New methods of analysis by 3D Imaging and Artificial Intelligence applied to archaeological remains

Abstracts

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Exploring variability in ceramic surface treatments using confocal microscopy

The main methodology of this study is experimentation applied to archaeology. Since it can help to reconstruct the relationship between the material record and the activities that generated it, in recent years experimentation has consolidated as a scientific method within prehistoric archaeology.The comprehension of some phases of past productive processes through material remains often requires the creation of references that can guide the identification and characterisation of the actions that generated them. In this sense, experimentation can reconstruct the connections between the archaeological record and past technological processes. It is therefore an excellent way to obtain information about productive activities and the economy of ancient societies, as well as to develop new analytical methodologies at macro- and microscopic levels. A test was carried out on a selection of pieces from an extensive experimental programme focusing on surface treatment and pottery working tools. In order to test whether the visual differences observed between the various surface treatments can be quantitatively measured, laser-scanning confocal microscopy (LSCM) has been tested. Laser-scanning confocal microscopy has proved to be an accurate and easy to use technique for surface microtexture measurement. For this analysis, we have used a Sensofar Plu Neox.

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Application of 3D modelling in the study and documentation of Holocene parietal and portable graphic expressions

The study of cave and portable graphic expressions of past societies requires increasingly precise and high-resolution recording techniques. This documentation, which must in turn meet standards of respect and protection of the decorated support, has become a fundamental support in the in-depth study of these graphic expressions, in promoting cultural heritage and in the implementation of new protection policies. In recent years, substantial improvements in digital imaging and 3D modelling protocols have been key to offering new possibilities in the recording of panels decorated with paintings and engravings, but also in the restitution and virtual reconstruction of ceramic vessels and other portable supports used for decoration. In this communication we will discuss several examples of the im plementation of 3D modelling, such as Levantine rock art, Neolithic impressed ceramics and Mesolithic engraved plaquettes. We will assess the wide possibilities of recording from a heritage point of view, as well as their contribution to the development of more accurate studies on the execution technique, the decorative composition or the use of graphic space.

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De la détection à l'analyse des sites monumentaux néolithiques en volume : premiers résultats de l'ANR Monumen

Depuis 2018, le projet ANR Monumen propose un changement de paradigme dans l'échelle d'observation des sites monumentaux néolithiques – mégalithes et grandes enceintes à fossés –, entre Loire et Pyrénées ,en les analysant dans leurs trois dimensions, puis en les intégrant dans une approche territoriale s'appuyant sur une maîtrise des contextes géomorphologiques et environnementaux. Au travers des recherches en cours, la présentation explorera l'utilisation de l'imagerie et de la 3D pour la détection et l'analyse de ces sites. Dans les différentes thématiques de ce projet multidisciplinaire les données sources sont devenues majoritairement numériques. Elles nécessitent l'utilisation de plusieurs outils tout au long de la recherche archéologique. La détection des sites néolithiques s'appuie historiquement sur les prospections pédestres et aériennes. Ces informations sont désormais complétées par les investigations non invasives tels que la géophysique et le Lidar. Ces outils ouvrent la possibilité d'étudier un site dans un espace et sur un territoire. L'imagerie en 3D est devenue incontournable pour le relevé des mégalithes. Que ce soit le Lidar, le scanner 3D, la photogrammétrie ou encore la RTI, ces techniques changent les données brutes mises à disposition de l'archéologue. L'étude multiscalaire du global jusqu'à l'art pariétal modifie la précision et la résolution de travail. La 3D a parfaitement trouvé sa place dans les fouilles archéologiques depuis une dizaine d'années. Sans modifier le travail de l'archéologue, l'enregistrement en volume réduit le temps sur site et tend à développer le chantier virtuel.

