A Study on UI based Channel Simulator for Indoor LED Communication

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Abstract

In this paper, the simulator for LED communication channel in indoor was studied. Indoor circumstance was supposed that the shape was hexahedron type and LEDs were located on the ceiling and receiver could be located anywhere. Simulator UI was designed so that upper considered parameters could be easily set. Channel characteristics was composed of LOS(Line Of Sight) and NLOS(Non LOS) LED signal which navigated through indoor after starting at LEDs. Finally channel characteristics which was delay time and attenuated power of received signal was saved as a text file and the result graph was displayed after post-processing.

Keywords: *LED, communication, simulator*

1. Introduction

LED lightning is a rising hot topic because it has excellent energy efficiency and it can be concurrently used as a communication medium [1-3]. Actually LED is a semiconductor so its lightning intensity can be adjusted as fast. LED communication can be applied at indoor where natural optical noise like sunlight does not affect on LED optical signal. Although many study have been performed to investigate LED channel characteristics [4], it is hard to say that these articles can cover every indoor circumstance. So I am going to suggest to use optimal channel characteristics created by channel simulator whose parameter can be set when needed. In chapter 2, LED communication circumstance of simulator will be shown and in chapter 3, simulator design, sequence diagram and example result will be shown and in chapter 4, finally conclusion will be written.

2. LED Communication Circumstance

Indoor was supposed as a hexahedron place and LEDs were can be located on the ceiling and receiver could be located at any position, which was painted as Figure 1. The number of LED was up to three and their data was supposed as same because different data stream could affect their signal. It can be thought as a multiple transmission system. Photons emitted from LEDs were moved within indoor and reflected by walls and finally reached on receiver or diminished out. If signal reached

on receiver, it undergo time delay and power attenuation, which was represented at Equation 1. S(t), one of LED photons, was delayed as and attenuated as. If we applied this routine to whole photons, it could be expressed as Equation 2. Finally h(t) was extended regarding whole LEDs, which was expressed as Equation 3.

Attenuated and delayed optical signal affected adjacent signal which degrade communication performance and reliability.

$$h(t) = \alpha S(t - \sigma) \tag{1}$$

$$h(t) = \sum_{j} \alpha_j S_j (t - \sigma_j) \tag{2}$$

$$h_{AllLEDs}(t) = \sum_{LED=1}^{3} \left(h_{LED}(t) \right)$$

$$h_{AllLEDs}(t) = \sum_{i=1}^{3} \left(\sum_{i,j} \alpha_{i,j} S_{i,j} (t - \sigma_{i,j}) \right) \tag{3}$$

3. Channel Simulator of Indoor LED Communication

3.1. User Interface

Simulator's User Interface was designed like Figure 2, which consists of Indoor size, LED position, LED power, FOV(Field Of View), Receiver Coverage, Receiver position, PD(Photodiode) size, Propagation, Grid resolution and Reflection. Using these parameters, any hexahedron space based LED communication circumstance could be represented. The number of LED can be 1~3 and receiver area can be selected one point(Spot) or Range. If user choose Range, loop will be run for calculating many receiver spots. LOS, NLOS propagation parameter can be selected in propagation section, if Both is selected LOS, NLOS signal are considered when calculating. Grid resolution means the span of latticed coordinate, if it is small, the number of path would be high. Regarding reflection, normal concrete wall and glass wall can be selected, at this time, the reflection rate is different. Glass wall position should be checked in order to apply glass wall.

3.2. Module Sequence Diagram

Simulator was composed of four module blocks which are Init module, Check module, Simulation module and Calculation module. In Init module, variable initialization is performed and input parameter's validity is checked. In Check module receiver coverage is checked, if the value is range, loop will be run in order to cover all receiver spots. In Simulation module, photons emitted from LEDs are proceeded, if photons meet receiver, the delay time and attenuation are saved at text file. In Calculation module, each photon's moving is simulated via navigation route. Sequence diagram of this program is as Figure 2.

