UTD-based Simulation of Multiple Scattering in SAR Imagery

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Although early efforts to exploit the potential of synthetic aperture radar (SAR) for mapping and monitoring the Earth's surface focused on the responses of relatively simple natural terrain, interest in using SAR to resolve complex structures in urban environments has increased steadily in recent years. With the advent of SAR interferometry (InSAR), SAR can be used to measure uplift and subsidence of scatterers and surfaces with unprecedented accuracy. The potential for using satellite-borne InSAR to monitor the integrity of civil engineering structures such as bridges, trestles and viaducts by observing small changes in the location of key points on their structures that have been augmented by radar cross section enhancement devices such as corner reflectors has attracted considerable interest from the engineering community. Unfortunately, radar returns from such structures, especially bridges over water, are complicated by the multiple scattering that may place between the elements of the bridge and between elements of the bridge and the surface of the water. Such interactions must be understood and controlled if monitoring of civil engineering structures using InSAR is to be reduced to standard practice.

Most SAR studies are based upon the application of sophisticated signal processing algorithms to measured radar data; the use of physical simulation techniques to gain insight into artifacts in the SAR image is still fairly rare. Here, we present the results of a simulation study of multiple scattering in SAR scenarios that we have conducted using XGtd, a popular ray-based electromagnetic analysis tool suitable for high frequency radiation, antenna, and EMC applications. We began by establishing a geometric representation of the bridge structure, any cooperative targets and the surface of the water. We generated SAR returns by specifying a suitable track then generating a matrix of monostatic complex impulse response data as a function of position along the track. The final step was to recover a simulated SAR image by applying a suitable processing algorithm and comparing the results to the simulated scene geometry and SAR imagery of similar scenes. The results demonstrate the feasibility of using this approach: 1) to gain insight into artifacts in the SAR image caused by multiple scattering and 2) to plan installation of cooperative targets that can be used to improve the situation.