

## Two-Stage Filter and Multi-Head EEGNet for Multi-disease Brain Screening: A Dual-Track Deep Learning Approach

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### Abstract

Electroencephalography (EEG)-based artificial intelligence shows promise for screening neurological disorders, but cross-dataset generalization and consumer-grade hardware deployment remain open challenges. We present a deep-learning system that screens four neurological diseases (Alzheimer's, Parkinson's, epilepsy, stroke) plus healthy controls, deployable on an 8-channel OpenBCI Cyton headset. The pipeline uses two novel components: (1) a two-stage filter—broadband 1–100 Hz before independent component analysis (ICA) so the ICLabel artifact classifier sees its training-time spectrum, then 0.5–45 Hz after ICA for downstream clinical analysis; and (2) a multi-head EEGNet architecture with auxiliary binary heads that pressure the encoder to separate bottleneck classes. We curated 552 subjects from nine public datasets (86 GB), preprocessed to 178,791 epochs of 4-second 19-channel data at 250 Hz, and evaluated with 5-fold subject-independent cross-validation. The 5-class system reached 0.67 accuracy (macro-F1 0.70, AUC 0.90); the multi-head approach raised healthy-class F1 from 0.47 to 0.63. Reframing as 3-class clinical screening (healthy / other-disease / stroke) reached 0.76 accuracy (macro-F1 0.81, AUC 0.90), with stroke F1 of 0.99. Notably, the multi-head architecture acted as a regularizer that allowed 30-epoch training without overfitting—a behavior the single-head baseline did not exhibit. The dual-track design demonstrates both the limit of fine-grained EEG diagnosis (Parkinson's bottleneck) and the practical value of clinical-screening reframing, providing a deployable AI tool for brain-disorder triage on consumer-grade hardware.

**Keywords:** Electroencephalography, Deep Learning, EEGNet, Multi-Head Architecture, Clinical Screening