An Optical Wireless Receiver using a Hemispherical Lens for MIMO Visible Light Communications Systems

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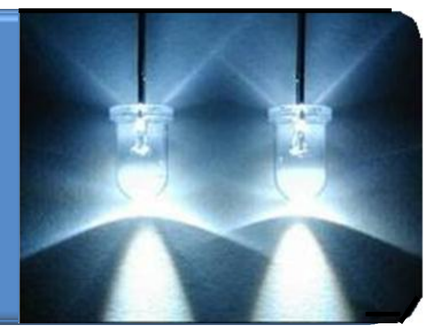
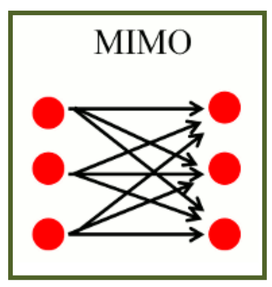
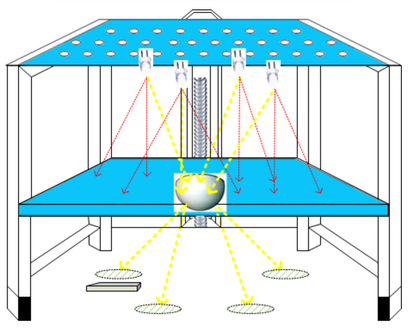


Background

White lighting LEDs are fast replacing conventional lighting because not only are they **energy efficient** light sources but also can be modulated at frequencies up to 20MHz for **high-speed** wireless communication, especially for **indoor applications**. Moreover, using visible light as the source for multiple-input multiple output (**MIMO**) communication systems prevents interferences between rooms as light cannot pass through opaque barriers. However, there is the lack of **diversity** (separation amongst the received signals) in the receivers and using **hemispherical lens** can achieve diversity in MIMO communications.