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Prehistoric ornamental and symbolic productions. Method and on-going analytical development by 3D surface imaging and AI applied to Neolithic impressed ceramics and Palaeolithic engraved animal hard tissues

The increasingly systematic use of 3D imaging instruments and Artificial Intelligence in archaeology is leading to a continuous renewal of analysis methods. Studies of prehistoric ornamental and symbolic productions are an example. In this communication, we will present the method developed in the framework of a PhD thesis, supported by the ANR CIMO, on ceramic ornamentations (Cassard, 2020). This recent work on North-Western Mediterranean Early Neolithic pottery has provided a new method for analysing impressed decoration. Based on 3D surface imaging, the data acquisition is both extensive and fine, making it possible to consider the ceramic assemblages in their entirety and to analyse each component of the decorative *chaîne opératoire* in detail. Its application has permitted a step forward in the characterization of decorative technical traditions and in the understanding of ceramic ornamentations, leading to a dynamic and anthropological vision of these productions. Efforts are now focused on the development of methods using Artificial Intelligence to process 3D scans of decorative imprints in order to increase their interpretative potential and lead to the automatic recognition and classification of tools and impression techniques used by Neolithic potters. We will report here on a first study on imprinted shell decorations, conducted within the framework of the ARCH-AI-STORY project in collaboration with the MSc Data Science & IA (University Côte d'Azur), which gave us a first glance on the methodological obstacles that need to be overcome in order to achieve the above-mentioned objectives. In the last part of this communication, we will discuss the potential of the method in the analysis of other artefacts from different chrono-cultural contexts. In this perspective, we will present the ERC QUANTA project, which aims, among other things, to renew the methods of analysis of engraved artefacts in animal hard tissues, dating from the Upper Palaeolithic, and possibly from the Middle Palaeolithic, which could symbolize the first digital information storage systems.

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Applications of Learning Methods to ancient ceramic manufacturing classification

Ancient pottery-manufacturing sequences can act as representative information for past human migrations and interactions. Studying the patterns characterising the internal structure of archaeological ceramic fragments leads to the identification of the sequences of technical gestures underlying manufacture, which represent pivotal information for archaeological studies. Modern archaeological studies involve numerical data analyses. The aim of this work is to analyse and classify ceramic sherds tomographic images following the discovery of a particular manufacturing process (the Spiral Patchwork Technology) in early Neolithic Mediterranean sites, along with a more traditional coiling technique. Identifying the manufacturing sequences can help archaeologists in learning about the fabrication processes of ancient pottery, and act as representative information for past human migrations and interactions. It has been shown that the ceramic pore distribution in available tomographic images of both archaeological and experimental samples can reveal which manufacturing technique was used. Indeed, with the spiral patchwork, the pores exhibit spiral-like behaviours, whereas with the traditional coiling technique, they are distributed along parallel lines. However, in archaeological samples, these distributions are very noisy, making analysis and discrimination hard to process. Here, we investigate how Learning Methods, such as Convolutional Neural Networks and Support Vector Machines, can be used to answer these numerically difficult problems. In particular, we study how the results depend on the input data (either unprocessed tomographic data, or after a preliminary pore segmentation step), and discuss the quality of the information they could provide to archaeological studies.

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First consideration of using artificial intelligence to distinguish morphologically related species' bones in archaeozoology: defining the issues and the appropriate tools

In archaeozoology, the methods used to identify animal species from bones recovered from archaeological sites are based on a combination of several anatomical and osteometric criteria. However, some species share very similar morphological traits that impede their distinction and thus limit their identification to the species level, especially when bones are poorly preserved, broken, or fragmentary. The objective of our study is to propose a new methodological approach based on machine learning methods to distinguish closely related species from their bones for archaeozoological applications. For this purpose, we selected four morphologically close caprine species: sheep, goat, mouflon and chamois; and we chose to study the shape of a particular bone, the astragalus, modeled in 3D image. As photography is the most common way of collecting and archiving archaeozoological data, we decided to test our approaches on 2D images obtained from the 3D models. Thus, the first step of the analytical procedure was to generate the datasets and select the most characteristic views. For this purpose, three datasets of various size and composition were produced using manual and automated methods. Then, the datasets were used as input data for the supervised transfer learning model to predict the mammal species. The chosen model structure is based on the convolutional neural network (CNN) with the deep residual network pre-trained on ImageNet (ResNet-18). Our results demonstrate that the combined use of these methods allow us to statistically distinguish the four species (around 60% accuracy). Moreover, they highlight the importance of the composition of initial dataset and the related hypotheses for such a study.