Appendix 3.1

Organisation: Magnitude Surveys
Author: Dr Chrys Harris, MCIfA
Topic: Making Ground Penetrating Radar more efficient

Background

At Magnitude Surveys, research and development has been the catalyst for our company's continued growth and development. The company was founded with only 2.5 FTE, which meant we had to develop systems and strategies to do more work with fewer resources in order to survive in a competitive commercial market. In order to do this, we needed to develop hardware and software systems for more efficient data collection and data processing to be able to create more time for analysing and reporting on data. This required us to manufacture our own systems and software because no off-the-shelf solution could fit our needs.

To improve data collection, we adapted technology used in precision agriculture, initially using off-the-shelf 'black box' systems before migrating to Android-based software. The biggest advancement we have been able to utilise is the rise of prosumer manufacturing technology. Using in-house 3D printers and CNC machines, we can make our own prototypes that are cheaper and more responsive to our requirements. For example, we have developed a modular survey magnetometer array that can be quickly converted between quad-towed cart, hand-pulled cart and hand-carried configurations. This allows us to quickly adapt to changes in site conditions or revise strategies on site in the event of unforeseen conditions. The modular nature of the array also lends itself to attaching additional systems, such as an electromagnetic conductivity meter, to collect multiple datasets simultaneously and tailor surveys to specific research objectives (Figure 3.1). To improve data processing and interpretation, we have drawn inspiration from automation and machine-based learning. We developed a system whereby our data is live streamed from the field back to servers in our office and processed in real-time. This is a massive time saver and has led to an improvement in our data quality because manual data processing is both laborious and suffers from user bias. This allows office staff to start directly on digitisation and interpretation while fieldwork is still ongoing. Report authors digitise data directly into a database, which allows multiple people to digitise the same site simultaneously. We are planning to incorporate FISH terminology into this database, then iteratively train a machine learning system to pick out broad anomaly types from datasets (Figure 3.2). This in turn will allow our staff to spend less time on digitising archaeological features in favour of analysing and interpreting the nature and context of said features, thereby improving the report quality as well as speeding up the overall reporting process. We have a dedicated research and development team working on these topics, which we have presented at several conferences, the proceedings of two of which have been published in conference volumes (The International Conference on Archaeological Prospection 2017 and 2019).

Example

The needs of commercial archaeology projects drive our research because they provide specific demands and time constraints that are not present in academic and/or research work (which generally has longer timescales and different budget requirements). Our innovation approach is building or taking existing products and modifying them to meet our requirements. One of our current foci is to make ground penetrating radar (GPR) data collection and processing more efficient. Current standard GPR methodologies are much slower than magnetometry because you have a single instrument that requires laborious data processing. This means it is more expensive than a standard magnetometer survey, which makes it less likely to be commissioned as a primary geophysical evaluation technique unless there are specific survey questions or survey environment limitations. For a relatively large GPR survey in the New Forest, we used an off-the-shelf multi-channel GPR system to be able to collect data more rapidly, but compared to fully '3D' GPR systems, this was limited by a lower data resolution and a design that could not be towed by a quad system. We knew we could build a better system that could be adaptable to different survey environments and requirements, so we purchased an off-the-shelf 3D GPR system that contained nine individual antennas. These costly systems are normally used in utility surveys for their high resolution, but they have been used in archaeology mainly by research institutes (e.g. the Stonehenge Hidden Landscape Project). One of our live research and development projects is reverse engineering this multi-channel system into a more lightweight case and carrier that will be better suited to greenfield sites, with adjustable channel spacings to suit different resolution needs. We also aim to build on our experience in automating our magnetometer processing, applying the same principles to GPR data. Optimising our radar data collection and processing workflows will reduce our turnaround time for GPR surveys and in turn decrease deployment cost, making large-scale surveys a more viable option for commercial projects (Figure 3.3).

Figure 3.1 Modular cart system simultaneously collecting magnetometer and electromagnetic conductivity data (© Magnitude Surveys)

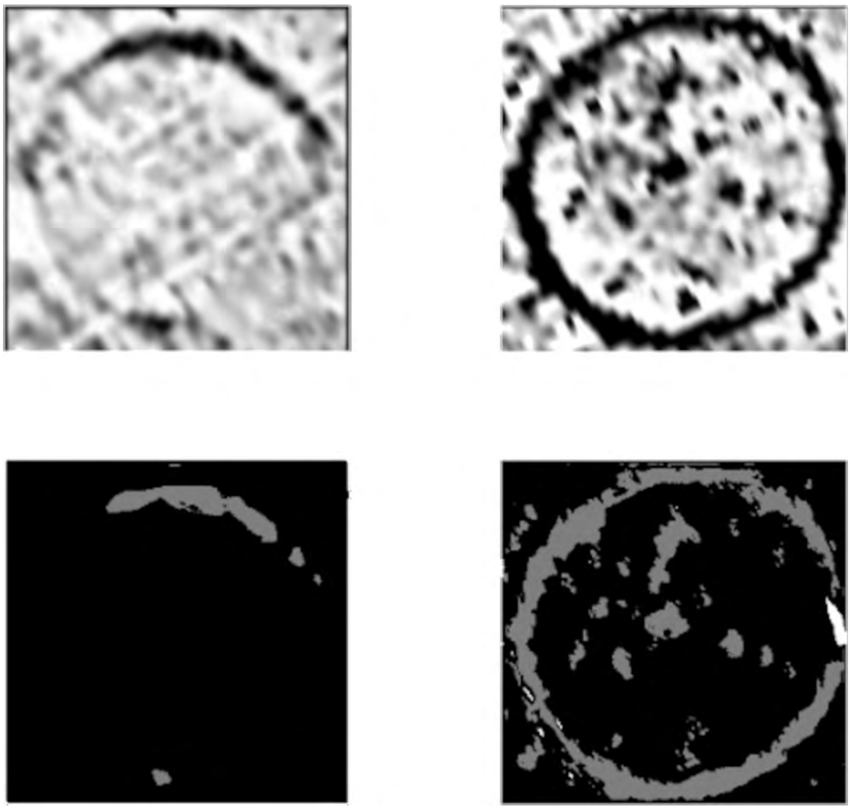

Figure 3.2 Greyscale images of magnetometer data (above) with predictions (below) from a neural network trained on ring ditches. These preliminary results show that archaeological features with significant magnetic contrast from the background material are easier to pick out. The results of this are very successful, but still require a person to QA. Additional training datasets are currently being run to improve the identification of weaker or more ephemeral features (© Magnitude Surveys)

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Figure 3.3 The stages of building a bespoke 3D GPR system, starting from the bottom left and moving clockwise: measuring the GPR array to determine the size of the case; assembling a form from CNC-milled MDF and foam; finishing the form surface with polishable primer and resin; curing the first stages of a multi-part mould onto the form using a temperature-controlled cupboard; vacuum infusing resin through the final part in its mould; finished component undergoing initial testing (© Magnitude Surveys)