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TO ENHANCE THE POWER RATIO OF OPTICAL WIRELESS CHANNEL USING DIFFUSED TECHNOLOGY

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ABSTRACT

The spot-diffusing technique provides better performance compared to conventional diffuse system for indoor opti-cal-wireless communication (OWC) system. Optical wireless communication represents an emerging and dynamic research and development area that has generated a vast number of interesting solutions to very complicated communication challenges. For example, high data rate, high capacity and minimum interference links for short-range communication, inter-building communication or computer to computer network. In its many applications, optical wireless communication links have succeeded in becoming a part of everyday lives at homes and offices. Optical wireless products are already well familiar, ranging from visible-light communication (VLC), television remote control to infrared data association (IrDA) ports. Optical wireless is also widely available on personal computers, peripherals, embedded systems and devices of all types [1]. Obviously, the data rate, quality of service delivered, and transceiver technologies employed have improved greatly from those early optical wireless technologies, but light emitting diode which acts as optical wireless transmitter has raise fall period which restricts the data rate progress of optical wireless systems and bandwidth exploitation. In this paper, a proposed modulation scheme named interval shift key modulation (ISKM) is introduced to enhance the utilisation of huge bandwidth of optical wireless communication (OWC). MAT Lab is used to build a code to measure the data rate, spectral efficiency and bit error rate which directly related to the performance of OWC. Simulation results are obtained and found in a good agreement with those presented in state of arts.

I. INTRODUCTION

With the increasing development of ultra-broadband wireless application the radio frequency (RF) spectrum became congested and scare resources. Thus optical wireless communication (OWC) has drawn considerable attention to the researchers. OWC for indoor application was first proposed by Gfeller and Bapst [1]. In number of applications where higher data throughputs is more of requirement than the mobility, transmission link based on optical wireless would be one of the best options as out-lined in [2-5]. The performance of OW systems depends on the propagation and type of system used. The basic system types fall into diffuse or line of sight (LOS) sys-tems. In LOS systems, high data rates in the order of Gbit/s can be achieved [6], but the system is

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vulnerable to blockage/shadowing because of its directionality. In a diffuse OW system, several paths from source to receiver exist, which makes the system robust to blockage/ shadowing. However, the path losses are high and multi- paths create inter-symbol interference (ISI) which limits the achievable data rate [7,8]. There are several advan-tages of OWC over traditional RF systems, these are: an abundant free spectrum, extremely high communication speed is possible by all network, does not interfere with the over congested RF spectrum. But limitations are: a beam is short ranged, may be harmful for eye. The first limitation can be overcome by wavelength reuse tech-nique, whereas eye safety can be ensured by maximum transmit power. It can be classified as line of sight (LOS) and diffuse system. Many researchers have considered diffuse systems for indoor applications it offers robust link and overcomes the problem of shadowing [7], does not require transmitter-receiver alignment and uses the wall or ceiling for multi path reflection [8]. The multi-path reflections increases delay spread or inter-symbol interference. Ambient light such as florescent, incandes-cent light and Compact Florescent Lamp (CFLs) pro-duces channel noise which reduces signal-to-noise plus interference rat o (SNIR). In order to improve the system performance several spot diffusion configuration using multi beam transmitter have been proposed [9]. Multi beam transmitter is place in center of the room and pointed upward. A multi-spot pattern have been gener-ated, illuminated multiple small areas in the ceiling and then reflected multiple spot have been received by re-ceivers. In [10], to improve the bandwidth, reduce the effect of inter-symbol interference, and increase the sig-nal to noise ratio (SNR) when the transmitter operates at a higher data rate under the impact of multipath disper-sion, background noise, and mobility in conjunction with an imaging receiver. It proposed different line streaming multi-beam spot diffusion (LSMS) model to gain about 32.3 dB SNR at worst communication path. But the multi path dispersion reduces the performances due to trans-mitter power and can be improve using power adaptive system by [9]. User mobility is very important aspect of wireless communication especially with today's hand hold devices. As the user device can mobilize with the room then power adaptation will be a great solution to get higher SNR. In this aspect [12] propose a genetic algorithm for multi spot diffuse system in indoor wireless communication. But it is noted from different research that if the diffuse system has a predefined spot for a room calculation.

