Non-Contact Electrical Resistivity Techniques

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The theme for this presentation – “Can I extract any additional information about the ground from alternative uses of existing technology?”

As an overarching desire, we have four areas of interest:

1. Could we reveal the extent of tree root structures?
2. Could we determine the depth of cracks, or detect cracks and voids that are not visible at the surface?
3. Could we detect wet areas under paved surfaces, possibly originating from leaks or poor drainage?
4. What would happen if we used smaller and smaller mobile sensors?
In the past, you have seen me start with archaeological electrical resistivity surveying techniques and evolve these. But isn’t that very similar to a CAT and Genny?

Yes: But I use non-contact injection and very precise navigation (position & heading)
Demonstration Results

Move a sensor around at random with a positioning accuracy of ~20 mm and heading accuracy of less than one degree.

This took about four hours.

Take one car park at Southampton that will be excavated later.
Demonstration Results (Passive)

The electro-magnetic signal has three vector components in the X, Y and Z axes.

Shown here is the combined X-Y scalar field for ease of visualisation.

Initially, just listen for signals-of-opportunity – passive mode.

Raw data reveals interesting statistics.
Remember your School Physics?

Can we use these predicted shapes to provide depth and confidence?
A three-dimensional filter can then be run over the whole of the data set to provide depth estimations and confidence levels.

A Pearson product-moment correlation coefficient provides a standard method of providing confidence levels.

Values of greater than 0.95 generally have high significance.
These results may be cleaned up to provide a standard utility map with estimated depths overlaid.

Assets with low confidence levels have been removed from this map.
Interesting Academic Question

Do the wiggles running along the ridges provide any useful information about the number of cables and cable type?
Take any slice across a cable ..... 

The signal falls away more rapidly than a cable in a vacuum would predict.

Could we detect damp patches near cables in the future?

Do the spatial variations of the signal levels reveal any information about the condition of the paved surface?
Demonstration Results (Active)

Injected signals provide lower-resolution information about the ground, but are not ‘easily’ revealing information about the ground condition.
Demonstration Results (Active)

The process of extracting the interesting information is called 3D ‘inversion’ and is very computationally intensive.

We are probably interested in resolving to perhaps 0.5 m resolution.
This inversion process lets us see slices through the ground. The hope is that it will reveal wet patches and tree roots.

Other tricks may reveal the statistics of the surface layer (road condition).
Navigation Systems

An urban navigation system is required that is capable of a positioning to an accuracy of ~20 mm and heading accuracy of less than one degree.

This has been achieved by stitching together nearly one million scans from a rotating laser range finder.

However, the practicalities are commercially prohibitive.
Radio Navigation Systems

GPS navigation systems use a radio bandwidth of 1 MHz and a pulse length equivalent to 300 m. This is not good enough for our needs.

We have been experimenting with a radio navigation systems with 1 GHz bandwidth and a pulse length equivalent to 300 mm.
The vision would be to temporarily place beacon-transponders on the top of lamp posts during surveys. These could be deployed in minutes.
Ultra-Wideband Radio Navigation Systems

We are using commercial ultra wideband modems manufactured by Time Domain. A demonstration is available downstairs.
Conclusions

In this brief presentation, I have asked – “Could the humble CAT and Genny reveal any additional information about the ground?”

In particular, we have four areas of interest:

1. Could we reveal the extent of tree root structures?
2. Could we determine the depth of cracks, or detect cracks and voids that are not visible at the surface?
3. Could we detect wet areas under paved surfaces, possibly originating from leaks or poor drainage?
4. What would happen if we used smaller and smaller mobile sensors?