CNN based Adaptive 4D-8PSK-TCM Design

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***Abstract*—In this paper, we design convolutional neural network (CNN) based adaptive 4 dimensional 8-ary phase shift keying trellis coded modulation (4D-8PSK-TCM) that applies the parameter value of T-Algorithm by estimation the E_b/N_0 of received signal to maintaining BER performance and minimize complexity for every E_b/N_0. The system is evaluated in terms of complexity.**

I. Introduction

The consultative committee for space data systems (CCSDS) recommends 4 dimensional 8-ary phase shift keying trellis coded modulation (4D-8PSK-TCM) for a high-speed transmission technology in the X-band [1]. The 4D-8PSK-TCM can reduce complexity with T-algorithm [2]. However, when using small parameter value, there is a problem with degraded BER performance in high energy per bit to noise spectral density ratio (E_b/N_0). In this paper, we design convolutional neural network (CNN) based adaptive decoder that applies the parameter value of T-Algorithm by estimation the E_b/N_0 of received signal to maintaining BER performance and minimize complexity for every E_b/N_0.

II. Proposed Model

The proposed adaptive 4D-8PSK-TCM system is shown as Fig. 1. The estimation model consists of an image generation unit (IGU) consisting of a mapping unit (MU) and a reduction unit (RU) and a CNN model. The MU map the 20,000 symbols in the range [-2, 2, -2, 2] of the I-Q graph and generate image. The RU reduce size of the image to reduce the complexity of the CNN model. The generated image is classified in the CNN according to the E_b/N_0 class. When the class is classified, the T according to the class is set for a specified period. The system repeat the above process at the end of the period. The parameters for the system are shown in Table I.

III. Performance Evaluation

The conventional 4D-8PSK-TCM is designed by referring to [3]. The complexity of the adaptive 4D-8PSK-TCM is shown in Fig. 2. If the classification period is 1 ms, the complexity

TABLE I. System parameter

4D-8PSK-TCM	Transmission efficieny	2.75
	Trace-back depth	28
	Channel model	AWGN
	Bit rate	640 Mbps
	Complexity	967
CNN model	Layer	conv(3), pool(3), fc(3)
	Dataset	50,400
	Class	0,1,2,3,4,5,6,7,8 dB
	Period	1, 10, 100 ms
	Input size	50x50
	Accuracy	98.59
	Complexity of CNN	3,795,761

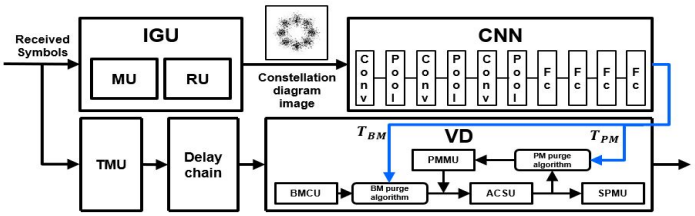

Fig. 1. Block diagram of adaptive 4D-8PSK-TCM

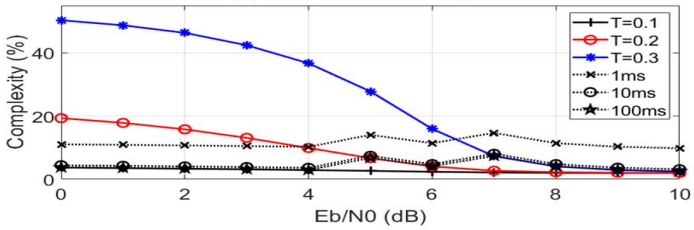

Fig. 2. Ber performance of adaptive 4D-8PSK-TCM

is reduced in the lower E_b/N_0, but in the higher E_b/N_0, the complexity is increased because of the complexity of the CNN model. However, if the period is 10 ms, the complexity of the system is less than 10% for all E_b/N_0 because the complexity of CNN model are relatively smaller compared with conventional 4D-8PSK-TCM system. Also it approaches the minimum complexity of the system when the period is 100 ms. As a result, we confirm that the 4D-8PSK-TCM system based on CNN can be used to minimize the complexity without degradation of BER performance.

IV. Conclusion

In this paper, the CNN based adaptive 4D-8PSK-TCM system was designed and evaluated in terms of the complexity. The CNN-based adaptive 4D-8PSK-TCM system sets the T of T-Algorithm by generating constellation image of received symbols and estimating the E_b/N_0 with a CNN model. The estimated accuracy of the CNN model with an accuracy of 98.59. When the system has an estimated cycle of 100 ms, the system have maintained the BER performance of the conventional 4D-8PSK-TCM system and reduced the complexity to the maximum.

References

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