II. SIGNAL TO NOISE PLUS INTERFERENCE RATIO

In indoor optical-wireless communication, the ambient light affects signal-to-noise-plus interference (SNIR) at the receiver. Many researchers have considered intensity modulation with direct detection (IM/DD) as most viable approximation. The received signal, denoted by *y(t)*, can be expressed as

$y(t)\ R_x(t)\ h(t,,)\ n(t,,)\ I(t,,)$ (1) where, R is the receiver responsively , $x(t)$ is the instantaneous optical transmitted power, $h(t,,)$ is the impulse response of the OW channel, $n(t,,)$ is the ambient light noise, $I(t,,)$ is the instantaneous interference power.

The SNIR, denoted by, of the received signal can be calculated by [9]

$$R^2\ (P_{s1}\ P_{s0})h^2 \quad (2)$$

where, P_{s1} and P_{s0} are the optical power associated with the binary 1 and binary 0 respectively, $_{s1}$ are $_{s0}$ are the shot noise variation component with P_{s1} and P_{s0} re-spectively.

2.1 Proposed System Model

Consider an empty room with floor dimensions of 8×4 m^2 and ceiling height of 3m as shown in **Figure 1**. The reflection coefficient of the ceiling is considered to be 0.8. There are eight spot lights on the ceiling. In the Fig-ure, is the elevation angle, is the azimuth angle, $d = 8$, $w = 4$ *and* $h = 3$, x_0 and x are the position of the imag-ing receiver and v is the velocity. Neuro-Fuzzy (NF) adaptive multi-beam transmitter is located at the center

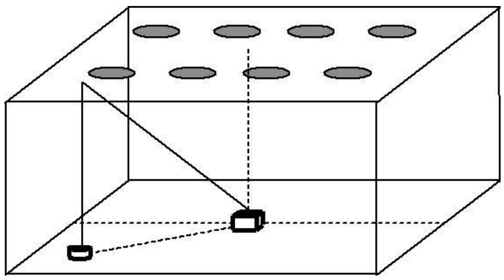


Figure 1

2.2 Delay Spread

The delay spread of an impulse is expressed as rms value by,

$$D \sqrt{\frac{(t \quad)^2 P^2_R}{P^2_r}} \qquad (9)$$

where, and t is the delay time and P is the received power

$$i \; i \qquad 1 \left| \frac{x \quad c_i}{a_i} \right|^{2b_i}$$

where, i Ai , Bi is the input vector, ai ,bi ,ci the premise parameters.

Nodes in the first hidden layer calculate the firing strength of a rule via multiplication. The output of the each node, denoted by O2 , can be written as

$$O_i^2 \quad i \quad A_i \, B_i(x) \qquad (13)$$

2.3 Doppler Shift

Light waves require no medium and being able to travel even through vacuum. Let ~~v~~ is the relative velocity between transmitter and receiver, the proper frequency of the transmitted information signal from the optical transmitter is f_0 . Let f is the frequency of the received signal accepted by the moving receiver with a velocity ~~v~~ , then

$$f \;\; f_0 \sqrt{\frac{1}{1}} \qquad (10)$$

where, ~~v~~/c-,c–is the speed of light. For low speed, i.e. 1 , the above eqn. (10) is reduced to

$$f \quad f_0 (1 \quad)^{\frac{1}{2}} \quad (11)$$
$$= f_0 (1 \quad \tfrac{1}{2}^{2})$$

2.4 ANFIS Model

NF inference system is considering if learning capabili-ties are required. In this paper, we consider the adaptive

