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ANALYTICAL MORPHOMETRY IN ANTHROPOLOGY: MORHOLOGICAL DISTANCES FOR HOMINID SKULL SHAPE

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Abstract: *Curves with a very little cross error with smoothed function curves by Kth order polynomials from Hominid fronto-facial profiles giving fundamental shapes, may be obtained by Bezier interpolation using a strongly reduced set of points. Such determinant points may be considered as nodes suitable to build composition parallelograms whose resultant are to be considered vectorial description of the different segments of the worked profiles. Four vectors were obtained.*

Key words: *Analytic morphometry; Bezier interpolation; Hominids.*

Introduction

In this work we tried to have a vectorial description of sagittal fronto-facial profiles of Hominid skull specimens. The given profiles were considered as curves, so that it was possible to submit them to analytical procedures (Pesce–Delfino & Ricco 1983). One of these procedures implemented by us to describe the profiles of Hominid skull was based on Kth order polynomials (Pesce–Delfino et al. 1984, Pesce–Delfino et al. 1987). Function curves gave a smoothing of the profiles reducing them to less irregular curves characteristic of different evolutive groups. The smoothing effect was able to reduce the influence of local profile characteristics that could be referred to individual morphology. In the present work the aim was to find the set of minimum number of points, strongly reduced in respect to the number of points in which original curves were subdivided, that was able to give new curves with very little cross error with respect to polynomials. We called these points "determinant points". Such determinant points may be considered as vertex points suitable for building up a composition parallelograms, whose resultant could be considered vectorial description of the different districts of the worked profiles. For this aim Bezier interpolation was used (Pesce–Delfino & Lettini 1987).

Materials and methods

The following fronto-facial profiles were worked: *Plesianthropus transvaalensis, Zinjanthropus boisei, Homo habilis and Homo sapiens s.* These profiles are digitized by a contour-following procedure, under conditions of positioning standardization within a coordinate system, according to Frankfurt plane, and normalization that consists of an optical scaling, for each profile, to the same height, to allow comparisons of size independent shapes (Fig. 1a). The normalization adopted subdivided all the profiles into the same number of known coordinate points. Kth order polynomials were used for an approximation of the profiles by a function which gives a new smoothed curve (Fig. 1b), whose fitness was calculated in terms of square root of mean square error. This evaluator for each comparison was computed at the end of the progressive shifting, along abscissa axis, of a profile with respect to the other one, so that the minimum evaluator value was achieved. For each profile Bezier curves were obtained using six determinant points interpolation. These curves (Fig. 1c) were directly comparable with polynomial functions; in fact, as reported in Table 1, the values of square root of mean square error are very low, .less than the values in the match between original profiles and polynomials. The six determinant points represent the vertex points of an open polygonal, that has the same height of the worked curves. The obtained polygonals (Fig. 2a–d) amplify the differences existing among Bezier curves. Each pair of consecutive segments was considered within a composition parallelogram; so, for each polygonal, having six vertex points and five joining segments, we obtained four parallelograms (Fig. 3a–d), whose resultants we suggest have the meaning of a vectorial description.

Table 1. **Morphological distance evaluator: mean quadratic error square root**

Original curves/Polynomial functions		Polynomial functions/Bezier's curves
P. transv.	2.94	1.39
Z. boisei	2.3	1.86
H. habilis	1.81	1.25
H. sapiens	2.04	1.9

