ISAPNEWS

The Newsletter of the International Society for Archaeological Prospection

Issue 60, September 2020

Editorial – Issue 60

It took me some days during production before it really sunk in: **this is issue 60**! It is incredible how far we have come. With our newsletter overall and with its contributions. Have a look, for example, at issue 2: http://www.archprospection.org/isapnews/isapnews-2 . It already showcased a range of very interesting topics, including some "country reports". It had, like the current issue, some data from Canada and articles featuring, or even written by, some of our Honorary Members: Andrew David and Yasushi Nishimura, respectively. By the way, there is still time to add your short contribution on the web page that we have set up in honour of the latter.

The other main contribution we feature in this issue shows first results from Machine Learning analysis of magnetometer data – with the potential to make the subsequent task of data interpretation easier.

And keep on sending your fieldwork photos – either to the list (isap-all@archprospection.org) or to the editor (editor@archprospection.org). They are great!

Armin Schmidt
editor@archprospection.org

The Cover Photograph shows a geophysics field camp in the Canadian arctic. Photo by Lisa Hodgetts (see p. 3 for details).

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Membership renewal

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Magnetometer Surveys in Arctic Canada

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The Arctic does not instantly come to mind when thinking of suitable places to conduct magnetometer surveys. The periglacial environment, with its limited soil development, glacial till deposits of diverse geological (often igneous) origin, remote location and the relatively small, irregular features left behind by arctic hunter gatherers certainly make geophysical survey in the region challenging (Figure 1).

Figure 1. Our field camp. The logistics of northern research are complex and expensive.

However, with a little perseverance, geophysical techniques can provide considerable additional information about arctic archaeological sites. In particular, they can play a significant role in the management of sites in the face of the increasing impact of climate change (Figure 2). Here we present results from a magnetometer survey from Agvik (Hodgetts and Eastaugh 2017), a Thule Inuit (ca. cal A.D. 1350–1550) site on the south coast of Banks Island, Canada (Figure 3). The results of the survey allowed us to distinguish two seasonal dwelling types at the site, and to identify large frost features that pose an imminent threat to some of the dwellings.

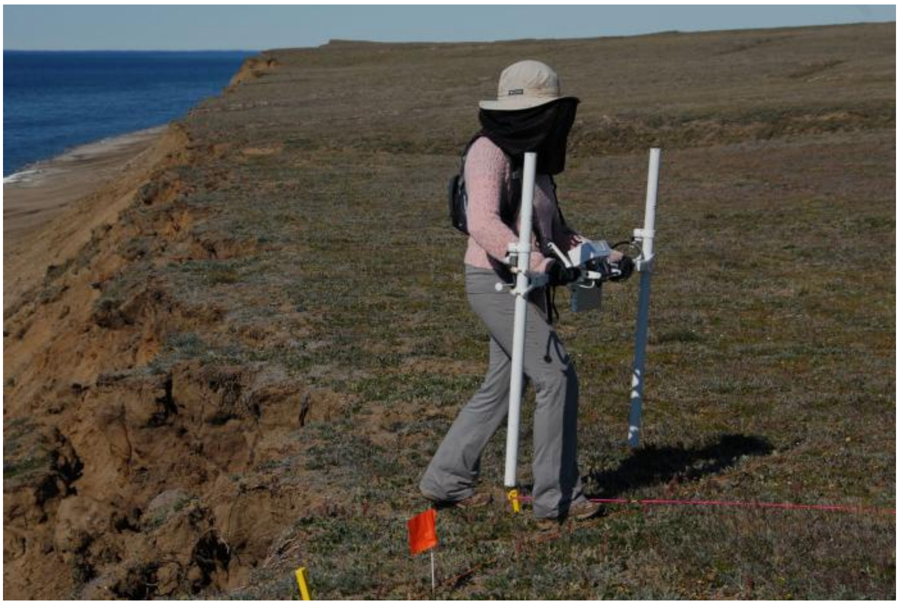

Figure 2. Letitia Pokiak surveys near the eroding cliff edge at Agvik.

