Virtual Reality and Wireless Telecommunication Applications

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Conteúdo

Resumo: Este documento descreve uma aplicação não imersiva de ambientes virtuais em telecomunicações sem fio. Ele descreve uma aplicação da linguagem de modelagem de realidade virtual (VRML) em uma visualização modelo digital de terreno (MDT) e análise. A análise mostra os locais mais adequados para a implatação de uma antena. Considerações físicas e geométricas são observadas para modelar o problema, os dados e a solução. Modelos tridimensionais e bancos de dados podem ser acessados pela internet e intranet usando os mundos VRML, levando a uma implementação do projeto completo. É mostrado um exemplo simulado em VRML.

Palavras chave: VRML, Telecomunicações, Realidade Virtual

Abstract: This paper presents an application of non-immersive virtual environments in wireless telecommunications. It describes an application of Virtual Reality Model Language (VRML) in Digital Terrain Model (DTM) visualization and analysis. The analysis seeks for adequate sites for antenna placement. Geometrical and physical considerations are employed to model the problem, the data and the solution. Three-dimensional models and databases can be made available on the Internet and over intranets using VRML worlds, allowing the implementation of a complete project. A simulated example in VRML is shown.

Keywords: VRML, telecommunications, Virtual Reality

1. Introduction

This works employs Virtual Reality tools for searching and assessing solutions to the problem of antenna placing. This is a broad problem, with many particular approaches and restrictions depending on the specific application (frequency, power, gain, among others.). A relevant particular case arises when searching for optimum antenna placing for wireless communication applications. The relevance of the problem stems clearly from the spread of personal wireless devices in technological societies. Companies that provide this service have to place their radio base stations in strategic places, in a number that satisfies user's requirements but, also, with economic restrictions. Antenna placement plays a critical role, since well-located devices reduce the need of redundant radio base stations. Modeling user mobility for optimum resource management is one of the hottest research topics in the area (Zonoozi and Dassanayake, 1997a, 1997b).

As the technologies of Virtual Reality evolve, VR applications become more and more powerful and widespread. VR is reshaping the interface between people and information technology by offering new ways for the visualization, exploration and discovery and creation of information. Examples can be seen in cartographic projects and correlates areas, where can determine real planning of highways and archeology survey among others areas that need topographic information.

Antenna placing can be effectively aided by low-cost widespread desktop VR tools. A VR model of the target area can be used to find and assess candidate places for radio base stations, and the quality of these candidates can be qualified by relevant physical parameters and quantified by visual inspection. The dynamics of contemporary urban areas does not impair limitations on such a tool since, with the aid of simple editors, the models can be readily updated. Most current methodologies for antenna placing are manual and, thus, not as efficient as automatic or semiautomatic ones.

These facts, and the need for simple distribution of information across the Internet and intranets, are the motivation for the proposal of a methodology for automatic antenna placing for wireless telecommunication applications based on the interaction with digital terrain models and urban descriptions in VRML.

2. Virtual Reality Model Language

VRML (Virtual Reality Modeling Language) is a standard that allows the distribution of interactive and functional three-dimensional models over the Internet. A user, connected to the Web, can access a VRML application and navigate through or interact with the model. To do this, a VRML plug-in for the Web browser in use (Netscape or Internet Explorer) is required. This language was created in addition to HTML (HyperText Markup Language), the standard authoring framework for the creation of home pages. VRML provides three-dimensional worlds with integrated hyperlinks on the Web.

With VRML home pages become home spaces. The viewing and exploring of VRML models is usually done on a graphics monitor with mouse and keyboard control and, therefore, the experience is not fully immersive. However, the syntax and data structure of VRML provide an excellent tool for the modeling of three-dimensional worlds that are functional and interactive and that can, ultimately, be transferred into fully immersive viewing systems. The current version VRML 2.0 has become an international ISO/IEC standard under the name VRML97. Details about VRML can be found in Ames et al. (1997), Carey and Bell (1997), Hartman and Wernecke (1996), Pesce (1996) and Tittle et al. (1997), among others.

Groups of research developed versions of VRML, as Web3Dconsortium, creating the GeoVRML. In GeoVRML model the degree correct Earth curvature is in conformity with parameters of WGS84 (World Geodetic System 1984). The use of GeoElevationGrid node allow to change heights and geographic coordinates in cartesian x, y and z. Otherwise, Geocoordinate node is allow of to insert UTM (Universal Transverse Mercator) coordinates directly in VRML model, converting UTM coordinates in cartesian coordinates.

3. Some Fresnel Ellipsoid Considerations

Electromagnetic signal (microwave) transmitted/received between antennas installed in towers positioned over topographic profile where wavelength λ is in centimeter. Microwaves are emitted by antennas that focus, direct and propagate them. An electromagnetic energy flux needs to be defined between two antennas, then a space zone is defined and called Fresnel ellipsoid that radius depends on the λ wavelength. Fresnel ellipsoid is based on Huygens definition (Smit, 1988).

