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Full Coverage Prediction with UTD and GO model

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Abstract

In order to improve the quality of service in UHF broadcasting systems, extracting of coverage map is so important. Coverage map is drawn after electric field is predicted by means of Uniform Theory of diffraction (UTD) and Geometrical optic (GO) models. In urban areas, direct, reflected and diffracted fields are used to generate the coverage map. In this study, coverage maps are extracted for two different scenarios.

Keywords: Coverage mapping, UTD, Geometrik optic, Diffraction, Wave propagation

1. Introduction

In urban areas, generally transmitter and receiver cannot see each other. Always there are lots of obstacles between them, such as mountains, hills, buildings, cars and trees. In this situation electromagnetic waves emanate from the transmitter, can reach to receiver by reflection and diffraction. To increase the quality of service of digital broadcasting systems like FM, TV or GSM, firstly coverage map should be drawn and then base station for these broadcasting systems be installed into optimum places. In order to draw coverage map, electric field strength have to be calculated in the first place. High frequency techniques, like UTD and GO models, are used to calculate the field strength accurately. To calculate the field strength caused by reflected and direct rays, Geometrical optic model could be used [1]. Whereas, diffracted fields cannot be calculated by geometrical optic model [2]. These diffracted fields could be computed by another high frequency technique, which is called UTD model, introduced in [3]. Coverage map is drawn after electric field prediction with UTD and GO models. In this study, coverage maps are generated for two multiple diffraction scenarios. In the following sections, UTD and GO formulations and simulation results are given.

2. Material and Methods

In coverage prediction, reflected and direct fields are calculated by Geometrical optic model. Electromagnetic fields are reflected from the surface as shown in Figure 1.

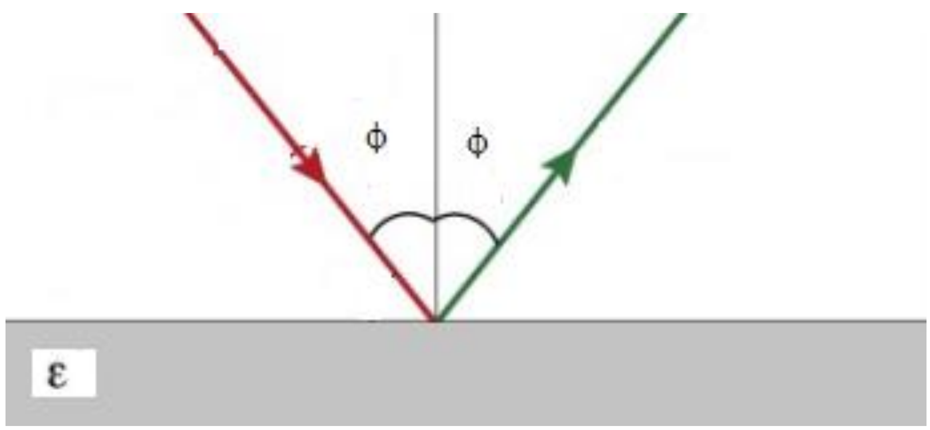

Figure 1. Reflected wave.

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Reflected field can be expressed by,

$$E = \left[\frac{E_i R_{s,h}}{s}\right] e^{-jks} \tag{1}$$

where, E_i is incident field, s is total distance, k is wave number and $R_{s,h}$ is reflection coefficient for soft and hard polarizations, respectively. Direct field can be calculated by

$$E = \left[\frac{E_i}{s}\right] e^{-jks} \tag{2}$$

where, E_i is incident field, k is wave number and s is total distance. Behind an obstacle, electric field strength [4] is expresses by,

$$E = [E_i D] A(s) e^{-jks} \tag{3}$$

where, E_i and *D* are incident field and amplitude diffraction coefficient, k refers to wave number, *A(s)* stands for spreading factor and finally *s* is travelling distance. The amplitude diffraction coefficient [5] is expressed by,

$$D(\alpha) = -\frac{e^{-j\pi/4}}{2\sqrt{2\pi k}\cos(\alpha/2)} F[x] \tag{4}$$

where, α is angle between incident and diffracted wave as illustrated in Figure 2. $F[x]$ is transition function in [6] and changes between 0 and 1.

