Computational Electromagnetics within the RF modelling and simulation group

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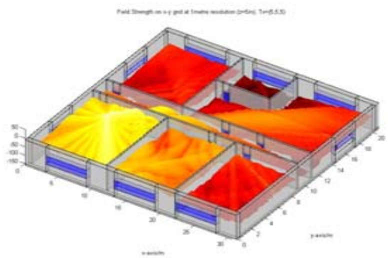
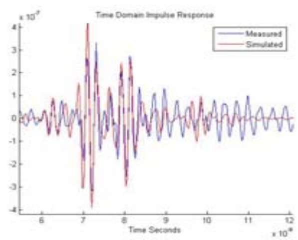
Ray tracing for indoor/outdoor wireless systems



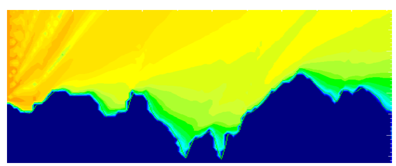


Ray tracing is an approximate asymptotic solution to the problem of computing EM wave scattering from large flat structures. As such it is ideal for modelling wave propagation indoors (top left) and within city environments (above).

The primary computational challenge lies in efficiently handling the geometric growth in the number of source images as the number of reflecting facets increases and computing the response over the increasingly wide bandwidths favoured by modern radio systems.

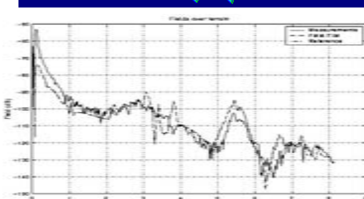
Our group has developed novel visibility algorithms as well an Ultra-Wideband (UWB) simulator which can accurately model the propagation of UWB signals in indoor environments (left). Such UWB signals are proposed for high data rate communications as well as indoor user location.

Full wave integral equation techniques for UHF propagation over terrain

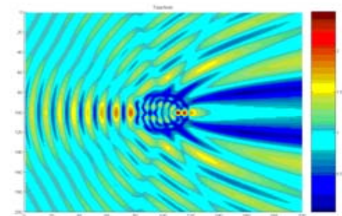


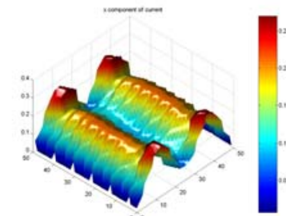
Network planning for UHF radio systems is generally based on empirical propagation models such as Okamura-Hata or COST 231. Such models do not take account of the particular topography of the link, and are consequently limited in their accuracy. In contrast a deterministic formulation such as that based on the surface integral equation (IE) can achieve much higher accuracy (the bottom figure on the right compares simulated IE results to drive-test data gathered in Northern Denmark).

Naïve implementations of the IE model can take of the order of days to run due to the necessity to solve a dense linear system of order up to 100,000 and above. Acceleration algorithms developed by our group such as the Tabulated Interaction Method (TIM) can instead solve these systems to high accuracy in under a second



Full wave deterministic modelling of EM wave scattering





EM wave scattering is a fundamental physical process underpinning many diverse application areas, such as antenna design, medical imaging, wireless system planning, RF circuit analysis and TeraHertz waveguide design. The numerical discretisation of the integral equation formulation results in large dense linear systems that are challenging to solve. We have developed a range of techniques for reducing this burden.

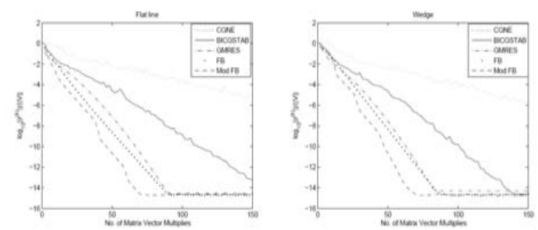


Fig. 2. Comparison of different solvers when applied to 2D line and wedge scattering problems.

The figure above shows the Buffered Block Forward Backward (BBFB) method being applied to the problem of EM wave scattering from a corner reflector (of side 3 wavelengths) excited by a vertical dipole. The BBFB is a generalisation of the block Successive Symmetric Over-Relaxation (SSOR) stationary method, and is designed to dampen the spurious diffraction terms that arise when the scatterer is artificially decomposed into distinct regions. Convergence rates are plotted showing the system error decreasing more rapidly with each iteration of the BBFB as compared to several Krylov subspace solvers.

In addition we have developed several model order reduction techniques which can significantly reduce the computational burden when computing scattering over a wide bandwidth. Our most recent work modifies the Well-Conditioned Asymptotic Waveform Evaluation algorithm to allow it to be applied to materials with frequency-dependent electrical properties. We are presently working on extending these techniques to the modelling of TeraHertz waveguides and planar monopole antennas.

Thanks to: