PhD Dissertation Defense Announcement
Mechanical and Aerospace Engineering Department
University of Texas at Arlington

Understanding brain health in the accelerative environment using integrated signal analysis, phantom head tissue manufacturing, and Electroencephalography (EEG)

By

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10:00 a.m., Monday, Oct 14, 2024
Woolf Hall, Room: 413

Abstract

Traumatic Brain Injury (TBI) is considered a 'silent epidemic' because of its high incidence and great threat for disabilities. In the aerospace scenario, sudden and severe turbulence can cause occupants of an aircraft to lose balance and fall, leading to head injuries. Objects in the cabin or overhead bins can also act as projectiles. Other situations, such as high altitude-induced hypoxemia, may cause an inflammatory response in the brain and amplify the severity risk of a TBI. TBI may result from Traumatic brain injury that causes electrophysiological abnormalities that can be visible in Electroencephalogram (EEG). EEG is used to sense and localize the brain's neural activities, where it records the electrical field on the scalp of the brain tissue. Here, a synthetically generated brain-like signal is passed through a newly designed phantom head tissue and sensed by conventional EEG systems. The goal is then to develop a methodology to uncouple EEG signals from motion-induced signals and accurately detect the location of potentially injured region inside a brain tissue. Such injuries might result from exposure to severe turbulence and blunt impact from cabin objects, among other causes.
The first phase of the study involves developing a source localization algorithm for EEG using a combined experiment and simulation to enable greater accuracy than the degree of accuracy available in commercial EEG systems. This algorithm has been evaluated using a 32-channelwet EEG electrode setup. Our second phase focused on advancing the technologies by applying EEG to realistic phantom heads. A real human head tissue is made of several layers, such as the scalp, skull, meninges, and brain tissue. Polydimethylsiloxane (PDMS)-Carbon fiber (PDMS-CF) composites were chosen to produce a multilayer head phantom model. Different concentrations of CF are used to achieve different targeted conductivity. The results were then compared with the statistical studies of 56 previously conducted experimental data on various head tissue layers.

Finally, a phantom head is manufactured. Mobile EEG and industrial-grade robotic arms have been used to mimic different dynamic motions and conduct experiments in a dynamic environment. An algorithm is developed for uncoupling unwanted motion artifacts and environmental noises. The algorithm has been tested and compared with commercial methods.