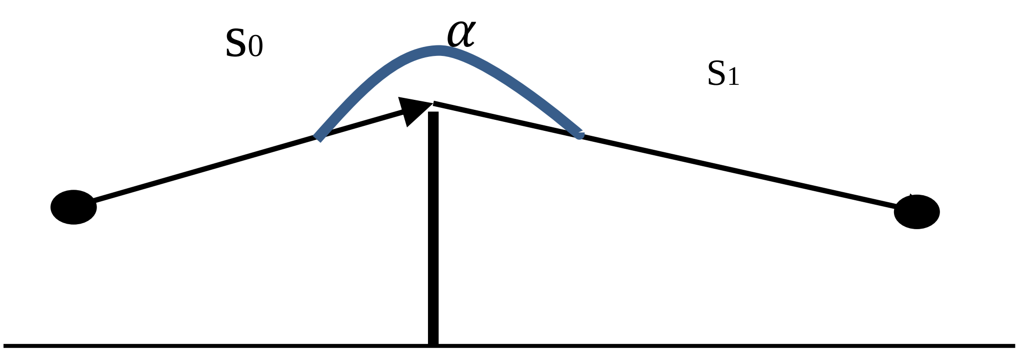

Figure 2. Diffraction angle

A(s) is spreading factor and can be calculated by,

$$A(s) = \sqrt{\frac{s_0}{s_1(s_1+s_0)}} \tag{5}$$

where, s_0 and s_1 are the distance before and after the diffraction, respectively.

3. Results and Discussion

In this section there are two simulation results for city center and hilly terrain. Operational frequency is selected 1800 MHz for GSM broadcasting. In the first scenario, roofed and rectangular shaped houses are modeled as shown in Figure 3. Base station is deployed 20 m from ground. Houses are deployed from 0 to 400 m on the ground. In the first case, only reflected fields are demonstrated in Figure 3.

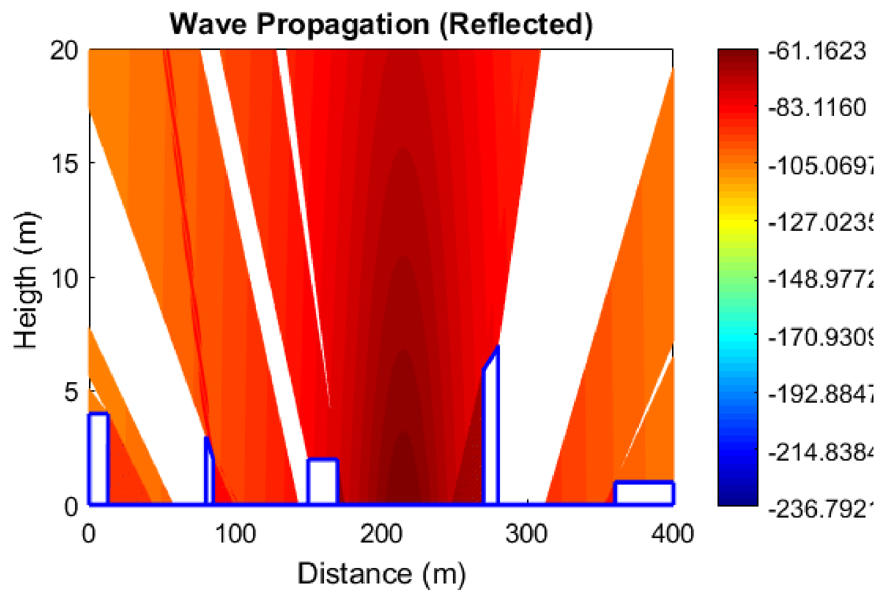

Figure 3. Case 1 (Reflected waves)

As can be seen in Figure 3, reflected waves from the ground are drawn. Far away from the ground reflected waves attenuates towards to -80 dB. In white places, there are no reflected waves due to that ground reflected waves are blocked by the houses. In the second case, only diffracted waves are considered and coverage map is drawn as it is indicated in Figure 4.

