Performance Analysis of Indoor Communication System Using Off-the-Shelf LEDs With Human Blockages

Jaiklen Singh, Puneet Kumar, Harshit IIITD

Mentor - Anand Singh

Indraprastha Institute of Information Technology Delhi,New Delhi 110020,India

ABSTRACT **(Some information might changes according to results)**

In this report we analyze the downlink performance of an indoor visible light communication(VLC) system with human blockages with the use of geometry model-based approach. The system performance is analyzed for a regular placement of light emitting diodes(LEDs) in the circular configuration. The analysis is divided into two parts. In the first part we analyze the performance of LEDs placement configuration with multiple radii and with 5x5x5 & 10x10x5 room dimensions further we compared it with 4 and 8 LEDs configuration with the predefined power constraint. Then we extend it with the static human blockages and conclude that at the higher density of human blockages gives low total average received power and the 4-LEDs configuration outperformed the 8-LED configuration. So the proposed analysis will be useful for designing a VLC based indoor communication system where designers can switch between these two configurations depending on the number of blockages and room dimension.

INDEX TERMS: Visible light communication (VLC), human blockage, matern hardcore point process (MHCP), random waypoint model (RWP).

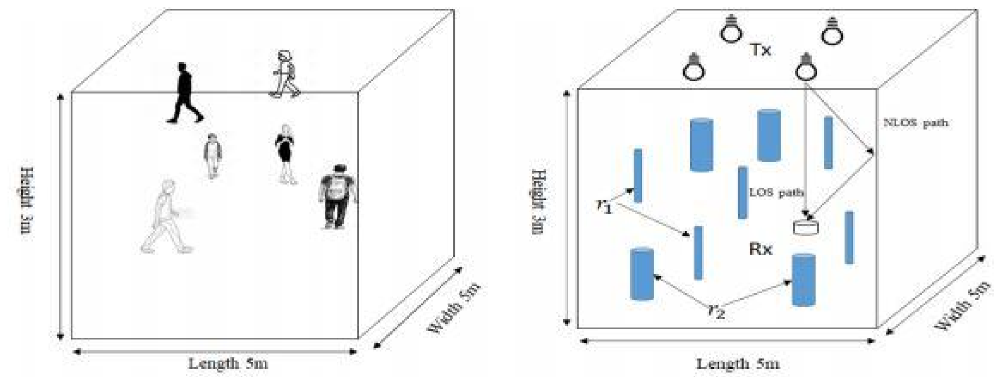
INTRODUCTION

- Related Work
- Contribution and Outline

SYSTEM MODEL

As mentioned before, we consider two scenarios of 4 and 8 LEDs in the circular configuration in 5m x 5m x 5m and 10m x 10m x 5m room. The receiver plane is assumed to be 0.85m above the floor and both LoS and NLos paths are considered. The receiver plane is divided into 25 x 25 and 100 x 100 grids for 5x5x5 and 10x10x5 dimensions respectively, which cover the whole room for the analysis. We have used the Matern type-II process to distribute the location of static blockages in the plane with an intensity (λ_B). The blockages are assumed to be cylindrical with height (h_B) and radius (r) as shown in Fig. 1(a).

For the proposed system model, we consider two types of blockages having radius r1 and r2, which are equivalent to varying sizes of humans.



(a) Human blockage inside the room.
(b) Human blockages modeled as a cylinder.

FIGURE 1. System Model.

In the following subsections, we discuss in detail the VLC channel and the spatial model of human blockages.

A . VLC Channel Model

Lambert radiator is a typical radiation model that can model LED light sources in VLC. Radiation pattern of a few commercially available LEDs are assumed to be Lambertian. It has also been pointed out in, that the Lambertian model can accurately reproduce the LoS and NLoS luminous intensity pattern of the phosphor-coated multi-chip LEDs, the batwing LEDs, or the side-emitting LEDs.

- Spatial Model

CHARACTERIZATION OF STATIC HUMAN BLOCKAGES USING MHCP

- **INTENSITY OF HOMOGENEOUS BLOCKAGES USING MHCP**

  In this part, we use the poisson point process for generating human blockages in a 2-D plane. Each human blockage is generated randomly and if the mark is repeated for human blockage then a random point is deleted from the parent poisson process within the hardcore distance of δ.

