NEXUS: Neurophysiological Emergency eXternal Understanding System- An AI-Integrated Wearable Device Using Multi-Mode Communication and Emotional State Detection in Autism Spectrum Disorder Populations for Elopement Prevention

Chaturvedi, Anvi (School: Urbana High School)
Chaturvedi, Tanvi (School: Urbana High School)

Elopement/wandering affects nearly 49% of children with Autism Spectrum Disorder (ASD), and 71% of these cases result in fatal outcomes. Existing tracking systems rely on cellular subscriptions or short-range Bluetooth, which leads to high cost, limited range, and unreliable alert delivery. Our project aimed to develop a low-cost, subscription-free safety device capable of predicting elopement risk and ensuring reliable caregiver notification without needing a cellular connection or Wi-Fi. We engineered a modular wearable device equipped with a 3-axis accelerometer, GNSS/GPS module, and long-range LoRa communication. A kinematic-based algorithm activated location tracking only during high-risk movement, reducing power consumption. Data was transmitted to a local gateway, which applied a dual-layer geofencing system using RSSI-based signal degradation and Haversine distance calculations. When the thresholds were exceeded, alerts were sent through a connected application using a communication pathway that was designed to bypass standard notification restrictions. Results showed a 12-fold improvement in battery efficiency compared to continuous GPS tracking. The motion-based classifier achieved 93.4% accuracy with less than 1% false negatives. Additionally, long-range communication reduced alert latency to 120 ms compared to 3.5 s for standard cellular systems. NEXUS demonstrates a reliable, user-friendly, cost-effective, and scalable approach for early detection and prevention of elopement without reliance on cellular or Wi-Fi, with a strong potential to improve safety outcomes in neurodiverse populations.

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