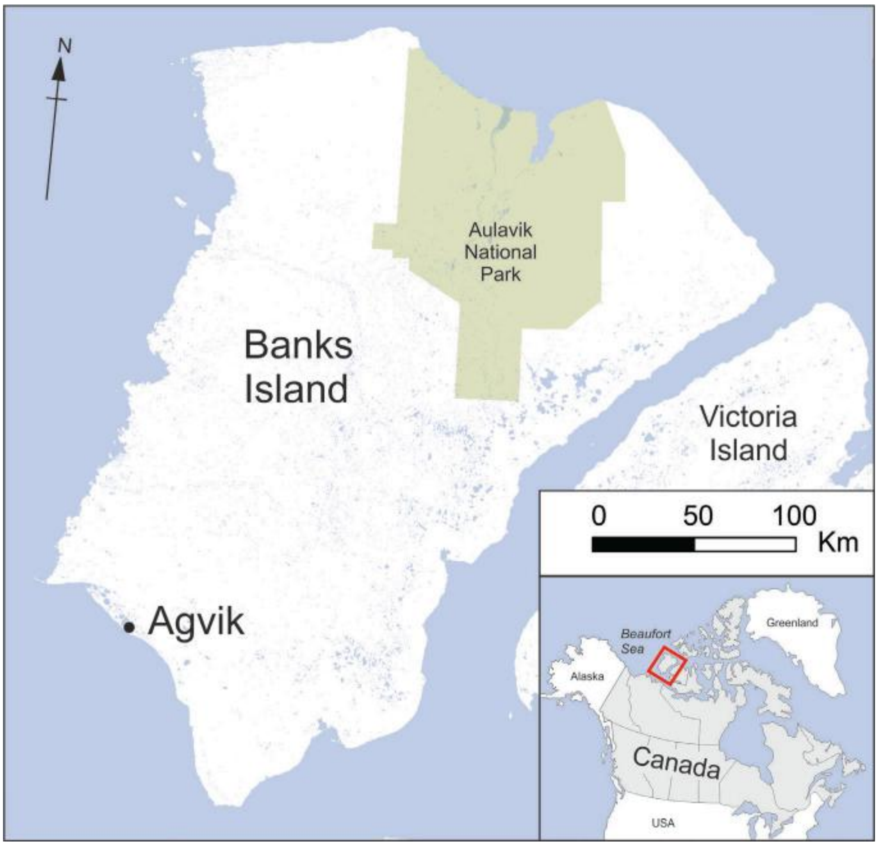

Figure 3. Location of Banks Island and Agvik.

We conducted the Agvik survey with a Bartington Grad 601 Dual Sensor Fluxgate Gradiometer. The surveys utilized grids of 20 m by 20 m, and logged readings at 0.125 m intervals along parallel traverses spaced 0.25 m apart over a 6400 m^2 area. We used Geoplot 3.00t for processing and conversion into grayscale images.

Agvik includes the remains of 14 dwellings, 11 of which cluster near a gully (Figure 4), and a further three of which are located between 100 and 200 m to the northeast. They are visible as shallow round depressions ringed by low mounds (Figure 5). Until our field season, all the dwellings were considered to be winter dwellings (Arnold 2010).

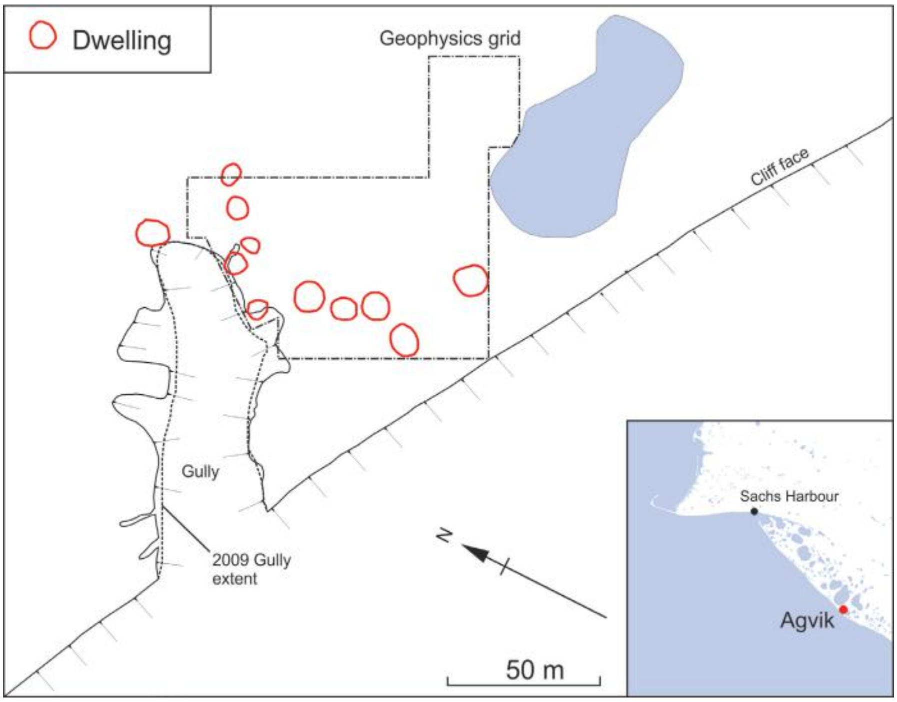

Figure 4. Location of geophysics grid and archaeological features at Agvik.

Figure 5. Graduate student Colleen Haukaas standing behind one of the many dwelling depressions at Agvik.

Our magnetometer survey allowed us to identify numerous archaeological and natural features. The most obvious are those resulting from ice wedges, which show as negative, and, to a lesser extent, bipolar anomalies that crisscross the site. There is little surface evidence for many of these, so the survey results are useful in establishing the level of threat from buried permafrost features to individual dwellings. The most prominent ice wedge is represented by the negative linear anomaly that runs southwest to northeast across the entire survey area (Figure 6: a). Between 2009 and 2015, the gully erosion was greatest along the line of this ice wedge with up to 20 m falling into the sea in that six-year period. At least two dwellings are under direct threat along this erosion line. The cliff edge is another area of concern, since the south coast of Banks Island is eroding rapidly due to permafrost thaw and increased storm activity as a result of climate change. The magnetometer data indicate that an ice wedge runs parallel to the cliff (Figure 6: b), forming a weak point along which the sandy coastal soils could cleave.

