NeuroAcoustix: Revolutionizing Brain Health Through Sound

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Intracranial aneurysms (IAs) often rupture before detection, causing hemorrhagic stroke that is fatal in 50% of cases. Expensive ($800 - $8400) hospital-based diagnostic tests are conducted only after complications occur. NeuroAcoustix was developed as a non-invasive early screening device that flags for risk of IA presence by analyzing the acoustic response produced by altered blood flow in brain vasculature. A working prototype was built using piezoelectric microphones to capture acoustic signals generated by cerebral blood flow. These signals were amplified, digitized, and processed on a Raspberry Pi. CFD vascular simulation data was analyzed using spectral analysis, principal component analysis, logistic regression, and random forest classification. Similar measurements and data analyses were done on 3D printed Circle of Willis models with normal and aneurysm anatomy. The biological feasibility of the device was validated using decellularized spinach leaf scaffolds recellularized with Human Aortic Endothelial Cells. ML models were optimized for recall to flag for risk. Statistically significant differences ($p<0.05$) were observed between normal and aneurysm acoustic responses, with the average signal-to-noise ratios being 24.35 dB and 18.83 dB, respectively. PCA projections showed distinct clustering separation for both cases across all frequencies. The ML models achieved 93.33% recall. NeuroAcoustix successfully recorded a repeatable acoustic pattern (2.2-3.2V) based on the normalized frequency (Hz). It demonstrates the efficacy of a portable screening device costing under $200 and weighing under 3 pounds. This technology could enable early at-home screening for brain aneurysms, supporting timely medical intervention and saving lives.

Awards Won:
Sigma Xi, The Scientific Research Honor Society: Second Life Science Award of $800