Démêler et quantifier les sources de variation morphologique à multiples échelles. Nouvelle méthode de partition de la disparité morphologique à l'aide d'arbres de classification et de régression

Matthias Vignon

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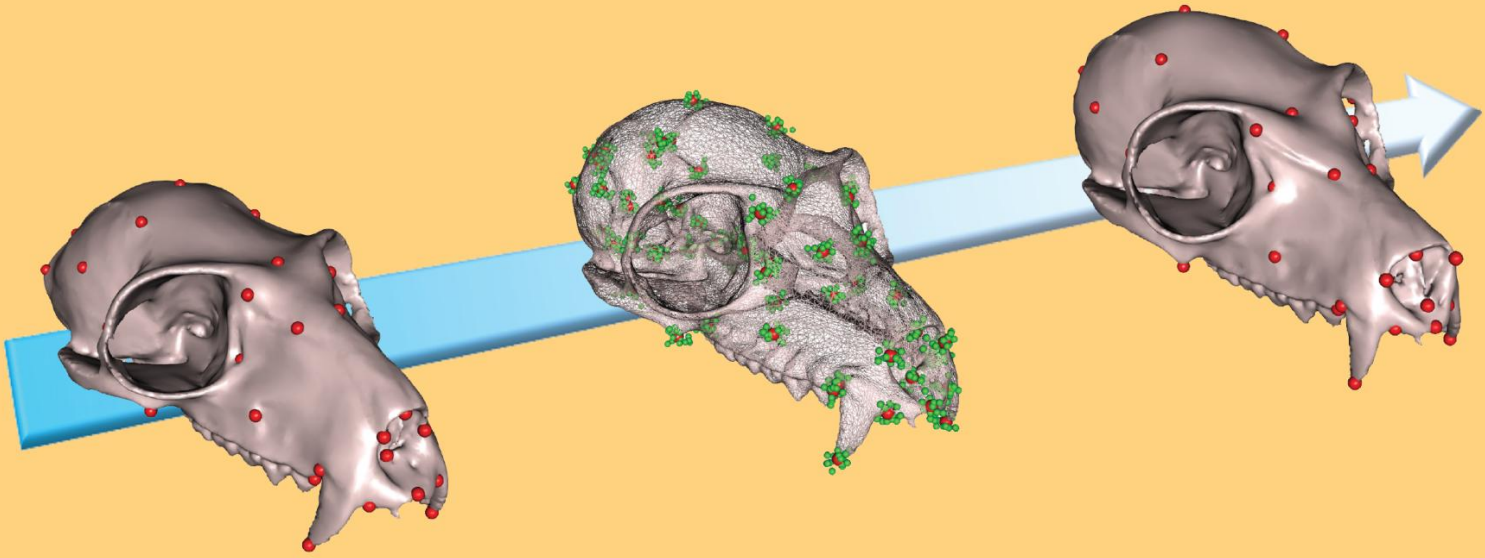

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Pour tout contact :
paul.alibert@u-bourgogne.fr ; remi.laffont@u-bourgogne.fr

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application of this method allowed to identify an ontogenetic effect on otolith shape for a majority of fish species as well as sexual dimorphism in and asymmetry between right and left inner ear of otolith shape in a few species.

Biomechanical modelling of human femora: a comparison between agriculturalists and hunter-gatherers using FEA, GMM and beam theory.

