Enhanced EEG Utilizing a Tripolar Concentric Ring Electrode

W. Besio[1], K. Koka[1], R. Patwardhan[2].

[1]Dept. of Biomedical Engineering, Louisiana Tech University-Ruston, LA
[2]Dept. of Neurosurgery, Louisiana State University-Shreveport, LA

Background-Brain activity generates electrical potentials that are spatio-temporal in nature. EEG is the least costly, most widely used non-invasive technique for diagnosing many brain-related problems. Despite good temporal resolution, blurring effects of the volume conductor impair spatial resolution. A surface Laplacian sensor, performing the second spatial derivative of the potential, can significantly enhance the spatial resolution and selectivity of the surface electrical activity. A five-point finite difference method as an approximation to the surface Laplacian has recently been used in a bipolar electrode configuration.
Objective-To develop an EEG electrode system with a significant improvement over current systems.
Methods-A nine-point finite difference method approximating the surface Laplacian was used as a model for a tripolar electrode configuration. Electrode properties and dipoles at various depths below the electrode surface were modeled for bipolar, quasi-bipolar, and tripolar electrode configurations. A tank experiment was conducted to verify the computer-simulated potentials. A 2cm diameter electrode system was verified. Concentric ring electrodes of 5mm diameter were used to record EEG signals from humans as well as rats. The EEG signals were analyzed to extract the different rhythms of EEG activity.
Results-A mean correlation coefficient of 0.82 ± 0.1 between simulated and empirical values confirmed that our computer model was accurate. The proper frequency content of the EEG was observed when the subject's eyes were closed, open, and while they conducted mental exercise. We found that the tripolar electrode configuration has significantly (1% confidence level) better localization of sources and signal-to-noise ratio than the other configurations.
Conclusion-Our new, Laplacian concentric electrode system allows for more accurate measurement of localized EEG activity in comparison to currently available systems.