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Semi-individual head models constructed from a standard head model and evaluations of their usefulness in the dipole analysis of EEG

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Abstract

We propose here a technique for constructing a semi-individual head model, which is an approximation to the individual one, by deforming a standard head model based on three size parameters measured on the subject, and present the results from computer simulations performed to evaluate how good are these semi-individual head models in the dipole analysis of EEG.

1. Introduction

A variety of methods for solving EEG inverse problem had been proposed. Among others, because of its simplicity, we have been concerned with the equivalent dipole method in which the electromotive forces in the brain are approximated by a few dipoles, and their locations and moments are determined by means of the least square method from the measured potential distribution on the scalp. In order to calculate the potential distribution generated by the dipoles, a real-shaped three-shell head model or a Scalp-Skull-Brain (SSB) head model is constructed for each subject based on his/her MRIs or X-ray CTs. However, they are not always available. And even if they are available, it is time consuming to construct a head model. So, we had devised a technique for constructing approximate head model, which shall be called the semi-individual head model, by modifying or deforming a standard model based on some measurements on the subject. We also performed computer simulations for 10 subjects to evaluate how good are these semi-individual head models for the dipole analysis compared with the individual head models.

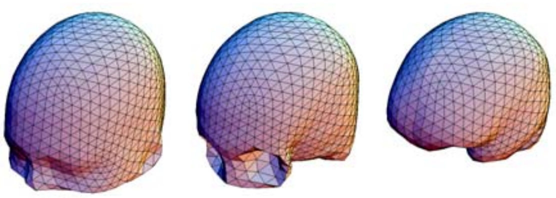

Fig.1 Standard Head Model

2. Head models

The standard head model was constructed from averaged MRIs (MNI305) provided by the Montreal Neurological Institute [1] as shown in Fig.1. Each shell of the model is triangulated with 912 nodes in this case, but the number of nodes can be adjusted easily as occasion demands [2].

In the same way, individual head models for 10 subjects including 4 males and 6 females were

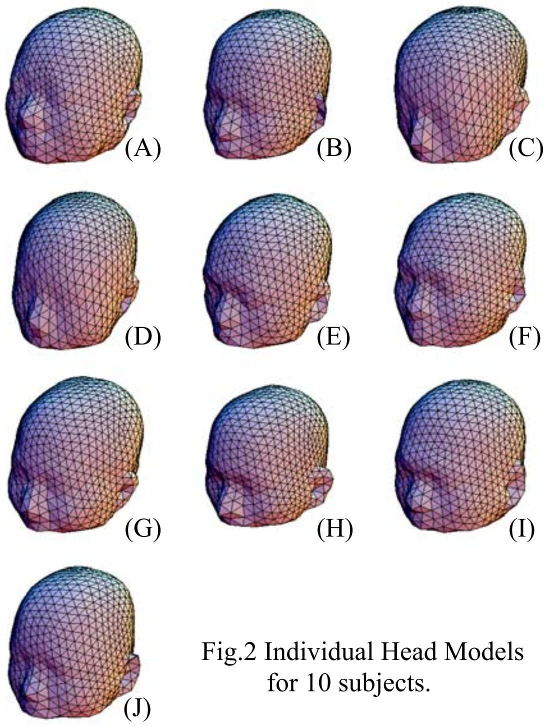

Fig.2 Individual Head Models for 10 subjects.

constructed from their own MRIs. Fig.2 shows the scalp part of the head model for each subject (A) through (J). The standard head model as well as the head model for subject (H), for example, lacks lower part of the face, but it works well for dipole estimation, because the electrodes are arranged over upper part of the scalp surface and the brain is surrounded by skull with low conductivity. So, the lower part of the face does not affect the potentials at electrode sites.

