A Comparative Analysis of Implementing 5G through Deep Learning

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Abstract: Fifth Generation of Cellular Networks will give ubiquitous and wide reliable coverage as well as find its applications in powering critical-mission, huge IoT deployments, and M2M Communications. These utilisation need low latency and high capacity capable technology that can suggested as Generalized Frequency Division Multiplexing due to its highly supportive physical structure for 5G. Deep Learning(DL) is implemented to the large value of complex data of GFDM input Signal in order to analyse the performance in terms of Bit Error Rate(BER) along with Signal to Noise Ratio(SNR).In this paper, two different methods of DL is considered and compared for better designing and performance purpose. Various methods of Deep Learning are analysed for technical advancement of 5G Cellular Network. This paper consists analysis of different aspects of DL in 5G such as implementation in Massive MIMO, mm Wave Communication and NOMA systems.

1 INTRODUCTION

During last decade, studies show that consumption of data exchanged by users over internet is increasing and this growth will enhance with staggering factor in upcoming years. The reason behind is the increase in population, application of smartphones and highspeed broadband services. Fourth Generation works on LTE is considered to be one of the versatile technology, but nowadays a low latency communication is needed. This led evolution of 5G that supports IOT applications, M2M, vehicular networks, tactile communications and many more. Various modulation methods have been proposed for 5G such as Orthogonal frequency division multiplexing (OFDM), Universal Filter Multicarrier Modulation (UFMC), Filter Bank Multicarrier Modulation (FBMC) and Generalised Frequency Division Multiplexing (GFDM). Advanced LTE in OFDM had been utilized in 4G but this method of multicarrier modulation suffers from high Out-of-band (OOB), high peak to average power ratio (PAPR) that makes it not suitable for 5G and trending communication network. Generalized frequency division multiplexing (GFDM) is considered to be one of the most promising technology for future emerging communication network. Positive side of the GFDM are spectral efficiency, low latency, block structure and bandwidth efficient make it most suitable candidate for 5G Cellular System. (Amirhossein, 2018) Deep learning technique has off late gained significant attention as it provides solution to bulk complex with high performance in several fields like object detection problems, language processing as well as computer vision. Researchers have been implementing DL to design various wireless communication techniques as it has high potential in various aspects like channel estimation, optimization of performance as well as in multiples access.5G can be implemented more practically in order to meet new demands of forth coming cellular network by designing DL- based Non-Orthogonal Multiple Access (NOMA), DL- based massive MIMO and DL-based mm Wave. This paper gives description of GFDM with implementation of DL as GFDM is considered to be one of the prominent waveforms that fulfils vital challenges of upcoming wireless networks. It has various advantages over OFDM such as reduced OOB emission, bandwidth efficiency and lowest latency. Several research had showed that MIMO transmission unquestionable spectral efficiency, so its application is compulsory for 5G modulation candidate. In this paper, deep convolutional neural network-based GFDM-IM detector is compared to DL-aided GFDM detection

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and demodulation scheme in terms of BER and SNR for performance analysis. (G.Gui,2018)Several applications of Deep Learning in wireless communication are examined and best method for implementation in 5G with GFDM is concluded.

This paper comprises of three sections in which Section.2 explains the reason behind implantation of deep learning in wireless communication, Section3 deals how DL is applied into channel estimation and performance analysis of DL in 5G and Section 4 gives explanation about GFDM, its block structure and how spectral efficiency is enhanced by using DL scheme.

2 DEEP LEARNING IN WIRELESS NETWORK

DL gives immense support to new demands of 5G communication network. Three methods are considered to be best one for practical implementations with technical advancement.

Deep learning-based NOMA: NOMA has potentials to enhance spectral efficiency as well as system capacity, so it is assumed to be a 5G technique but mobility in user results to complex channel issues in each link. (B.H.Juang, 2018) Over all operation of NOMA frameworks depends on CSI. Therefore, there is a necessity of deep learning for better NOMA performance.

Deep learning-based massive MIMO: Channel State Information (CSI) has favourable gain effects of massive MIMO. It is required to know about channel estimation for getting perfect CSI. Deep Learning is considered for designing frameworks with utilization of spatial information of MIMO systems. Deep Neural Network is a suitable candidate that assures reconstruction of CSI for enhanced performance of massive MIMO with channel estimation. (Hongji, 2019)

Deep learning-based mm Wave: Millimetre Wave communication is frequently coming into scenario nowadays because of its low latency and ten-fold enhancement in bandwidth as compared to present wireless networks. (H.Huang, 2018) Deep Learning approach can help in sensing mmWave with the help of hybrid precoding in terms of matrices.

