International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8, Issue-1, May 2019

Channel Estimation of Wirless Communication Systems using Neural Networks

Dr.P.Satyanarayana, G.Durga Tushara, G.Tejaswini

Abstract: ***An exceptional circumstance of multiple-carrier transmission is Orthogonal Frequency Division Multiplexing (OFDM). It can domicile more data rate which will be helpful for multimedia wireless communications. The estimation of channel is an intrinsic parts. The understanding of channel estimation of OFDM systems is strenuous. So a Deep learning (DL) technique for channel estimation of OFDM is presented .The traditional techniques estimate channel characteristics first and then reconstruct the original data by means of expected Channel characteristics. Technique, which is projected in this paper first, evaluates Channel characteristics indirectly and reconstructs original data. A model on Deep Learning is first developed by means of the output obtained from model depending on channel characteristics, it helps to reconstruct original transferred symbols implicitly. The outcomes, which are obtained, are compared to Minimum Mean Square Error (MMSE) estimator. DL was a hopeful technology for channel estimation in wireless communications with channel disturbance.***

Keywords: ***Channel Characteristics, Channel disturbance, Deep Learning, Interference***

I. INTRODUCTION

Importance and use of great speed data communication is increasing rapidly due to development of digital communication in modern years. Wireless communication methods are advancing towards 5G standards. OFDM is a technique of multiple carrier modulation which is a favorable technology for achieving more speed rates in mobile communication[7]. OFDM became popular because of its more transmitting ability with it strength to multiple-path delay and high bandwidth efficiency. Generally received data was manipulated by the channel characteristics. For reconstruction of transferred signal at receiver, the channel effect must be valued and recompensed.To estimate the channel of OFDM system[8], there are two types of techniques [1]. One is blind channel estimation and second is pilot based channel estimation. In the first type channel estimation[9], statistical information of the channel is evaluated. The estimation of channel can be done without using preamble or pilot signals. It requires many number of expected data to get the assets of channel and it will be useful for gradually phase-changing channels. The outcome of this technique is not good when compared to conventional channel estimation techniques which needs pilot signal. In second type channel estimation [2], channel is estimated at receiver by means of data called pilots, which will have its values and positions in time-frequency domains. The pilot arrangements[6] are 3 types: Block, Comb, Lattice-types. Pilots were transferred repeatedly on starting of block in block-model arrangement. Whereas comb-model, the pilots exist in some subcarriers of some OFDM data. For Lattice-model, the pilots were added on time and frequency axis in a rhombus fashioned constellation with given periods. Regular methods to estimate channel are Least Square (LS) and MMSE. These methods use pilot values in time-frequency grids which evaluate channel response. Least Square method do not require statistical information of a channel. The MMSE method requires channel statistics and noise variance. The results of MMSE is better compared to LS method, but complexity is more for MMSE.

Deep Learning (DL) became more popular in Communication systems. To enhance the performance of modulation recognition [3], equalization of channel, channel state information, signal detection and estimation of channel [4], few techniques are projected in Deep Learning.

II. OFDM SYSTEM

A.Block Diagram

The data bit stream is given as input for encoding of channel at transmitter, which is used to decrease the chance of mistake at the receiver due to effect of channel. Generally, the data plotted into the symbols of digital modulation of 16-QAM or QPSK. Data series is transformed to parallel format and Inverse Fast Fourier Transform (IFFT) is used and once again the order is converted into serial format. Guard time is filled with cyclic extension of the OFDM symbol and provided between the OFDM symbols.

Revised Manuscript Received on 30 May 2019.
***** Correspondence Author

Dr.P.Satyanarayana*, Electronics and Communication, Koneru Lakshmaiah Education Foundation, Vaddeswaram, India.

Gudimetla Durga Tushara, Electronics and Communication, Koneru Lakshmaiah Education Foundation, Vaddeswaram, India.

Gudimetla Tejaswini, Electronics and Communication, Koneru Lakshmaiah Education Foundation, Vaddeswaram, India.

