IMAGE ACQUISITION & ANALYSIS TO ENHANCE THE LEGIBILITY OF ANCIENT TEXTS

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1. BACKGROUND

When transcribing Ancient inscribed texts, Classicists are confronted with several difficulties. Incisions of heterogeneous depths, palimpsests, pronounced woodgrain, and the physical state of the document (which can be damaged, stained, or fragmentary) add to the complexity of reading Ancient documents. The "e-Science, Imaging Technology, and Ancient Documents" project aims to build an advanced software tool to support communities of Classicists in their deciphering task. Our first endeavour is to enhance the legibility of the documents. Acquisition of images of the documents and image analysis are our focus here.

2. MATERIAL AND METHODS

Images of wooden Roman stylus tablets (e.g., from the Roman fort of Vindolanda, $\sim$100A.D. [1]) form our test set. Originally incised in a thin layer of wax spread on the surface of the tablet, the remains of the original text are the incisions that the writing stylus made in the wood, through the wax layer, which has since perished.

Multiple images of a tablet are acquired. The camera and tablet are fixed, and a light source spans a range of azimuth and elevation angles. For each light position an image is captured (as for Polynomial Texture Mapping [2]). Low elevation angles are favoured as they result in marked adjacency of shadow and highlight areas along the incisions, and allow to exploit the shadow-stereo principle [3]. Azimuth angles running parallel to the woodgrain are also important as they minimise the shadows cast by the woodgrain.

Each acquired image undergoes: (a) illumination correction, through homomorphic filtering using a low-pass filter; (b) woodgrain removal [3]. Two methods of woodgrain removal were evaluated, both assume that the woodgrain direction runs along the X-axis of the image (horizontally). The first method is additive and performs horizontal smoothing and equal leveling based on moving-average. The second method is multiplicative and exploits the surface properties of the wooden tablet. It assumes Lambertian reflectance as well a constant local colour (albedo), so that the grey values of the image I obey: $\forall y,\ \sum_x I(x,y) = c \cdot \cos\theta_y$, where c is the constant colour and θ_y is the angle between the incident light and the surface normal (which is assumed to be constant for a fixed y, in accordance with the woodgrain direction).

Using the motion of the shadows throughout the images (shadow-stereo), we combined them by generating: (a) the maximum image, which, for each pixel, keeps the brightest corresponding pixel in the set of images; (b) the minimum image, which, for each pixel, keeps the darkest corresponding pixel in the set of images; (c) the absolute difference of the maximum and minimum images, which emphasises the areas where the adjacent highlight and shadow areas overlap throughout the images, thus revealing the incisions.

3. RESULTS AND DISCUSSION

We applied the above methods to a published tablet [4], whose transcription is currently being revisited. By studying this tablet we want to evaluate if, with contemporary image processing techniques, uncertainties in the original transcription can be lifted and consequently the tablet dated more precisely. Woodgrain and uneven lighting can be quite distracting during the transcription effort [1] and the Historians working on the reading stated that the results of illumination correction alone, and of woodgrain removal "helped" (Fig. 1). Regular reading sessions, where Classicists use the processed images, enable us to evaluate the adequacy of the algorithms and adapt them to the experts' needs. The combined images also proved to be useful, making the writing more visible (Fig. 2).

Future work will investigate extraction of incisions and identification of strokes as components of characters. A wider range of wooden tablets will be processed, as well as lead and stone inscriptions, which present very different surface properties. Ultimately, we will integrate these image processing capabilities in a software tool that will allow experts to manipulate images of texts and facilitate their reading. Further, based on the reading sessions, we are starting to build knowledge maps to analyse the thought processes involved

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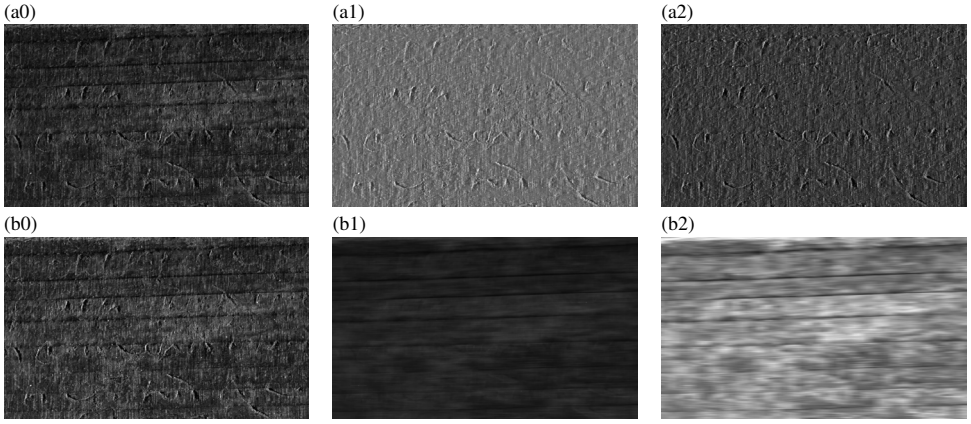

Fig. 1. Close up on a region of a stylus tablet. (a0): Original image; (a1): Image after woodgrain removal via the additive method; (a2): Image after woodgrain removal via the multiplicative method; (b0): Image after illumination correction; (b1): Woodgrain as identified by the additive method; (b2): Woodgrain as identified by the multiplicative method.

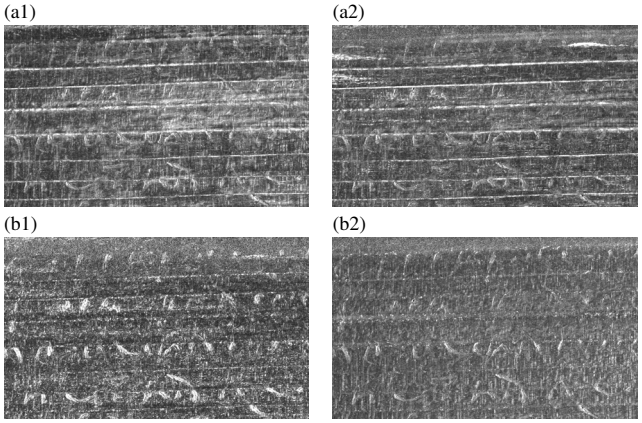

Fig. 2. Result of the combination of 16 images into the absolute difference of the maximum and minimum images. Close up of the same region as in Fig. 1. (a1): Combination of the raw images; (a2): Combination of the illumination corrected images; (b1): Combination of the images after woodgrain removal via the additive method; (b2): Combination of the images after woodgrain removal via the multiplicative method.

in the transcription task. This is a preliminary step in building a system to support reasoning under uncertainty thus enabling to document and share transcriptions, data sources, and datasets. Developing and assessing the image processing algorithms is thus the first step in the process of creating an advanced computational e-Science tool for the Digital Classicist community.

4. REFERENCES

[1] M. Terras, *Image to Interpretation. An Intelligent System to Aid Historians in Reading the Vindolanda Texts*, OUP, 2006.

[2] T. Malzbender, D. Gelb, and H. Wolters, "Polynomial texture maps," in *SIGGRAPH '01 (Proc.)*, 2001, pp. 519–28.

[3] M. Brady, X. Pan, V. Schenck, M. Terras, P. Robertson, and N. Molton, *Images and Artefacts of the Ancient World*, chapter Shadow stereo, image filtering and constraint propagation, pp. 15–30, British Academy, 2005.

[4] C. W. Vollgraff, "De tabella emptionis aetatis Traiani nuper in Frisia reperta," *Mnemosyne*, , no. XLV, pp. 341–52, 1917.