Expedite and upscale

large area archaeological survey in the age of big data and machine learning

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Archaeology is something of a magpie discipline, with a track record of appropriating approaches, theory, and techniques from other fields that has helped, for example, to drive the 'digital revolution' in archaeological practice. Digital documentation, 3D datasets and complex analyses are now routine practice rather than revolutionary, but it is one thing that such methods are widespread, and quite another for their implications to be fully explored. Archaeologists at Historic Environment Scotland (HES) are exploring these implications for their workflows, recognising that sometimes assimilation of new technology or practice can happen organically, but also that sometimes a more fundamental reassessment is required of how we do what we do.

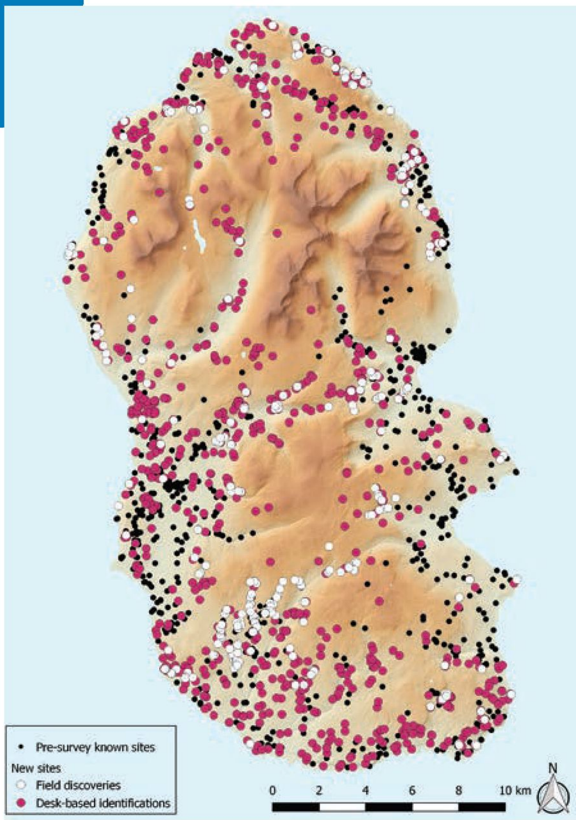

Figure 1: Even on the relatively well-known island of Arran, recent survey doubled the number of known sites, with a mix of desk-based and field discoveries. © Historic Environment Scotland

Large area survey – expediting coverage in a digital world

Archaeological survey of various kinds is one of the foundations of knowledge about the past. Indeed, most of our monuments are known from survey alone. Routinely, area survey will increase the numbers of known monuments by 100 per cent or more, adding to the evidence for where people in the past lived, farmed and buried their dead. This information informs management, research and our appreciation of the historic environment. The 'humps and bumps' of archaeological earthworks and airborne laser scanning (ALS) or lidar has proved a game-changer, creating digital landscapes that can be explored with the roll of a mouse wheel, zooming effortlessly from the general to the detail. While this is now routine, it remains remarkable how much information digital landscapes hold – a treasure chest of archaeological sites and landscapes. A recent ALS-based HES survey of Arran, popularly known as 'Scotland in miniature' because of its varied landscape types, added over 900 sites to the record, more than doubling the tally of known archaeological monuments (Figure 1). Moreover, the detailed and textured view of the landscape provided by the ALS-derived visualisations gave our team the confidence to complete the survey at a dramatically faster rate than normal.

We are also asking questions that explore aspects of our practice. These include how to address the variations between different observers and how to better document the strengths and weaknesses of different processes (ie desk-based and field work). For example, we did some desk-based mapping where multiple interpreters looked at the same ground, and this demonstrated how variable results can be from person to person (Figure 2). This highlights the importance of working in a team, learning from each other's different ways of looking, and putting in place processes of peer review and quality control. We used handheld GPS units to record the routes we walked during the field work phase of the project. This information helps end users understand how a survey was conducted, as all too often archaeological data is presented with little documentation that can inform considered use. Central to our exploration of approaches to large area survey is ensuring we can reflect on workflows – and that means good documentation of how we did what we did.

