Decode NFDM-QAM signals with carrier phase and frequency offsets using convolutional neural network

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Similar to linear Fourier domain, which can be used to carry information for fibre optic communication, a new type of transform called nonlinear Fourier transform (NFT) opens the access to a nonlinear Fourier domain where different nonlinear frequency channels do not suffer from nonlinear interference [1]. Hence, the infamous Shannon capacity limit can be overcome. However, due to the mathematical complexity, hardware implementation of the direct NFT algorithm is not trivial [2]. To circumvent this challenge, an indirect approach of using machine learning and convolutional neural network (CNN) was proposed recently [3, 4]. In practice, compensations of carrier frequency offset (CFO) and carrier phase offset (CPO) need to be carried out before the neural network can be applied. Here, we explore the possibility of using the same neural network for decoding to accomplish CFO and CPO compensations as well. We demonstrate a CNN, which is shown in Fig.1, with 16-subcarrier 16-QAM signals and show that when CNN is trained with separated signal bursts, it is limited by the phase ambiguity originating from the symmetry of the constellation such as at 0, 90, 180 and 270 degrees. But if the constellation diagram is modified to remove rotational symmetry, the CNN can demodulate the signal without CFO and CPO compensation.

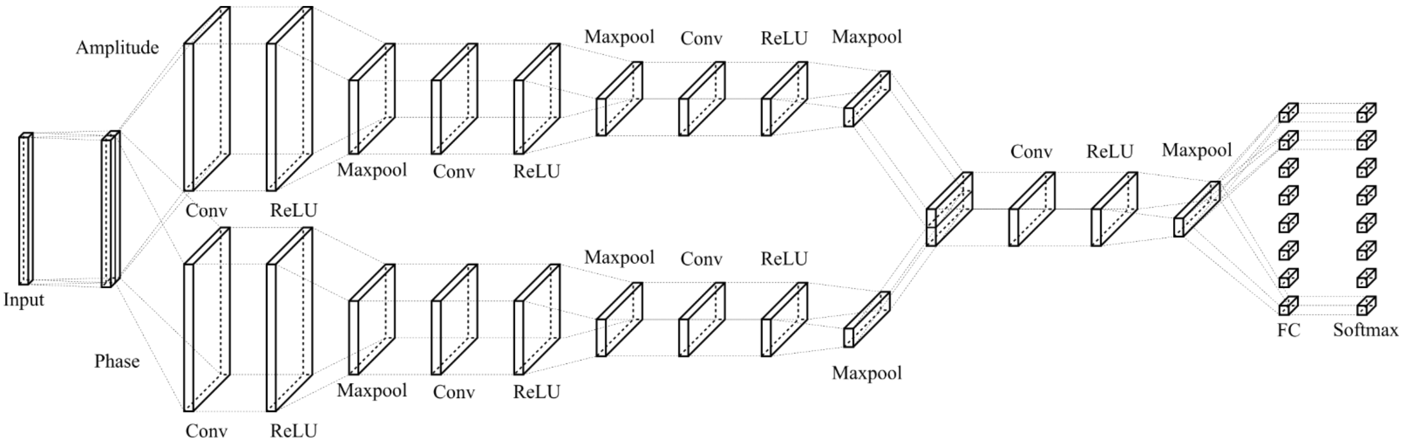

Fig. 1: Schematic of the convolutional neural network

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[2] A. Vasylchenkova et al., in Nonlinear Optics and Applications XII, 2021, vol. 11770, pp. 111–120.

[3] W. Q. Zhang, et al., Sci Rep, vol. 12, no. 1, p. 7962, May 2022.