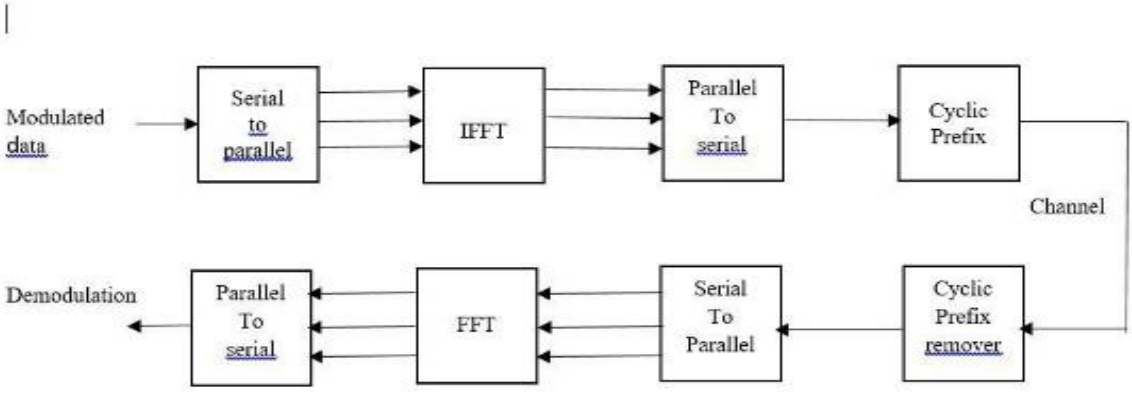

Fig.1 Block Diagram Of OFDM

B. OFDM Principle

In this system, the bandwidth is split into more carriers and each carrier is modulated by a less speed stream bit. OFDM is parallel to FDMA in term of multiple access technique, which was accomplished on segmenting the bandwidth into multi-channels that are provided for operators. By spacing, channels are closer together, OFDM use spectrum extra proficiently. To prevent interference between closely spaced carriers we must make all the carriers orthogonal to one another. The variance of traditional non-overlapping multiple carrier method and overlapping multiple carrier modulation method is shown in the figure 2. 45% of Bandwidth can be saved by using overlapping multiple carrier modulation method.

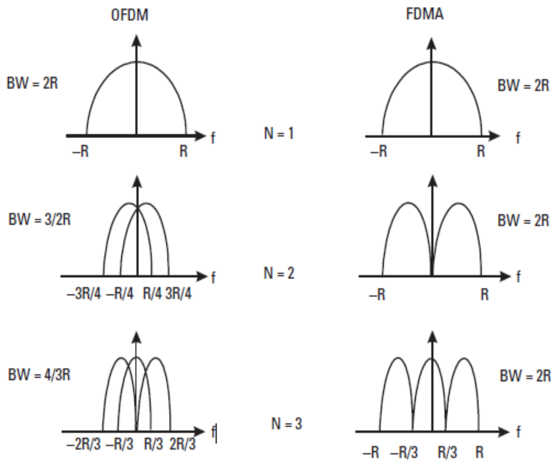

Fig 2: Orthogonal Multiple carrier Method Versus Traditional Multiple carrier Method [5].

Meaning of orthogonality of the carrier is, every carrier will have an integral number of cycles over a symbol duration. Because of this, center frequency of every carrier becomes null in the spectrum of carriers. Due to this, there will be no interference among the carriers. Problem of overhead carrier spacing is reduced which is required in FDMA. This results in symbol rate which is low due to narrow bandwidth of carrier in an OFDM symbol.