Püschel T.[1], O'Higgins P.[2]

1-Faculty of Life Sciences, University of Manchester, Manchester, United Kingdom; (thomas.puschel@postgrad.manchester.ac.uk)
2-Hull York Medical School, University of York, York, United Kingdom; (paul.ohiggins@hyms.ac.uk)

Any behavioural reconstruction based on skeletal morphology relies on the principle that bone is functionally adapted to its mechanical environment during life. Traditional beam theory has commonly been applied in biomechanics to model the behaviour of past lifestyles of human populations. Despite its usefulness, the application of beam theory to long bones makes several unrealistic assumptions. The most noticeable one is the fact that long bones are modelled as simple beams, without taking into account their complex shapes. To this day few studies have assessed the amount of error inherent in simplification as compared with other techniques. One such alternative is the use of finite element analysis (FEA), a mechanical engineering technique that allows for more complex forms, but is much more complicated to perform. The aim of the present dissertation was to contrast the two techniques by applying both to a classical bioanthropological example: the comparison of skeletal performance between agriculturalists and hunter-gatherers. 20 male Native American left femora belonging to two distinct populations a) Norris Farm (n=10): agriculturalists and b) Black Earth (n=10): hunter-gatherers, were compared by applying both classical beam theory and FEA. The femora were scanned using a Medical CT-Scan and the data volumes were manually segmented. Cross-sectional properties were then estimated in the model and each dataset was converted into a finite element mesh to perform FEA. Statistical analyses were applied to the resultant datasets to test which technique was better differentiating between hunter-gatherers and agriculturalists. Geometric morphometrics (GMM) analyses were also carried out, in order to compare their competence when distinguishing between past lifestyles as compared with the other techniques applied. These results are expected to contribute in a better insight when assessing lifestyle from femoral shaft morphology.

Démêler et quantifier les sources de variation morphologique à multiples échelles. Nouvelle méthode de partition de la disparité morphologique à l'aide d'arbres de classification et de regression.

Vignon M.[1,2]

1-UMR ECOBIOP INRA-UPPA, « Ecologie Comportementale et Biologie des Populations de Poissons », Pôle d'Hydrobiologie de Saint Pée sur Nivelle, INRA, Quartier Ibarron, 64310 Saint Pée sur Nivelle, France ; (matthias.vignon@univ-pau.fr)
2- UMR ECOBIOP INRA-UPPA, « Ecologie Comportementale et Biologie des Populations de Poissons », UPPA, UFR Sciences & Techniques de la Côte Basque, 1 Allée du parc Montaury, 64600 Anglet, France.

De très nombreux traits morphologiques présentent une plasticité phénotypique extrême, aussi bien au niveau inter/intraspécifique qu'inter/intrapopulationnel, voire intersexuel. Dans un contexte hypothético-déductif traditionnel les paramètres environnementaux d'intérêt sont généralement testés, en prenant parfois en compte d'éventuelles variables confondantes (paramètres intrinsèques tels que le sexe, la taille, *etc.*) mais sans pour autant que leur influence relative soit quantifiée. Il est donc très regrettable de constater que très peu d'études exploratoires aient quantifié l'importance relative d'un grand nombre de paramètres environnementaux et intrinsèques sur la variabilité morphologique de structures d'intérêt. Ceci limite fortement l'utilisation morphologique de certains traits morphologiques comme un outil de discrimination des groupes/stocks phénotypiques puisque les causes de cette discrimination demeurent le plus souvent inconnues.
Dans ce contexte, une nouvelle méthode de partition de la disparité morphologique basée sur une approche de morphométrie géométrique et utilisant les arbres de classification et de régression est présentée. Il

en résulte une quantification précise de l'influence relative des différents paramètres environnementaux et intrinsèques à multiples échelles. Cette approche se prête très bien à l'analyse de volumineux jeux de données pour lesquels un grand nombre de paramètres environnementaux ont été relevés et pour lesquels le collectionneur n'a pas d'idée *a priori* de la façon dont est structurée la variabilité morphologique. Des hypothèses plus fines de modularité, d'intégration morphologiques et d'interactions entre facteurs peuvent également être testées de façon identique. Mais la méthode proposée va bien au-delà de cette simple quantification et devrait permettre une meilleure compréhension du déterminisme morphologique de certains traits hautement variables.

Using Hough transforms for the characterization of the *Aurelia aurita* jellyfish shape.