Results

Fig. 4a–d shows for each profile the series of first (a), second (b), third (c) and fourth (d) vector with their numerical values. Modulus is expressed by arbitrary units; direction is expressed in degrees referred to abscissa axis with the sign referred to ordinate axis. This figure shows the differences recurring for vectors corresponding to the same districts of different specimens: a) for the upper part of the frontal profile; b) for the lower part of the frontal profile; c) for the upper part of facial profile; d) for the lower part of facial profile. We have seen that a Bezier curve obtained by a polygonal built up by six vertex points, that is a very small set with respect to the 190 points in which the original curve was subdivided, is able to give a satisfactory redrawing of the smoothed profile. In addition, the polygonal gives the ability to obtain a family of vectors, that express the main information on the considered object for morphological, phyletic and biomechanical evaluations. The first vector (a) describes differences related to platicrany and orthocrany; the second vector describes the supraorbital thickening or flattening; the third vector describes differfences related to more or less pronounced folding of nasal profile; the fourth vector describes differences related to different degree of prognatism or orthognatism. If we accept that the Bezier alghoritm based procedure actually gives a vectorial description, the possibility of obtaining a satisfactory understanding of the shape could be stated.

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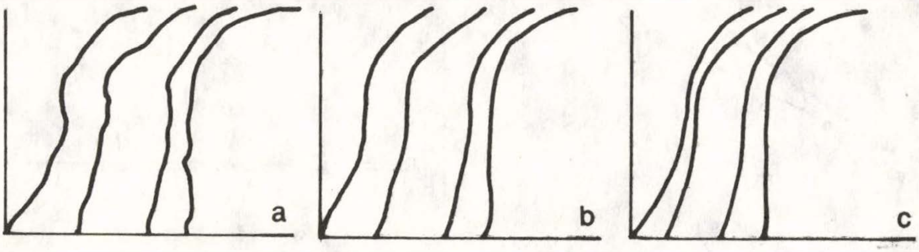


Fig. 1: a) From left to right, the sagittal fronto-facial profiles of ***Plesianthropus transvaalensis*, *Zinjanthropus boisei*, *Homo habilis*** and ***Homo sapiens s.*** are reported; b) Function curves by sixth order polynomials from the same profiles of previous figure; c) Curves obtained by Bezier interpolation from the same profiles of figure 1a.

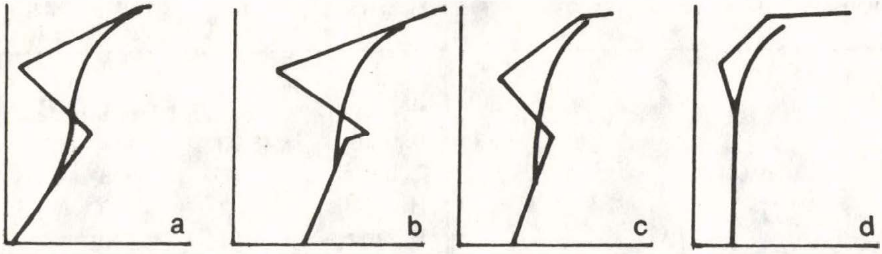


Fig. 2: Individualization fo the six determinant points from *Plesianthropus transvaalensis* (a), *Zinjanthropus boisei* (b), *Homo habilis* (c), and *Homo sapiens s.* (d). In *Homo sapiens s.* (d) fifth and sixth points lie on the same straight line correspondent to the facial district.

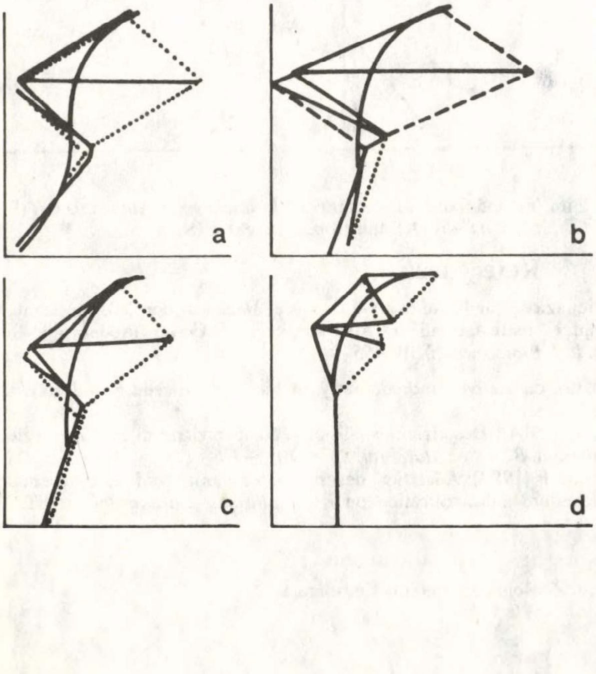
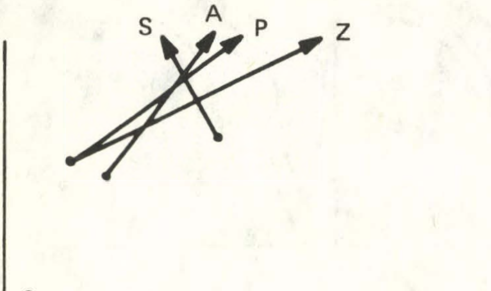
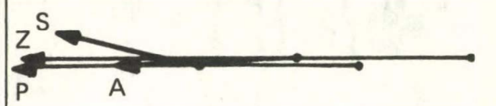


