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CONTENTS

Reflectance Transformation Imaging (RTI) for visualising leather grain surface morphology as an aid to species identification: a pilot study.

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The identification of the animal species is an essential aspect of archaeological leather analysis. There are several routes now available for species identification. One is to submit small samples for either ZooMS, a form of protein fingerprinting using mass spectroscopy (Collins *et al.* 2010), or DNA analysis (Schlumbaum *et al.* 2010). When these are not feasible, the more traditional route is through a microscopic examination of the cellular structure of hair or skin. The analysis of hair is common to textile and fur research. The analysis of skin is particular to leather research and is based on a deep understanding of the fibrous structure of collagen viewed in cross section and the grain surface pattern of different species (e.g. Haines 2006; Leather Conservation Centre 1981; Michel 2014). This form of identification is based on the comparison of diagnostic features in leather of known species with features seen in archaeological leather artefacts of unknown species. It is based on the premise of moving from the known to the unknown.

One of the problems with visual analysis is that many leather specialists do not have access to the extensive reference collections or equipment needed to become familiar with the diagnostic features of leather from different animal species. The purpose of this pilot study was to test the value of Reflectance Transformation Imaging (RTI) as a digital imaging method for visualising leather grain surfaces and to assess its potential as an online tool for aiding species analysis of archaeological leather. Preliminary observations are reported here. The pilot was carried out by the authors using an RTI illumination dome at the University of Oxford.[1]

Reflectance Transformation Imaging (RTI)

Reflectance Transformation Imaging (RTI) is an advanced digital imaging technique that entails taking multiple captures of an object. With a high-resolution camera and macro lens an excellent level of surface detail can be recorded. Using either a lighting dome or arm, or the highlight technique (Mudge *et al.* 2006), the object is illuminated in a hemispherical configuration. These images are then compiled into a single file called a .ptm file (Malzbender *et al.* 2001) that can be viewed using open access software such as RTIViewer 1.1.0.[2] The viewer can virtually relight the object's surface from any direction, much like tilting it back and forth to catch the light and shadow that best reveal features of interest. RTI is especially effective for detecting faint traces or documenting complex surface shape where self-shadowing otherwise leads to information loss, e.g. cuneiform tablets, rock art, textiles, lithics, coins etc. (Earl *et al.* 2010; Frank 2015; Piquette 2011) and, of interest to us here, leather.

Method: image capture of the leather grain surface

Leather has two distinct surfaces. The surface once covered in hair and subsequently exposed after dehairing by the tanner is called the grain layer. The surface originally connected to the underlying muscle is called the flesh layer. The grain and flesh layers are connected by a fibrous network called the corium (Haines 2006, 12, fig. 3.2; Michel 2014, 25-6). This study focuses on the leather grain surface. RTI data was captured for the leather grain surface of 22 samples from reference collections held by Dean Sully of the UCL Institute of Archaeology, Roy Thomson, Leather and Conservation Scientist and Laura Youngson-Coll, Contemporary Maker in Leather and Vellum (Fig. 1). To achieve a suitable level of magnification we used a Nikon digital SLR

Fig. 1 Leather samples from the reference collections of Dean Sully, Roy Thomson and Laura Youngson Coll (Photo Susanna Harris).

camera, fitted with an AF-S NIKKOR 200mm lens. Leather samples were placed one at a time, grain side up, in the Oxford RTI illumination dome (Fig. 2). Equipped with an array of 76 LED computer-controlled light sources, the camera then captured 76 images in the RAW file format, each illuminated by a different LED (Fig. 3). This capture process was repeated for all leather samples. The resultant image data were subsequently processed into .ptm user files. Fig. 4 shows the RTIViewer interface. As can be seen from these images, the view can be magnified (Fig. 5) and the light position altered to bring out different features of the grain surface pattern (Fig. 6a-b). The ability to view images at varied magnifications will assist those who have access to different magnification equipment with which to compare their archaeological material (e.g. hand lens, microscope). In addition, viewer tools enable mathematical enhancement of grain surface features (Figs. 5c-d, 6c-d). The default and enhancement views bring out different features of the grain surface. For example, by adjusting the light source the alignment of raised features changes (Fig. 6a-b). In other views, the hair follicles are more evident (Fig. 4, Fig. 6c). Some enhancements may be more useful than others. It is worth noting that the original captured images are retained in the archival .dng format. This provides an image that can be used for further digital processing and analysis.