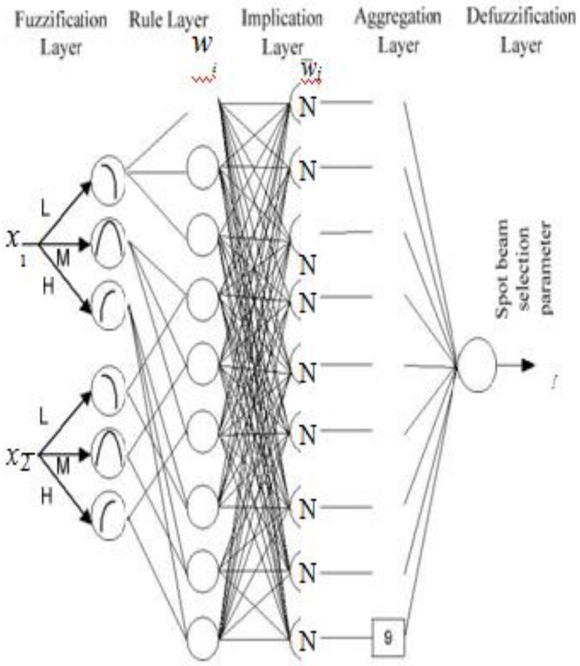


Figure 2. System Model for OWC based on spot-diffusing technique.

where, i=1,2,3 . ANFIS performs AND operation in this layer. Nodes in the second hidden layer compute the normalized value of the firing strength. The output of the each node, denoted by O_i^3 , can be written as

$$O_i^3 \quad \_{ii/i} \qquad (14)$$

Nodes in the third hidden layer compute the contribu-tion of i-th rule towards the overall output. The output of the each node, denoted by O_i^3 , can be written as

$$O_i^4 \quad \_ f_{i\ i} \quad \_ (p x \ q y \ r)_{iiii} \qquad (15)$$

Signal node in the output layer computes the overall output, denoted by O_i^5 as follows:

$$O_i^5{}_i \quad \_{i} f_{i} \qquad (16)$$

Spot hologram matrix has been generated using Eqn. (16) or matrix, H.

Step 1 A spot beam scans the ceiling, SNIR, and delay spread, for each beam have been calculated by the image receiver using Eqn (2) and (9).

Step 2 Based on the required minimum SNIR, i.e., $_{min}$ and maximum delay spread, i.e., $_{max}$, transmit-ter selects the spot-beam matrix (H) by NF controller.

Step 3 The transmitter allocates the power for each se-lected beam adaptively using Eqn (7)

Step 4 Based on Doppler shift, the transmitter adapts the beam angles and .

Step 5 Multi-spot optical transmitter further reduce the by scheduling.

Step 6 Finally, Multi-spot optical transmitter transmits the spot beam matrix to receiver via ceiling.

Step 7 Go to Step 1 if transmitter gets receiver's posi-tion update.

