On Neural Network Data Predistortion and Constellation Shaping for Satellite Channels

David Kopyto and Gerhard Bauch
Institute of Communications
Hamburg University of Technology
Hamburg, Germany
{david.kopyto, bauch}@tuhh.de

***Abstract*—In communication over transparent satellite payloads, traveling wave-tube amplifier (TWTA) cause nonlinear distortion to the transmit signal. Together with filters involved in the transmission chain, the TWTA causes distorted decision regions (warping) and intersymbol interference (ISI) at the matched filter output. This nonlinear channel can be compensated by means of data predistortion. The remaining interference results can be interpreted as a channel and the transmit constellation can be optimized for the joint channel with influences from additive white Gaussian noise (AWGN) and phase noise. This work shows how constellation shaping and data predistortion can be designed using neural networks. Particularly, a novel data predistortion algorithm based on a recurrent neural network (RNN) which accounts for the ISI is presented. For constellation shaping, different constrained optimization techniques are presented, including quadrant-symmetric optimization, spiral constellations and amplitude and phase-shift keying (APSK) constellations. All constellations are shaped by implementing the communication chain as an autoencoder, which is trained on a channel with the abovementioned impairments, which occur in satellite links. Resulting constellations are presented together with data predistortion, bit error rate (BER) and information rates.**

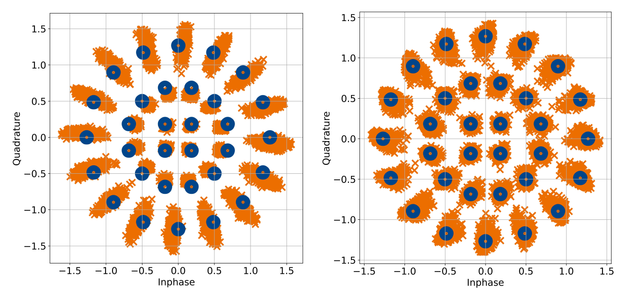
***Index Terms*—digital predistortion, satellite communications, constellation shaping, autoencoders**

Transparent satellite payloads, which are detailed in the broadcasting standards DVB-S2 [1] and DVB-S2X [2] involve challenging hardware impairments, including nonlinear power amplifiers, i.e., the TWTA and phase noise caused by the local oscillators [3].

In previous work, we have shown that warping and ISI impairments caused by the TWTA can be efficiently compensated by means of neural network-driven data predistortion [4]. In this work, we used a neural network with memory, i.e., an RNN, which reduces the ISI caused by the power amplifier effectively. The technique has been shown to outperform previous approaches of data predistortion, in particular the centroid-based approach [5]. Centroid predistortion has been included in DVB-S2 and is shown for comparison in Fig. 1. The figure shows the matched filter output for centroid-based and RNN predistortion. In RNN predistortion, the remaining ISI is better separated, which results in improved information rates and BER.

In this poster session, we show how the RNN approach differs from the centroid approach. We provide an introduction to communication autoencoders and how the cross-entropy loss can help to maximize channel mutual information [6]. We then present BER and information rates for centroid and RNN predistortion and illustrate how the communication autoencoder improves performance for data predistortion.

Lastly, we give a summary on how constellation shaping can be used to further improve the results, particularly when phase noise impairments additionally degrade performance in satellite channels.



(a) RNN predistortion [4]. (b) Centroid predistortion [5].

Fig. 1: Data predistortion with RNN and from DVB-S2.

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