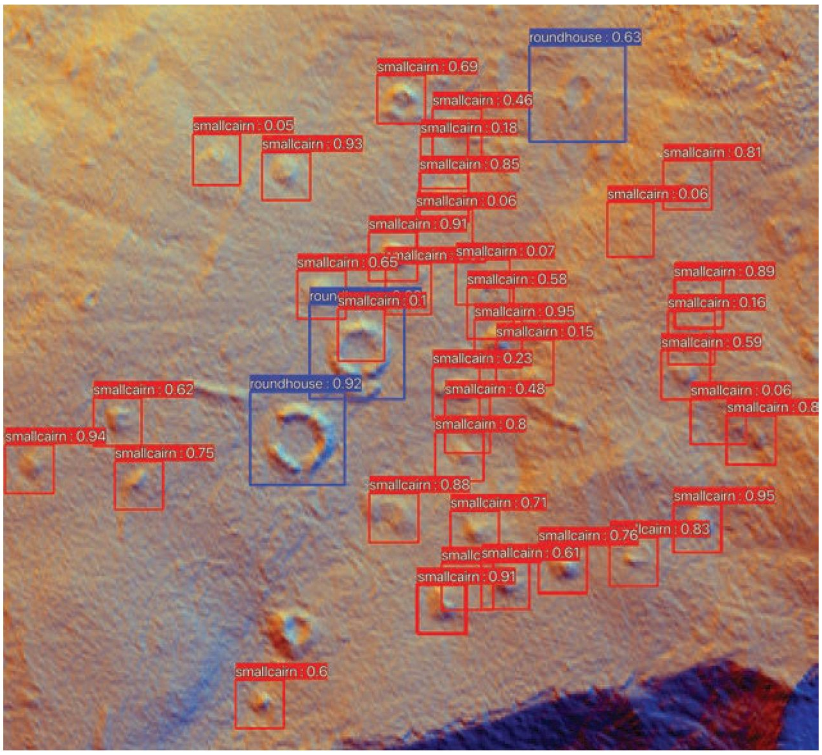

Figure 2: The results of four different desk-based interpreters shown against a multi-direction hillshade, illustrating variability in detections and the confidence attached to those identifications. © Historic Environment Scotland

