ABSTRACT

The primary aim of the research is to develop novel pattern identification integrated self-supervised frameworks for fully automated segmentation of brain Magnetic Resonance (MR) images for brain tumor detection obviating supervision or training. Initially, we have proposed a Quantum Bi-directional Self-organizing neural Network (QBDSONN) architecture for binary image segmentation and detection of complete brain tumor using TCIA data set collected from nature repository. The QBDSONN architecture comprises a trinity of layered architecture viz. input, intermediate/hidden and output layers. Each one of the layers is composed of *qubits* or quantum neurons and these quantum neurons are intra-connected through intra-layer connections. The input, intermediate, and output layers of the network architecture are interconnected using an 8-connected neighborhood-based fashion through forward, and counter-propagation precluding the complex standard quantum back-propagation algorithms. The segmented outcome is obtained once the network stabilizes or converges. The parallel version of the QBDSONN architecture for pure color image segmentation is also proposed and it is named as Quantum Parallel Bi-directional Self-Organizing Neural Network (QPBDSONN) architecture. The QBDSONN and QPBDOSNN architectures employed standard Sigmoidal activation function in quantum-inspired computing environment and found it suitable for bi-level segmentation while compared with the state of the art techniques and its classical counterpart. However, owing to wide variations of gray levels of brain MR images, a novel Quantum-Inspired Self-supervised Neural Network (QIS-Net) architecture characterized by Quantum-inspired Multi-level Sigmoidal (QMSig) activation function is proposed for fully automatic segmentation of brain MR images from TCIA data set. An adaptive activation procedure is introduced in the QMSig activation function to address the spread of intensity in underlying images. Four distinct adaptive thresholding schemes are incorporated in the underlying architectures encompassing image context-sensitive thresholding in quantum formalism. An optimized version of the QIS-Net architecture referred to as Optimized Activation for Quantum-Inspired Self-supervised Network (Opti-QISNet) is suggested advocating the hyper-parameters in optimal settings and yields optimal segmentation of brain MR images. The improvement in segmented outcome in terms of dice score is observed over QIS-Net on the same TCIA data sets collected from nature repository. Despite respectable accuracy and dice score reported by QIS-Net and Opti-QISNet, these *qubits*-based network architectures still suffer from slow convergence problems. A novel Qutrit-inspired shallow Fully Self-supervised neural Network (QFS-Net) model is proposed to enable faster convergence of the network architecture, thereby enabling better segmentation results while compared with QIS-Net and Opti-QISNet and also reported similar accuracy and dice similarity as U-Net and UResNet. The aforementioned network architectures (QBDSONN, QPBDSONN, QIS-Net, Opti-QISNet, QFS-Net) are validated on 2D brain image slices and hence they fall short in contextual semantic segmentation of Brain MR images. A 3D version of QIS-Net is developed incorporating 26-connected voxel-wise segmentation for volumetric brain tumor detection using Brats 2019 data sets and reported promising accuracy and dice similarity while compared with 3D CNN-based architectures (3D-UNet, VoxResNet, DRINet, 3D-ESPNet).

KEYWORDS: Quantum Computing ; Brain MR Image; Deep Learning; Medical Image Segmentation.