TDMA based BFNN Using Deep Learning for B5G Cellular Communication System

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ABSTRACT

Beamforming neural network (BFNN) using deep learning (DL) is a key issue to optimize the beamformer to maximize the spectral efficiency and mitigate the challenge of imperfect channel state information. For beyond 5G (B5G) cellular communication system, a suitable BFNN technique using DL is proposed in this paper to enhance the cell center and cell edge user channel capacities and sum channel capacity by utilizing time division multiple access technique.

I. INTRODUCTION

In present, hybrid beamforming (HBF) for millimeter-wave communication in case of beyond 5G (B5G) cellular communication system [1-2]. Beamforming neural network (BFNN) is a suitable technique to optimize the analog beamformer in case of imperfect channel state information (CSI) since HBF is consists of analog and digital beamformer as well [3]. So a suitable technique is required to provide significant user channel capacities and sum channel capacities (SC) for B5G cellular communication by optimizing the imperfect CSI. Thus, time division multiple access based BFNN using deep learning (DL) (TDMA-BFNN) is proposed in this paper for the B5G cellular communication system.

II. SYSTEM MODEL

A TDMA-BFNN based downlink cellular communication system with two users (cell center user (CCU) and cell edge user (CEU)) is illustrated in Figure 1. The user placed near to the source (S) is termed as CCU (UE_1) and the user near to the cell border is termed as CEU (UE_2). The optimization technique of proposed TDMA-BFNN is illustrated in Figure 2, where n ϵ {1, 2}. Two different time slots are used to transmit x_1 and x_2 with full power (P) from S to UE_1 and UE_2. MISO based millimeter-wave (mmwave) Saleh-Valenzuela channel is considered in this case with zero mean and covariance σ^2, where N is the total number of transmit antenna. A well-known Saleh-Valenzuela mmwave channel model (h_n^H) is considered here with one line-of-sight (L) path and (L-1) non-line-of-sight paths [4]. The channel capacity of the UE1 and UE2 due to the proposed TDMA-BFNN scheme is discussed in section 3.

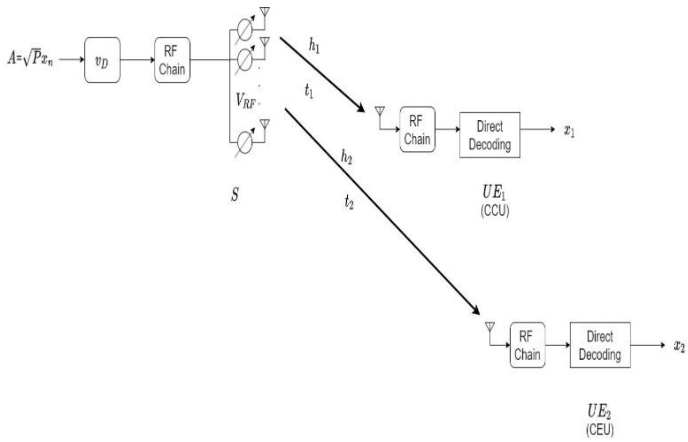

Fig. 1: Proposed system model for B5G downlink cellular communication system

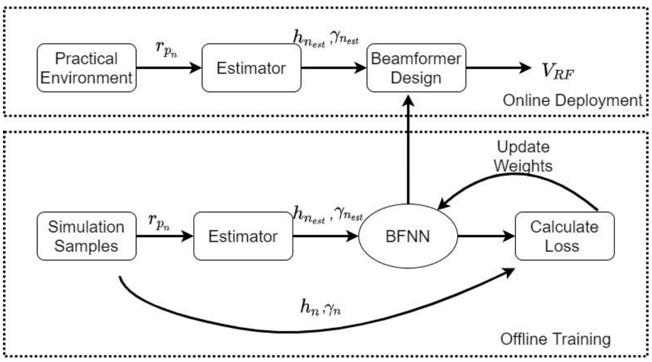

Fig. 2: Proposed TDMA-BFNN scheme

III. CHANNEL CAPACITY ANALYSIS

The achievable channel capacity of CCU and CEU for the proposed TDMA-BFNN scheme is derived as below by equation 1 and 2 [1].

$R_{CCU} = 0.5\, log_2 \left(1 + \frac{\gamma}{N} || h_1^H v_{RF} ||^2\right)$.......... (1)

Subjected to $|[V_{RF}]_i|^2 = 1,\ for\ i = 1 \dots N$

$R_{CEU} = 0.5\, log_2 \left(1 + \frac{\gamma}{N} || h_2^H v_{RF} ||^2\right)$ .... (2)

Subjected to $|[V_{RF}]_i|^2 = 1,\ for\ i = 1 \dots N$

Where γ is the transmit SNR, $\gamma_{n\ est}$ is the estimated SNR for corresponding user, v_D is the digital precoder, and v_{RF} is the analog precoder [3]. Furthermore, h_1 and h_2 are two-channel response matrix between S and CCU and CEU respectively. The loss function can be calculated for the TDMA-BFNN as following equation:

$Loss = -\frac{1}{M}\sum_{m=1}^{M} log_2 \left(1 + \frac{\gamma}{N} || h_n^H v_{RF,m} ||^2\right)$ .... (3)

Where M is the number of training samples. Based on the Loss, the optimization of v_{RF} is performed. In addition, the sum capacity can be expressed as below:

$R_s = R_{CCU} + R_{CEU}$ .... (4)

IV. RESULT ANALYSIS

The result analysis analyzes the user and sum channel capacities of the proposed TDMA-BFNN scheme. Parameter N = 64, L = 3, and PNR = 20 dB are set [3]. Figure 3 illustrates that the proposed TDMA-BFNN scheme provides significant user channel capacity in the case of CCU and CEU. Hence the SC is enhanced for the proposed scheme.

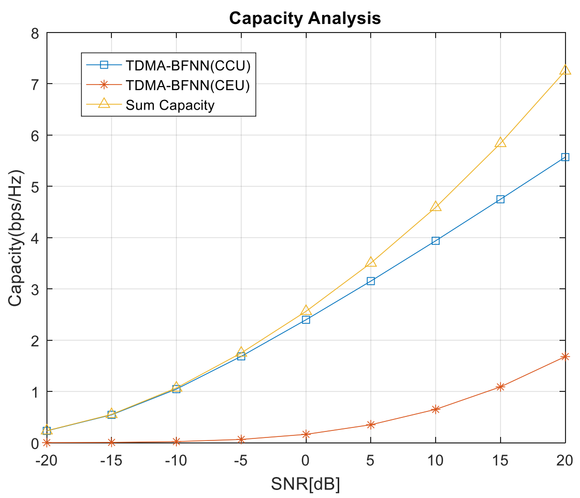

Fig. 3: User channel capacities and SC vs. transmit SNR for TDMA-BFNN scheme.

Because the proposed scheme optimizes the analog beamformer of HBF due to imperfect CSI hence the user channel capacities as well as SC are improved as well.

V. CONCLUSION

The proposed TDMA-BFNN scheme provides optimization of HBF based B5G cellular communication system in case of imperfect CSI. Moreover, the result analysis illustrated that the proposed scheme provides significant user channel capacities and SC in the case of imperfect CSI and different users with different channel conditions.

ACKNOWLEDGMENT

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