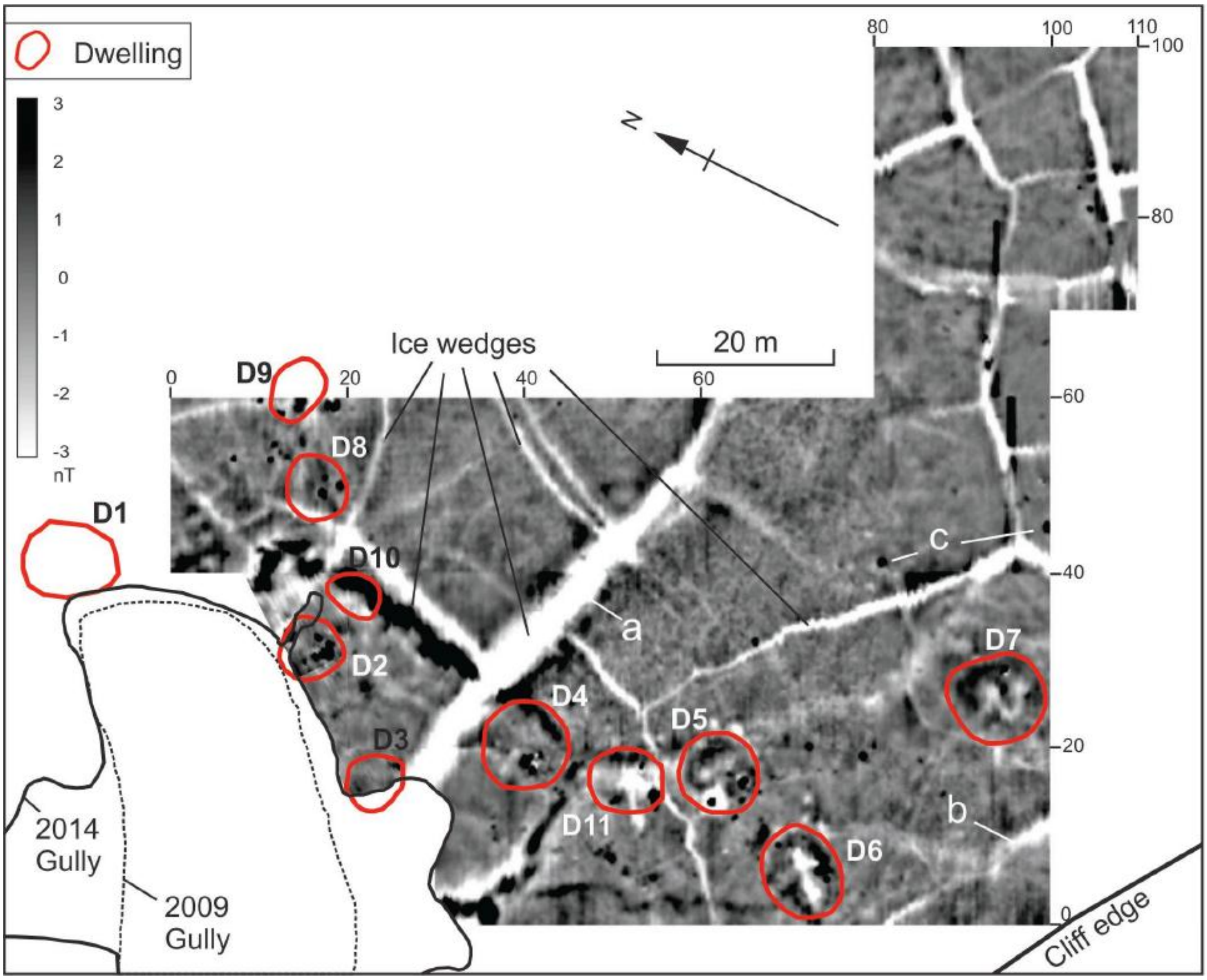

Figure 6. Results of magnetometer survey at Agvik.

The survey also identified many anomalies associated with the depressions (Figure 6). Differences in their number, distribution and magnetic properties suggested that there were at least two dwelling types: winter houses (Figure 7: D5 and D7) and qarmat (Figure 7: D2). Early Inuit winter houses were large, oval semi-subterranean structures with a flagstone or driftwood floor; a raised rear sleeping platform of stone slabs; walls of stone and whalebone; a sod roof; and an entrance tunnel (McGhee 1978). Qarmat are less substantial structures with a smaller, shallower central depression, and a skin as opposed to sod roof (Boas 2013 [1888]; Mathiassen 1927). They were primarily occupied in the transitional seasons of spring and fall. Subsequent excavation confirmed the presence of both dwelling types.

