ABSTRACT

Electroencephalography and Magnetoencephalography are non-invasive methods, used in the recording and study of the brain's electromagnetic activity. During the stimulation of the brain's neuronal populations, an electric and magnetic field is generated in both the interior as well as the exterior of the brain. The neuronal activity is equivalent to the flow of dipoles which, in turn, is tantamount to the precence of a current in the interior of the brain; this results in the generation of electric and magnetic fields by a current source. The electric field is recorded through the Electroencephalogram (EEG) while its magnetic counterpart the Magnetoencephalogram (MEG).

The current study deals with the solution of the direct problem of Electroencephalography and Magnetoencephalography, via the use of mathematical analysis. The main objective is the determination of the electric and magnetic fields induced by a dipole source in the interior of the brain.

The first part of the thesis pertains to the solution of the direct problem of Electroencephalography based on spherical homogeneous and inhomogeneous models. Specifically, the inhomogeneous model takes into consideration the different geometry of the brain tissue, the cerebrospinal fluid, the cranial bones and the skin.

The second part of the thesis involves the solution of the direct problem of Magnetoencephalography in an ellipsoidal geometrical setting. The ellipsoidal geometry, because of its intrinsic anisotropy, is a more accurate geometrical characterization of the brain.

Finally, it is noted that the induced magnetic field is represented via quadrupolic and octupolic approaches and as such a comparison of the two approaches is implemented. The resulting analysis shows that the quadrupolic term cannot adequately capture the source, whereas the octupolic term provides a more complete picture because it successfully recovers the magnetically “silent” sources of the field.