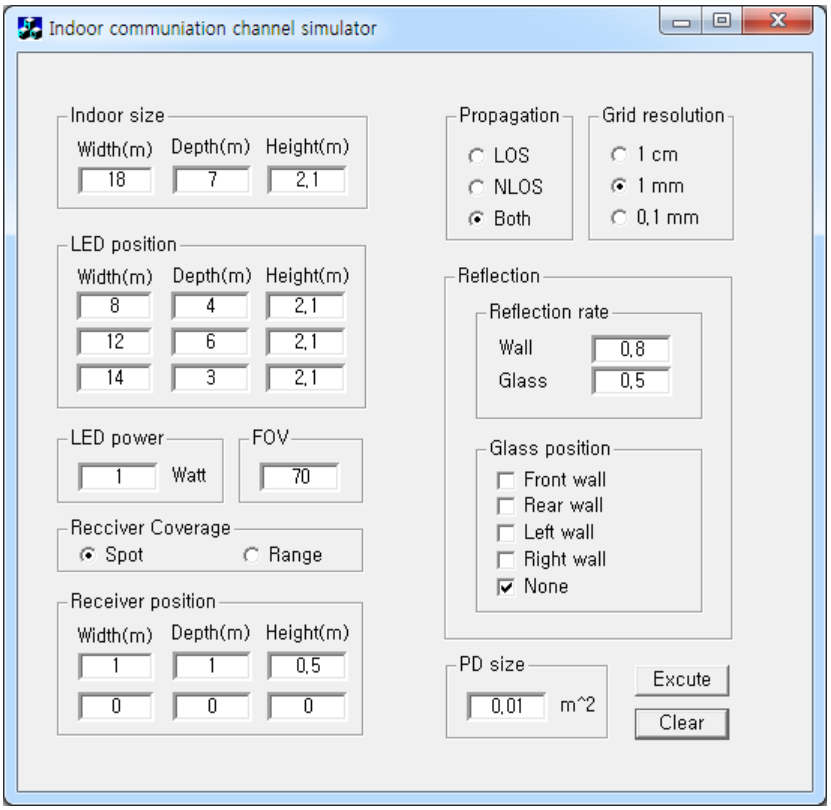

Figure 1. User Interface of Simulator

3.3. Execution of Simulator

In this chapter, channel simulation was performed to check the validity of simulator and the simulator parameter are shown in Table 1. Width, depth and height of Indoor was 18, 7, 2.1m and 3-LEDs are located on the ceiling. PD was located 50cm above of the bottom and FOV(Field of View) was 70 degree. The reflection coefficient of wall was supposed as 0.8.

Table 1. Channel Simulation Parameters of LED Communication in Indoor

Items	Values
Indoor size	18/7/2.1m(W/D/H)
LED Position	LED1: 8/4/2.1m(W/D/H)
	LED2: 12/6/2.1m(W/D/H)
	LED3: 14/3/2.1m(W/D/H)
PD position	1/1/0.5m(W/D/H)
FOV	70 º
Wall reflection Coefficient	0.8

