Date: Sun, 8 Jun 1997 13:50:36 -0400
Posted to: Biological Morphometrics Mailing List <MORPHMET@CUNYVM.BITNET>

Forum: Morphmet; http://life.bio.sunysb.edu/netforum/morphmet/a/1
Topic: Precision and/or Comparison of Data Acquisition Hardware
Subject: Comparison of Polhemus 3Draw Pro and Microscribe 3DX

Introduction

We conducted a small experiment to compare precision and determine the difference between two 3D digitizers: Polhemus 3DRAW PRO and Microscribe-3DX. The Polhemus uses interacting magnetic fields to locate the tip of a stylus in the active space, while the Microscribe uses a mechanical arm with several rotating joints. Manufacturers specifications are given at the www sites for the two companies:
http://www.immerse.com/WWWpages/MS.html#SPECIFICATIONS;
http://www.polhemus.com/3drawds.htm. We purchased a metal probe with a thinner shaft diameter than the standard one for the Microscribe.

Procedure

We fixed a baboon skull, with the Frankfurt plane horizontal, on the lower left corner of the 3Draw active area. A large piece of millimeter paper had been set under the plastic cover on the 3Draw stand. Using the mm paper, we calibrated both instruments by setting x, y, z at 0.00,0.00,0.00 cm at the lower corner of a virtual box; and with the end of the x axis at 40.00, 0.00,0.00 cm, the end of the y axis at 25.00, 0.00, 0.00 cm In this way we could compare raw coordinate data, and also do some fitting to compensate for some differences in the instruments. The Polhemus was calibrated and measurements recorded without the metal Microscribe present, and afterwards the Microscribe was placed on the corner diagonal from 0, 0, 0 for data collection.

Each of us measured the skull three times on each instrument during one session on one day. We randomized the order of persons measuring in each of the three replicates for each instrument. Eleven landmarks were digitized: Inion, Bregma, Glabella, Nasion, Rhinion, Nasospinale, Prosthion (=Alveolare), Right Zygomatico-maxillary suture inferior lateral point (ZMI), Right Porion, Left ZMI, and Left Porion. Significance tests are either reported as p values, or a 0.05 significance level is used for multiple comparisons if not stated. All computations were done using SAS 6.12 and GRF-ND.

Analysis

Raw coordinates were compared by two way analysis of variance (ANOVA) for each landmark coordinate and by MANOVA for each coordinate triplet, testing for no device difference, no person differences, and no interaction between device and person. We used GRF-ND to compute centroid size (CS) for each replicate and found the GLS residuals as well. We also did a 2 way ANOVA on CS. In order to compensate for differences in the initial instrument calibration, the data were reanalyzed after centering the skull landmarks at the mean for x, y, and z for each device. Using SAS IML, all 55 distances between landmarks were computed, as were all 11 distances from the centroid for each object. Some of the 55 inter-landmark distances are comparable to traditional physical anthropology measurements.

Results

Centroid size (CS) was larger for the Polhemus than the Microscribe by 0.54 mm ($p<0.0001$) and the maximum inter-person difference of 0.15 mm was significant, but the other two were not. The Root MSE was 0.06 mm for CS.

The 55 distances among landmarks differed (Polhemus - Microscribe) by between -0.30 to 1.66 mm (mean 0.70 mm) The difference was correlated with the distance between landmarks which varied from 6 to 224 mm (r = 0.75 and slope = 0.009 difference per mm of distance, i.e. about 1%) All distances differing by a value of greater than 1.00 mm involved the three landmarks at the front of the skull (Rhinion, Nasospinale, and Prosthion), but they were also further from the others. When these three landmarks were excluded, all remaining 28 differences were less than or equal to 0.82 mm, avaraging 0.36 mm. Most instrument differences were significantly different at the 0.05 level, with a Bonferroni adjustment using an actual 0.05/55 for significance as 55 distances were being compared. Interpersonal differences were only significant on some of the distances, and these differences were smaller than for the devices.

Examining the distance from each landmark to the centroid, the differences were not correlated with distance for the raw data, while for the centered data they were. In the latter case the differences varied between 0.20 and 1.63 mm. Correlation with distance was 0.88 and the slope of the regression of difference on distance was 0.01510.003

A separate ANOVA for each device for all coordinates was conducted to estimate repeatability of each device. The average root MSE for the Polhemus was 0.20 mm (range 0.07 to 0.41 mm) and for the Microscribe 0.24 mm (range 0.05 to .50 mm).

Discussion

The Polhemus results give a significantly larger "skull" than those for the Microscribe in our small experiment. The differences between the two devices are correlated with the size of the distance measured and are estimated to be on the order of 1 % of that distance. Inter-person differences are smaller than device differences; and are usually not significant. There were only rarely significant interactions between device and persons. The Polhemus gave a 20% smaller root Mean Squared Error for coordinates, and similar results were obtained for distances. We noted after we had concluded the experiment that each of us had placed the pointer at slightly different locations consistently for some landmarks, and that could account for some of the significant person differences.

Our root MSE for each instrument are close to what the manufacturers suggest, and each seems precise enough. We can't know the accuracy without a study of known sized objects. We do not suggest that our results provide guide lines for which instrument is superior. However, Marcus thought the differences were large enough to consider using only one instrument on a given project. It these results are found to be general it would be possible to adjust distances between instruments; but landmarks would be harder to adjust.

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