Non-Invasive Tree Root Inspection with Ground Penetrating Radar (GPR)

Evaluate tree roots and soil conditions with ease

Many countries around the world are planting more trees in urban areas for aesthetic, public health and environmental reasons, however this increases the risk of injury and death due to falling trees. Especially for large trees, it is very important to inspect the full system of tree roots to detect any root damages which can lead to tree death or collapse.

Ideally, roots are monitored non-invasively to minimize time and labour expenses, and to reduce the chance of damage being done to the tree root structure and soil environment.

Challenge

Traditionally, several methods have been utilized to evaluate tree root systems. These include taking photographs with a miniature camera placed inside a transparent tube (minirhizotron) that is inserted into the soil; high-pressure air shovels and physical excavation. These methods are time-consuming, labour-intensive and potentially damaging to the tree root structure and the soil environment. They are also unsuitable for continuous monitoring of roots over long periods of times.

Ground Penetrating Radar (GPR) is a practical, effective and suitable NDT method for large-scale root inspection. Its resolution is sufficient to resolve coarse roots with diameters of 2-3cm and above.

The goal of this study was to conduct a GPR investigation of several trees in two locations to identify underground tree roots structures (especially the anchorage roots; diameters above 2 to 3cm), investigate the soil conditions and understand the environment below.

In the past, difficulties with GPR set-up and low-quality data made this application very difficult. It was previously challenging to collect and view data on site and several spurious reflections were visible.

Solution

Two types of GPR can be used for a successful investigation of tree roots: single channel GPR and multichannel GPR. Proceq GS8000 is a single channel subsurface mapping GPR system which uses Stepped Frequency Continuous Wave (SFCW) technology for improved signal-to-noise ratio and dynamic range. The system integrates the electronics into a 4-wheel cart, as well as two encoders on the rear wheels. Two power banks can be mounted for a full day of data acquisition. Proceq GS8000 comes with a GNSS receiver, MA8000, for real-time accurate (centimeter) data positioning.

In the first location, the GS8000 was pushed around the tree in concentric circles of reducing diameter. GPR data was collected and visualized in real-time through an iPad (wirelessly connected to the GS8000), using the GS app. Data processing like Bandpass filtering, background noise removal, migration and dielectric calibration can be done in real time on the iPad itself. Field data was stored locally on the tablet and synchronized with a cloud-based data management platform.

Proceq GS9000 is a multichannel GPR (MCGPR) with interchangeable arrays. MCGPR technology, provides enough trace density in all directions and paired with highly accurate positioning systems, can deliver high-resolution and easy to interpret horizontal slices of the shallow subsurface including curvilinear and point targets. With up to 50 channels at 2.5cm spacing, the exceptional data quality easily uncovers details such as tree roots.

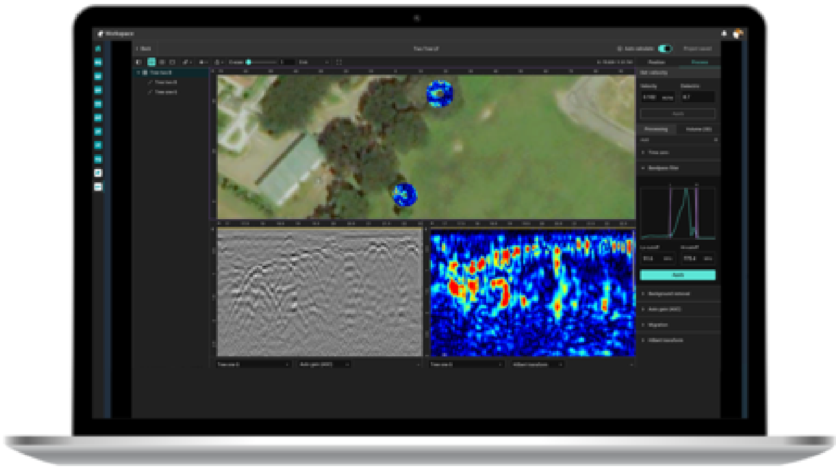
In location 2, the GS9000 was pushed along a large stretch of road to identify underground pipes and tree roots with 3D full-resolution imaging live data visualization on the iPad.

Results and Data Processing Procedures

The finished data from both GPR systems was instantly synced to Workspace for viewing on a web browser at any location. By visualizing horizontal slices at different depths, the tree root system architecture can be studied.

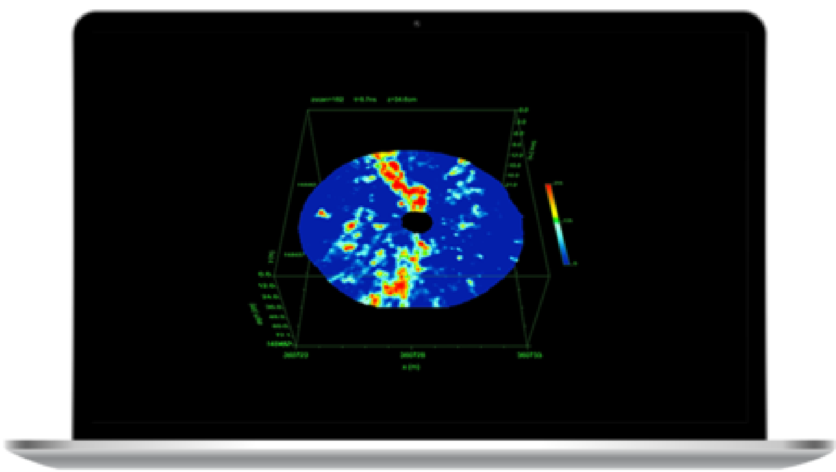
Data post-processing can be performed directly in the field using the iPad or later going back to the office with GPR Insights, (accessed online via Workspace on any web browser, or as a Standalone installed version in your computer).