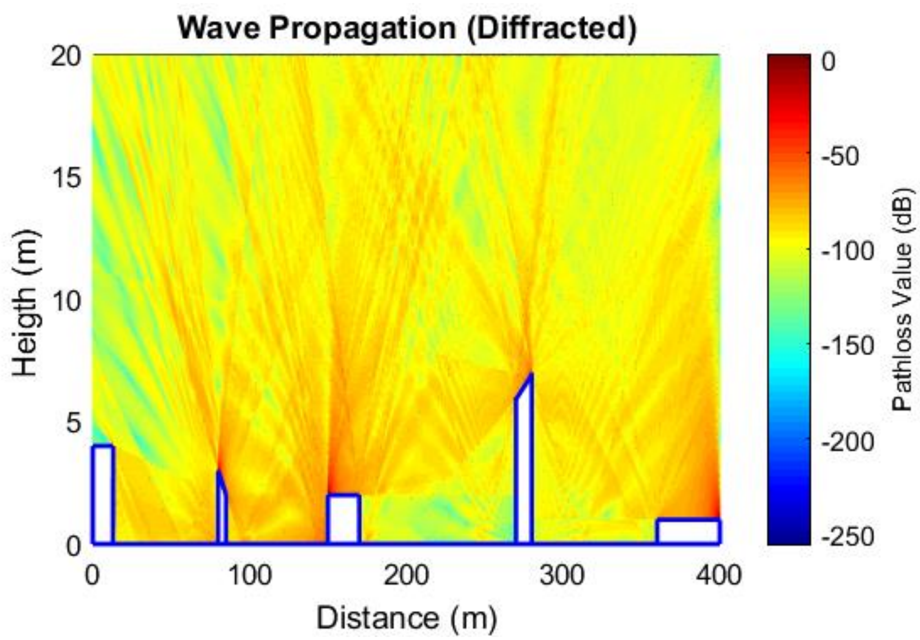

Figure 4. Case 2 (Diffacted waves)

As it is illustrated in Figure 4, diffracted waves from the houses are drawn. Diffracted fields can reach the point where there is no reflected waves. Diffacted fields decreased to -120 dB far away from the diffraction point. In the third case, full coverage map is drawn by using direct, reflected and diffracted rays as showed in Figure 5.

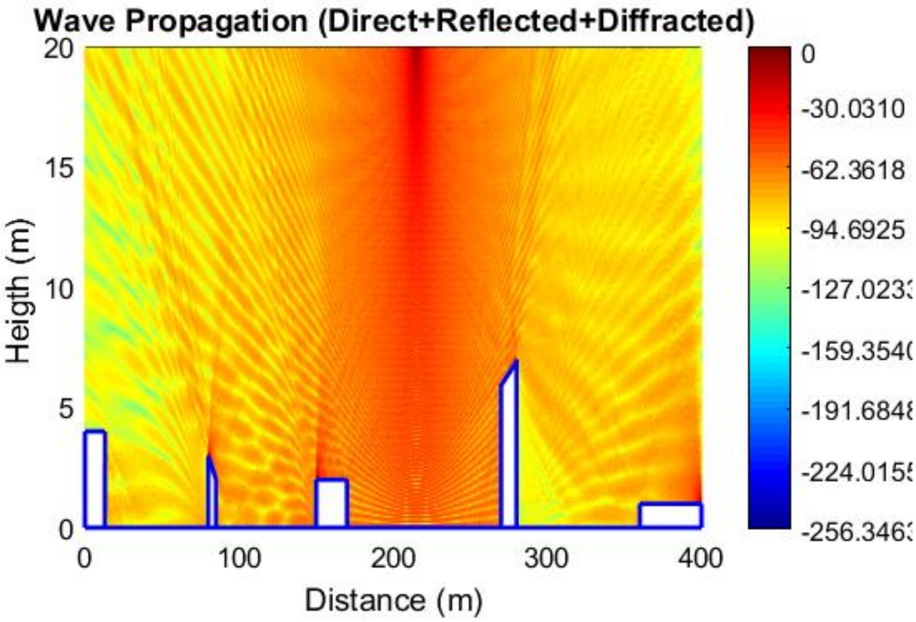

Figure 5. Case 3 (Full coverage)

