orientation of the objects, creating a virtual environment with smooth transitions. Interactive maps provide information on historical development and present-day buildings, as well as on the interpretation of the historical heritage of Mosul. Questionnaire about possible restoration or reconstruction of endangered buildings, as well as the preservation of information about their architecture, urban planning, both in printed and virtual form, is also in the process. The creators of the interactive portal of individual buildings and their virtual presentation,Lenka Starková, may users also be able to view a virtual map of the historical centre of Mosul in the time before the violent occupation by ISIS.

One of the main outputs of the project is a map portal (available at www.monumentsofmosul.com), where visitors can view satellite images of individual destroyed buildings. Part of the portal is a layer, where records are stored about still-standing historically important buildings. Currently, the primary focus of the project is to map the state of those buildings, located in the historical center of the city after the liberation of Mosul in the summer months of this year. Information about these buildings will be made available for scientific purposes or in order to provide them military protection.

Urban historical topography

Satellite imagery

GIS-project (ESRI ArcMap)

Database of monuments

Visual archive of sites

Detailed gazetteer of destroyed sites

Presentation, scientific interpretation, rescue strategy
Abstract

One of the best indicators of aerial archaeology are crop marks and besides the traditional aerial photography nowadays, many technologies are at our disposal. However, in some cases, the detection of these crop marks is limited, or their discovery needs costly technologies, the latest research using cost-effective Unmanned Aerial Vehicle (UAV) pointed out that at known archaeological sites these faint, mostly invisible crop marks are detectable by their minimal growth differences using highly accurate and detailed image-based 3D modelling and Digital Surface Models (DSM) of the crops and by relief-visualisation techniques.

The hidden third dimension of crop marks

In the last decade Airborne Laser Scanning became a widespread technology using in the detection of archaeological objects by topographical micro-relief difference, and these elevation or surface models can help us to understand trend-like features in the landscape (Nohel et al. 2011; 2013; Bakó et al. 2013; Herrera 2019). Although we talk about its feasibility, also tend to forget that we can consider the growth differences of plants (crop marks) as a surface model. In this respect ALS test verified its effectiveness (Stoit et al. 2015), but laser scanning is an expensive technology to use for such tasks. Let us observe images of aerial surveys or drone photos-series with image-based 3D modelling to reveal the hidden third dimension of crop marks (Verhoeven; Vermeulen 2016).

Yes, it is working!

We can consider that the clearly visible crop marks can also provide outstanding results in both cases, with traditional oblique and drone’s vertical aerial photographs, but what can we do when archaeological features are wide and seek with us? I think anyone who has been flown over the fields and searched for archaeological features has already felt the meaning that something can be there, but it is almost invisible. Oh, we can’t see, but are there really any kind of crop marks there? As a trial, we compared the high-detailed drone verticals’ absolute orthophoto and the DSM, both based on image-based 3D modelling.

Let’s play! Take a look at this orthophoto and count the faint crop marks of the Roman burial chambers! What is your tip? And what can we find on its DSM?

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Are we there yet?

At first sight, the results look promising, but our further research remind us that sometimes less is more. Although the UAV aerial photograph and photo 3D are cost-effective, high-detailed and precise techniques, and with the use of relief-visualisation processing they are very useful in the research of known sites, but these kind of faint crop marks can sometimes provide many, hardly understandable picture with much more questions than answers.