Ray Tracing Channel Generation for 6G Scenario Dependent Research

Abraão de C. Albuquerque, Victor F. Monteiro, Tarcisio F. Maciel, Diego A. Sousa and Fco. Rafael M. Lima

***Abstract*— Some of the envisioned 6G applications, e.g., integrated sensing and communication (ISAC), are scenario dependent, requiring physically accurate knowledge of the scenario. One envisioned solution is to use ray-tracing (RT) based channel models. In this context, this work introduces a methodology for generating scenario-dependent channel samples using RT, allowing for realistic evaluation of wireless networks. The methodology includes defining the geographical area, creating a 3D model, simulating user equipment (UE) movement, and generating channel impulse responses between transmitter (Tx) and receiver (Rx). Computational results in an urban area of Fortaleza, Brazil, demonstrate the effectiveness of the proposed approach, highlighting the importance of considering real-world scenarios instead of statistical channel models.**

***Keywords*— Ray tracing, mobility, channel data, 6G.**

I. Introduction

As research on the sixth generation (6G) of wireless cellular networks gains momentum, the need for channel models that take into account the scenario geometry increases [1]. Specifically, some of the envisioned applications, e.g., integrated sensing and communication (ISAC), are scenario dependent, requiring physically accurate knowledge of the scenario [2]. Stochastic channel models do not fit this requirement. Thus, even though they have been extensively used in the past, they are not a suitable solution to evaluate these applications. The ideal solution is to use channel datasets obtained through measurement campaigns. However, currently, there are not many real measurement datasets freely available. An alternative is the use of ray-tracing (RT) based methods.

In this context, this work presents a methodology to generate channel samples based on RT. Moreover, results of a performance evaluation are presented. The considered methodology allows researchers to consider real scenarios, e.g., investigate network coverage in a given area of a city of interest. In addition to consider a real geographic area, researchers can also take into account the real position of a given operator's transmitter (Tx), as will be presented. As we will show, the proposed methodology also allows researchers to consider the mobility of the user equipments (UEs) in the streets of the investigated area, taking into account even the traffic lights.

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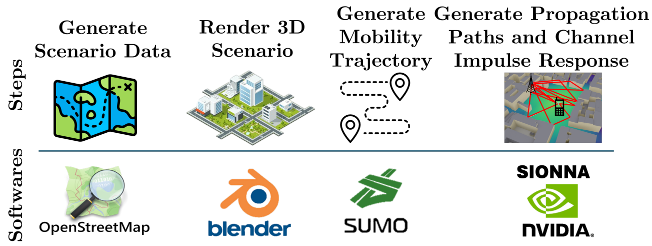


Fig. 1: Methodology to generate scenario dependent channel.

In [3], a similar methodology was presented. However, different softwares were used. We highlight that the RT simulator used in [3], i.e., Wireless InSite, is not open source, while the one considered here is. Moreover, the methodology considered here already takes into account the most up-to-date features of the considered softwares, which were not available at the time when [3] was published.

II. Methodology for Channel Samples Generation

As illustrated in Fig. 1, the methodology to generate scenario-dependent channel samples is split into four steps.

The first step consists in defining the real geographical area that will be considered. The area is usually defined by two longitudes and latitudes, called bounding box. In this work, we have considered the Open street map (OSM), which is an online free map that gives you the bounding box of a selected area and other related data[1].

The second step consists in generating a three-dimensional (3D) model of the area selected in the first step. For this, we use the Blender Software[2]. Among other features, Blender is able to render a 3D model of a given geographical area. The necessary data to render the area is extracted from the files provided by the OSM.

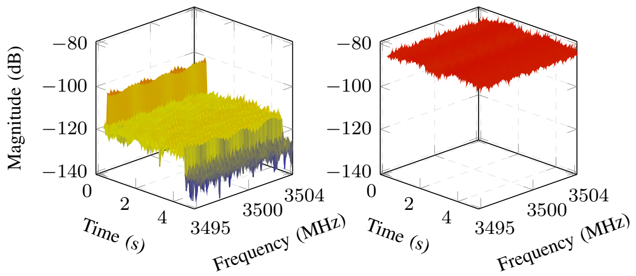
In the third step, we generate a dataset with the coordinates of mobile UEs along the simulation time interval. For this, the bounding box defined in the first step is used as input of the SUMO Software [4]. This software is an open source traffic simulator. It allows us to combine in the imported scenario different nodes, e.g., cars, trains, bicycles, pedestrians, etc. It even takes into account traffic light schedules.