Following is showed Figure 1 that shows the Fresnel radius and the equations associate to it (Smit, 1988). Where A and B are the antennas. D is the distance between A and B, rf is Fresnel radius. λ is the microwave length associated.

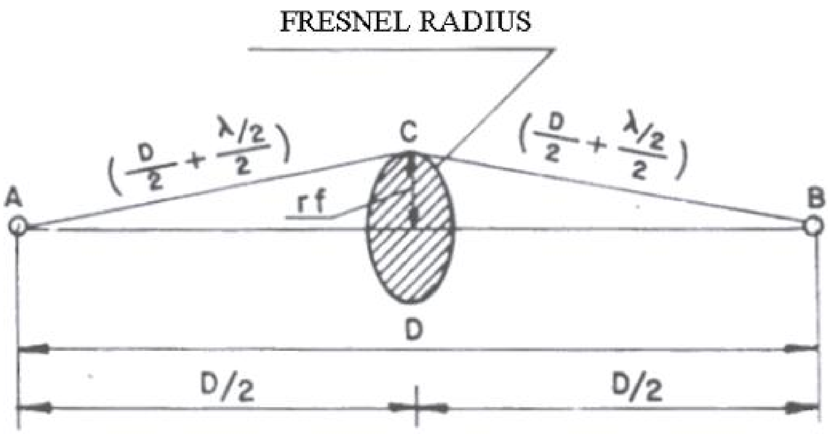

Figura 1 : Fresnel radius
(Smit 1988)

Fresnel radius (*rf*) in Smit (1988) is defined by :

$$r_f = (1/2)\sqrt{D\lambda} \qquad (1)$$

To have a good transmission/receive all the Fresnel ellipsoid need to be free of obstacles and depends on wavelenght (Equation 1).

4. Manual Approach In Antenas Implantation

Radio base stations require special geographical distribution: they have to be placed in such a fashion that they are visible from each other, a requirement called *antenna intervisibility*. In this manner, since they employ microwaves, they have to be free of physical signal interruption. Therefore, the following factors ought to be considered in antenna placing: cartographic data like distances, difference of heights, relative positions, position and height of edifications and trees, terrain geometry and geomorphology of the area (Coates, 1976; Fookes and Vanghen (1986); Hart (1986); Mathewson and Coole (1992)).

Propagation signals characteristics in troposphere region is occupant in transmission/reception of signal, this region corresponding an revolution ellipsoid where in the focus stay antennas dipoles called Fresnel ellipsoid. Then direct intervisibility is not sufficient to solve this problem; it is necessary to add a Fresnel ellipsoid to verify problems in transmission (electronic intervisibility of microwaves). Then wavelength, antenna gain and other information need to be defined in radio enlace with topographic profile and information about soil occupation, etc.

Figure 2 shows a topographic map with isolines (isometric lines) and one ruler that defines the profile direction where, in terrain points A and B were selected to implant the antennas towers. The objective is to define the intervisibility line between the dipoles of directional signal (microwave) antennas A and B. This manual solution has low flexibility and requires a long time in its definition. Fresnel Ellipsoid is represented in profile of Figure 1, because electronic intervisibility of microwaves needs to be specified too.

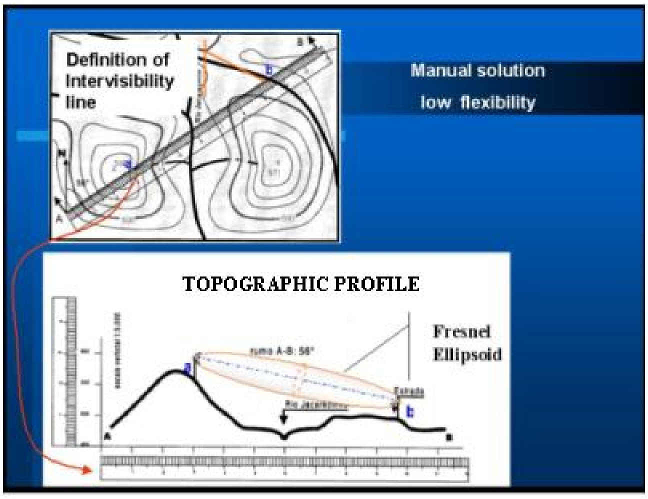

Figura 2 : Manual Approach for the placement of antennas A and B

5. Methodology

Methodology used here is based on the use of a digital terrain model (DTM) of the target area and a VRML world customized to the problem. This approach aims at aiding the semi-automatically definition of antenna placement, through the use of their intervisibility Fresnel ellipsoid. Specifically, this methodology is divided in three steps.

1. Input data
    1.1. Digital Terrain Model;
    1.2. Positions heights of trees, buildings, top of relief and height of every relevant building and obstacle in the area, possibly extracted from orthophotocarts documents, cadastral plants.
    1.3. Antennas parameters electronics.

