

Title: Enhancing Autism Spectrum Disorder Classification with Lightweight Quantized CNNs and Federated Learning on ABIDE-1 Dataset

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Abstract: Autism spectrum disorder (ASD) is a complex neurodevelopmental condition that presents significant diagnostic challenges due to its varied symptoms and nature. This study aims to improve ASD classification using advanced deep learning techniques applied to neuroimaging data. We developed an automated system leveraging the ABIDE-1 dataset and a novel lightweight quantized one-dimensional (1D) Convolutional Neural Network (Q-CNN) model to analyze fMRI data. Our approach employs the NIAK pipeline with multiple brain atlases and filtering methods. Initially, the Regions of Interest (ROIs) are converted into feature vectors using tangent space embedding to feed into the Q-CNN model. The proposed 1D-CNN is quantized through Quantize Aware Training (QAT). As the quantization method, int8 quantization is utilized, which makes it both robust and lightweight. We propose a federated learning (FL) framework to ensure data privacy, which allows decentralized training across different data centers without compromising local data security. Our findings indicate that the CC200 brain atlas, within the NIAK pipeline's filt-global filtering methods, provides the best results for ASD classification. Notably, the ASD classification outcomes have achieved a significant test accuracy of 98% using the CC200 and filt-global filtering techniques. To the best of our knowledge, this performance surpasses previous studies in the field, highlighting a notable enhancement in ASD detection from fMRI data. Furthermore, the FL-based Q-CNN model demonstrated robust performance and high efficiency on a Raspberry Pi 4, underscoring its potential for real-world applications. We exhibit the efficacy of the Q-CNN model by comparing its inference time, power consumption, and storage requirements with those of the 1D-CNN, quantized CNN, and the proposed int8 Q-CNN models. This research has made several key contributions, including the development of a lightweight int8 Q-CNN model, the application of FL for data privacy, and the evaluation of the proposed model in real-world settings. By identifying optimal brain atlases and filtering methods, this study provides valuable insights for future research in the field of neurodevelopmental disorders.

Key words: autism spectrum disorder (ASD); ABIDE-1 dataset; fMRI data; Int8 quantized CNN (Q-CNN); NIAK pipeline; brain atlases; federated learning (FL)

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