III ADAPTIVE SPOT-BEAM SELECTION ALGORITHM

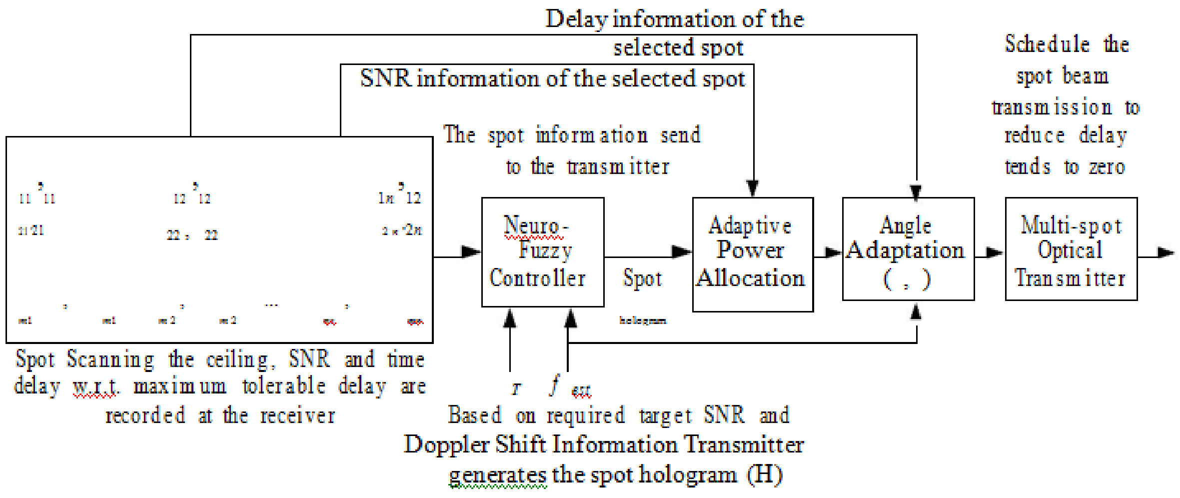
Figure 3 shows the block diagram of the adaptive spot-beam selection algorithm. In the first step the beam hologram or matrix generates 40×20 equal powered spot-beams in the ceiling. The SNIR and delay spread for each beam have been calculated by the image receiver. The receiver periodically evaluates the SNIR after 1 second interval whereas the delay spread for each beam is same if the receive is not moving. In the second step, the receiver sends the spot-beam information which con-tains SNIR and delay spread to the transmitter. Based on the minimum SNIR and maximum delay spread, trans-mitter select the spot-beam matrix by NF based algo-rithm in the third step. The transmitter allocates the power for each selected beam adaptively using eqn. (8) in the fourth step. Finally based on the velocity of movement of the receiver, transmitter moves spot-beam matrix for the receiver. The algorithm is summarized as follows:

The following algorithm will find the spot beam with an equal power allocation over 40 × 20 beam hologram

IV. NUMERICAL ANALYSIS

In this section, Neuro-Fuzzy based multi-beam system (NFMS) is investigated with diversity receiver configuration. It is compared with other spot-beam diffusion method. The ANFIS model, adaptive power allocation and multi-spot diffuse pattern formation are implemented in MATLAB/SIMULINK. ANFIS consider two inputs such as SNR and delay.

Simulation parameters considered for the analysis are: length, width and height of the room are 8m, 4m and 3 m; the reflection coefficient of the ceiling is 0.8 ; there is one transmitter which is located at (2, 4, 1) location; there is also one receiver; the area, acceptance semi-an-gle of the each photo-diode are 2 cm^2 and 65^0 respec-tively. The number of pixel at the receiver is 200 (with area of 0.01 cm^2) Pedestrians move typically at the speed of 1 m/s. If the SNIR is computed after 10 *s* ; there are 8 spots lamp in the room which are located at (1,1,1), (1,3,1), (1,5,1),(1,7,1),(3,1,1), (3,3,1), (3,5,1), and (3,7,1); and the wavelength of the light is 850 nm.



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The 80 ms adaptation time will give overhead of 8%. Adaptation time depends on environment. Receiver computes the SNIR and delay spread and sends this in-formation via a low rate channel to the transmitter. ANFIS consider two inputs. Iterative training of the ANFIS has been done to achieve the desired output. After a predefined simulation time to obtain the simulation result and use them to train. Based on the training data set, ANFIS.

Figure (a) and figure (b) shows the effect of receiver position on the SNIR for proposed model, line strip multi-spot diffuse system (LSMS) and conventional diffuse system. The SNR calculations were performed for the receiver is moving towards the transmitter (i.e., the values of *x* is increasing) while neglecting the movement along *y-axis*. Significant SNIR improvement of almost 3 dB is ob-served as the NFC moves the spot beam, selects the best positioned spot only, and allocate the power adaptively based on the channel condition of the selected slots. It is also found that the SNIR performances have been de-graded as the receiver is moving. This degradation in SNIR increases as the velocity of the receiver increases.

Figure(c) and figure (d) shows the SNIR for proposed model has been improved further (almost 1 dB), if we change the slot beam angle of the selected slot.