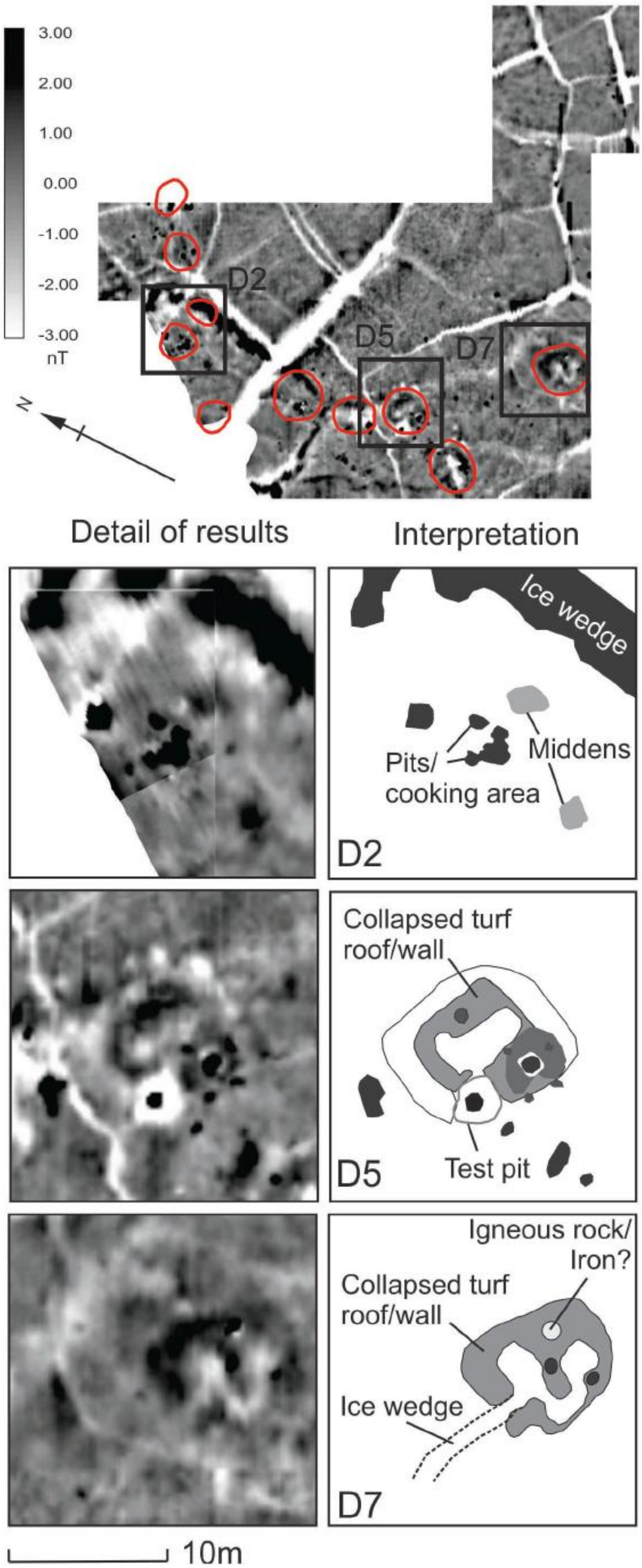

Figure 7. Detail of magnetometer survey at Agvik, showing anomalies associated with three of the depressions.

Agvik is just one of several Arctic sites where we have had good results using magnetometer survey. If you are interested in learning more, see Hodgetts and Eastaugh (2017) and Hodgetts *et al.* (2011).

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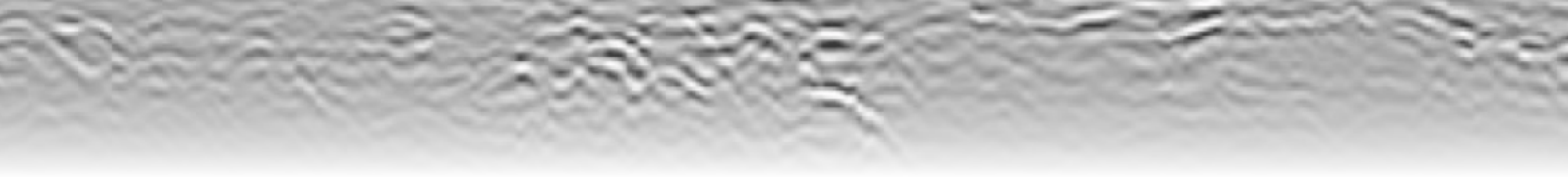

These Are Not the Ring Ditches You Are Looking For:

Some early results of semantic segmentation on magnetometer data

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Introduction

Machine learning algorithms, such as artificial neural networks, are being applied to an increasing variety of archaeological data (see Trier *et al.* (2018), Green and Cheetham (2019), and Verschoof-van der Vaart and Lambers (2019) for examples). However, very little has been published on their application to magnetometer data. Due to the increasing demand for rapid near surface geophysics in Britain, especially magnetometer surveys, there is a commercial potential to the application of these algorithms as a feature extraction tool for geophysics. This paper presents the early results of a project run by the Research and Development department at Magnitude Surveys, a geophysical contractor based in the UK, aimed at developing an automated feature extraction workflow for magnetometer surveys.

Neural Networks

Neural networks (NN) are a type of machine learning algorithm whose design mimics the structure of the human brain. The networks are comprised of layers of neurons, nodes in the network which sum their inputs based on weights and apply a function to this sum. Semantic segmentation is a task within the field of NN, where the desired outcome is the pixel-by-pixel classification of an image. This task lends itself to feature extraction, as the output labels describe the extent of one or several features within a provided image.

The U-Net architecture by Ronnenberger *et al.* (2015) has been particularly popular for segmentation tasks and features a contracting path, which abstracts image features from the data, and an up-sampling path, which scales the results back to the original size of the inputs. This architecture has previously been adapted by Küçükdemirci and Sarris (2019) for the detection of features within GPR data. In the sections below we will discuss our results of adapting this architecture and a variant derived from it on our own dataset.

Data

For this pilot study we decided to focus on a small dataset of ring ditches. The data was collected over the last four years across a variety of sites and geographical backgrounds in Britain. It is comprised of about 150 ring ditches and associated archaeological features, and 150 background and confusion classes.

We made few modifications to our digital interpretation drawings of the anomalies, as shown in Figure 1, because we wanted to see if the 'typical' digitisation by a variety of interpreters was compatible with our neural networks. The data was rasterised and clipped to 224 px × 224 px tiles, or 56 m^2.