III. Deep Learning Based Estimation

A.Methods Of Deeplearning

Deep Learning became popular technology in applications of computer vision, natural language processing, speech recognition etc.. The meaning of DNN is the presence of more number of invisible layers in neural network. As the number of invisible layer increases, the performance and efficiency to recognize and estimate also increases. In a neural network each layer has various nerves, every layer has an output which has a nonlinear function of weighted sum of neurons of its adjacent layer. The non-linear functions used in the model are Sigmoid function and ReLU function. The ReLU function is defined as $f_R(a)=max(0,a)$ and Sigmoid function is defined as $f_S(a)=\frac{1}{1+e^{-a}}$. The output of the network of input data A, statistically equated as

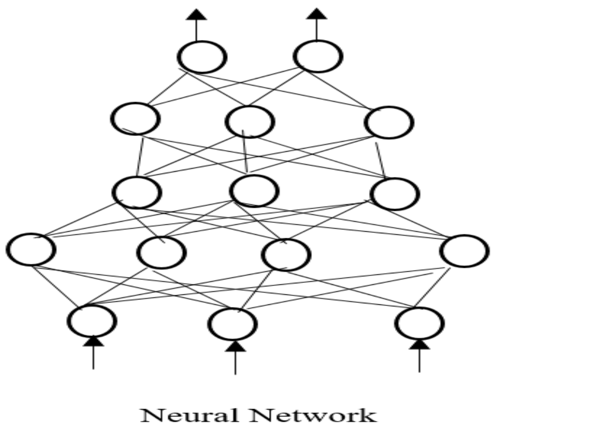

Fig. 3. A sample deep learning models.

$$z=f(A,\omega)=f^{(A-1)}(f^{(A-2)}(\ldots.f^{(A)}))), \quad (1)$$

Where A denotes the sum and ω symbolizes the weights. Optimal loads were trained on a data set, with estimated result.

Parameters of model are loads for the nerves, which must enhanced earlier stage of online deployment.

B. Architecture Of System

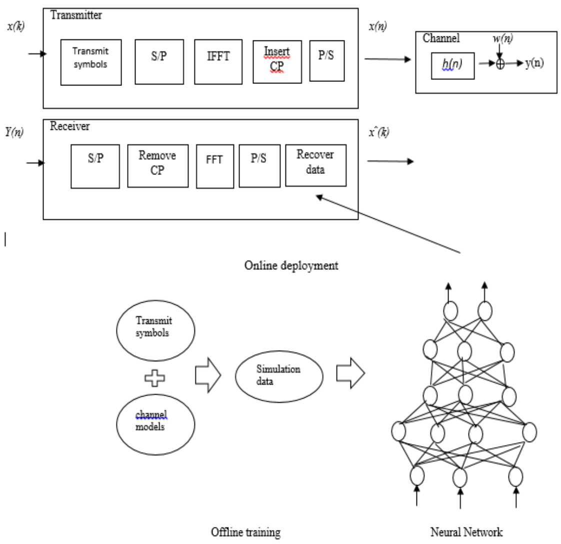

Fig. 4. Model of System.

Transmitted data is injected with pilots were translated to a data bit stream, then the IFFT is used for translation of message from the frequency domain to spatial domain or time domain at the sender side. Next, CP was injected to reduce inter-symbol interference (ISI). Size of CP should greater than maximum delay spread of Channel. Consider a multi-path channel described by complex random variables $\{d(i)\}_{i=0}^{N-1}$. Received signal is equated as

$$y(n) = x(n) * h(n) + w(n) \qquad (2)$$

Here * indicates circular convolution while e(i) and c(i) denotes the noise and transmitted signal. Later CP is removed, perform FFT, the received signal in Frequency domain is

$$Y(k) = X(k).H(k) + W(k) \qquad (3)$$

We consider first OFDM block has pilot symbols while resulting OFDM blocks contains of transferred data. A Frame is formed with the data blocks and pilot blocks and the channel is considered as constant spanning, but change from one frame to another. To get an efficient DNN model for channel estimation two steps were involved. In the offline training step, first step, trained with the received OFDM samples which were produced with different data series and below different channel conditions with some statistical properties. In the online deployment step, the second step, yields output that recovers the transmitted data without explicitly estimating the wireless channel