Fig. 2 Kathryn Piquette placing a leather sample into the RTI dome in the Centre for the Study of Ancient Documents (CSAD), Oxford University (Photo Susanna Harris).

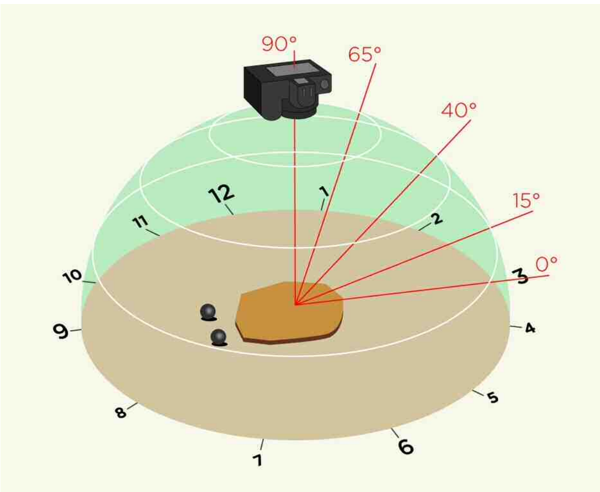

Fig. 3 Diagram of a RTI dome showing the position of the camera directed towards the sample and virtual clock indicating light locations according to hour positions and angle (diagram by Charlotte Gudmundson in Frank 2015, 6, Fig. 2 reproduced with kind permission).

Potential of RTI for species identification

The pilot study provided sufficient results to evaluate RTI as a tool for imaging leather grain surfaces from reference collections. The resulting image files were discussed with committee members of the Archaeological Leather Group and Prof. Matthew Collins of York University. Some of the advantages and drawbacks of this technique are listed in the table on p. 16. The main advantage of this technique is the production of multiple high quality digital images which can be viewed in two dimensions or using an RTI viewer for augmented visualisation. The RTI data, with its ability to provide the *appearance* of 3D surface information, offers a more natural

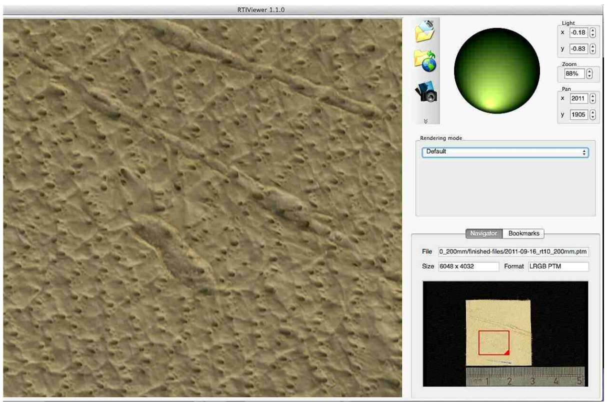

Fig. 4 Screenshot of RTIViewer 1.1.0. On the left is the display panel, showing the grain surface of a chrome tanned deer skin. The green circle **upper right** enables the user to alter the light direction. A dropdown menu **centre right** offers different enhancement modes. **Bottom right** is the full view of the digital source image with centimetre scale, with red frame indicating pan.

