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(Article begins on next page)

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Ultra-wideband (UWB) optical communication systems, envision to operate in O+E+S+C+L band, are a viable solution to cope with the network's exponential traffic growth [1]. One of the main challenges to provide beyond C-band transmission is a lack of optical amplifiers. Since the erbium-doped fiber amplifiers (EDFAs) are limited to C and L bands only, new technologies will have to be explored to cover the remaining bands. Some examples of amplifiers able to provide amplification beyond C–band are: bismuth doped fibre amplifiers (BDFA) [2], semiconductor optical amplifiers, (SOAs) [3] and Raman amplifiers (RAs) [4]. Compared to the solutions based on BDFA and SOA, optical amplifiers based RAs offer a higher degree of commercial maturity [5]. Most importantly, RA amplifiers can provide gain in any band provided a proper allocation of pump powers and wavelength.

The ability to provide arbitrary gain profiles in a controlled way has a broad application in the field of optical communication. As an example for the UWB systems due to the non-linear interactions between different bands, a tailored gain profile is needed to maximize the achievable information rate. Moreover, non-flat gain profiles are beneficial for compensating wavelength-dependent gains of EDFAs, BDFAs and SOAs, or flattening frequency combs.

Configuring pump powers and wavelengths that would result in a targeted gain profiles is an inverse problem. We have recently demonstrated that the techniques from machine learning (ML), such as multi–layer neural networks can be used to solve the aforementioned problem [6, 7, 8]. In short, our approach relies on using multi–layer neural network (NN) to learn the mapping between the gain profiles and the pump powers and wavelength, (inverse NN), as well as the pump powers and wavelength and the gain profiles (forward NN). We then employ an autoencoder–like structure where we present the target gain profiles to the inverse NN to obtain a configuration of pump powers and wavelengths which are the passed to the forward NN to obtain the gain. The obtained gain is then compared to the target gain and is the error is not acceptable, the error is backpropagated through the forward NN and the pump powers and wavelength are adjusted.

We have used the machine learning framework to realize arbitrary gains in a controlled way of RAs working in C and S+C+L–band [6, 7]. In [7], the proposed machine learning approach provided the designs of more than 1000 programmable gains profiles with a very low maximum error of $1.6 \cdot 10^{-2}$ dB/THz over an ultra–wide bandwidth of 17.6–THz. This result demonstrates the potential of the proposed ML-based programmable RA to become a reference tool to wisely exploit the future UWB transmission systems.

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