3 IMPLEMENTATION OF DL IN CHANNEL ESTIMATION

Fig.1 is block structure of OFDM system with implementation of Deep neural network (DNN) for better performance in terms of channel estimation. Pilot symbols are given into IFFT that converts signal into time domain from frequency spectrum. (Michailow, 2014) Cyclic prefix (CP) is added so that interference (ISI) can be reduced. Received and transmitted signals are produced into DNN for minimizing the difference between both ends. In this manner channel estimation with high resolution can be achieved.

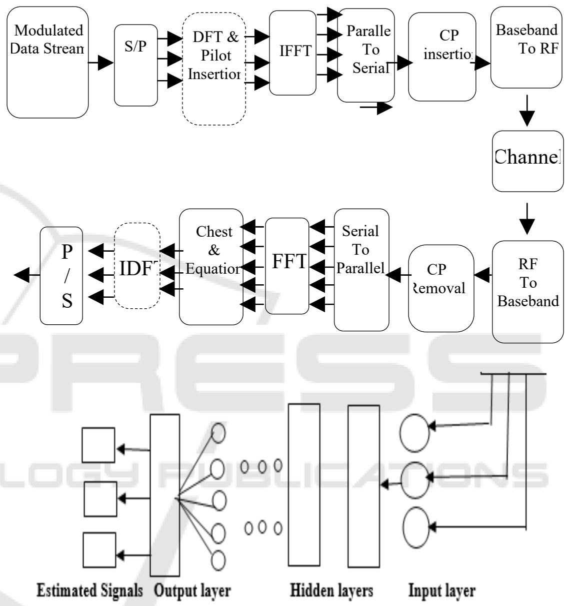

Figure 1: Channel Estimation DNN Architecture in OFDM System

Performance Analysis of Deep Learning in 5G:

Deep Learning in NOMA framework plays important role for optimization of CSI issues. Typical NOMA system is considered where many users are served by Base Station and several channel conditions are present in communication link individually. DNN is utilised for estimation of CSI at user separately and to solve optimization problems in encoding as well as signal detection. There is a requirement of learning policy to put DNN into NOMA framework. Present techniques help in designing simulator for various channel conditions like slow and fast fading channels. Every simulation result in generation of data sequences further CSI is produced by channel models

depending upon NOMA principles. Output data at DNN are named as training data set.
Channel detection in real time is achieved by perfect DNN framework depending on present input signals and channel. Fig.2 is the graphical representation of proposed DNN that supports Single Instruction and Single Data Stream (SISD) algorithm. NOMA frames along with pilot symbols are obtained for generation of data sequences. (Mrinalini,2018) Finally, channel vectors are produced after feeding NOMA frames into channel model. Here, analysis of 250,000 is taken for training of DNN with 24 data sequences present in each batch. From this graph it can be seen that deep learning has proved as effective technique for solving problems related to power allocation and data detection in NOMA[9,10]. It provides high precision to each user linked with base station.

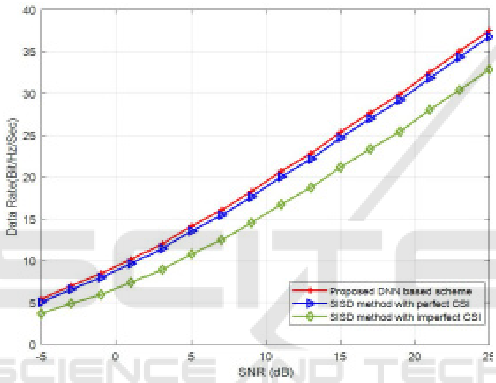

Figure 2: Deep learning data rate at different CSI

Massive Multiple Input Multiple Output (MIMO) is one of the suggested methods for coming communication networks that deals with enhancement in spectrum efficiency but increased spatial complexity of system result in decrease in performance. Deep learning is applied massive MIMO for channel estimation problems. (R.Li al.,2017) Fig.3 is the comparison analysis deep learning scheme and spatial basis expansion model (SBEM). There is transmission of unit signals in different direction of massive MIMO in uplink. Finally, received vectors as output is obtained that have specific direction. In this MIMO analysis of we transmit unit signals to the uplink massive MIMO model in different direction and corresponding received vectors are obtained. Samples taken for analysis are 150,000 training dataset,20000 testing dataset and 30000 validation datasets respectively. Offline Learning method is processed to the network for performance analysis of DOA estimation. It can be clearly seen that BER shows 4 decibel better performance in DL scheme as compared to other methods. BER plays a vital role in analysing performance in terms of degradation and upgradation of signals.