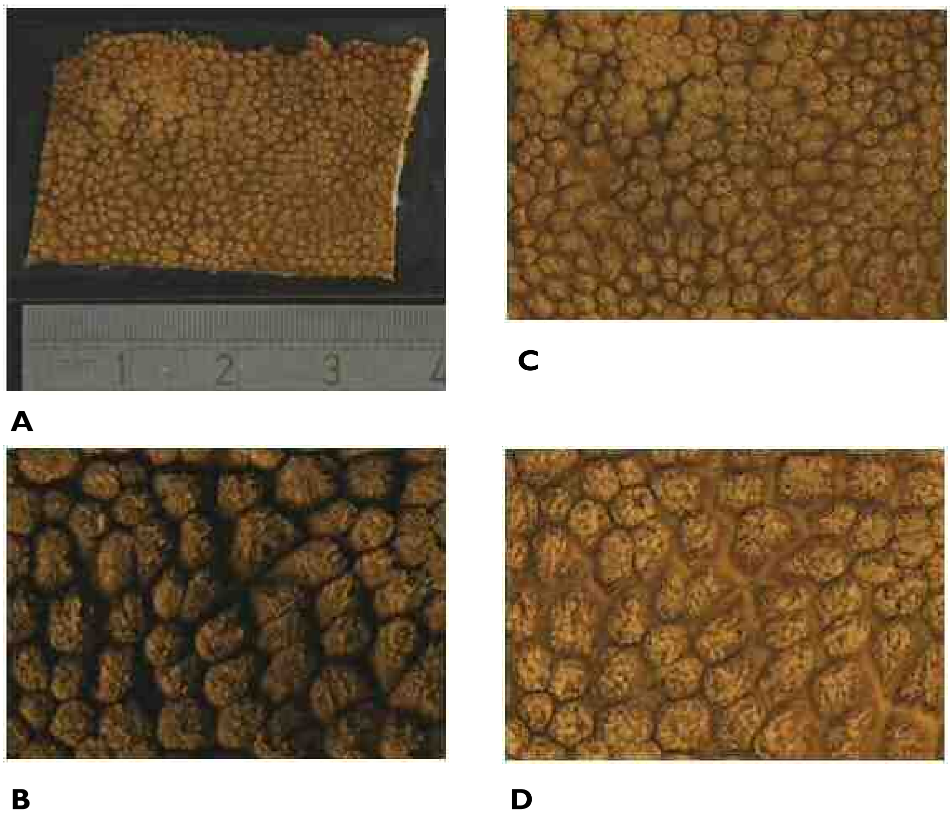

Fig. 5 The grain surface of chrome tanned elephant skin: **A** Default view at 20 % of source image, **B** at 50%. **C** Static Multi Light view at 100%, **D** Luminance Unsharp Masking view at 100% (RTI snapshots Susanna Harris).