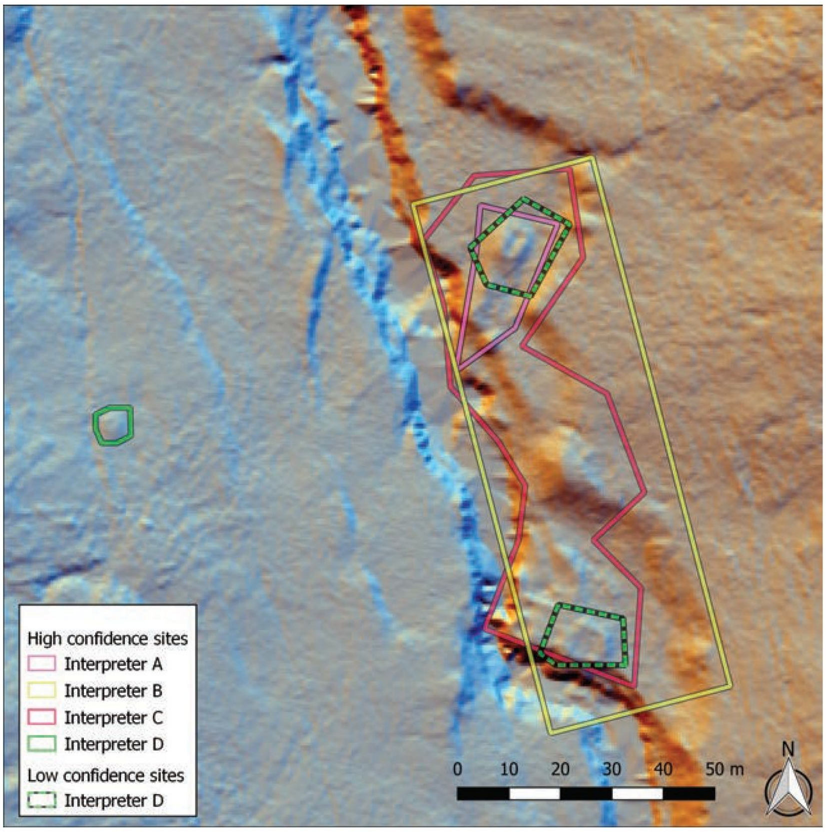

Figure 3: Automated detection in practice: this ALS-derived image of an area on Arran shows the footings of prehistoric round houses, small clearance cairns and possible huts overlain by squares indicating AI detections with a confidence score. The high confidence detections clearly match visible sites, although some features were missed. Image Iris Kramer; ALS source Scottish Government

Artificial intelligence – automating archaeology?

The survey work on Arran was based on largely 'manual' methods that rely on desk-based human observation supplemented by 'boots on the ground'. While the ALS data significantly increased the rate at which we covered the 432 km^2 of the island, the survey still required considerable staff resource. This raises the challenge of how rates of coverage can be upscaled for very large areas without unrealistic increases in human resourcing. Since only about 10 per cent of Scotland has benefited from systematic survey to contemporary standards, even with the rates of coverage achieved for Arran it would require decades of work to complete the country. Moreover, the available (and proliferating) remote sensed data has already outstripped our capacity to examine it.

This is our primary reason to explore how automation, AI and machine learning can help detect archaeological sites and features in digital data and inform survey processes. Fully manual methods cannot address the growing availability of spatial data like ALS and satellite imagery – much less fully explore the complexity in such data. With the threat of accelerating change in our landscapes, for example through impacts of climate change, the need is pressing for reliable systematic survey data to manage and understand our finite archaeological assets. The use of automation for aspects of data management and processing, as well as detection, should allow human resources to focus on interpretation and better understanding of the past. Bringing AI and machine learning into the mix can also contribute to exploring how we currently detect archaeological features and monuments, providing feedback on our own (human) survey practice.

Studies have established that a computational approach to automated detection has potential. On Arran we got good results in some areas with relatively clear distinctions between the natural terrain and archaeological monuments, but also chaos in areas where the lumpy, broken terrain created confusion and an overwhelming number of 'false positives'. A promising start, but one that also made it clear that there is still lots of work to do. However, this is a fast-developing field and ongoing work is improving performance all the time (Figure 3), moving the discussion on from 'should we use AI in archaeological survey?' to 'how are we going to use it?'

The superficially simple question of 'how?' hides a number of issues that require exploration – centred around understanding what works, why it works, the character of the outputs, and how we integrate AI into our workflows.

For example, there are a multitude of neural networks, which all perform differently, and this is important as some may be 'better archaeologists' than others. We need to consider the implications of trying to teach a neural network, for example, to see like us, or perhaps to see things from a different perspective? It is also crucial that we understand the character of outputs – how reliable they are, how 'competent' the system that produced them is, and so on. In doing this, we need to reflect on our established knowledge-creation processes and subject them to the same critical review as we do when thinking about how we work with AI. This is a fascinating prospect for anyone interested in how archaeological sites and features are identified and classified. Our understanding of the character of outputs from automated detection will bear on what we do with them – might sites detected with a high probability of being 'correct' be added to national and regional historic environment records without human input? Or, how might a fuller range of detections, including those with lower probabilities of being 'right', be used in a development control context?

Us, our landscapes, and our AIs

Until recently archaeological survey has been an inherently manual process based on fieldwork and desk-based mapping by human observers. It remains a tried and tested approach that continues to provide us with lots of information about the past. The increased availability of vast digital landscapes to explore has reinforced the value of survey in documenting the material remains of the past. Developments in computational approaches to imagery analysis, under the broad umbrella terms of automation, AI and machine learning, are highlighting the potential of heavily automated approaches for some aspects of the survey process. As this field develops it will challenge our approaches to survey and should make the rapid exploration of vast complex landscape datasets a realistic prospect. It will, of course, bring new issues and problems. Exciting times for archaeological landscape interpretation and mapping!

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Left to right: Dave Cowley, Łukasz Banaszek, Kirsty Millican and George Geddes

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Iris Kramer

Further reading

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