C. Model Training

Model is trained by assuming OFDM modulation and the wireless channels as hidden data. In the past years, researchers developed various channel models which explain the channel by means of channel data. The received OFDM signal is achieved on OFDM frame undergoes channel distortion together with noise. The received signal and original signal were gathered as training data. 1 pilot block and 1 data block are given as input of DL model. Then the model is trained to reduce variance between the output of neural network and original message. The L_2 loss is shown below

$$L_2=\frac{1}{N}\sum_k (z^{\wedge}(k)-z(k)) \qquad (4)$$

Whereas z^(k) is estimated data and z(k) is original data. Neural Network model consists of 5 layers, 3 of them are hidden layers. The weights each layer is 768, 512, 256, 128, 16. The input represents real part and complex part of 2 OFDM blocks. It consists of pilots and transferred data. The transferred data are combined and estimated, of every 16 bits depending on model, which is then combined for the output. The activation function of all layers is ReLU function except the final layer which uses Sigmoid function, used to plot the output in the range of [0,1].

IV. RESULTS

Many experimentation have done to determine performance of the deep learning methods for channel estimation in wireless communication systems. Based on simulation data, the DNN model is trained and is related to conventional techniques in terms of Signal-Error Rate (SER) under different signal-to-noise ratios (SNRs). The deep learning based approach is proved that it is more efficient than MMSE.

```
Epoch 122/150
 - 1s - loss: 0.0025 - acc: 0.9843
Epoch 123/150
 - 1s - loss: 0.0026 - acc: 0.9866
Epoch 124/150
 - 1s - loss: 0.0026 - acc: 0.9868
Epoch 125/150
 - 1s - loss: 0.0026 - acc: 0.9850
Epoch 126/150
 - 1s - loss: 0.0026 - acc: 0.9860
Epoch 127/150
 - 1s - loss: 0.0026 - acc: 0.9856
Epoch 128/150
 - 1s - loss: 0.0026 - acc: 0.9863
Epoch 129/150
 - 1s - loss: 0.0026 - acc: 0.9852
Epoch 130/150
 - 1s - loss: 0.0025 - acc: 0.9868
Epoch 131/150
 - 1s - loss: 0.0026 - acc: 0.9860
Epoch 132/150
 - 1s - loss: 0.0027 - acc: 0.9869
Epoch 133/150
 - 1s - loss: 0.0027 - acc: 0.9859
Epoch 134/150
 - 1s - loss: 0.0027 - acc: 0.9858
Epoch 135/150
 - 1s - loss: 0.0027 - acc: 0.9874
Epoch 136/150
 - 1s - loss: 0.0027 - acc: 0.9870
Epoch 137/150
 - 1s - loss: 0.0028 - acc: 0.9856
```

Fig.5 Results obtained at particular epochs

An OFDM system with 64 sub-carriers and the CP of length 16 is used. Keras and Tensor flow with Graphics Processing Unit (GPU) were used for implementation. The learning rate is fixed to 0.01 with batch size of 128 and only 150 epochs. The training and testing set consist of 3000000 and 1000000 channels. Training the model is very hard in regular desktops and personal computers. For faster training it requires GPU's. So we trained the model on Google Colab with GPU. We got the accuracy of 98.5%.

