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Study of SWT-ANN Based Indoor Optical Wireless Communication System

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Abstract: This work presents the concept of SWT based optical wireless communication system. It provides the concept of artificial neural network for minimizing the error on receiver side. The different types of errors are getting introduced in the system which are ISI, artificial light interference and Bit error. The main challenge faced by this work is to seek the most optimized modulation scheme that can provide maximum system throughput while capable of withstanding most if not all of the intense channel interferences at a target BER requirement. The use of SWT helps to transform received data into another form that helps to provide better BER value. The results are implemented in MATLAB and calculate the BER value.

Keywords: SWT, Wireless Communication, Artificial Neural Network, Wavelets etc.

I. INTRODUCTION

The increasing demand for bandwidth had driven researchers to explore new technologies to accommodate more data throughput over the decades. As the conventional radio frequency (RF) domain becomes heavily congested, the search for an alternative in for motion transmission medium took priority. Optical wireless communication attracted considerable attention from the academic community. Starting from short distances and low speed experimental links, the optical wireless communication domain became a viable addition to communication systems, and showed promising prospects [1].

Communication systems using electrical and electronic technology have a significant impact on modern society. Telecommunication is defined by the International Telecommunication Union as the transmission, emission or reception of any signs, signals or messages by electromagnetic systems. Wireless communication involves the transmission of information over a distance without help of wires, cables or any other forms of electrical conductors [2].

The simplest scheme of wireless communication would be to convert the speech or music to be transmitted to electric signals using a microphone, boost up the power of the signal using amplifiers and radiate the signal in space with the air of an antenna. This would constitute the transmitter. At the receiver end, one could have a pick-up antenna feeding the speech or music signal to an amplifier and a loud speaker [3.

The origin of optical wireless communication can be traced back to ancient times when fire beacons were used to transmit simple message over long distances. In comparison to RF optical wireless communication enjoyed benefits such as: lower implementation cost, higher security, unregulated spectrum and operational safety. On the other hand, the channel can be severely interfered with by background noise: shot noise induced by the background ambient light (radiation from the sun if the system operated near a window or outside) and the interference induced by artificial light sources.

In indoor optical wireless systems, laser diodes (LDs) or light emitting diodes (LEDs) are used as transmitter and photo-diodes as the receivers for optical signals. These opto-electronic devices are cheaper as compared to RF equipment as well as wire line systems. Further, IR transmission does not interfere with existing RF systems and is not governed by Federal Communications Commission (FCC) regulations. The IR signal does not penetrate walls, thus providing a degree of privacy within the office area. In addition to privacy, this feature of IR systems makes it easier to build a cell-based network [4].

For optical wireless communications systems using intensity modulation, the desired channel model depends on the intensity of the background light. In low background light, the received signal can be modelled as a Poisson process with rate $\lambda_r(t) = \lambda_s(t) + \lambda_n(t)$ where λ_s and λ_n are proportional to the instantaneous optical power of the received signal and the power of the background light, respectively. For $\lambda_n = 0$, the channel is quantum limited just like the optical fiber communication system. However, as mentioned previously, infrared transceivers usually operate in the presence of high levels of ambient light, emanating from both natural and artificial sources [5].

II. LITERATURE SURVEY

Rio Hou et. al. [2015] represents the brief survey of optical wireless systems. He explains the basic components of the optical wireless communication

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network, and explains that why optical wireless communication networks are preferred over the RF links. He explains indoor optical wireless communication systems, modulation schemes in that system [6].

Garima Saini et. al. [2014] states that higher order MIMO systems needs to be simulated and implemented along with the multicarrier modulation, is to be considered to achieve higher data rates. The hardware implementations for the source and receiver system along with their connection to the Ethernet cables, receiver mobility is to be considered as well as dimming of light to sufficient level is considered. That is done so that the connection is never lost. Indoor optical wireless communication systems offer a huge potential to provide high speed data transmission for various indoor applications like inflight entertainment, video transmission and other multimedia services [7].

Steven De lausnav et. al. [2014] describes the use of optical code division multiple access (CDMA) codes for an indoor localization system using visible light communication (VLC) VLC used intensity modulation direct detection (IM/DD). So that CDMA codes can be used as a baseband signals, which make the driving electronics less complex. When bipolar codes were used the receiver should equipped with an appropriate high pass filter (HPF) [8].

Jaria Panta et. al. [2014] proposed pre equalisation for indoor optical wireless communication systems based on asymmetrically clipped optical orthogonal frequency division multiplexing with intensity modulation and direct detection (IM/DD). Bit loading was applied to minimize the transmit optical power for a fixed target BER. Similar to pre equalization, for diffuse indoor optical wireless channel's partial equalisation can reduce the transmitted optical power over post equalization for point to point transmission [9].