As it is demonstrated in Figure 5, full coverage map is generated. At closer points to source, electric field strength increased. Moreover, there is interference pattern caused by phase difference of direct, reflected and diffracted waves. In the second scenario, a hilly terrain is considered as shown in Figure 6. Operational frequency is selected as 1800 MHz. There is a transmitter in the point (380, 15) in xy-plane. Also 5 knife edge type obstacles are deployed in the hilly terrain. In the first case only reflected fields are demonstrated in Figure 6.

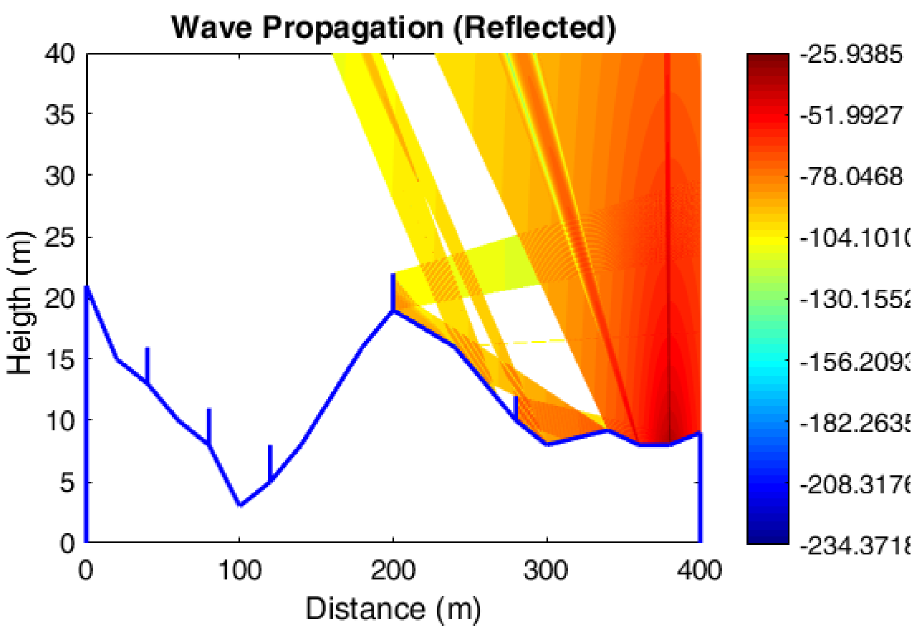

Figure 6. Case 1 (Reflected waves)

As can be seen in Fig.6, reflected waves from the ground and knife edges are drawn. Far away from the source, reflected waves attenuate towards to -104 dB. In white places, there is no reflected waves due to that reflected waves are blocked by the knife edge type obstacles. In the second case, only diffracted waves are considered and coverage map is shown in Figure 7.