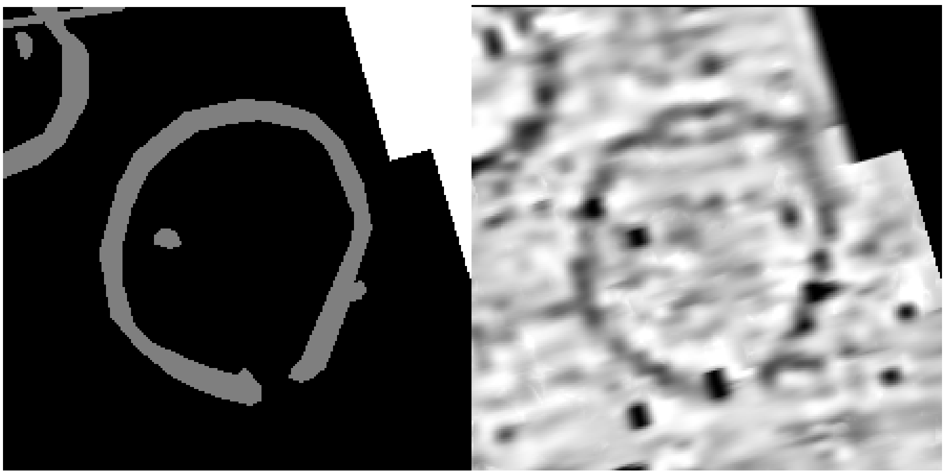

Figure 1. An example of a ring ditch close to the edge of a survey area. The label for this tile includes three categories: no archaeological feature (black), archaeological feature (grey) and out of bound (white).

Training

We implemented our machine learning algorithms leveraging the Keras and Tensorflow libraries in Python, which were trained on two RX2060S GPUs. We performed a parameter exploration to investigate which parameters were best suited to our problem.

For this study, we chose to implement the original U-Net architecture as well as a so-called 'residual' variation (based on work by Diakogiannis *et al.*

(2020)) with skip connections that were introduced to deal with an issue known as vanishing gradients, typical for very deep NN with many layers (He *et al.* 2015). The parameters for the two sets of results were identical, with the exception of the network architecture itself (Table 1).

Table 1: Parameters for Neural Network training.

Parameter	Value
Batch Size	2
Epochs	60
Loss Function	Sparse Categorical Cross-Entropy
Tile Size	224 px × 224 px
Network Depth	5
Filters	16, 32, 64, 128, 256

Results

Overall, our initial results are promising. Figure 2 shows an example of data, previously unseen by the network, ingested into a U-Net implementation. The labels below these were produced by the network indicating pixels where it predicted the presence of a feature (in grey). This unseen data includes ring ditches as well as background and confusion cases. The algorithm was able to detect ring ditches as well as other features, however it also produced many false positives. Overall, this applied to both networks we tested, although the residual variant performed slightly better (Figure 3).

