The reconstruction of the appearance of the Acancéh frieze by 2.5D printing

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Abstract

The aim of the project is to reconstruct the appearance of the Maya frieze of the Palace of the Stuccoes in Acancéh Yucatán, dating from c. 350 BC to AD 850. The frieze itself is destroyed by now but was documented by Adela Breton in 1907. Her watercolours on drafting linen and few black and white photographs taken by her at the same time are the basis of 2.5D prints which reconstruct the appearance of the frieze. After analyzing the colours recorded in the watercolours and the shadows in her photographs, we employ Woodburytype and the combination of photogravure, relief printing and embossing to generate a print which comes close to the optical and haptic appearance of the original.

Introduction

Mesoamerica is a vast area encompassing Mexico, Guatemala, Honduras, and Belize. The landscape is a range of environments from lowland tropics and highland forests to arid plains, where each ancient cultural region developed its own identity and artistic traditions, with colours playing an important role in the worldviews and aesthetics of the ancient inhabitants [1].The cultural tradition of stuccoed and polychromatic murals in central Mexico dates back to Early Classic Teotihuacan (100-600AD) and continued into the subsequent epiclassic period in Xochicalco and Cacaxtla (ca. AD. 650–1000) [2]. In the Maya area, examples of mural painting have been found in Mexico and Guatemala, with dates that range from the late preclassic to the postclassic period. Most significant are those from Uaxactun (250 bc–ad 550), Tikal (250 bc–ad 900), Holmul (250 bc–ad 600), Yaxchilan (ad 300–900), Bonampak (ad 300–900), Dzibilchaltun (300 bc–ad 900), Coba (ad 300–900), and Chichen Itza (ad 900–1000) [3].

In terms of conservation the Maya area is specially challenging due to the humid and hot tropical climate. Degradation of excavated archaeological stone structures is caused mainly by wind and water and the rapid wet dry cycles. Damage to the limestone and stucco is accelerated by the chemical and mechanical effects of lichens, mosses, algae, fungi, and bacteria that are endemic to the region [4]. This has often represented a critical hazard for the wall paintings that are not transferred to a protected environment immediately upon their excavation [5].

Chemical characterization of materials via different analytical techniques has allowed a better understanding of the technology and practices involved in the making of polychrome relieves in the Maya lowlands [6]. There are few examples of original polychrome murals that have been partially preserved and that are a priceless source of information such as the Bonampak murals. Some ancient relieves have been reconstructed using modern cements such as the case of the full colour reconstruction of the Rosalila Temple exhibited at the Copan Sculpture Museum [1]. The strategy of the reburial of modelled and painted lime plaster facades, in conjunction with the construction of exposed replica facades overlying the reburied originals, has been or is being considered as a preservation strategy at a number of sites in the Maya region [7].

At present, buildings in the Maya region are recorded using 3D scanning and photography. These methods are useful tools for the collection of information for future reference or reconstruction projects. Virtual reconstructions offer the possibility to disseminate an overview of the heritage worldwide. The mesh and colour information collected via 3D scanning [5], photogrammetry and reflectance transformation imaging (RTI) can be presented in a virtual format or processed into printed replicas.

In the beginning of the 20th century, American and European archaeologists started to focus their attention towards Mesoamerican ruins [3]. With the technology available at the time, they captured what they saw in the ancient temples and buildings before these were dismantled or naturally erased. Even though the technology for recording colour and surface structure was limited to analogue photography, tracing and painting, today's tools for image rendering allow to digitally or materially reconstruct the appearance of the ancient images based on the records made by the earliest explorers. One example is the 360° render of the 'Temple of the Warriors' of Chichen Itza, generated by the Bristol City Museum based on the drawings by Adela Breton in 1907 [9]. Another approach for disseminating the visual heritage, that might be situated in the middle of the replication and the virtual display, consists in replicating the appearance in terms of colour, texture, relief and all relevant aspects that provide an haptic view similar to viewing an original.

In 1906 residents of Acancéh, Yucatan, a town 25 km southeast of Merida, were dismantling an ancient structure for building material when they uncovered a 2 m high wall decorated with brightly painted stucco reliefs that later was called the Palace of Stuccoes. It was a 13 m long surface, protected by a coat of whitewash and the rubble of later buildings, displayed two rows of animal, bird, and human figures modeled in relief and contained within twenty one overlapping cartouches. The scene was framed at either end by large stucco birds and above and below by decorative moldings [10].