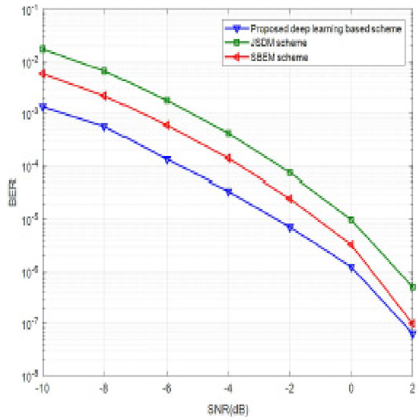

Figure 3: Massive MIMO based DL scheme

4 GENERALIZED FREQUENCY DIVISION MULTIPLEXING (GFDM)

GFDM is a flexible multicarrier technique that is one the best approach for 5G communications. This robust technique has CP of low bandwidth that makes GFDM more spectral efficient.(Nichola, 2014) GFDM is known for its block structure 'N' that consists of subcarriers(M) and subchannels(K). OOB is reduced by applying circular convolution on subcarriers. GFDM signal is derived by superposition of all transmit signals given by following expression:

$$x(n)=\sum_{k=0}^{k-1}\sum_{m=0}^{M-1} d_{k,m}g_{k,m}(n) \quad (1)$$

where gk,m(n) is a time as well as frequency shifted version of a prototype filter g(n).
Fig.4 is block structure of GFDM in which $g_{k,m[n]}$is assumed to be a filter with N samples and k, m and n are subcarrier, sub symbol, and time indices. GFDM is flexible for TTI length that helps in taking data to specific user making it most waveform for low latency network. GFDM is composed of adjustable filters present at transmitter end that helps in reduction of OOB emissions. This structure deals with the scheduling of many users in frequency and time domain. This technique is free from high OOB as well as PAPR values and it finds applications in white space aggregation.
GFDM Signal is given by following expression:

$$g_{k,m(n)}=g((n-mk)\mathrm{mod}(N)\exp(j2\Pi(kn/N)) \quad (2)$$

where n is sampling index.

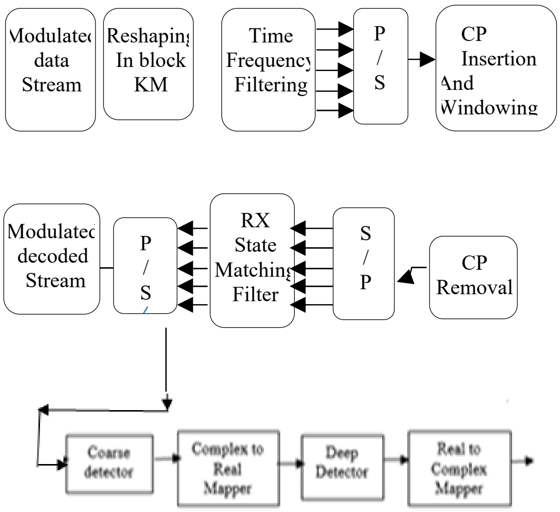

Figure 4: DL Based GFDM Transreceiver

Deep Learning is implemented in GFDM, above proposed method is Joint Detection and Demodulation JDD DL Scheme.(T.J. O'Shea,2017) It is a process that contains two stages firstly coarse detection obtained by using linear detectors like Zero Forcing (ZF) and Minimum Mean Square Error (MMSE) and second stage is application of neural network for getting fine detection.(X.Gao, 2017) In fig.5 performance analysis is done which has given parameters training data has 160000 symbols, GFDM symbol has 90000symbols and testing data have 90000 symbols.