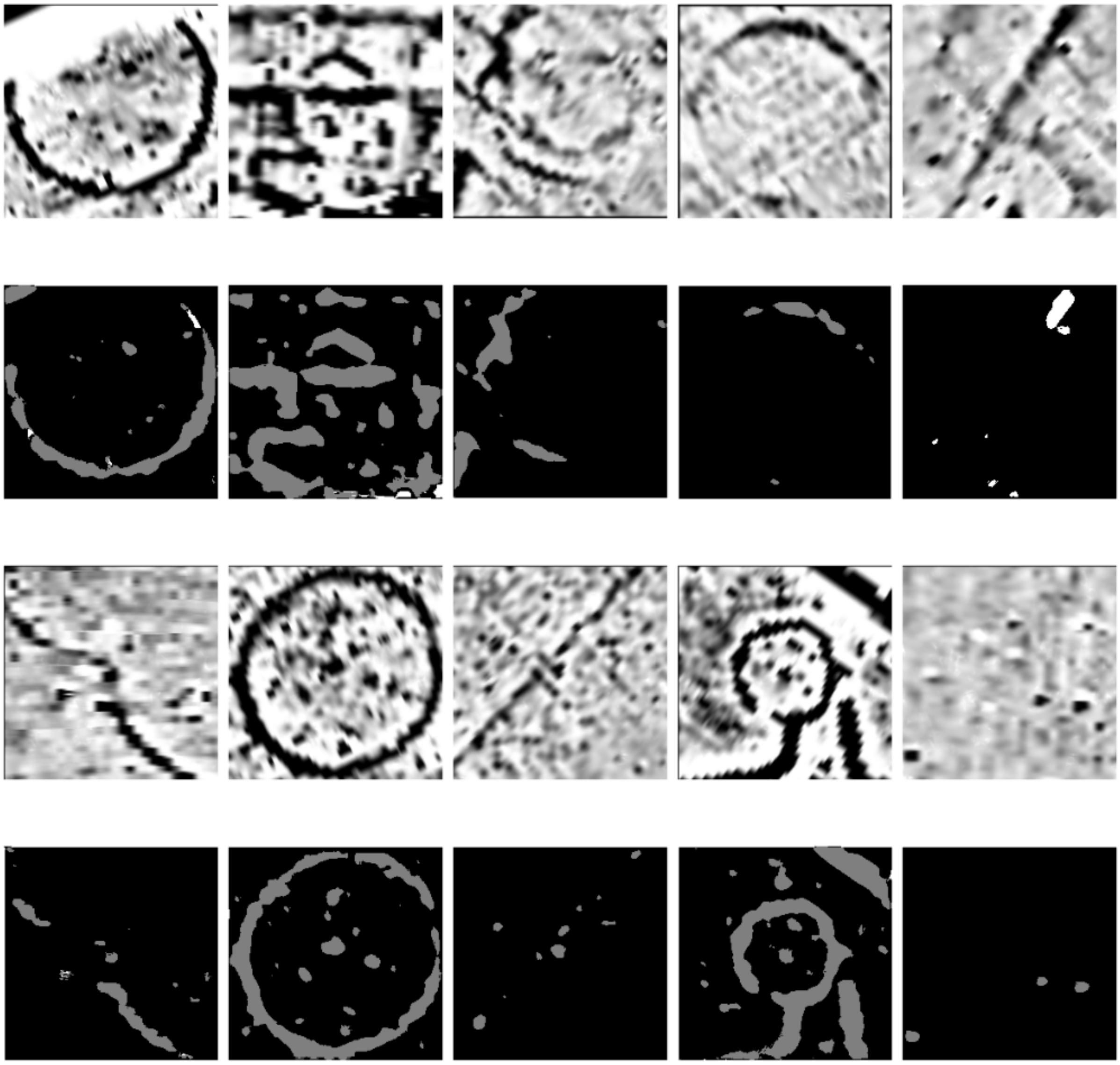

Figure 2. Predictions on unseen data using a U-Net network trained for 60 epochs with sparse categorical cross-entropy. The network positively identified three ring ditches, however struggled to identify the faint ring ditch in image 4. Black indicates no archaeological feature, grey archaeological feature, and white 'out of bounds'.

The networks tended to focus on anomaly strength as an indicator for the presence of archaeological features, as opposed to context or shape. Faint ring ditches such as the fourth image in Figure 2 proved very difficult to detect for most networks and were only identified by the most 'optimistic' networks.

We also discovered that quite regularly the network was falsely labelling archaeological features with the 'out of bounds' category. In most cases, this was happening where the anomaly was particularly strong, however as seen in Figure 3 this also occurred on moderately faint features such as the fifth image.

Very busy tiles, or areas with high magnetic backgrounds proved particularly difficult for the networks to unpick, as seen in the second image in Figures 2 and 3.

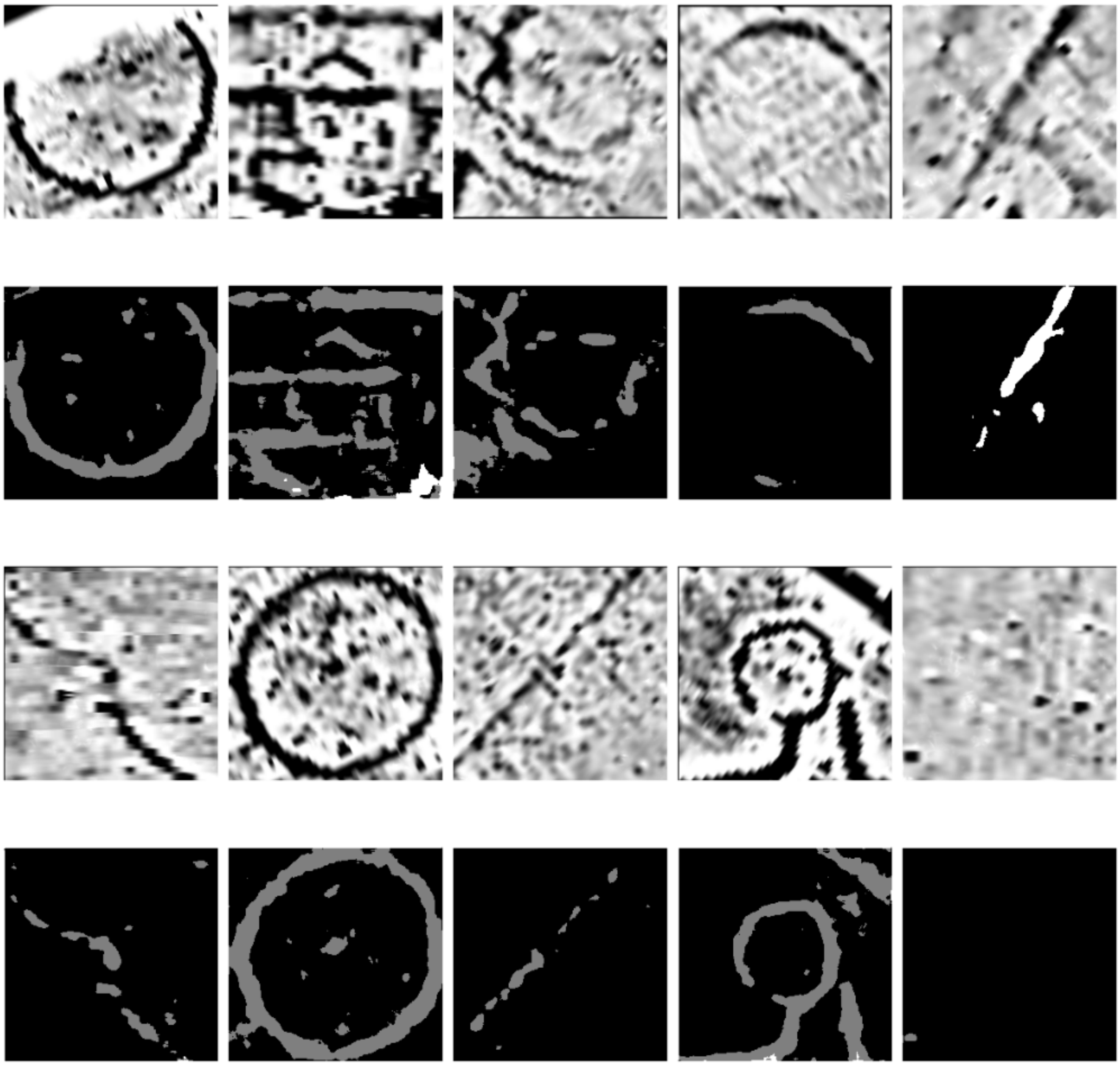

Figure 3. Predictions on unseen data using a residual U-Net trained for 60 epochs with sparse categorical cross-entropy. The network managed to produce fewer false positives than the one in Figure 3 and performed slightly better at predicting the faint ring ditch in image 4. Black indicates no archaeological feature, grey archaeological feature, and white 'out of bounds'.

Future Plans

At the moment we are rasterising our interpretation without any modification. As seen in Figure 1, these include other features adjacent to ring ditches. Our next tests will be focusing on just the ring ditches themselves, ignoring adjacent features. We hope this will improve the recognition of fainter ring ditches, as the networks would be forced to distinguish ring ditches from adjacent features.

We also intend to supplement our dataset with data augmentation. This comprises of image manipulations such as rotating, flipping and zooming to increase the number of samples.

Lastly, we plan on testing the performance of the networks with reduced tile sizes. Currently the images are 224 px × 224 px. This has caused some performance bottlenecks, as our graphics cards could not handle the amount of computing power required, particularly for the more computationally intensive residual networks. By reducing the size by 50% or 75%, we may be able to test more complicated and deeper network architectures, where we would expect to see a much stronger performance of residual variants compared to the 'vanilla' U-Net architecture.

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The ISAP News Gallery

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Introduction

Dear ISAP Members,

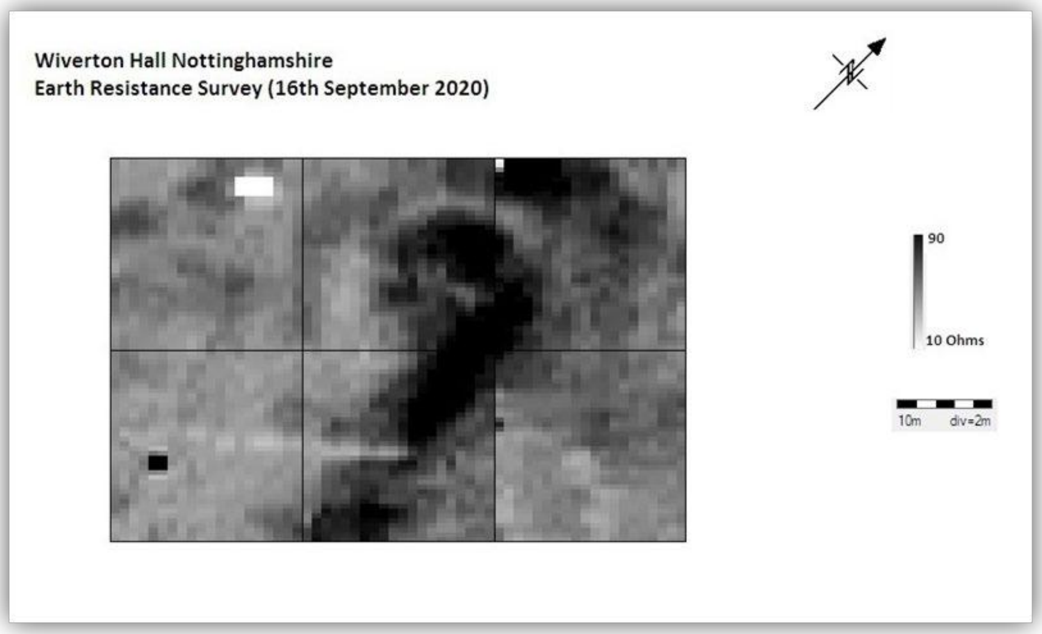
I hope that despite the COVID-19 pandemics, you all stay safe and have already managed to get to the field for some projects!

In this issue we have some more throwbacks from the past, nice moments from recent studies, as well as some quaint and interesting results.

I would like both to thank those who sent their pictures, as well as to encourage everyone to send even more. This column cannot exist without your content. I confess that I really enjoy your snapshots from the recent as well as from the more distant past.

Michał Pisz – ISAPinacotheca Associate Editor

1. A picture of a survey Kris Lockyear undertook for Antony Harding at Sobiejuchy, Poland, in 1987. *We were using an RM4. Of course, at the time, we had to wait until we got back to the UK to process the data on the mainframe at Durham (once it had been input by the ladies of the "Data Preparation Service"). The results provided us with an excellent plan of where the hay was lying in the field to dry* [picture and description by Kris Lockyear].



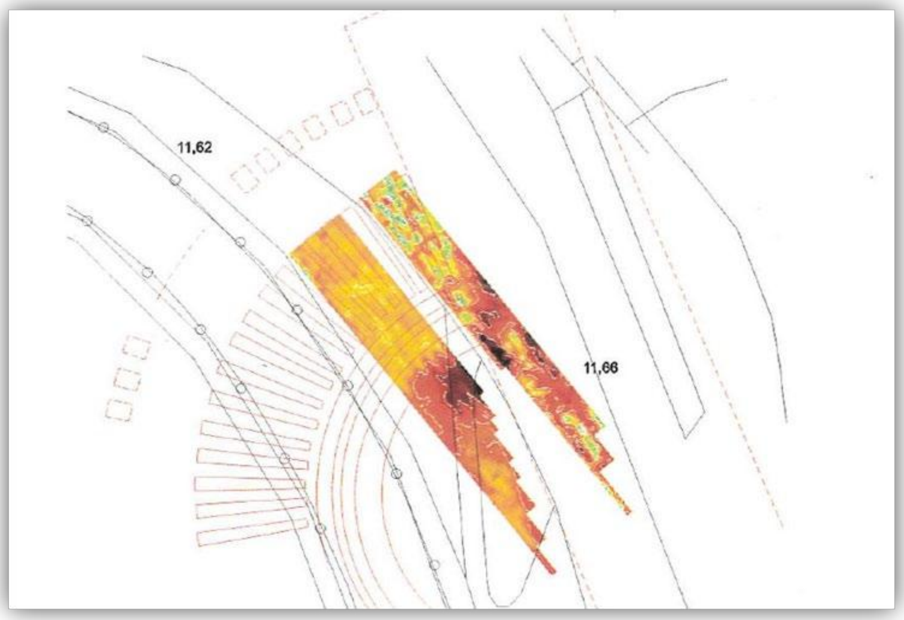
2. Alan Morris on his recent survey results from the Vale of Belvoir, Nottinghamshire: *When I downloaded the results I had to smile, an anomaly in the shape of a giant question mark – how very appropriate as at this stage I have no idea what it is!*