2. VRML definitions and associated programs
    2.1. Interactive Virtual Modeling World using
        2.1.1. Cartographic data obtained from a DTM.
        2.1.2. Software development to calculate differences of coordinates transformation
        2.1.3. High and azimuths based on DTM.

3. Comparative tests (validation)
    3.1. Comparative tests of intervisibility and radio link: simulation vs. real case
    3.2. Modifications of virtual world indicated in comparative tests.

To define the direct interception of DTM and direct view without ellipsoid, supposing a referential system, compare GRID of DTM with line between A and B. if a point or more than touch the DTM there is not a intervisibility. This way to define can be made with the ellipsoid two because mathematically both of then have an equation representation.

The heights and coordinates x, y of ground in VRML was to supply of MDT previously assembly for engineer cartographer, where to adopt computational programs from task to calculate parameters of coordinates ellipsoidal, geoidals, and projections systems, among others concepts.

6. Results

Figure 3 shows the result of a VRML visualization of a simulated example. It is possible to see that there is not intervisibility between these antennas because the Fresnel ellipsoid has intersection with the DTM. In this manner, this placement can be considered unfit for the application. The use of transparency, a native feature in VRML, allows the determination and assessment of complex intersections.

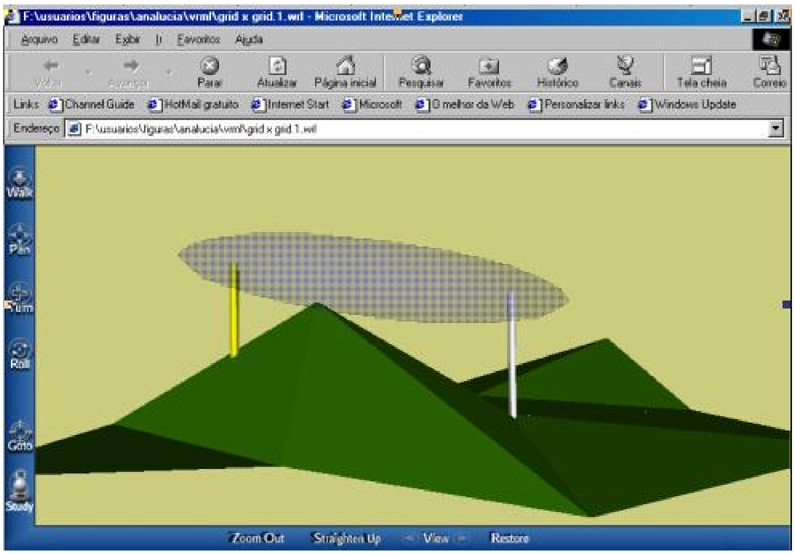

Figura 3 : VRML visualization of a simulated example

Figure 4 shows the same example with a vertical plane slicing the scene. This plane simulates the line over the topographic map (Figure 2). The visibility of this plane can be changed and shows the lateral view. With this is possible to generate topographic profile.

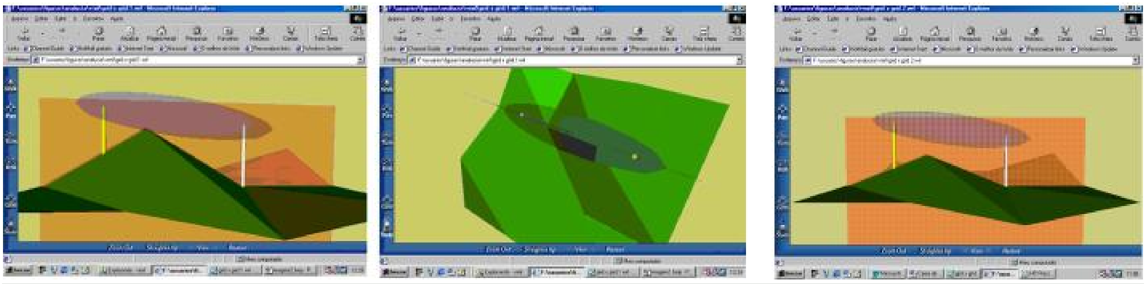

Figura 4 : Normal views, with scene slice, vertical view, and a view with interception

7. Conclusions

The Mathematics and Cartographic Engineering supports are essentials while to consider aim demanding accuracy and precision of data to process calculations and intervisibility analysis, to go ahead those intuitive aspects of virtual reality.

Methods involving virtual reality show the necessity of interactive among researchers with different formations and science segments. A specialist in Cartographic Engineering or in Geodetic Science and Geoinformation Technology need to support this method with a Telecommunication Engineering or someone that know these areas.

This work will facilitate to define new areas to put new antennas with a 3D approach. This is a strategic area that VRML, Remote Sensing and Cartography can help in a special way. The editor to define the places of the antennas with cartographic parameters in MDT is yet object of study.

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