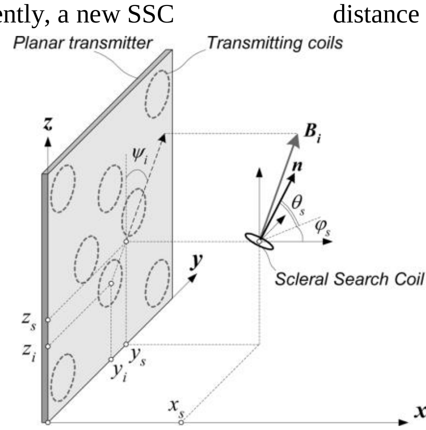
Magnetic Eye Tracking using a Planar Transmitter

Timothy Alberg: Biomedical Engineering student, University of Rhode Island

The ability to successfully track the movement of the head and eyes is very important in the diagnosis of neurologic, ophthalmologic, and vestibular disorders. This tracking is done by monitoring the position and voltages generated by scleral search coils (SSC). Traditionally, these coils were monitored by a large cubic transmitter, which used a wide area of transmitting coils to increase the SNR and tracking precision of the SSCs. It also uses simple analytical algorithms, allowing for a high tracking speed, and a low computational power. Unfortunately, the device is bulky, costly, and difficult to maintain, transport, and install. It also may cause distractions and discomfort for the test subjects as well. Recently, a new SSC tracking approach was designed and tested using a Planar Transmitter.



The Planar Transmitter utilizes an arrangement of thin coplanar transmitting coils to allow for strong magnetic fields over a large volume. The coplanar transmitting coils are arranges in two patterns on a thin square board: one coil in each corner, and four coils in a diamond shape in the center of the board. Each coil has its own specific excitable frequency (6.25, 8.3, 10, 12.5, 14.3, 16.7, 20, and 25 kHz), which allows for continuous and simultaneous excitation of the coils.

The coils to be used on the test subject included one SSC and a head coil. The SSC is an induction coil embedded in a ring of silicone rubber. It is designed to adhere to the limbus of the eye, and varying horizontal and vertical magnetic fields are used to generate voltages across the coil. The varying voltages are proportional to the horizontal and vertical sine waveforms of the position of the eye. A second coil in the sagittal plane is used to aid in the measurement of eye position. For this experiment, the SSC had a radius of 9mm and the coil contained 7 turns. The head coil had a radius of 5mm, 200 turns, and was mounted on a piece of balsa wood to be inserted in the mouth.

The test consisted of finding the gain of vestibular-ocular reflex (VOR) for two volunteers: one who was healthy, and one who had bilateral Meniere's disease. Each volunteer was asked to stare at a point 4m ahead of them as a medically trained professional rotated their heads at varying velocities (150-500 degrees/second). With each rotation, the eye and head velocities are calculated, and a ratio is formed. Ideally, the gain would be 1, and for the left and right eyes of the healthy volunteer, the gains were 0.96 and 1.02 respectively. For the bilateral Meniere's disease volunteer, they were 0.58 and 0.21 respectively.

From this experiment, the following limitations were determined for the Planar Transmitter: The SNR and random tracking errors increased as the distance between the SSC and transmitter increased, and since the planar transmitter requires more time consuming algorithms, more computational power is required to achieve an update rate similar to the cubic transmitter. However, from this experiment, many optimal values were determined to significantly lower statistical and tracking error. Also, given the extra computing power, it can match the performance of the cubic transmitter.

The planar transmitter is very compact, making it highly transportable, and easier to maintain. It is more appealing to the eye, and less noticeable to patients. It can be used to study the location and orientation of the eyes and head, where the cubic one can only monitor the eyes. The planar transmitter can also be used in bedside testing, allowing for convenient eye tracking during sleep. Concerning eye monitoring, this device enables monitoring anytime, anywhere, and can be used to monitor many ophthalmologic, and vestibular disorders because of this.

References:

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