Micromagnetic Stimulation of Retina: Numerical Solutions and Preliminary Results

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Neural stimulation of the retina by direct current injection from an electrode array has been demonstrated by several groups. A retinal prosthesis based on this approach is being developed to partially restore vision to people affected by degenerative retinal diseases such as Retinitis Pigmentosa and Age-Related Macular Degeneration. In this paper, we explore the possibility of exciting neurons in the retina using eddy currents induced by time varying magnetic fields generated by an array of microcoils instead of traditional direct current injection by electrode arrays. This approach has a number of potential advantages: 1) currents in the neural retina induced by the microcoils can be more effectively controlled than those produced by traditional electrode arrays; 2) contact capacitances between the stimulator and the retinal tissue are avoided; 3) imperfect contact between the retina and the array of microcoils should not severely deteriorate the performance of the system; and 4) the array of microcoils, unlike the array of microelectrodes, can be entirely insulated from the vitreous humor, preventing the major potential source of damage to the stimulator.

We will present the formulation of a novel FD scheme used to analyze the performance of the microcoils, by solving the Diffusion equation for magnetic vector potential of cylindrically symmetric geometries and we will show numerical results for coils carrying time varying currents with embedded ferrite cores or sandwiched between ferrite materials. Further, we describe the assembly and testing of a basic magnetic stimulator circuit, where a capacitor is charged with a DC power supply and discharged through an inductor coil which acts as the stimulating coil to produce an under damped oscillation for the LCR circuit. After obtaining the rate of change of current inside the inductor coil in such circuit, we used our finite-difference based numerical code to estimate the eddy currents induced by such stimulating microcoils. The calculated rate of change of current in the inductor coil and the predicted induced eddy currents will be presented. We will also present a brief description of how the induced eddy currents can be shaped using an array of stimulating microcoils.