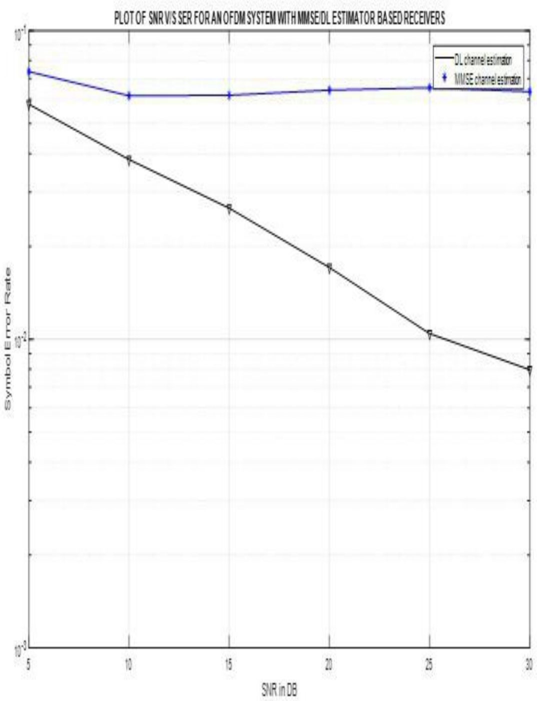

Fig.6.Comparison of SER for Deep Learning and MMSE at different SNRs

V. CONCLUSION

We have demonstrated our original efforts to employ DNNs for channel estimation in an OFDM system. Based on simulated data, model was trained. When wireless channels are effected by distortion and interference, we can validate that it is best method from the obtained results. It also shows that DNN has a capability to recollect and analyse the characteristics of wireless channels

REFERENCES

1. Chia-Hsin Cheng, "Neural Network based channel estimation for OFDM", in 2015, IEEE 29th International Conference on Advanced Information Networking and Applications. DOI 10.1109/AINA.2015.242
2. Mehran soltani, Vahid Pourahmadi, Ali Mirzaei, Hamid Sheikhzadeh "Deep Learning based Channel Estimation",published in IEEE Wireless Communications Letters (Volume: 7 , Issue: 5 , Oct. 2018).
3. T. OShea and J. Hoydis, "An introduction to deep learning for the physical layer," IEEE Transactions on Cognitive Communications and Networking, vol. 3, pp. 563–575, Dec 2017.
4. H. Ye, G. Y. Li, and B.-H. Juang, "Power of deep learning for channel estimation and signal detection in ofdm systems," IEEE Wireless Communications Letters, vol. 7, no. 1, pp. 114–117, 2018.
5. S. Chen, G. Gibson, C. Cown, and P. Grant, "Adaptive equalization of finite nonlinear channels using multilayer perceptrons," IEEE Trans. Signal Process., vol. 20, no. 2, pp. 107–119, Jun. 1990.
6. Zhongyuan Zhao, Mehmet C. Vuran, Fujuan Guo, and Stephen Scott,
7. "Deep-Waveform: A Learned OFDM Receiver Based on Deep Complex Convolutional Networks".
8. Sandeep Kaur, Gurpreet Bharti, "Orthogonal Frequency Division Multiplexing in Wireless Communication Systems: A Review", ISSN: 2278 – 1323,International Journal of Advanced Research in Computer Engineering & Technology.
9. Dhere Vikas Bhimsing, Dr. A.C.Bhagali," Performance of Channel Estimation and Equalization in OFDM System", IEEE International Conference on Power, Control, Signals and Instrumentation Engineering (ICPCSI-2017).
10. Tobias Gruber,Sebastian Cammerer_,Jakob Hoydis†, and Stephan ten Brink,"On Deep Learning-Based Channel Decoding", arXiv:1701.07738v1 [cs.IT] 26 Jan 201.

AUTHORS PROFILE

Dr. Penke Satyanarayana done his B.Tech in Electronics and Communication Engineering (ECE) in Koneru Lakshmaiah College of Engineering, Vaddeswaram, Vijayawada, India; M.Tech in Computers and Communications Systems from JNTU, Hyderabad, India; and Ph.D. in ECE from JNTU, Kakinada, India. He is a Professor in the ECE Department, K L E F, Guntur, India. He published over 20 research papers in reputed international and national journals and conferences. He is a member in Indian Society of Technical Education (ISTE). His research work includes Wireless Communication and Signal processing, Embedded Systems and VLSI.

G.Durga Tushara is a student of B.Tech studying fourth year in Electronics and Communication Engineering (ECE) from Koneru Lakshmaiah College of Engineering, Vaddeswaram, Vijayawada, India. Interested to do research in Signal Processing and Embedded Systems.

G.Tejaswini is a student of B.Tech studying fourth year in Electronics and Communication Engineering (ECE) from Koneru Lakshmaiah College of Engineering, Vaddeswaram, Vijayawada, India. Interested to do research in Embedded Systems, VLSI and Wireless Communication.