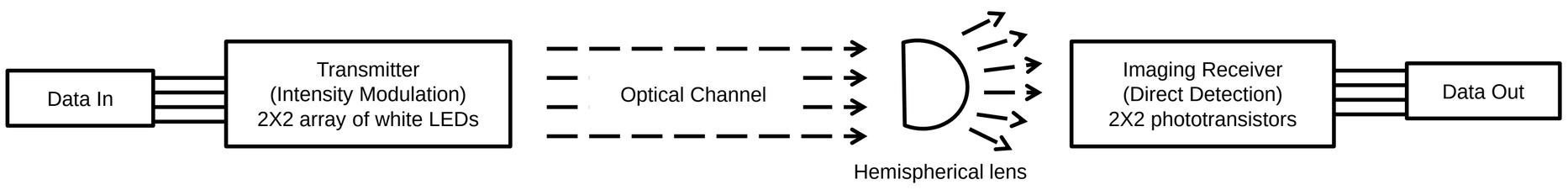


System Design



System Description

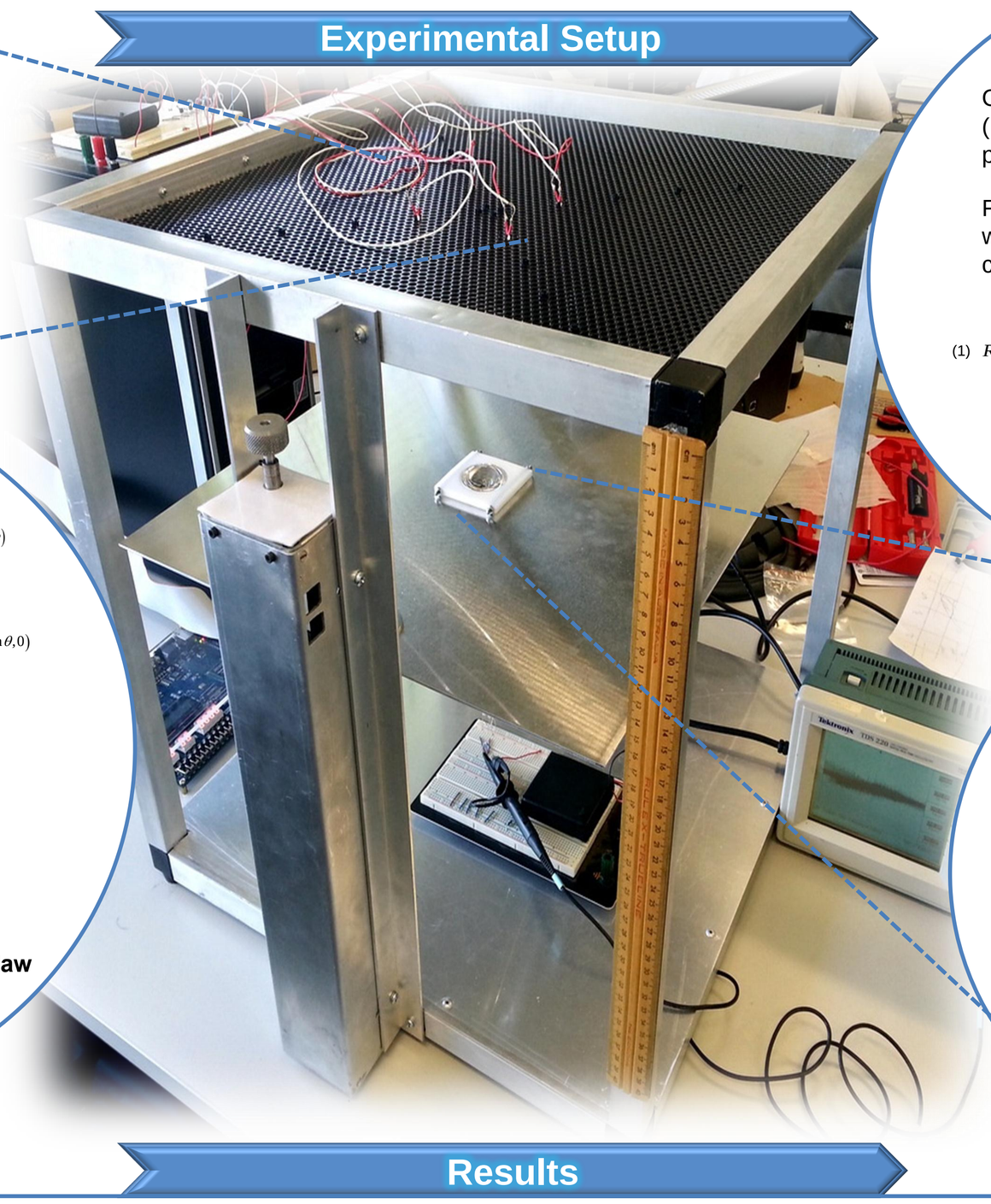
Optical signals transmitted from a 2x2 array of white LEDs transmit optical signals refract through the hemispherical lens and received by a 2x2 array of phototransistors. Height of the hemispherical lens can be adjusted which enables observations of varying spread of light patterns. Opaque barrier helps to prevent the non-LOS component light rays from passing through the hemispherical lens.



Applications

High-speed, secure, wireless communication and data transmission in indoor environments by using **ceiling mounted** white lighting LEDs

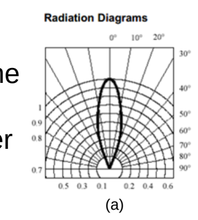
Experimental Setup



Radiation Pattern

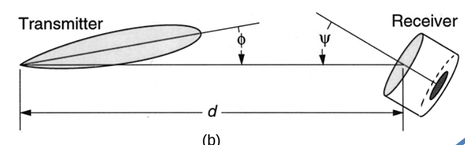
Generalized Lambertian radiant intensity (1) is used to find the received optical power in the simulations.[1]

Figure (a) radiation property of the white LED used (b) diagram of calculating received optical power



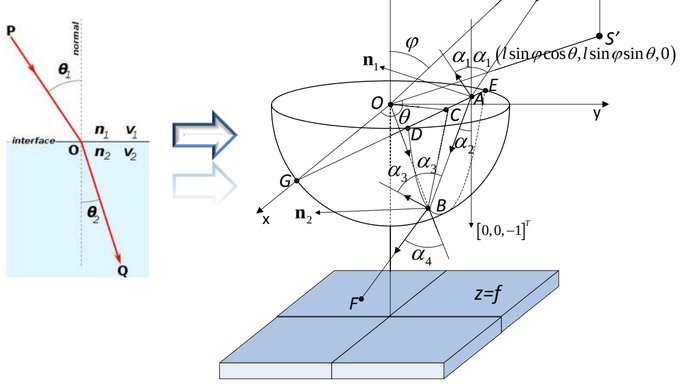
(a)

