A Convex-Space Discretization of a Building, Designed for Indoor Resource Optimisation using Ray-Tracing Techniques

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***Abstract*—The purpose of this work is to provide a fast multipoint ray-tracing algorithm when the location of many transmitters is not fixed. When optimising the location of multiple transmitters numerically using an optimization algorithm the visibility algorithm for reflective and diffractive surfaces is normally computed each time the transmitter is moved. However when splitting the building into a set of convex spaces, the visibility algorithm does not need to be changed at any iteration of the optimisation process, since the convex spaces inherently provide the visibility algorithm themselves.**

***Index Terms*—Indoor Scattering, Resource Optimisation, Spacial Splitting, Visibility.**

I. Introduction

The purpose of the Software Tool for Indoor Resource Optimisation (STIWRO) is to produce a software tool with advanced radio wave propagation techniques and an optimisation algorithm to optimally place the antennas in a picocellular/indoor environment [1]. A not dissimilar implementation in a two dimensional microcellular environment was produced by Yun[2], however this method is applied to the more complex picocellular environment in three dimensions.

The optimisation of the antenna locations to produce the best mobile receiver capacity is discussed in [3]. However, the positioning of the antenna and the ensuing ray-tracing process requires optimisations itself to produce a fast ray-tracing technique for use in the capacity optimisation problem.

II. Architecture

The three dimensional visibility algorithm comprised of locating two dimensional planes about a point source for ray-tracing is something that has been implemented for a number of years. Existing methods involve the calculation of closest planes, partial planes and variants such as bucket sorts and other optimisations. However, if one discretizes the building description as a set of convex spaces, that is, a space where any 3-D line passing through a 3-D volumetric space only enters and exits at one point on the boundary of that space, one then obtains a very useful way of creating the visibility list from the building plans rather than as an abstraction of visibility planes about a transmitter.

For convenience and to assist in the optimisation of the configuration, the building is split into a set $\{C_k\}_{k=1}^{N}$ of six sided polyhedra each of which connect at the boundaries b_i of convex space C_m and b_{7-i} of the contiguous convex space C_n. The convex spaces are defined as free when the convex space is occupied only by air in the rooms/corridors and filled when occupied by some material other than air. This improves the ray-tracing algorithm, particularly in the definition of reflection points using the method of images, and also in determining if a diffraction edge is inside a doorway, room or corridor in which case it cannot be disregarded.

III. Implementation

The method was implemented in software and tested on a three storey building where the boundaries of the convex spaces were confined to exist in the x, y or z planes. The method was also tested on the fictitious building described in Fig. 1, to ensure that the diffraction points and reflection points where fully accounted for. The electromagnetic wave scattering algorithm applied to the ray-tracing was tested in a real building using blueprints to design the building and using a network analyser and omni-directional antenna to calculate the field strength.

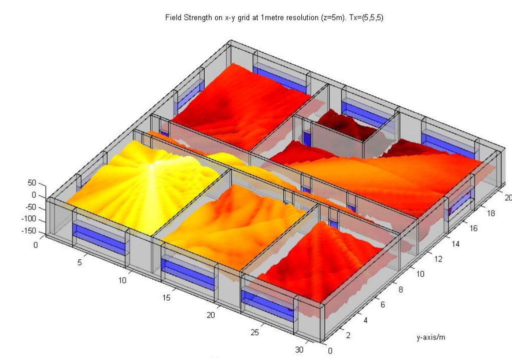

Fig. 1. Electric field at 9600 points with 3 reflections and 1 diffraction

IV. Conclusions

In recent years the advances in the object oriented building information modelling (BIM) platforms allows the convex space building definition to be fully automated. Therefore a building configuration can be integrated into proprietry tools relatively easily. Using the method outlined in this paper an optimisation algorithm for best transmitter locations as a function of capacity will not rely on the antenna position when calculating the ray-tracing making it computationally efficient.

References

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