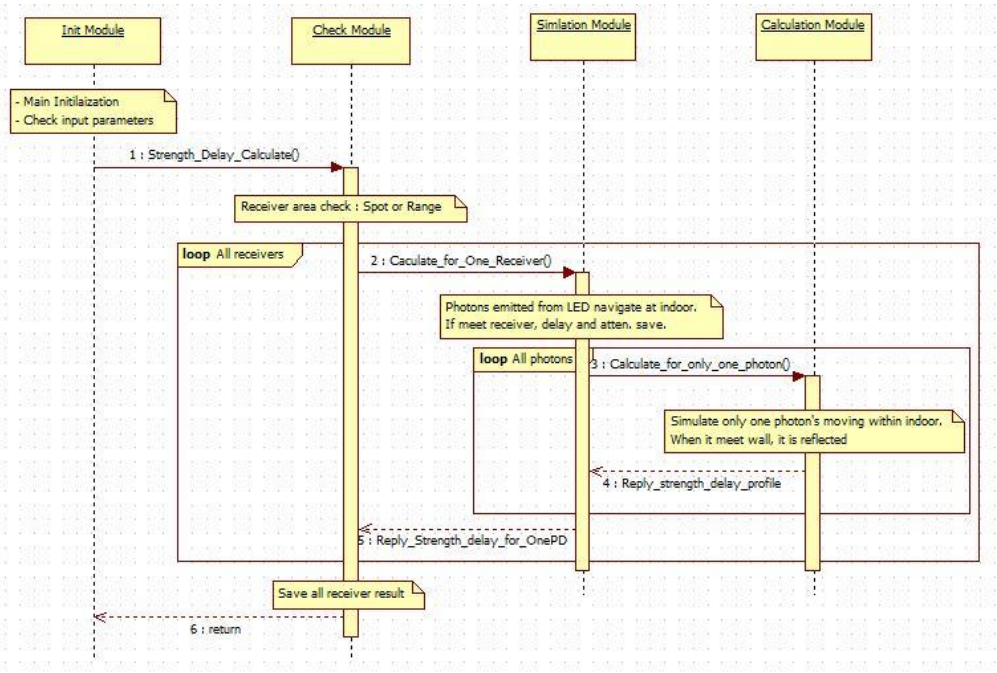

Figure 2. Module Sequence Diagram

The received signal from each LEDs was painted in Figure 3 and this can be characterized with delay time and attenuated signal strength. PD could receive LOS signal from LED1 and receive NLOS signal from other LEDs. LED1's signal was received from 30ns to 160ns and its strength was from 394e-14W to 1.27e-14W. LED2's signal was received from 44ns to 175ns and its strength was from 143e-14W to 1e-14W. LED3's signal was received from 48ns to 177ns and its strength was from 116e-14W to 0.9e-14W.

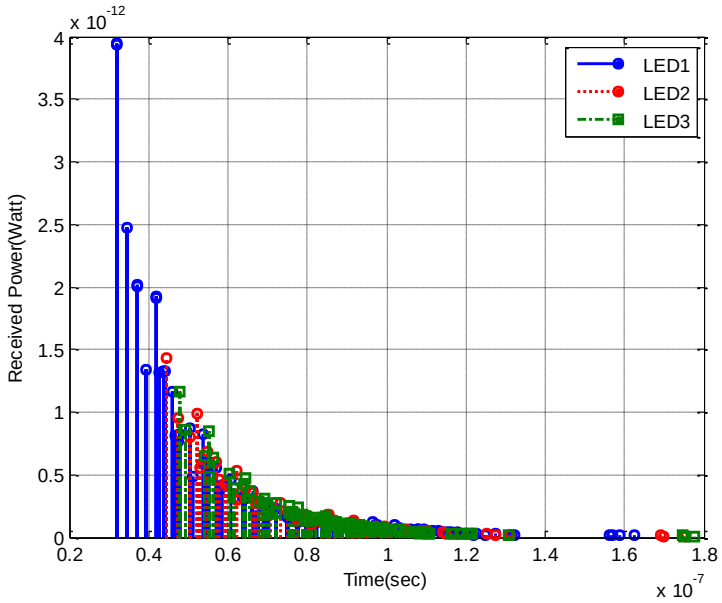

Figure 3. Impulse Response on PD

4. Conclusion

In this paper, channel simulator for LED communication was studied. Simulator was designed to support any hexahedron based place and kept track of LED photons. Finally their moving was characterized as a channel and this paper shown the simulator's the validity via actual example. This paper will be a reference for channel simulation.

Acknowledgements

This work has been supported partially by 'Broadcasting-Communications R&D Program' of Korea Communications Commission/Korea Communications Agency (No. 11911-01111).

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