Fig. 3: **The four composition parallelograms from the same profiles of Fig. 2**



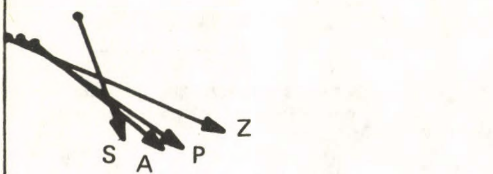
a.

	Modulus	Direction	Yersus
P. transv.	89	– 30°	PS
Z. boisei	118	– 21°	PS
H. habilis	69	– 44°	PS
H. sapiens	42	55°	AS



b.

	Modulus	Direction	Yersus
P. transv.	161	0°	A
Z. boisei	208	0°	A
H. habilis	122	– 3°	AI
H. sapiens	61	12°	AS



c.

	Modulus	Direction	Yersus
P. transv.	79	31°	PI
Z. boisei	105	21°	PI
H. habilis	65	34°	PI
H. sapiens	44	67°	PI

d.

	Modulus	Direction	Yersus
P. transv.	93	– 47°	PS
Z. boisei	75	– 78°	PS
H. habilis	72	– 73°	PS
H. sapiens	76	– 89°	AS

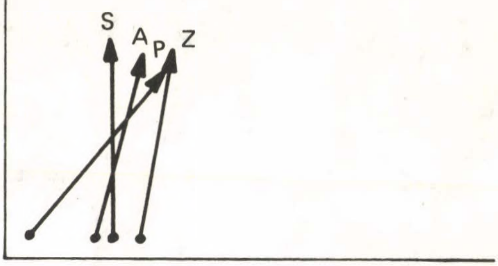


Fig. 4: The series of first (a), second (b), third (c), and fourth (d) vector for *Plesianthropus transvaalensis* (P), *Zinjanthropus boisei* (Z), *Homo habilis* (A), and *Homo sapiens s.* (S).

References

Pesce Delfino V, Lettini T (1987): Individuazione mediante interpolazione di Bezier di punti determinanti le curve fondamentali dei profili cranici fronto-facciali in Australopiteco e Uomo moderno e loro rappresentazione vettoriale. *Boll. Soc. Ital. Biol. Sper*, LXIII; 955–961.

Pesce Delfino V, Ricco R (1983): Remarks on analytic morphometry in biology: procedure and software illustration. *Acta Stereol., 2;* 458–468.

Pesce Delfino V, Scattarella V, De Lucia A (1984): Descrizione analitica e comparazione di profili e sezioni del cranio a mezzo di equazioni polinomiali. *Boll. Soc. Ital. Biol. Sper, 40;* 1–7.

Pesce Delfino V, Vacca E, Lettini T, Potente F (1987): Analytical description of cranial profiles by means of Kth order polynomial equations. Procedure and application on *Plesianthropus transvaalensis* (STS5). *Anthropologie, 25;* 47–55.

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