

Measurement of 3D electrode coordinates by means of a 3D photogrammetric head digitizer

Herbert Bauer*, Claus Lamm*, Stefan Holzreiter†, Igor Holländer†,
Ulrich Leodolter*, Michael Leodolter*

*Brain Research Lab, Department of Psychology, University of Vienna, Austria

†Institute of Information Processing, Austrian Academy of Sciences, Vienna, Austria

INTRODUCTION

In order to yield more accurate EEG mappings and coregistration with other imaging techniques (such as MRI/fMRI), measurement of individual 3D electrode coordinates is increasingly used in EEG studies. With large electrode arrays, the sequential assessment of electrode locations (e.g. by means of a sensor pen device) may be very time consuming, with accuracy of measurements depending on the cooperation of subjects and the precise and reliable determination of electrode coordinates by the experimenter [1]. Here, a device (Photogrammetric Head Digitizer, PHD) with which large arrays of electrodes can be measured within milliseconds and in a parallel manner is presented (see Fig. 1).

MATERIAL AND METHODS

Electrode coordinates are measured using twelve calibrated standard commercial digital cameras (resolution: 1024x768). From various directions, cameras simultaneously take pictures of the subject's head which is equipped with light markers attached to the electrodes or electrode sockets and landmarks as nasion,inion or preauricular points. By means of direct linear transformation, spherical and cartesian coordinates of electrodes and landmarks are reconstructed. The actual measurement takes only a few milliseconds and is independent of subject's and experimenter's cooperation during the measurement. Provided a sufficiently dense sampling of the scalp by electrodes and/or additional markers, reconstruction of individual headshape is possible. This can be utilized for EEG mapping using 3D-analytical interpolation algorithms [2-3]. The accuracy of the device was tested using both calibration objects and actual electrode array measurements.

RESULTS

The accuracy of the device was assessed to be ≤ 0.2 mm. Repeated electrode measurements yielded a mean standard deviation (Euclidean distance between mean coordinates and single measurement coordinates per electrode) of 0.18 mm with a maximal standard deviation of 0.29 mm. When PHD coordinates and reconstructed head shapes were used to match EEG with MR coordinates, the mean Euclidean distance between surface points was 2.29 mm (about 1/5 of the electrode diameter when using Ag/AgCl electrodes), and the maximal deviation was 4.78 mm [4].

CONCLUSION

Measurement of 3D electrode coordinates using PHD is an accurate and practicable method. The device can be easily used in both laboratory and clinical settings where large arrays of electrodes have to be scanned rapidly and with high accuracy.

ACKNOWLEDGMENTS

PHD development was supported by grant P12289-MED of the Austrian Science Fund. Matching with MR data was supported by grant # 7174 of the Austrian National Bank-Jubiläumsfonds.

REFERENCES

- [1] Towle et al., *Electroencephalogr. Clin. Neurophysiol.* 86, 1-6, 1993.
- [2] Babiloni et al., *Electroencephalogr. Clin. Neurophysiol.*, 102, 69-804, 1997.
- [3] Lamm et al., *Hum Brain Map* 2000 poster submission
- [4] Lamm et al., *MAG*MA*, 8 (S1), 164, 1999.

