NeuroHAT: Democratizing Brain-Wellness Monitoring Developing A Wearable System with fNIRs & EEG Multimodality Classification Engine & Miniaturized Device

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The human brain is one of the most unknown yet essential parts where many life threatening diseases such as strokes, Alzheimer's Disease (AD), and Parkinson's Disease (PD) begin silently. Brain signals have long been used to diagnose brain dysfunctions. However, most methods require in-clinic, expensive, stationary, and diagnosis-focused brain imaging after symptoms surface and damage occurs. NeuroHAT aims to fill the gap in a safe, affordable method for routine brain-wellness monitoring that detects brain dysfunctions and provides insights on naturalistic state. NeuroHAT is a two-part system: First, EEG and fNIRs cross-informed data preprocessing for artifact removal and XGB and CNN dual detection engine. Second, a miniaturized helmet with 16 EEG and 16 fNIRs channels on a 10-10 Modified Combinatorial Nomenclature (MCN) system to collect concurrent EEG and fNIRs data. Wearability and channel allocation were both optimized following a Human-centered AI-driven Technology (HAT) principle. Data is transferred from the all-in-one helmet to the detection engine on a computer through WiFi and Bluetooth. The prototype device costs < $300. In detecting AD and Mild Cognitive Impairment (MCI), NeuroHAT system achieved an accuracy of 93.1%, outperforming the existing EEG-fNIRs combined in-lab research accuracy by 12.8%. The breath-holding, finger-tapping, and sleep-learning validation tests all reached 85%+ accuracy. To my knowledge, NeuroHAT is the first system with EEG-fNIRs multimodality signals, cross-informed data preprocessing algorithm, XGB-CNN dual detection engine, and all-in-one device to achieve lab-equivalent results. It paves the path towards democratizing brain-wellness monitoring with safety, wearability, high spatial and temporal resolution, and affordability.

Awards Won:
International Council on Systems Engineering - INCOSE: Certificate of Honorable Mention, a 1-year free student membership to the INCOSE, and free virtual admission to the 2022 International Symposium of the INCOSE