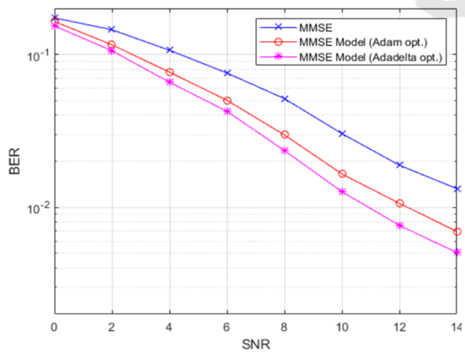

Figure 5: BER Performance of MMSE-JDD DL System

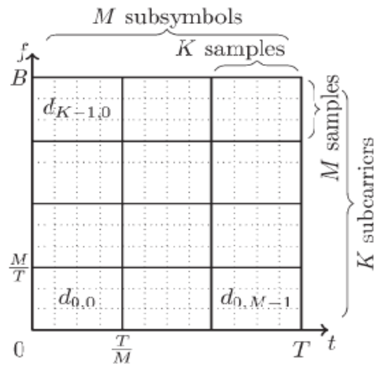

Figure 6: GFDM Samples

5 CONCLUSION

This paper deals with the explanation of deep learning and its perspective as well as implementation in 5G communication. It can be concluded that DL is one of the prominent methods to solve complex problems of future communications. Frameworks based on MIMO and NOMA is studied with performance analysis description. BER and SNR analysis is studied that shows better performance with implementation DL in 5G. Therefore, conclusion can be drawn that this method of optimization and analysis has positive approach with solution to many complex problems of 5G. Deep learning into 5G has given easy solutions to the complexity of high frequency networks. Designing of GFDM and receiving signals with minimal loss was a tough task but implementation of DL has helped out to meet performance and efficiency demands of future coming networks.

REFERENCES

5G Waveform Candidate Selection D3.25GNOW_D3.2_v1.3.docx.

Amirhossein Mohammadian, Abbas Mohammadi and Abdolali Abdipour, Mina Baghani, (2018) Spectral Analysis of GFDM Modulated Signal under Nonlinear Behavior of Power Amplifier,Electrical Engineering and Systems Science ,Signal Processing.

El Gamal, H., & Damen, M. O. (2002). An algebraic number theoretic framework for space-time coding in Proceedings IEEE international symposium on information theory.

G. Gui, H. Huang, Y. Song, and H. Sari, (2018) Deep Learning for An Effective Non-Orthogonal Multiple

Access Scheme, IEEE Trans. Veh. Technol., vol. 67, no. 9, pp. 8440-8450.
H. Huang, J. Yang, Y. Song, H. Huang, and G. Gui, (2018) Deep Learning for Super-Resolution Channel Estimation and DOA Estimation based Massive MIMO System, IEEE Trans. Veh. Technol., vol. 67, no. 9, pp. 8549-8560.
H. Ye, G. Y. Li, and B. H. Juang,(2018) Power of Deep Learning for Channel Estimation and Signal Detection in OFDM Systems, IEEE Wireless Commun. Lett., vol. 7, no. 1, pp. 114-117.
Hongji Huang, Song Guo, and Guan Gui, (2019) Deep Learning for Physical-Layer 5G Wireless Techniques: Opportunities, Challenges and Solutions,IEEE Wireless Communication Magazine.
Michailow, N., Matthé, M., Gaspar, I. S., et al. (2014) Generalized frequency division multiplexing for 5th generation cellular networks, IEEE Transactions on Communications, 62(9), 3045–3061.
Mrinalini, Kamlesh Kumar Singh (2018) Survey paper on Multicarrier Modulation Techniques ,in 5th IEEE International Conference on Electrical, Electronics and Computer Engineering.
M. Mirahmadi, A. Al-Dweik, and A. Shami (2013) BER reduction of OFDM based broadband communication systems over multipath channels with impulsive noise, IEEE Trans. Commun., vol. 61, no. 11, pp. 4602–4615.
Maximilian, M., Luciano, L. M., Nicola, M., et al. (2015). Widely linear estimation for space-timecoded GFDM in low-latency applications. IEEE Transactions on Communications, 63(11), 4501–4509.
Maximilian, M., Luciano, L. M., Ivan, G., et al. (2015). Multi-user time-reversal STC-GFDMA for future wireless networks. Journal on Wireless Communications and Networking.
Nicola Michailow, Maximilian Matthé, Ivan Simões Gaspar, Ainoa Navarro Caldevilla, Luciano Leonel Mendes, Andreas Festag (2014) Generalized Frequency Division Multiplexing for 5th Generation Cellular Networks,IEEE Transactions on Communications, vol. 62, no. 9.
R. Li et al., “Intelligent 5G: When Cellular Networks Meet Artificial Intelligence,” IEEE Wireless Commun., vol. 24, no.
T. J. O’Shea and J. Hoydis,(2017) An introduction to deep learning for the physical layer, IEEE Trans. Cognitive Commun.and Networking, vol. 3, no. 4, pp. 563-575.
X. Gao, L. Dai, Y. Zhang, T. Xie, X. Dai, and Z. Wang, (2017) “Fast Channel Tracking for Terahertz Beamspace Massive MIMO Systems,” IEEE Trans. Veh. Technol., vol. 66, no. 7, pp. 5689-5696