Gadreaud J.[1], Martin-Garin B.[2], Viseur S.[2], Gourio G.[2], Thiéry A.[1]

1-Aix-Marseille Université, Univ. Avignon, IMBE UMR CNRS 7263, 13331 Marseille, France ; (justine.gadreaud@gmail.com, alain.thiery@imbe.fr)
[2]Aix-Marseille Université, CEREGE UM 34, 13331 Marseille, France ; (martin-garin@cerege.fr, viseur@cerege.fr, gourio@cerege.fr)

Among jellyfishes of the French Mediterranean coasts, the most common species are *Pelagia noctiluca* (Forskål, 1775) (Scyphozoa, Pelagiidae) – small purple urticant jellyfish very well-known by swimmers – and *Aurelia aurita* (L., 1758), [Scyphozoa, Ulmaridae], harmless, with a clear blue umbrella, short tentacles, and four horseshoe-shaped gastro-gonadal pouches. If anatomy of the latter is well-known, with a characteristic radial symmetry, some cases of malformations of their gastro-gonadal lobes were recently discovered in the Étang de Berre: impaired symmetry ranging from three to eight lobes more or less misshapen. Frequency of morphogenetic abnormalities is higher than in other populations. So the question is to know if the contaminants present in the water or sediment, which are in contact with strobili polyps – producing ephyra larvae, young jellyfishes – are responsible for these malformations. The microcosm study permits to determine the conditions of teratogenic jellyfish production. Two types of contaminants were chosen: chromium (III) – metal used by industries in many catalytic reactions – and spherical silver nanoparticles coated with polyvinyl pyrrolidone (PVP), 50 nm in diameter, new contaminants frequently found in the washing urban waters – silver nanoparticles having bactericidal properties.
The study proposes to combine two approaches for analyzing the relationship between degrees of teratology *versus* contaminant levels. First, an experimental *in vivo* approach has been implemented to test the effects of different concentrations of chromium (III) – salt $CrCl_3$ $6H_2O$ – and silver nanoparticles on morphogenesis. Second, digital photos of jellyfishes were taken and processed for an automated morphometric analysis. To achieve this, an ImageJ® (OpenSource) plugin was implemented. The developed algorithm aims at approximating the outline of the jellyfish and its gastro-gonadal lobes by ellipses to extract geometrical characteristics (sizes, numbers, etc.). This algorithm combines an original edge detector and an optimized Hough transform. This protocol permits to rapidly obtain several morphological characteristics that can be statistically analyzed and compared to explicative variables (contaminants, etc.).
This study aims to determine the dose-dependent effects and to test the model *A. aurita* jellyfish as a bioindicator of contamination in marine and lagoon environment.

Unsupervised models for typological classification of archaeological artefacts.

Wilczek J.[1,2], Monna F.[1], Gabillot M.[1], Navarro N.[3], Rusch L.[1], Chateau C.[4]

1-ArTéHiS, UMR 6298 CNRS-Université de Bourgogne, ArTéHiS, Bat. Gabriel, F-21000 Dijon, France ; (josef.wilczek@hotmail.com, Fabrice.Monna@u-bourgogne.fr, Mareva.Gabillot@u-bourgogne.fr, lucilerusch@yahoo.fr)
2-Ústav archeologie a muzeologie, Masarykova univerzita, Arna Nováka 1, 602 00 Brno, Česká republika.
3-Laboratoire PALEVO, Ecole Pratique des Hautes Etudes, UMR uB/CNRS 6282-Biogéosciences, Université de Bourgogne, 6 Boulevard Gabriel F-21000 Dijon, France ; (nicolas.navarro@u-bourgogne.fr)
4-Université de Bourgogne, UFR SVTE, 6 bd Gabriel, F-21000 Dijon, France ; (Carmela.Chateau@u-bourgogne.fr)

The classification of flanged axes dated to the middle Bronze Age is very complex. Many types of axes exist, and most of them are composed by numerous variants. For example, in the recent and well-established French terminology, those axes are represented by two generic groups: namely "Atlantic" and