  $\lambda_{B1} = (1 - \exp \lambda_p * \pi\delta^2)/ \pi\delta^2$, where λ_p is the intensity of the parent point process

  The connection between two hubs situated at a distance d_B from one another is obstructed if a component of point measure falls in the shadow area of the blockage. The probability that the center of one blocking object falls in the shaded area is given by $P_B(d) = 1 - \exp(-2\lambda_{B1} d_B r_B^2)$, where λ_{B1} is the blockage intensity and r_B is the blockage radius.

- **INTENSITY CALCULATION OF HETEROGENEOUS BLOCKAGES USING MHCP**

  This subsection has portrayed the heterogeneous blockage measure with radius r_1 and r_2 utilizing MHCP. The blockages inside the room have been displayed in two stages. In the initial step, the focuses with fixed radius r_1 and r_2 are produced and the individual weights are $W_1(r_1)$ and $W_1(r_2)$.

In the second step, A point is kept in the event that it has a higher weight in all pairwise correlations. Given a couple of blockages focuses [x1;r1], [x2;r2] ∈ , we give point independent weights, $W1(r1)$ and $W2(r2)$ separately for radius r1 and r2, for the proposed model ($r1 < r2$), therefore ($W1 < W2$). If the respective cylinder intersects then the point with the lower weight is eliminated, and the point with the higher weight will be held.

$Pretain(r) = E \ \ exp\ −λPπr\ 2 \ \ ∞\ 0\ \{P(W1(r) ≤ W2(y)\} × (r + y)\ 2Fpr(dy)$: (**expression in wrong format)**

Therefore, we can modify our retaining probability for $E[P(W1(r) ≤ W2(y))] = 1\ (r ≤ y)$, where $W1(r)$ and $W2(y)$ are independent weights and Fpr is the distribution of radius before thinning.

$Pretain(r) = exp\ −λPπr\ 2 \ \ ∞\ r\ (r + y)\ 2Fpr(dy)$

Now, we consider the probability of blockage P1 and P2 with respective radius r1 and r2. Therefore, retaining probability of blockage radius r1 and r2 can be expressed as:

$Pretain(r1) = P2(9P1 + 16P2)\ P1(4P1 + 9P2)\ −1 + P2(9P1 + 16P2)\ −1$

$Pretain(r2) = P1(4P1 + 9P2)\ P1(4P1 + 9P2)\ −1 + P2(9P1 + 16P2)\ −1$

The intensity of thinned point process with retaining probability Pretain(r) is given by:

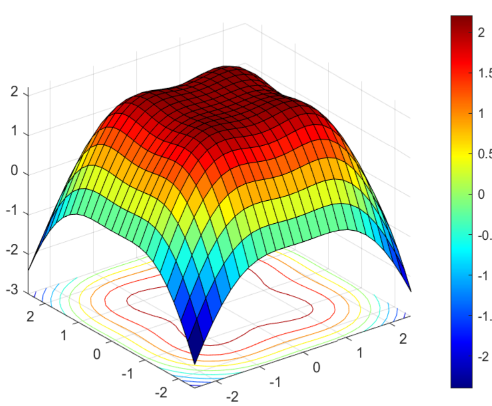
$λth = λPPretain(r)$

RESULT AND DISCUSSION

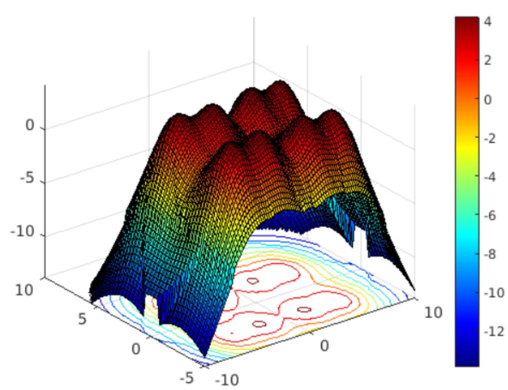
- 4 and 8 LEDs configuration with room dimension 5x5x5 and 10x10x5
  - With changing radii of circular radius.
- Average received power versus blockage density with above combinations.