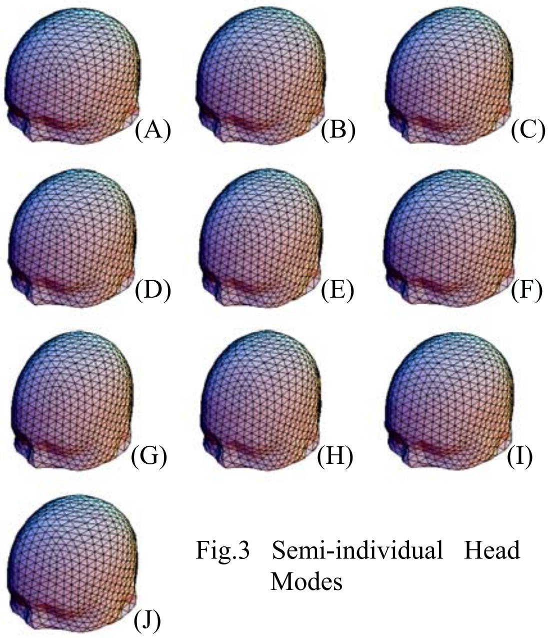

Fig.3 Semi-individual Head Modes

A semi-individual head model is constructed based on three size parameters measured from the subject, namely (1) the distance between nasion and inion, (2) the distance between both ears, and (3) the distance from nasion to inion along the cross line of the scalp surface with the median plane. The standard model is elongated or contracted along x, y and z-axis in order to approximate the subject's head. Elongation or contraction coefficients are determined so that the three scale parameters of the scaled model equal to those of the subject. Fig.3 shows the semi-individual head model thus constructed for each subject (A) through (J).

3. Usefulness of the semi-individual head models in dipole estimation

In order to evaluate the usefulness of semi-individual head models, computer simulations were performed as follows. At first, potential distribution generated by a dipole specified in an individual head model was calculated, and then, some noise was added to simulate measured potential distribution. Next, dipole was estimated from this potential distribution using the individual and the semi-individual head models. Finally, the dipole thus estimated was compared with the original dipole. Simulations were performed for all 10 subjects, 8 original dipoles sites

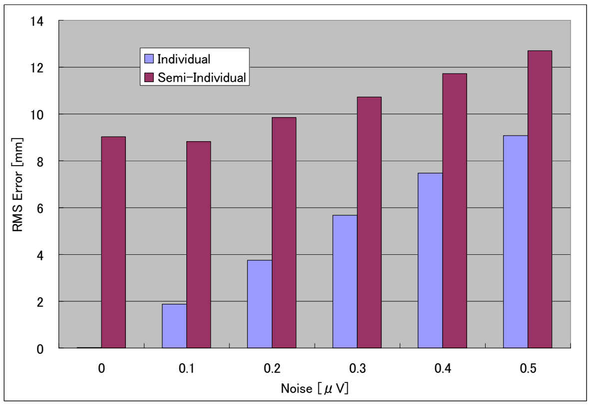

Fig.4 RMS Error in the Estimation of Dipole Location

for each subject, and 100 directions for each site.

Results from the computer simulations are summarized in Fig.4. When the individual head models are used in the inverse estimation, the localization error is proportional to the noise level as indicated by light blue bars. On the other hand, if the semi-individual head model is used, localization error is about 9mm even if the potential distributions are noise free. But the difference in the localization becomes smaller as the noise level increases. For example, if the noise is 0.3[μV], the difference is about 5[mm]. Since RMS value of noise free potentials is about 3[μV] per electrode, 0.3[μV] noise means that the signal to noise ratio in amplitude is about 10. For applications in which the estimation error of 10 to 15[mm] on average is allowable, the semi-individual head models would be useful. But for the applications in which the accuracy is crucial, we have to construct individual head models.

References

[1] http://www.bic.mni.mcgill.ca/cgi/icbm_view/

[2] Y. Okamoto, I. Homma: Development of a user-friendly EEG analyzing system specialized for the equivalent dipole method, International Journal of Bioelectromagnetism, 2004, Vol.6, No.1, http://www.ijbem.org/