ASSESSING THE UNDERWORLD – Determination of Deep Cracks within Road Slabs

The assessment of the condition of road slabs is frequently conducted using visual identification, supported by laser-range profiling, of surface cracks and degradation. Such methods have no capability for determining the depth of a crack, or the presence of a bottom-up crack within a road slab.

Electrical resistivity survey techniques have been used to good effect for archaeological surveying and larger-scale geophysical material properties investigations. Traditional techniques are very time-consuming, they require fixed deployment geometries and direct electrical contact with the ground. The current state-of-the-art developed by University of Birmingham has been to implement an arbitrary-geometry, non-contact, electrical resistivity system capable of rapidly surveying a paved urban area. Current is injected into the ground using fixed, widely-spaced injection points (a bipole) – thus yielding the possibility of detecting deep-buried assets with a physically small mobile sensor package. The electric field is sensed using a small, non-contact dipole mounted on a mobile platform. Movement of the platform introduces significant sensor noise, requiring sophisticated spatial processing to reveal electrical resistivity anomalies. Currently, 2D Lomb-Scargle periodograms are used to convert the non-uniformly sampled and non-monotonic spatial data into the spatial-frequency domain. Multiple hypothesis testing is implemented via a range of spatial-frequency filter coefficients to provide track-before-detect capabilities tuned to underground assets of different length and laid at varying angles. The asset detection stage is further complicated by the rapid variations in signal strength with range from the current injection points (as range cubed). In reality, a minimum of two source bipoles are required to detect assets laid in varying directions. The resulting arbitrary-geometry, bipole-dipole arrangements present onerous demands on the navigation and heading measurements of the mobile sensor package, and are not achievable with existing GNSS or optical survey systems. Data fused from GNSS, robot surveying total stations and scanning LIDAR systems have been used to address this challenge. Such techniques have direct applicability to the assessment of the interaction between above-ground (trees and buildings) and below-ground (water leaks and tree root damage/risk) infrastructure by being able to map the spatial extent of such interactions.

The arbitrary-geometry, electrical resistivity technique effectively induces currents within the road slab and may therefore provide lateral anomaly information about cracks at the millimetric, to centimetric, spatial scale. Analytical and numerical modelling will be supported by laboratory and small-scale urban measurements to assess the feasibility of such a technique. Arbitrary-geometry inversion techniques capable of providing depth indication in addition to the lateral anomalies indicated by bipole-dipole systems will be investigated.

Funding is currently available at the standard EPSRC studentship rate to a UK, or EU, student. Self-funded international students will also be considered.

Ideally, the appropriate candidate will have a good first degree in Physics, Electrical Engineering or Geophysics and will be capable of building the experimental equipment required to deliver the research programme. Ideally, candidates should be multi-talented and be capable of collaborating with researchers from multiple Universities and disciplines. Extensive field-work is expected to validate your ideas.

A detailed technical annex showing how this work integrates with a multi-University research programme is included at

http://www.eee.bham.ac.uk/acs_gr/ATU%20Technical%20Annex%20Birmingham%20WS3c.pdf

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Electronic, Electrical and Computer Engineering

ASSESSING THE UNDERWORLD – Determination of Tree Root Extent in Paved Areas

The Mayor of London has recently been responsible for adding a further 10,000 'street trees' to the City. Very little is known about the long-term implications of such initiatives. For example, damage is likely to increase to water pipes, sewers, cables and the costs related to building subsidence are also likely to grow. However, no scientific method exists of non-invasively measuring the extent of a tree root structure under a paved area. The aim of this programme is to measure changes in the near-surface caused by tree toots using geophysical techniques.

Electrical resistivity survey techniques have been used to good effect for archaeological surveying and larger-scale geophysical material properties investigations. Traditional techniques are very time-consuming, they require fixed deployment geometries and direct electrical contact with the ground. The current state-of-the-art developed by University of Birmingham has been to implement an arbitrary-geometry, non-contact, electrical resistivity system capable of rapidly surveying a paved urban area. Current is injected into the ground using fixed, widely-spaced injection points (a bipole) – thus yielding the possibility of detecting deep-buried assets with a physically small mobile sensor package. The electric field is sensed using a small, non-contact dipole mounted on a mobile platform. Movement of the platform introduces significant sensor noise, requiring sophisticated spatial processing to reveal electrical resistivity anomalies. Currently, 2D Lomb-Scargle periodograms are used to convert the non-uniformly sampled and non-monotonic spatial data into the spatial-frequency domain. Multiple hypothesis testing is implemented via a range of spatial-frequency filter coefficients to provide track-before-detect capabilities tuned to underground assets of different length and laid at varying angles. The asset detection stage is further complicated by the rapid variations in signal strength with range from the current injection points (as range cubed). In reality, a minimum of two source bipoles are required to detect assets laid in varying directions. The resulting arbitrary-geometry, bipole-dipole arrangements present onerous demands on the navigation and heading measurements of the mobile sensor package, and are not achievable with existing GNSS or optical survey systems. Data fused from GNSS, robot surveying total stations and scanning LIDAR systems have been used to address this challenge. Such techniques have direct applicability to the assessment of the interaction between above-ground (trees and buildings) and below-ground (water leaks and tree root damage/risk) infrastructure by being able to map the spatial extent of such interactions.

The arbitrary-geometry, electrical resistivity technique effectively induces currents within the ground and may therefore provide lateral anomaly information about tree roots. It is also possible that the tree may be used as one of the current-insertion bipole electrodes. Analytical and numerical modelling will be supported by laboratory and small-scale urban measurements to assess the feasibility of such a technique. Arbitrary-geometry inversion techniques capable of providing depth indication in addition to the lateral anomalies indicated by bipole-dipole systems will be investigated.

Funding is currently available at the standard EPSRC studentship rate to a UK, or EU, student. Self-funded international students will also be considered.

Ideally, the appropriate candidate will have a good first degree in Physics, Electrical Engineering or Geophysics and will be capable of building the experimental equipment required to deliver the research programme. Ideally, candidates should be multi-talented and be capable of collaborating with researchers from multiple Universities and disciplines. Extensive field-work is expected to validate your ideas.

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