(1) $R_o(\phi) = \frac{(m+1)}{2\pi}\cos^m\phi$ where $m = -\ln 2 / \ln(\cos\Phi_{1/2})$



(b)

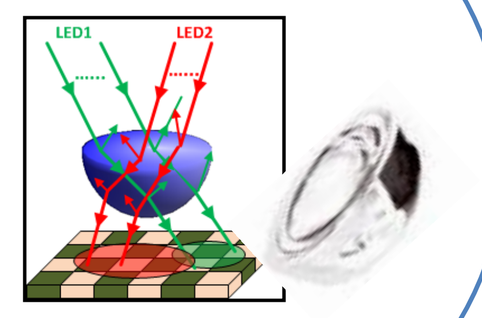
Ray Tracing Technique



Direction of the light rays are governed by **Snell's law**

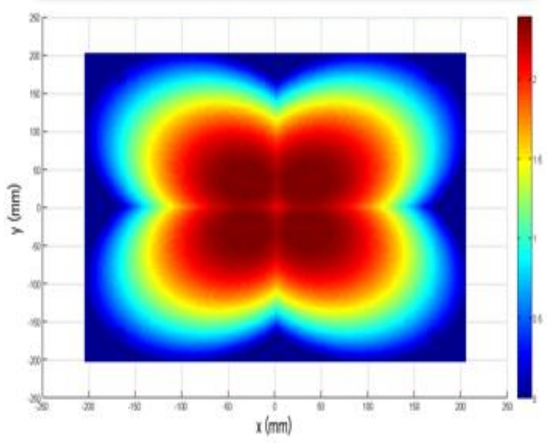
$$n_1 \sin\alpha_1 = n_2 \sin\alpha_2$$

Achieving diversity in MIMO communication using hemispherical lens



Results

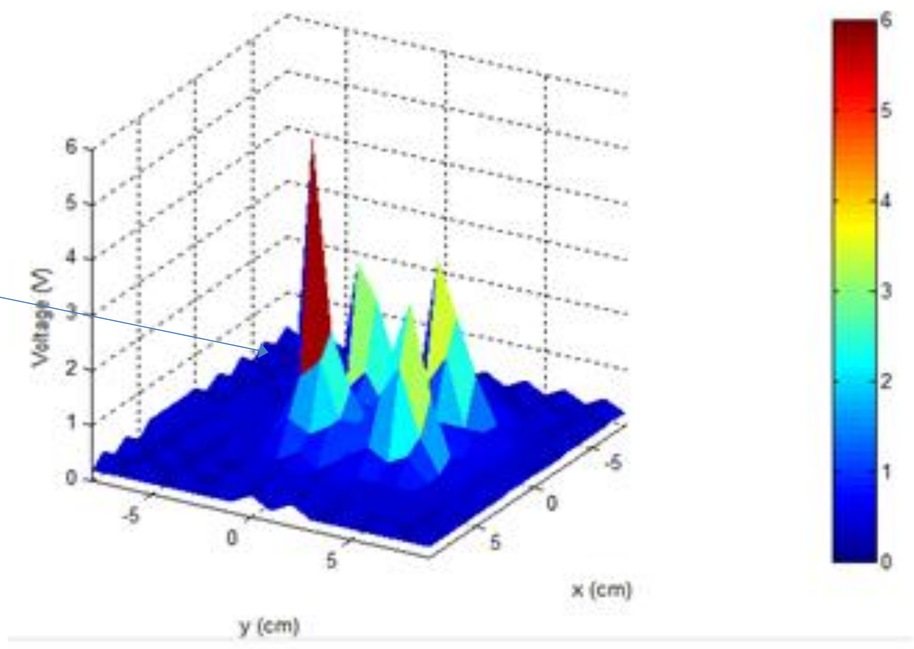
Photograph taken at the experimental setup shows the diversity projected onto the array of receivers.



Theoretical image obtained through the simulation models.

→ Experimental results match the simulations.

Experiments show that diversity is achieved as there are four distinctive peak optical signals received from the array of phototransistors



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