SIMULATION RESULTS

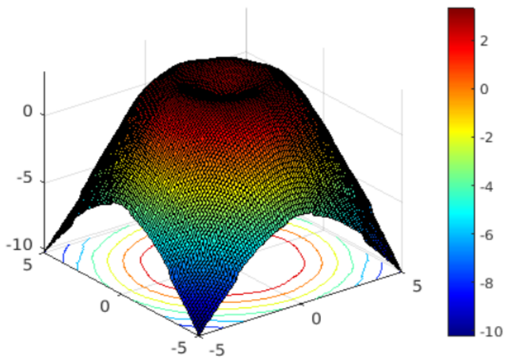
Rectangular (5x5x3, 4 LEDs)



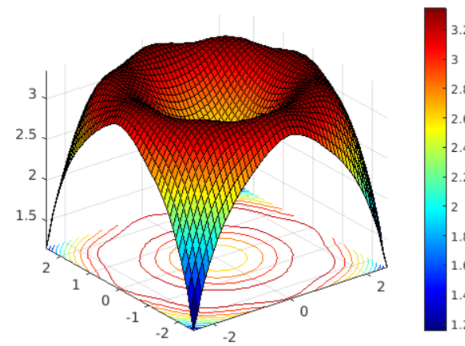
Rectangular (10x10x3, 8 LEDs)



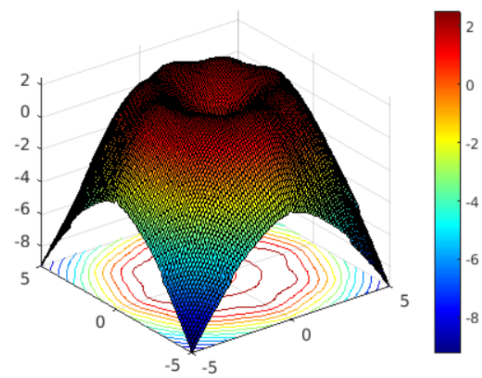
Circular (r=2.5, 10x10x3, 8 LEDs)



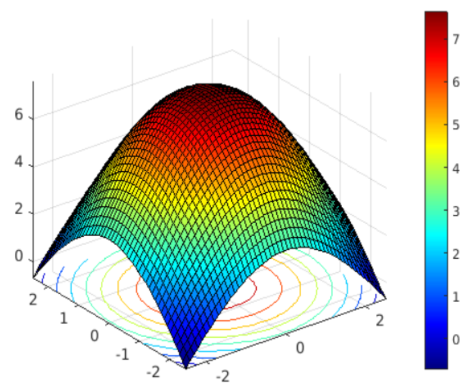
Circular (r=2.5, 5x5x3, 8 LEDs)



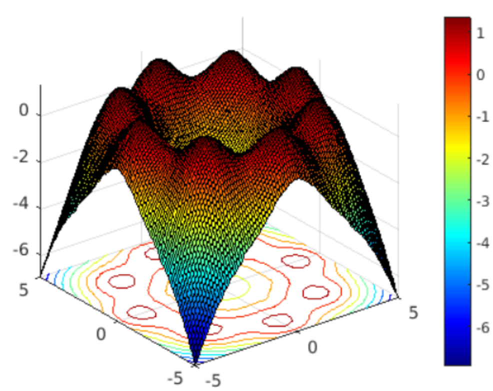
Circular (r=3, 10x10x3, 8 LEDs)



Circular (r=1, 5x5x3, 8 LEDs)

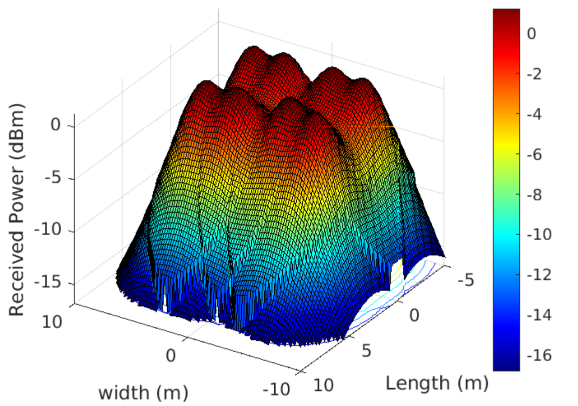


Circular (r=4, 10x10x3, 8 LEDs)

