Comparing morphometric methods in *Macaca mulatta* crania

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INTRODUCTION

Accurate, reliable, cost-effective methods of measuring skeletal remains are vital to biological anthropology and related disciplines. Photogrammetry is a new method that is being utilized in various fields including, but not limited to anthropology, archeology and paleontology[1]. We compared the precision of 3D photogrammetry using Agisoft Photoscan[2], to that of two well-known methods for collecting 3D landmarks: NextEngine Laser Scanner[4] and Microscribe 3DX[3] .

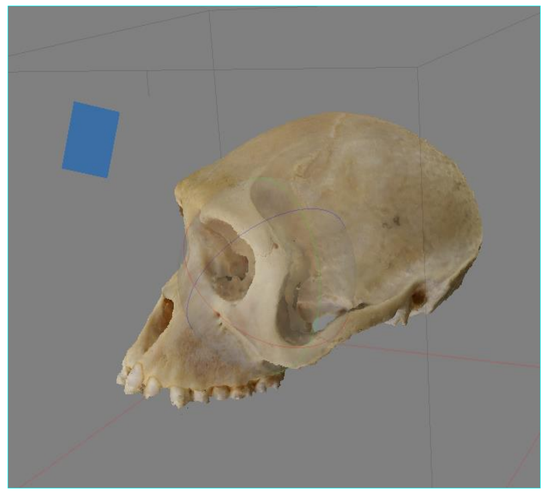
METHODS

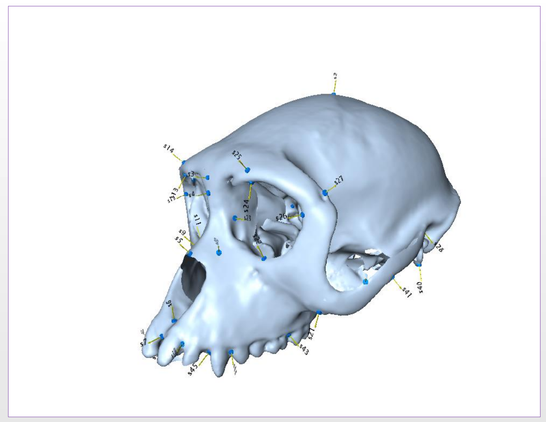
Two specimens (one male, one female) of *Macaca mulatta* from the University of Oregon Comparative Primate Collection were digitized by two users (RG, KC) who each collected 10 replications with all three methods using a well-established 45 landmark protocol[6]. Landmark Editor[5] was used to place landmarks on laser and photo scans. All 120 replications were then superimposed with generalized Procrustes analysis (GPA) in Morpheus with the scale restored[7]. Photo scans were scaled based on measurements taken directly on the specimens. To asses the overall precision of the three different methods standard deviations for the 135 coordinates were calculated. Overall variation among methods and users was also assessed with Principle Component Analysis (PCA) (Figure 1).

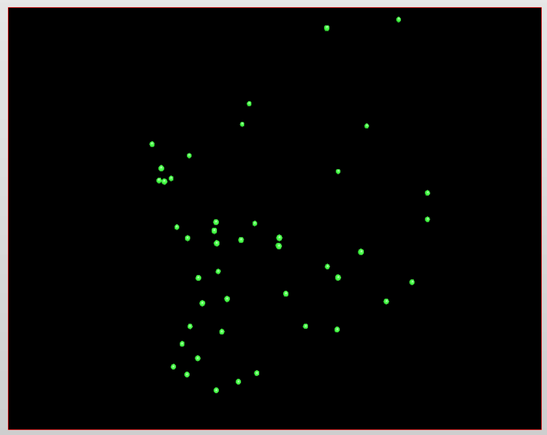
RESULTS

NextEngine laser scans had the best average precision (0.42mm). Microscribe 3DX (0.62mm) and Agisoft photo scans (0.67mm) were similar in precision to each other and quite precise compared to shape differences between the specimens studied.

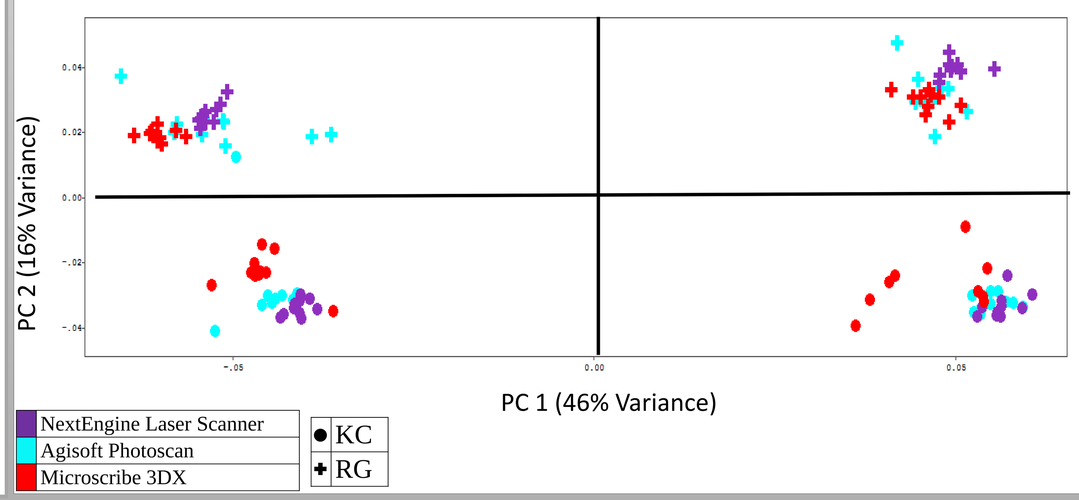
PCA indicated the general comparability of the three methods, and illustrates that differences among specimens are greater than those introduced by user or method. PC 1 (46% variance) widely separates the two specimens. PC 2 (16% variance) separates the two specimens by user. PC 3 (6% variance) sorts Microscribe 3DX from the other methods. There is some significant separation within user based method ($P < .0001$), but this was much smaller than the other factors.







(**Figure 1.** PCA of 120 replicates of 45 landmarks. Differences due to method are generally smaller than those due to users or shape difference between specimens. Axes scaled in proportion to eigenvalues.



DISCUSSION

We found landmarks derived from Agisoft photo scans were as precise as those collected using the Microscribe 3DX, but somewhat less precise than those from NextEngine laser scans. Whether the level of precision is sufficient depends on the goals of any particular study.

Compared to the Microscribe the photo scans had the advantage of producing a full surface model. They also preserved better full color representation of surface detail than the Next Engine. Photo scans are also significantly more cost effective than the either of the other devices. It was also significantly faster to take the photographs than to complete Next engine scans, at least in terms of time with the specimens in hand.

However, the methodology of Agisoft is much more difficult to develop and tends to be somewhat labor intensive compared to the others, especiallly when post processing time is taken into account. It was also less dependable than the other two methods as it was not always successful at building a model from photographs or at aligning different views to build a complete 360^0 model. We would like to see Agisoft Photoscan enhance their location alignment of digital photos and a method that is guaranteed to provide accurate and reliable scans every time.

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