Worldview: A Virtual Reality Framework for the Design, Optimization and Management of Mobile Telematics Infrastructure

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1 Project Description

In the current transition from a monopolistic to an open telecommunications market, more and more companies begin to offer telecom services to the general public. Some of these companies face the problem of designing and setting up a network based on electro-magnetic wave technology, with transmission stations that cover the area to be serviced. The design of a mobile telecommunication system includes an optimal placement of transmitters with regard to radiation power, transmission carrier frequency, propagation delays as well as population distribution. Yet, the optimal placement of transmitters with respect to the above-mentioned parameters may not always be realizable due to boundary conditions such as the governmental restrictions on transmitter placement.

While the broad popularity of mobile telecommunication applications such as paging, mobile phones, and mobile computing leads to an ongoing and still increasing demand, the placement of electro-magnetic antennas next to frequently used buildings becomes more and more an issue, because of the putative increased radiation. In this context, network planning staff need powerful calculation systems to minimize the number of antennas and virtual reality based tools to plan and visualize the wave propagation of existing and new antennas.

The goal of our project is to provide a virtual reality tool (WorldView) that supports the design, optimization and management of mobile telecommunication network systems. Because of WorldView's partial mobile usage in the terrain, a helpful subset of the tools is also running on a mobile personal computer.

2 Key Results

To meet the demands of a real-time virtual reality system, WorldView needs to be able to reflect changes in antenna placements almost instantaneously. We do not want the user to wait for several minutes while the system is busy within the time-consuming computation of the exact wave propagations of a couple of antennas. Hence, instead, we are using a simple and fast version of electro-magnetic wave propagation prediction in rural and suburban areas and employ real-time exploration for very large topographic scenes. The prediction is guaranteed to fulfill certain quality standards.

Terrain Explorer

Very large topographic scenes make it infeasible to hold the whole terrain data in main memory. The visualized terrain is a combination of adaptively triangulated digital elevation data and texture (e.g. remote sensing satellite data, aerial ortho-photos, topographic pixel maps). The texture helps the user to better recognize terrain parts and prevents her from getting lost in space. The necessary concepts to handle huge amounts of terrain and texture data in a virtual reality manner are taken from a former project of our research group (ViRGIS) [1].

Propagation model

Our prediction method is based on a line-of-sight (LOS) approach combined with an empirical propagation model for ultra high frequencies (UHF, 300–3000 MHz). The electro-magnetic waves propagate in the same way as visible light, but are bounded by a maximum distance due to free-space path loss and a maximal path loss. Various types of scattering that occur in reality, such as reflections, refractions and diffractions, are disregarded.

This simplification of the model above drastically reduces the terrain parts covered by an antenna; it turns out to be too restrictive. Therefore, a method to compensate the scattered waves and multipath phenomena – which can cause severe signal fading – is necessary. Instead of an almost exact ray tracing of the reflections we approximate the scattering and multipath phenomena with the empirical model of Okumura/Hata. This approximation ensures an efficient and yet sufficiently accurate wave propagation.

The empirical Okumura/Hata model that we use is recommended by the International Radio Consultative Committee (CCIR) as a method for estimating field-strength values in the land mobile services using the UHF band. The higher the carrier frequencies, the more important a direct line-of-sight between the transmitter and the receiver becomes, as obstacles (e.g. parts of the terrain, trees, buildings) may block the free space connection and thus reduce the quality of the transmission.

Our LOS approach is realized with a modified, output-sensitive hidden surface removal algorithm in object space [2]. Most similar tools realize LOS computations with ray tracing methods which is very time-consuming with the presence of many triangles in the transmitter's environment. Since efficiency is a major issue for the more complex wave propagation computations, we think that it is necessary to develop more sophisticated data structures and algorithms from the very beginning.

Optimization

Recently, we implemented algorithms to place antennas automatically. The goal thereby was to minimize the number of antennas needed to completely cover a predefined area. Because it is hard to find an optimum solution, we focused on approximation algorithms.

Antenna Management

WorldView also acts as a management tool for antenna data. It permits to store antenna-specific data (e.g. height, carrier frequency, power, antenna type) in a standard database. The type of an antenna determines its horizontal and vertical wave propagation characteristics. WorldView allows the use of a wide variety of antennas of well-known antenna suppliers.

3 Contact Addresses

For a more detailed description refer to the 1998 Progress Report [3] or to the home pages of the research groups at ETH [4] and MultiMediaLab at University of Zurich [5], or contact Christoph Stamm (stamm@inf.ethz.ch), Prof. Dr. Peter Stucki (stucki@ifi.unizh.ch), or Prof. Dr. Peter Widmayer (widmayer@inf.ethz.ch).

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Bibliography

[1] Pajarola, R., Ohler, T., Stucki, P., Szabo, K., Widmayer, P.: The Alps at your Fingertips: Virtual Reality and Geoinformation Systems. In: Proc. of 14th Int. Conf. on Data Engineering ICDE '98, pages 550–557, Orlando, 1998. IEEE Comp. Soc. Press.

[2] Beck, M., Eidenbenz, S., Stamm, C., Stucki, P., Widmayer, P.: A Prototype System for Light Propagation in Terrains. In: Proc. of Computer Graphics International, pages 103–106, Hannover, 1998. IEEE Comp. Soc. Press.

[3] www.inf.ethz.ch/personal/stamm/worldview/worldview.htm

[4] www.inf.ethz.ch/department/TI/pw

[5] www.ifi.unizh.ch/mml