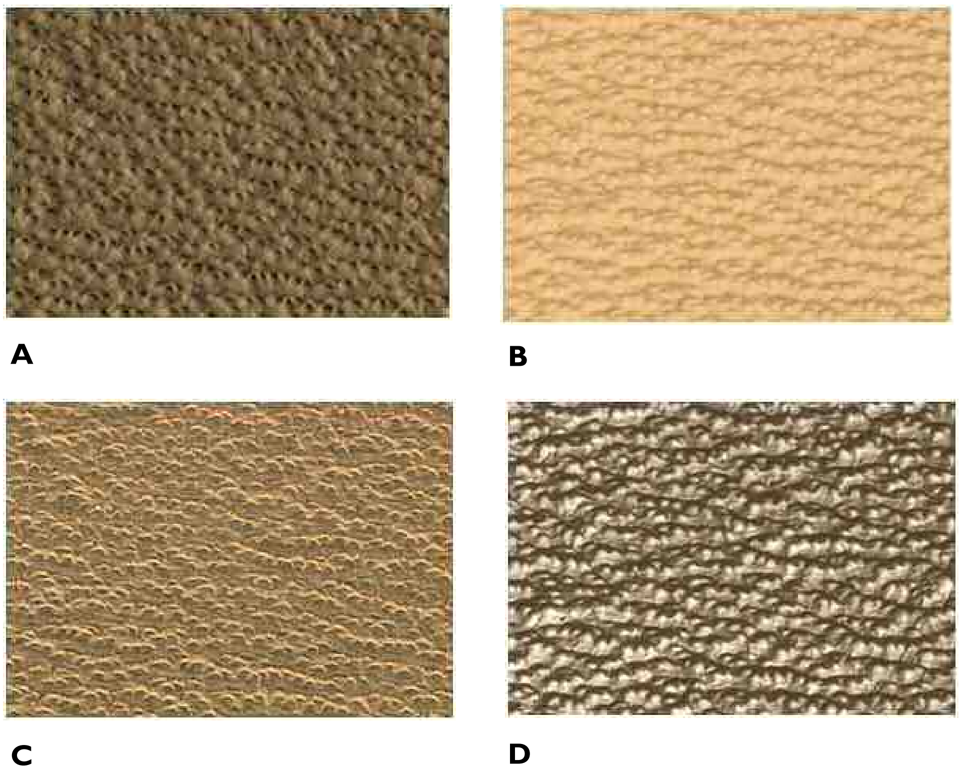

Fig. 6. The grain surface of vegetable tanned cattle skin. All show the same area of the leather sample at 100 % of source image: **A** & **B** Default view from contrasting light angles, **C** Luminance Unsharp Masking, **D** Specular enhancement (RTI snapshots Susanna Harris).

ADVANTAGES
Can be used on skins with epidermis and hair removed through processing into leather.
Potential for creating large reference image library for samples covering multiple species, tanning processes and areas of the hide.
Provides detailed two and three dimensional views of leather grain surface pattern morphology.
Digital image files can be viewed and interrogated as individual image files or using the RTIViewer.
Enables digital collation of leather reference collections held at different institutions and in private or public collections.
Potential for online reference collection of leather grain surface pattern, which can be viewed at different magnifications on a personal computer or handheld device.
RTI files can be viewed online either as individual images or using an online RTI viewer.
RTI files can be made accessible to a wide range of leather specialists to use as a reference collection, without the need to produce their own RTI files.
Potential to use digital RTI image files to develop an alternative to species identification by ZooMS and DNA analysis.
DRAWBACKS
Methodological problem that grain surface patterns of archaeological leather may be lost through tanning process, wear or decay.
Due to the RTIViewer design, the scale is not always visible when viewing the images. As a photographic rather than microscopic technique, images are viewed at uncertain degree of magnification; there is no method of calibrated measurement yet.
General requirement for well documented reference collections of samples with known species, tanning process and area of hide.
Depending on camera lens used, may not provide sufficient magnification of grain surface to view certain features. Microscopic RTI may provide a better solution.
Grain pattern is only one aspect of microscopic species identification and should be used in combination with other diagnostic features such as corium thickness, hair-shaft penetration and hair cuticle pattern.
Initial image capture requires good quality digital camera, training and specialist equipment. This expense and expertise may not be practical for all specialists.
Although collection managers may be concerned about the light exposure of archaeological leather objects during RTI capture, the use of safe LEDs and filters on other light sources alleviates this concern.

Table: Summary of the main advantages and drawbacks of using RTI in order to build an online reference collection to aid species identification of archaeological leather.

visual experience of the leather grain surface. This enables the user to see morphological details of the fine, interwoven collagen fibres just below the epidermis as well as the position, shape, size, density and distribution of the hair follicles: all potential diagnostic features of animal species (Leather Conservation Centre 1981, 9-11; Reed 1972, 25). This represents a major advance in leather grain surface pattern visualisation which has otherwise been illustrated by single fixed light photographs published in books and atlases (Haines 2006, 17-19; Michel 2014, 32-38; Reed 1972, 26-7, figs. 7-10).

One of the main drawbacks of RTI imaging for species identification is that the grain surface pattern should be observed in combination with other diagnostic features viewed in transverse cross section of the leather such as corium thickness and hair-shaft penetration (Michel 2014; Reed 1972, 25-35). Another important consideration is that in the face of advances in

ZooMS and DNA identification of plant and animal species, identification by visual observation of magnified morphological features is currently under scrutiny (e.g.Ørsted Brandt *et al.* 2014). In future projects, a combined approach verifying identifications across techniques would be desirable.