With its automatic processing and cloud computing power, 2D radargram and 3D slice view were automatically generated in less than a few minutes.

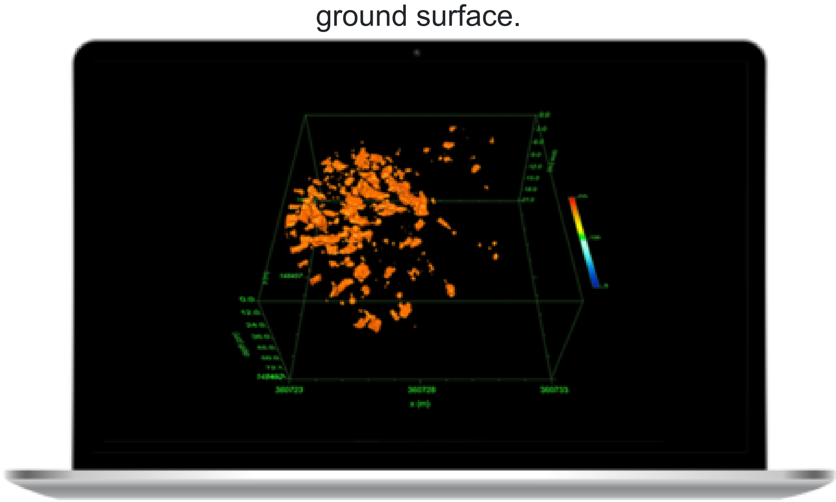


Since the GS8000 data was collected with centimeter level accuracy GNSS, depth-slice results could be superimposed on a satellite map. We can easily understand the distribution of tree root system within the measurement coverage. By pinpointing (e.g., double click) on any position we can locate how the tree root architecture looks like at actual depth.

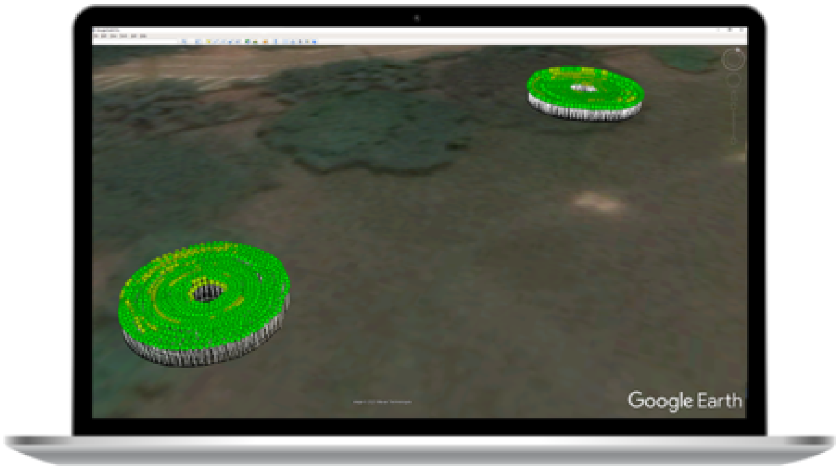
For even deeper analysis of the single channel GPR data, the GS8000 data was also processed using GPR-Slice software for advanced 3D processing and visualization. A 3D cylinder of data is obtained, with a hole through the middle representing the tree trunk. The data was sliced and gridded to obtain 40 profiles. It is possible to easily determine the exact location of the roots and any anomalies. For example, the 3D image clearly shows the tree roots distributed heavily to one side, from a depth of approximately 12cm till 60cm which is not ideal.



2D results of one tree displayed in GPR SLICE. A depth or time-slice view is shown. This is a cross-section parallel to the ground surface.



3D results displayed in GPR-SLICE. The 3D orange shapes are areas of higher reflection amplitude and they represent the architectures of tree roots, in particular the anchorage roots.



GNSS positions around the two trees, overlaid on Google Earth image. Green colour indicates an excellent GNSS correction status and yellow indicates a less good status.

The GS9000 multichannel data tells a different story at location 2, with both pipes and tree roots being detected along the road. With GPR Insights easy-to-use filters, it’s possible to really highlight the tree roots in different ways.

Above is the example of the GS9000 full-resolution 3D imaging capabilities in GPR Insights software mapping tree roots and pipes at location 2.

Conclusion

Both the GS8000 and GS9000 GPR systems have been proven to be an ideal for non-invasive, reliable inspection of tree roots. The method is quick, safe for the operator and does not damage the tree roots or soil. If necessary, it can be repeated at frequent intervals to closely monitor tree roots.

From this study, we strongly suggest that pairing accurate positioning systems with dense GPR data, is critical to map a complex tree root structure. See more case studies and applications for subsurface GPR on our Tech Hub.

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