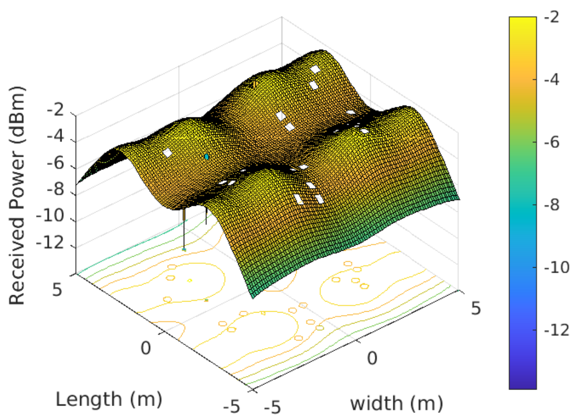


SIMULATION RESULTS FOR RECTANGULAR PLACEMENT OF LEDs WITH DIMENSION (10x10x3, 8 LEDs)

WITHOUT HUMAN BLOCKAGES

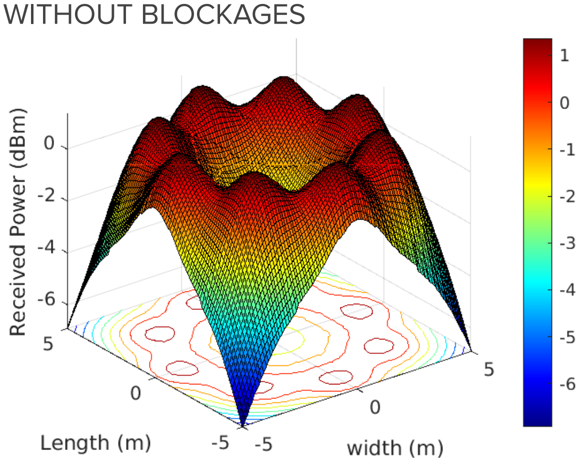


WITH HUMAN BLOCKAGES

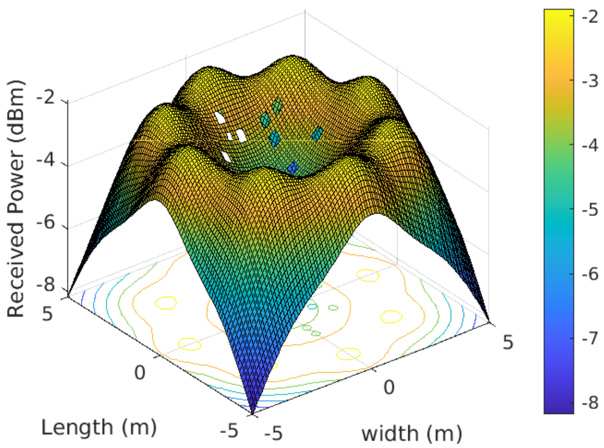


SIMULATION RESULTS FOR CIRCULAR PLACEMENT OF LEDs WITH DIMENSION (r=4, 10x10x3, 8 LEDs)

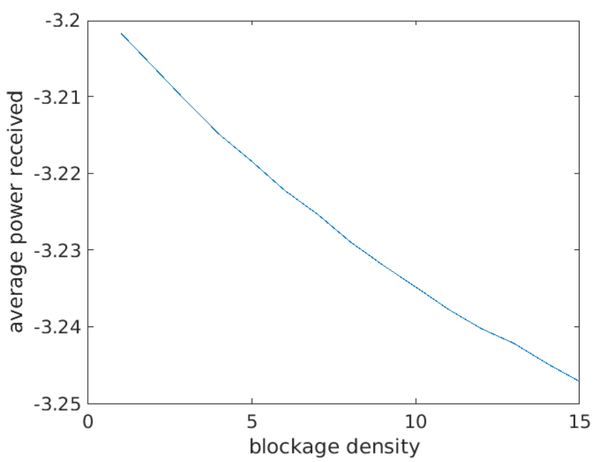
WITHOUT BLOCKAGES



WITH HUMAN BLOCKAGES



MEAN POWER FOR HUMAN BLOCKAGES



CONCLUSION

In this article, We analyze the performance of an indoor VLC system with static human blockages using the MHCP model. We have also calculated the blockage intensity profile for homogeneous and heterogeneous blockage density. We plot the analytical results with blockage density versus total average received power with 4 and 8 LEDs configuration. It can be observed that the received power decreases as the human blockages' width increases for different blockage densities.However, for lower number human blockage, the reduction is more as compared to higher human number blockage. We conclude that 8-LEDs configuration shows better performance as compared to 4-LEDs configuration for the higher number of blockages at the same amount of total power from transmitting LEDs.