Future directions

This pilot project was carried out to test the feasibility of RTI as a digital imaging technique to aid in the microscopic analysis of leather to determine species. It has provided promising results which we hope to develop into a larger project. We would like to hear from those who are interested in collaborating with this project and those with leather reference collections to which they would be willing to allow access for imaging. Please contact Susanna Harris:

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or tcrnsm4@ucl.ac.uk.

Notes

1. Built with AHRC DEDFI funding by the University of Southampton (Earl *et al.* 2011)

2. RTIViewer: http://culturalheritageimaging.org/What_We_Offer/Downloads/View/

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References

Collins, M., Buckley, M., Grundy, H.H., Thomas-Oates, J., Wilson, J., & van Doorn, N. (2010) "ZooMS: the collagen barcode and fingerprints", Spectroscopy Europe 22 (2) 6-10.
Online at: http://tinyurl.com/q7psybf

Earl, G., Basford, P., Bischoff, A., Bowman, A., Crowther, C., Dahl, J., Hodgson, M., Isaksen, L., Kotoula, E., Martinez, K., Pagi, H., & Piquette, K. E. (2011) "Reflectance Transformation Imaging Systems for Ancient Documentary Artefacts" in Electronic Visualisation and the Arts 2011, London.

Earl, G., Martinez, K., & Malzbender, T. (2010) "Archaeological applications of polynomial texture mapping: analysis, conservation and representation", Journal of Archaeological Science 37, (8), 2040-2050.

Frank, E. (2015) "Documenting Archaeological Textiles with Reflectance Transformation Imaging (RTI)", Archaeological Textiles Review, 56, 3-13

Haines, B. M. (2006) "The fibre structure of leather", in Conservation of leather and related materials, M. Kite & R. Thomson, eds., Oxford: Butterworth-Heinemann, 11-21.

Leather Conservation Centre (1981) The Fibre Structure of Leather, London, LCC.

Malzbender, T., Gelb, D. and Wolters, H. (2001) "Polynomial Texture Maps", Proceedings of the 28th Annual Conference on Computer Graphics and Interactive Techniques, SIGGRAPH, ACM Press, 519–528. Online at:
www.hpl.hp.com/research/ptm/papers/ptm.pdf

Michel, A. (2014) "Skin deep: an outline of the structure of different skins and how it influences behaviour in use", in Why Leather? The material and cultural dimensions of leather, S. Harris & A. J. Veldmeijer, eds., Leiden: Sidestone, 23-40.

Mudge, M., Malzbender, T., Schroer, C. and Lum, M. (2006) "New reflection transformation imaging methods for rock art and multiple-viewpoint display", Proc. 7th Intl. Symp. on Virtual Reality, Archaeology and Cultural Heritage (VAST), 195-202. Online at: http://tinyurl.com/nbfho4j

Ørsted Brandt, L., Lisbeth Schmidt, A., Mannering, U., Sarret, M., Kelstrup, C.D., Olsen, J.V., & Cappellini, E. (2014) "Species Identification of Archaeological skin objects from Danish bogs: comparison between mass spectrometry-based peptide sequencing and microscopy-based methods", PLOS ONE, 9 (9): e106875. doi:10.1371/journal.pone.0106875.

Piquette, K.E. (2011) "Reflectance Transformation Imaging (RTI) and Ancient Egyptian Material Culture", Damqatum: The CEHAO newsletter, 7, 16-20. Online at: http://tinyurl.com/psmx42w

Reed, R. (1972) Ancient Skins, Parchments and Leathers London & New York: Seminar Press.

Schlumbaum, A., Campos, P.F., Volken, S., Volken, M., Hafner, A., & Schibler, J. (2010) "Ancient DNA, a Neolithic legging from the Swiss Alps and the early history of goat", Journal of Archaeological Science 37 (6), 1247-1251.