BRAIN-COMPUTER WIRELESS DATA COMMUNICATION THROUGH VOLUME CONDUCTION

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Current research on implantable brain-computer interface has been focused on recording and interpreting signals from the human cortex. Sophisticated electrodes and implantable chips have been developed to interface with the brain. However, one extremely important problem has not yet been addressed: How do we wirelessly pass this information to the computer outside the human body? Radio transmission is unsuitable due to the shielding effect of brain tissues and power restrictions. We have been investigating an alternative approach based on the mechanism of volume conduction of biological tissues.

We have performed theoretical investigation on the volume conduction properties of the human head and computed scalp potential distribution in response to both implanted current dipoles and transmitters (antennas) of different shapes within the brain. A spherical model was physically constructed to verify theoretical results. A number of experiments have been performed on animals to wirelessly transmit data from an implanted volume conduction antenna.

Our study and experiments have produced encouraging results. We found that: 1) data can be transmitted wirelessly with a good signal to noise ratio by emitting a small amount of current from the antenna; 2) the volume conduction based data transmission channel obeys the reciprocity theorem which constitutes the same sensitivity regardless of the direction of information flow (from brain to computer or from computer to brain; 3) using a new antenna design the far-field potential distribution, which effectively passes signal from the transmitter to the receiver, can be greatly enhanced; and, 4) the data communication module on the implantable device within the brain is very energy-efficient, potentially providing a mechanism to support continuous operation lasting for a life time. The details of these results will be demonstrated on a poster at the conference.

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