Poompat saengudomlert et. al. [2014] analysed the performance of indoor optical wireless data transmissions based on the unipolar orthogonal frequency division multiplexing (OFDM). In particular it is shown that using frequency domain pre equalization can provide benefits in terms of reduction in required optical transmit power for a given desired BER from un-coded transmissions, known for its power efficiency and considered as a uni-polar modulation scheme for intensity modulation direct detection (IM/DD) [10].

Shamim Al Mamu et. al. [2013] discuss that spot diffusing scheme provides better performance as compared to the conventional diffuse system for indoor optical wireless systems. In that the performance of an optical wireless spot diffusing communication system using Neuro Fuzzy (NZ) system. Adaptive multi-beam transmitter configuration has been proposed. The multi beam transmitter generates multiple spots pointed in different directions. Hence forming a matrix of diffusing spots based on the position of the receiver and receiver mobility [11].

Hao Du et. al. [2013] provides the in depth discussion and analysis on the design and performance of MIMO system based on 2*2 indoor OOK modulation and regulated at 100kHz, 1MHz, and 10MHz bandwidth. This describes the advantages of an OOK based infrared MIMO system, through evaluating the BER performance, and making comparisons of the SISO system, the diversity and multiplexing gain process. It can be concluded that further research shall be conducted on infrared MIMO technology applications in association with issues concerning interference and background lighting [12].

III. PROPOSED IMPLEMENTATION OF SYSTEM

As we know that there are the several advantages of using the infrared links rather than RF links. But there are some design challenges in that also. That research is to minimize the error at receiver and to provide an acceptable signal to noise ratio. We know that higher order MIMO systems needs to be simulated and implemented along with the modulation schemes, is to be considered to achieve higher data rates. The hardware implementations for the source and receiver system along with their connection to the Ethernet cables, receiver mobility is to be considered as well as dimming of light to sufficient level is considered. That is done so that the connection is never lost. Indoor optical wireless communication systems offer a huge potential to provide high speed data transmission for various indoor applications like inflight entertainment, video transmission and other multimedia services. These systems are LED's as the source which can transmit and receive data by flashing light at a speed which is undetectable by the human eye. In that the deployment of optical wireless system for different applications and use of multiple transmitters and receivers (MIMO) in order to ensure low bit error rate along with high data rates.

As the demand of wireless access home networks is increase day by day, the RF spectrum is extremely congested and thus, thus the attention is drawn towards other technologies. Indoor infrared wireless communication was first proposed by Gfeller and Bapast. The infrared channels are not without drawbacks; however in many optical wireless systems it is not easy to achieve a high signal to noise ratio (SNR) since there may be intense ambient infrared noise. This noise is due to infrared spectrum components arising from the radiation of fluorescent lamps and sunlight. In addition the artificial light is also introducing interference. To improve channel throughput, the first step is to set up the appropriate channel model. This included fully understanding the mathematical model of the channel, noise sources and error performance under each or combined interferences. This work investigates the use of artificial intelligence and wavelet analysis as the main element of the indoor optical wireless receivers. The work uses the Matlab tool for providing the effects of ISI and light interferences on receiver. This included fully understanding the mathematical model. Results presented can be used for further demonstrate the capability of PPM and OOK modulation. The analytical model and simulation results helped in confirming the feasibility of the adaptive

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modulation techniques, which can be used for the optical wireless channel. The performance of the system is analysed on bit error rate.

1. On-Off Keying (OOK)
OOK is the simplest technique to implement in wireless infrared transmission. Prior to transmission, the information is translated to a specific code such as Manchester, RZ, or NRZ codes, to get a stream of pulses. In OOK, a pulse is transmitted if the code bit is 'one' during a fixed time slot and a 'zero' is represented by the absence of the pulse during the time slot. The pulse can have different duty cycles (d). When using a duty cycle d<1, the required bandwidth is increased by a factor of 1/d while the average power requirement is decreased. This is the reason why OOK with RZ pulses is common in infrared systems.

2. Wavelet Transformation for Optical Wireless Communication
The wavelet transform has become a useful computational tool for a variety of signal and image processing applications. For example, the wavelet transform is useful for the compression of digital image les; smaller les are important for storing images using less memory and for transmitting images faster and more reliably. This Quick Study describes the wavelet transform, illustrates why it is effective for noise reduction, and briefly describes several improvements of the basic wavelet transform and basic noise reduction method used in the illustration.

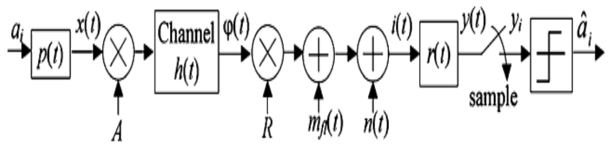

Figure 1: Block Diagram of OOK System

Continuous Wavelet Transform

- Historically, the continuous wavelet transform came first.
- It is completely different from the discrete wavelet transform
- It is popular among physicists, whereas the DWT is more common in numerical analysis, signal- and image-processing.
- Recall the CWT

$$W\Psi f - S(a,b) - \frac{1}{A}\int_{-\infty}^{\infty} f(t)\Psi\left(\frac{t-b}{a}\right)dt$$

This is an over complete function representation. (From one dimension, we trans- form into a 2D space!!). We want to be able to reconstruct f(t) from this representation. This is possible if the admissibility condition is satisfied:

$$C\psi = \int_{-\infty}^{\infty} \Psi(w)\frac{dw}{w} < \infty$$

A necessary (and normally also sufficient) condition is: $\Psi(0) = 0$ which means:

$$\int_{-\infty}^{\infty} \varphi(t)dt = 0$$

All functions with zero integral are wavelets

Discrete Wavelet Transform
Wavelet transforms provide a framework in which a signal is decomposed, with each level corresponding to a coarser resolution, or lower frequency band. There are two types of transforms, continuous and discrete. A continuous wavelet transform is performed by applying an inner product to the signal and the wavelet functions [9]. For a particular dilation a and translation b, the wavelet coefficient Wf (a,b) for a signal f can be calculated as

$$Wf(a,b) = < f\,\Psi(a,b)> - \int f(x)\,\varphi_{(a,b)}(x)dx$$

The original signal can be reconstructed by applying the inverse transform:

$$f(x) = \frac{1}{c\varphi}\iint_{-\infty}^{\infty} w_f(a,b)\varphi_{a,b}(x)db\frac{da}{x^2}$$

where C φ is the normalization factor of the mother wavelet. Although the continuous wavelet transform is simple to describe mathematically, both the signal and the wavelet function must have closed forms, making it difficult or impractical to apply. Stationary wavelet Transform
The Discrete Wavelet Transform is a translation- variant transform. The way to restore the translation invariance is to use some slightly different DWT, called Stationary Wavelet Transform (SWT). It does so by suppressing the down-sampling step of the decimated algorithm and instead up-sampling the filters by inserting zeros between the filter coefficients. Algorithms in which the filter is up-sampled are called "à trous", meaning "with holes".

Fundamentally, the problem of adaptive equalization can be formulated as a classification problem, and modern classifying tools like ANN can be utilized. ANN is more suitable for channel equalization because of highly parallel structure, adaptability and learning capability. Since there is no need for channel inversion then ANN equalization can be implemented in any channel. The functional unit of ANN is a neuron. A neuron cannot perform a complicated task on its own, but when combined and interconnected in some predefined manner, the composed ANN create a powerful tool for difficult tasks including nonlinear signal processing, adaptive learning, solution of nonlinear equations to name a few. Haykin has pointed out the rationale behind using ANNs instead of the traditional signal processing tools, the most importantly being the nonlinearity, universal approximation, adaptability to change its free parameter based on the environmental changes.

IV. RESULTS & DISCUSSSION

The multipath induced ISI, BER and FLI were the two most important impairments that affect the performance of indoor optical wireless communication systems. It contains the different blocks or we can say the different modules which are;

- Input data stream.
- Selecting a Modulation format.
- Modulation process.

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- Calculation of impulse response.
- Channel.
- Wavelet + Threshold detection.
- ANN decision.

There are the different kinds of the input data, which are analog and digital. The different models used the different data streams. In some cases the analog data is acceptable but in some cases it is not. Those cases in which the analog data is not acceptable we use A to D (analog to digital) convertor by which we convert the analog input data stream into digital data stream. The digital data stream is in the form of binary digits such that 0 and 1.But if we are using any of the digital modulation scheme, then we use the binary data input.
When the input signal is get modulated with the help of using any modulation scheme the input response of the system is getting calculated. When the input data is passed through the channel then AWGN noise is added into it.

There are the three basic types of wavelets; CWT, DWT and SWT. But in that work we use DWT. This is due to the reason that the implementation in case of CWT is very much complex and takes a lots of time rather than DWT.

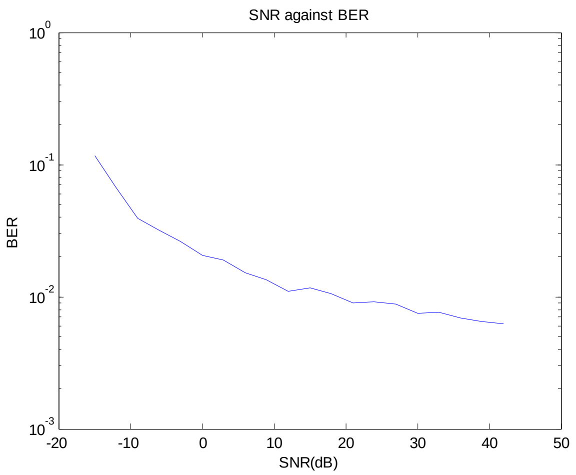

Figure 2: BER Performance using SWT

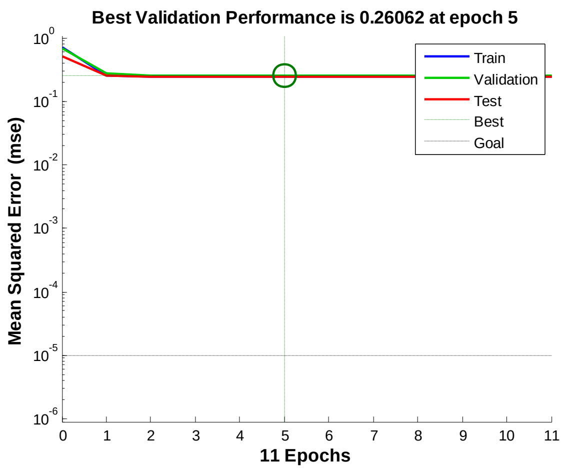

Figure 3: MSE Performance Using SWT

A wavelet transform is performed by applying an inner product to the signal and waveform functions. For a particular dilation a and translation b the wavelet coefficient for signal f is calculated as;
$Wf(a, b) = < f\,\Psi(a, b)> - \int f(x)\, \varphi_{(a,b)}(x)\, dx$

V. CONCLUSIONS

The study investigates the use of artificial intelligence and wavelet analysis as the main element of the indoor optical wireless receivers. The work uses the MATLAB tool for providing the effects of BER, SNR and light interferences on receiver. This included fully understanding the mathematical model. The implementation will goes through several steps as the ANN network has mainly three layers Input layer, hidden layer and output layer. The input layer takes the input, hidden layer apply operations on it and then output layer gives the output. The analytical model and simulation results helped in confirming the feasibility of the adaptive modulation techniques, which can be used for the optical wireless channel. The performance of the system is analysed that the value of BER is small in case of SWT.

REFERENCES

[1] J.R.Barry et al. “High speed-Non-Directive Optical Communication for Wireless Network,” IEEE Network, vol. 5, no. 6, Nov.1991, pp. 44-54.
[2] A.Moreira, R.Valadas, and A.Duarte, “Performance of Infrared Transmission Systems under Ambient Light Interference,” IEEE Proc. Opto elecronics, vol. 143, no. 6, Dec. 1996, pp. 339–346.
[3] A.C.Boucouvalas, “Indoor Ambient Light Noise and its Effect on Wireless Optical Links,” IEEProc. Opto elecronics, vol. 143, no. 6, Dec. 1996, pp. 334–338.
[4] B. Kantarci and H. Mouftah, “Delay-Constrained Admission And Bandwidth Allocation For Long-Reach EPON”, Journal Of Networks, Vol. 7, Issue 5, pp. 812-820, 2012.
[5] C. Liu, X. Fu, and H. Zhang, “QoS Guaranteed and Adaptive Downstream Bandwidth Utilization Scheme For Ethernet Passive optical Networks”, Journal Of Electronic Science And Technology, Vol. 9, Issue 2, pp. 145-154, 2011.
[6] J.R.Barry, J.M.Kahn, W.JKrause, E.A.Lee, and D.G.Messerschmitt, “Simulation of Multipath Impulse Response for Wireless Optical Channels”, IEEE J. Sel. Areas in Commun., vol. 11, no. 3, April 1993, pp. 367-379.
[7] S. D. Personick, “Receiver Design for Digital Fiber Optic Commnications Systems, I and II”Bell System Technical Journal, vol 52, no. 6, pp 843-886, July-August 1973.
[8] A.Moreira, R.Valadas, and A.Duarte, “Performance of Infrared Transmission Systems under Ambient Light Interference,” IEEProc. Optoelecronics, vol. 143, no. 6, Dec. 1996, pp. 339–346.
[9] S. Haykin, "Neural networks expand SP's horizons," IEEE Signal Processing Magazine, vol. 13, pp. 24-49, 1996.
[10] Debnath L. “Wavelet Transformation and their Applications, Birkhauser Boston, 2002.
[11] Meyer, Y. “Wavelets: their past and their future, Progress in Wavelet Analysis and its Applications” Gif-sur-Yvette, pp 9-18, 1993.
[12] L. Hanzo, C. H. Wong, and M. S. Yee, "Neural networked based equalization," in Adaptive wireless transceivers: Wiley-IEEE Press, 2002, pp. 299-383.