V. SIMULATION RESULTS

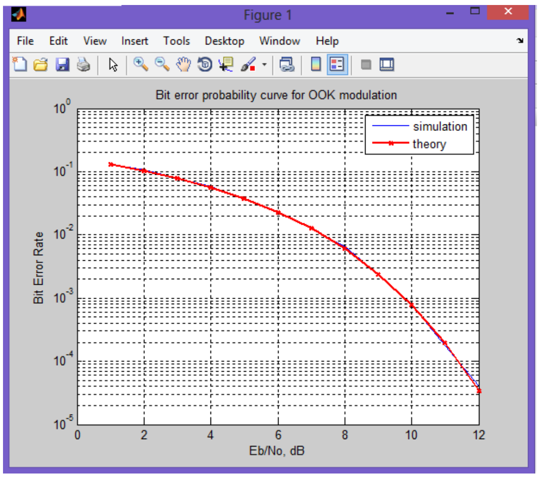

Figure a

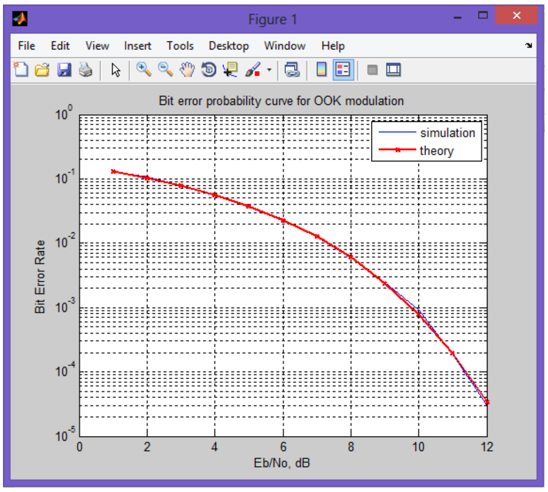

Figure b

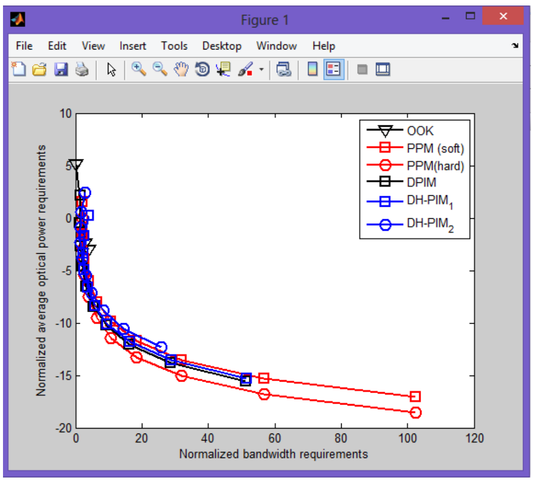

Figure c

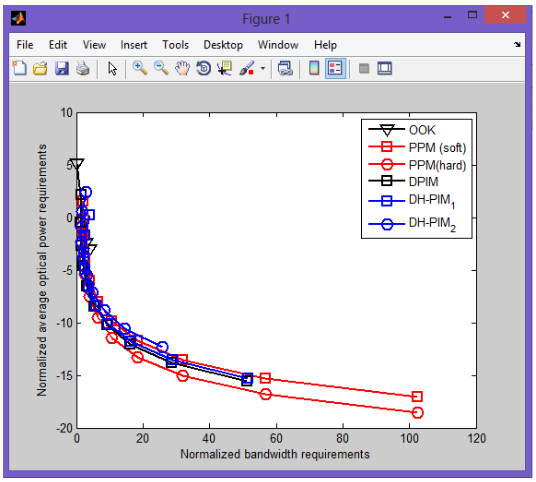

Figure d

VI. CONCLUSIONS

In this paper, we have proposed a new method of real-time beam and angle adaptation technique for optical wireless communication system using ANFIS. This NF controller has five layers and is trained with back-propagation gradient decent algorithm. The controller is trained with data obtained by simulations. Simulation results show that the proposed NF based OW spot dif-fusing communication system outperforms other spot-beam diffusion methods in terms of SNIR and delay spread.

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