3. When you are in the field, it is always good to have an expert dog to supervise the field work, especially when you do ERT [picture by Alexandru Hegyi].

4. Steven de Vore sent two pictures to show how history comes full circle: *Lew Somers, Bruce Bevan, and John Weymouth at the 1992 National Park Service archaeological prospection workshop on Brown Sheep Camp on Pinon Canyon Maneuver Sites, Colorado, USA.*

5. *Lew Somers and Kris Lockyear demonstrating the use of geophysical instrument to participants of the 2019 National Park Service Workshop at Fort Casimir, New Castle, Delaware, USA* [picture by Steven de Vore].

6. Another story from Michel Dabas: *Survey in Padova (Italy) in the 'Prato della Valle' square, where we were looking for a Roman theatre under the tarmac of the square. Vittorio Illiceto asked us to do this survey in the 90s and he was in charge of doing GPR and ERT. We drove from Garchy in France to Padova with the CCR electrostatic system, the theory of which had been developed by Alain Tabbagh. You do not have to worry about tire punctures with these wheels: the poles are located inside them!*



7. We used several systems: Electrical Vertical Sounding, continuous profiling and a small system that we also used later in the PROGRESS Feder program. It was not too difficult to position the survey, but as in my recent experience at Grand'Place in Brussels, I wish I could have no tourists in the streets (a dream horribly fulfilled by the recent lockdown) [data by Michel Dabas].

8. *Here I am with the beginnings of a field beard, looking for an early modern farmhouse as a part of my BA thesis fieldwork back in 2012. I thought, naïvely, that in the future equipment and software would be commercially available and immediately suitable for our needs. It will not come as a surprise to our esteemed colleagues that this was not to be the case. Emergency repairs, homemade software, cursing and desperate ad-hoc plans to rebuild ill-fitting survey systems - the more things change, the more they stay the same. Python and 3d printers may be easier to use, but very similar problems still need to get solved. I'm sure this will still be the case once we become venerable, and I look forward to seeing what the next generations will use to bodge their way through their fieldwork!* – I think we all know very well, what Mikko Heikkinen wanted to share with us here!

9. Radek Mieszkowski surveying with a GPR in Atacama desert in Chile. Not exactly an archaeological prospection survey, though a lovely picture to share!

Journal Notification

[Archaeological Prospection 2020: 27(3)]

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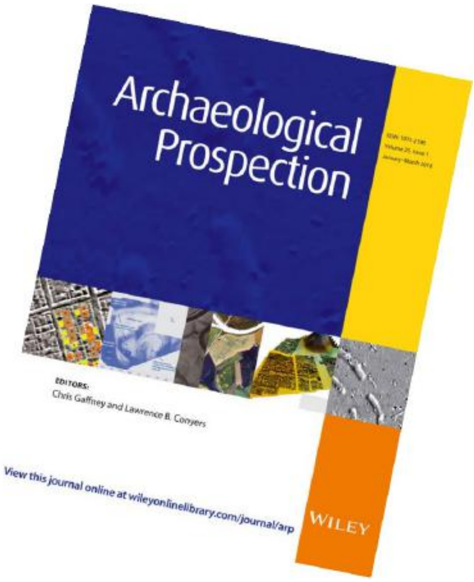

Large-scale geochemical survey by pXRF spectrometry of archaeological settlements and features: new perspectives on the method

Sabrina Save, Joseph Kovacik, Florence Demarly-Cresp, Régis Issenmann, Sandy Poirier, Simon Sedlbauer & Yannick Teyssonneyre

Non-destructive research in the surroundings of the Roman Fort Tibiscum (today Romania) – Open Access

Michał Pisz, Agnieszka Tomas & Alexandru Hegyi

Lost but revived. Revisiting the medieval village of Nieuw-Roeselare (Flanders) using large-scale frequency-domain multi-receiver EMI and landscape archaeological prospection

Gerben Verbrugghe, Timothy Saey & Wim De Clercq

Soviet topographic maps and burial mounds of the Yambol province: digital workflow for mortuary landscape verification

Adela Sobotkova & Barbora Weissova

Integrated results of aerial image, ground magnetics and excavation for settlement assessment at Dadan site, Al-'Ula area, Saudi Arabia

Abdulrahman Alsuhaibani & Mohamed Metwaly

Edge detection for the buried archaeological structures with the geophysical image processing method in the Alabanda Ancient Cistern in Turkey

Hasan Karaaslan

Evaluating ground-penetrating radar antenna performance for investigating Mississippian mound construction compared with data from solid-earth cores and magnetometry

Mark R. Schurr, G. William Monaghan, Edward W. Herrmann, Matthew Pike & Jeremy J. Wilson

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