2D Ray Tracing in Urban Environments Via Hierarchical Visibility Map Construction

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Due to the complexity of urban environments and to the fact that multiple-building interactions need to be captured, relatively simple ray trace techniques, such as the Shooting and Bouncing Ray (SBR) method have been preferred. More recently there has been interest in a more complex but potentially faster approach involving successive construction of visibility maps corresponding to source-illumination, reflection, and diffraction phenomena (E. Di Giampaolo and F. Bardati, 2005 IEEE AP-S Int. Symp,). This paper will describe a highly efficient two-dimensional approach to analysis of electromagnetic wave propagation in urban-canyon environments via hierarchical visibility-map construction. In this approach, urban-canyon environments are represented in terms of two-dimensional buildings of arbitrary polygonal shape. Hierarchies of visibility maps are extended outwards from multiple source and receiver loci simultaneously, and ray-path solutions connecting source with receiver loci are determined via identification of polygon vertices and sides that are common to source and receiver maps. The source/receiver visibility maps are defined in terms of polygon vertices, polygon sides (or portions thereof), and scenario-boundary regions that can be connected to the given source or receiver by a straight-line path without intermediary building-side intersections. For a case of reflection involving an illuminated section of a given side of a given polygon, vertices, polygon sides (or portions thereof), and scenario boundary regions that define the associated image-point visibility map reside exterior to the given building and are bounded by rays ("boundary rays") that that proceed from the image point through the endpoints of the illuminated section of the given polygon side. Visibility-map regions for cases of vertex diffraction are also defined in terms of boundary rays, which in this case extend from the diffracting vertex along the adjoining polygon sides. Any vertex that is common to one map that resides within a hierarchy of source visibility maps and to another map within a hierarchy of receiver visibility maps automatically defines a solution. Any portion of any building side that is common to a source and receiver map hierarchy defines a solution provided that Snell's law of reflection is observed at some point in the region of commonality by rays originating at the source and receiver locus. Ray-path solutions obtained by this method in a typical urban environment will be illustrated. A comparison with the SBR method will be made to demonstrate the computational efficiency of this approach.