Finally, in the last step, we use Sionna [5] to generate the channel impulse response between all pairs of Tx and receiver (Rx) in the considered scenario. Specifically, the 3D scenario created with Blender and the UEs trajectory created with SUMO are used to generate propagation paths with RT

[1] www.openstreetmap.org
[2] www.blender.org

(a) 2D view. (b) 3D view - Ray tracing from the BS point of view.

Fig. 2: Scenario used in the simulation.



(a) Link BS-UE. (b) Link UAV-UE.

Fig. 3: Time and frequency channel response.

between Txs and Rxs. Based on these propagation paths, the channel impulse response is calculated.

III. Performance Evaluation

In this section, we present computational results obtained by evaluating the methodology presented in the previous section.

As illustrated in Fig. 2, we considered an urban area located at the city of Fortaleza in Brazil. We have considered the real coordinates of an operator base station (BS) obtained from the Anatel website[3]. The BS antenna was deployed at the rooftop of a building and a UE was considered to be moving in a street nearby (movement direction illustrated by the red arrow in Fig. 2a). At the same street, we considered another BS mounted on an unmanned aerial vehicle (UAV), which was wireless serviced on the backhaul by the fixed BS.

In Fig. 2b, we can see some of the rays (black lines) propagating from the fixed BS toward the UE and the UAV-mounted BS. Notice in this figure that, for a short period of time, the link between the fixed BS and the UE had line of sight (LOS), with rays passing among the buildings. Other rays departed in other directions and arrived at the Rxs after propagation effects, e.g., reflection and diffraction.

The modeled system operated at a carrier frequency of 3.5 GHz with a total bandwidth of 10 MHz. The subcarrier spacing was considered 15 kHz. Fig. 3 presents the channel time-frequency response for the links BS-UE and UAV-UE. Since the UAV was closer to the UE and had LOS during the whole simulation, this link was stronger than the other. In Fig. 3a, we can see that the channel gain of the link BS-UE is mainly low, with a few instants with high values. The peaks in the channel frequency response in Fig. 3a are due to the presence of LOS when UE, BS and the hole between the buildings are aligned.

[3]https://informacoes.anatel.gov.br/paineis/infraestrutura/cobertura-movel

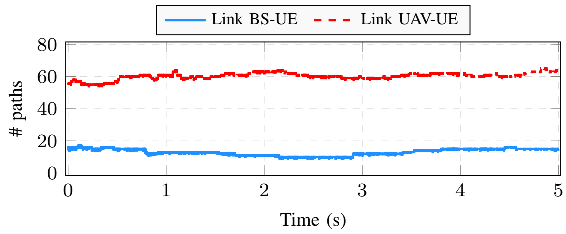


Fig. 4: Number of paths arriving at the receiver.

Fig. 4 illustrates the number of RT paths propagating parting from the BS and the UAV and received by the UE. Notice that this metric varied along the simulation, which highlights the difference between a stochastic channel and a channel generated with RT. Stochastic channels usually consider a fixed number of clusters and a fixed number of scatters (rays) per cluster.

Other metrics were also evaluated to compare the stochastic channel with the RT-based one. For example, the channel coherence bandwidth and its coherence time also varied, differently of a statistical channel model.

IV. Conclusions and Further Perspectives

The present work presented a methodology for generating channel samples based on RT and performed a performance evaluation to illustrate the applicability of the methodology. As we showed, the generation of channel samples with RT based channel samples allows to consider the physical scenario specificities, in opposition to statistical methods used for channel dataset generation.

As a future work, we will generate new channel datasets for specific areas and considering real position of operators' transmitters. These datasets will be used as input in a link-level simulator to evaluate the system performance of proposed solutions on 6G related topics.

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