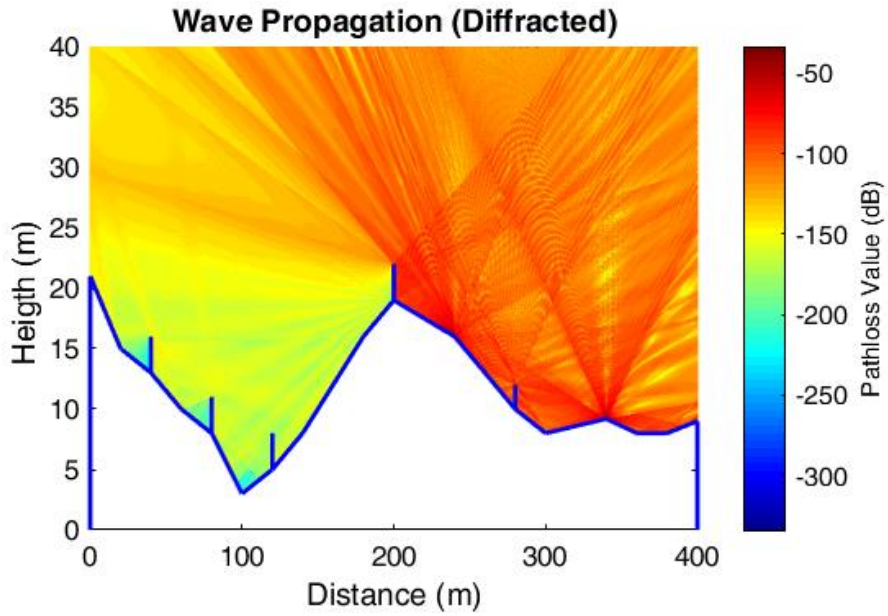

Figure 7. Case 2 (Diffacted waves)

As it is illustrated in Figure 7, diffracted waves from the knife edge type obstacles drawn. The diffracted fields can reach the point where there are no reflected waves. Diffacted fields decreased to -250 dB far away from the diffraction point and behind the obstacle. In the third case, full coverage map is drawn by using direct, reflected and diffracted rays as demonstrated in Figure 8.

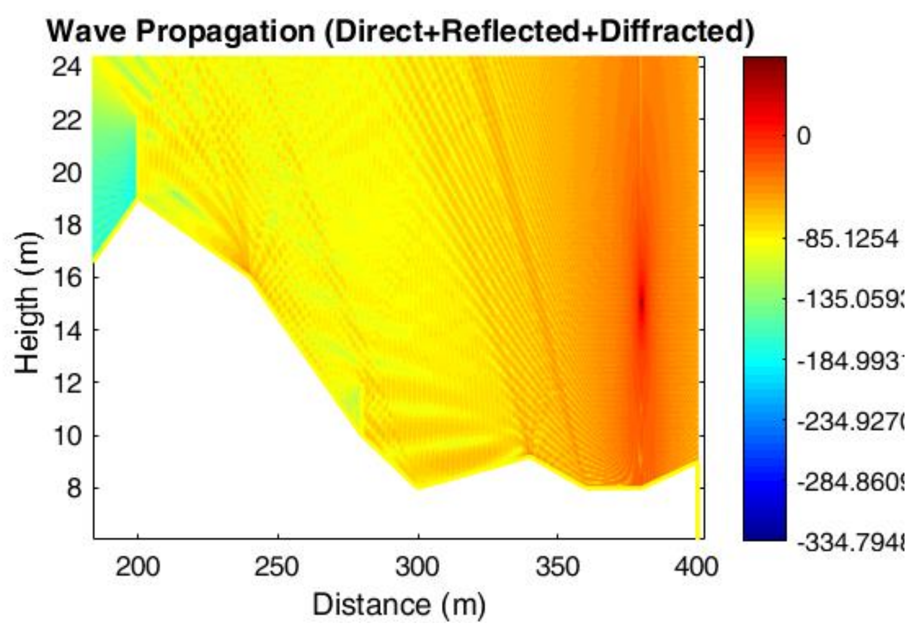

Figure 8. Case 3 (Full coverage)

As it is illustrated in Figure 8, full coverage map is extracted. At closer points to source, electric field strength greater than the farther points. Moreover, there is interference pattern caused by phase difference of direct, reflected and diffracted waves. Electric field can reach to behind of the fifth knife edge type obstacle, by refraction and diffraction.

4. Conclusion

Coverage map drawing is very important before deploying the base station for FM, TV or GSM broadcasting. In urban cases, direct field could not reach to last user directly. In these cases, reflected and diffracted waves have to be included for coverage prediction. Diffracted fields can reach to the points where the direct or reflected rays cannot reach. By using coverage map, base station can be deployed optimum places in order to increase quality of service. UTD and GO model should be used together in coverage prediction.

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