Deep Neural Network for Predicting Supercontinuum Broadening in Chalcogenide Photonic Quasi crystal Fiber

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***Abstract*—Generation SuperContinuum (SC) is a complex nonlinear process caused by chaotic and unstable behaviour, especially simulated by short duration pump pulses when the optical fiber work on the anomalous dispersion region. Understanding the spectral broadening behavior is difficult due to variations in fiber length and input pulse parameters. To address this challenge, we introduce a Deep Neural Network (DNN) to predict the SC spectrum broadening. Remarkably, the DNN provides accurate predictions across different lengths of Chalcogenide (ChG) Photonic quasi crystal Fiber (PQF), achieving a root mean square error (RMSE) of 1.3677 and an R-Squared value of 0.99. Additionally, this DNN significantly reduces the computational time compared to MATLAB and COMSOL Multiphysics software.**

***Index Terms*—Supercontinuum, Deep Neural Network, Chalcogenide, photonic crystal fiber**

I. Introduction

Deep learning (DL) encompasses a range of computational techniques aimed at classification, pattern recognition, prediction, and system optimization using extensive datasets. Recently, an interest has been grown in employing deep learning methods in optical systems, particularly for managing ultrafast dynamics, such as shaping and compression of pulse through neural networks and tailoring SC spectra using genetic algorithms [1]. Moreover, deep learning is a excellent tool to perform the quantitative analysis in complex systems with more number of data parameters. This capability can be effectively utilized to measure the maximum SC spectral broadening for different fiber lengths [2].

The broadband SC has become a versatile and widely utilized light source with important applications in spectroscopy, imaging, and precision frequency metrology. The Generalized Non-Linear Schrödinger Equation (GNLSE) is employed to analyse mid-infrared SC generation phenomena. While this equation provides a solution for SC generation in photonic crystal fibers PQF [1], it does not offer a direct method for selecting the appropriate fiber structure to achieve the desired optical characteristics of SC generation. As a result, researchers often turn to various numerical modeling techniques for fiber structural analysis, such as finite element method (FEM), finite difference time domain and finite integration. These techniques involve discretizing the computational fiber structure into numerous elements to analyze optical properties, requiring adjustments to configurations and frequent simulation iterations. Consequently, the computational time and complexity of fiber structure analysis gets increased [3]. To address this, we propose a deep learning-based model to accurately predict SC spectral broadening with varying lengths of Chalcogenide (ChG) PQF. This model demonstrates more efficient SC broadening spectral behavior compared to traditional simulation tools.

II. METHODOLOGY

The broadband SC is generated by injecting femo-second (fs) pulses of laser through the highly nonlinear and anomalous disperive behavioured ChG PQF, as shown in Fig.1.