In 1907 Adela Breton was already in Yucatán, when the news of the discovery of mural paintings on the stucco façade at Acancéh reached her. For a substantial time, the pre-colonial buildings of that site had been purposed as a quarry to erect the modern town of Acancéh and as a result of the ongoing activity the stucco frieze became exposed in 1906 [11]. Adela Breton

traveled to the newly discovered site and spent 5 weeks in 1907 copying the frieze of the Palace of the Stucco [12]. She traced it on drafting linen, also known as drafting cloth. This material was used for technical drawings from the end of the 19th century until the middle of the 20th century and is highly starched and calendered cotton or linen fiber. In 1908 Adela Breton published a short article in which she presented the watercolour reproductions she had made of the building wall paintings. Adela proceeded to identify each of the motifs and characters that make up the frieze, but she did not venture to propose any interpretation, hoping that subsequent excavations would reveal other portions of the frieze on the remaining facades of the building. Her watercolours remained unpublished in the City of Bristol Museum, England until 1991, the year in which Virginia E. Miller published them in their entirety together with his iconographic interpretation of both the frieze and of the wall paintings [10]. In 1907, Edouard Seler visited Acancéh too and documented the frieze in the state it was found in, using an ink drawing and photographs by Wilhelm von den Steinen. In 2000 Wolfgang Voss N et al presented a comprehensive report to the "Proyecto Arqueológico Acancéh" directed by the National Institute of Antropology and History where they explain what is known so far about the symbolism linked to the characters depicted in the frieze [13].

Figure 1: a) watercolour by Adela Breton, panels 6 to 11 of the Acancéh frieze. b) surviving part of the frieze, photo taken by Sue Giles in 2019

Image a) shown in Figure 1 is part of her 2.76 x 1.19 m watercolour of a section of the Acancéh frieze showing panels 6 to 11. Shortly after its creation the stucco relief was covered by cut stone mosaic and its brilliant colours were therefore preserved until its discovery. Unfortunately, the fragile stucco did not survive its discovery for long. From the 24 figures depicted only remains of 4 still exist [11]. The colour has gone completely. Image b in Figure 1 shows one of the 4 remaining figures in its present state of preservation. According to [13] the characters in the image are the mythic bath Camazotz' (cfr. Popol Vuh), a howler monkey, a macaw, and a rattlesnake.

Breton wanted to copy the frieze and its colour as accurately as possible and resisted all temptations to interpret what she saw. She understood the influence of surface structure on the appearance of the relief and was therefore unhappy with photographic recordings [11]. We assume therefore her watercolours to be chromatically accurate.

Printing method

In order to generate the appearance of the relief in a print, we chose the following three combinations of impact printing methods.

- Photogravure with process colours and a relief plate for the embossing.
- Photogravure with spot colours and a relief plate for the embossing
- Relief plates with spot colours.
- Full colour Woodburytype

From high resolution image files of the watercolours by Adela Breton, provided by Bristol City Museum, colour separated positive were made for photogravure and negatives for relief printing. The relief plate for the embossing plate was based on a greyscale version of figure 1a) modified in such a way that the figures would appear as positive relief in the final print. This is only a first approximation to generate the appearance of the frieze. An approach truer to the accurate representation of the height profile of the artefact demands 3D scanning or photogrammetry. However RTI [14] is able to render the surface structure very well but does not provide quantitative height measurements. 3D scanning, photogrammetry and RTI of the parts of the original still intact and/or of similar friezes from the same time period and executed in the same technique was planned for 2020 but had to be postponed because of travel restrictions caused by Covid-19.

To make the photogravure plates the colour separated files were printed in greyscale on transparent inkjet film. For the printing plates, we used Toyobo Printight KF95 plates. These plates consist of a photosensitive polymer film mounted on a transparent polyester film. The KF95 has a maximal relief depth of 0.65 mm. The plate cures when exposed to light between 300 and 400 nm [15]. Because of the lockdown we had to use the UV fraction of sunlight as our UV source. The plates were exposed between 12:00 and 14:00 BST to exploit the maximum UV index and keep exposure times manageable. Photogravure plates were made by first exposing the photosensitive film through the so-called screen for 45 sec with a UV intensity of about $5\ mW/cm^2$ followed by 80 sec exposure through each of the three colour separated greyscale films (see Figure 2). The screen provides the halftone dot by generating dimples in the plate which are close under the transparent parts of the positives and stay open under their opaque parts. The plate was then developed by washing it in water of 20° C with a sponge for 3 min. After drying the plate was hardened for another 15 min in sunlight.

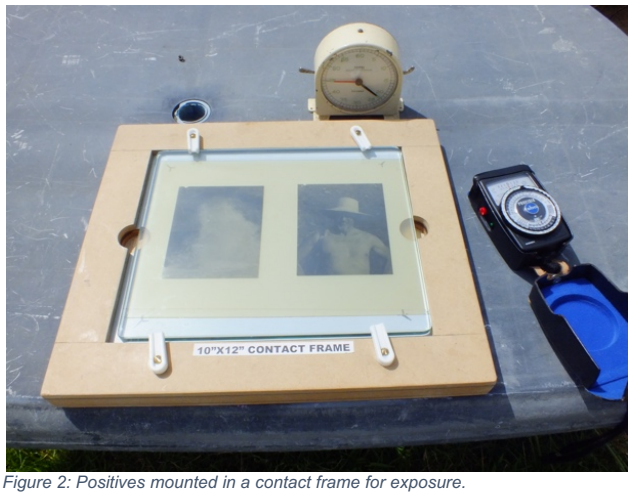


Figure 2: Positives mounted in a contact frame for exposure.

The procedure for the relief plates and the Woodburytype plates is slightly different. Instead of exposing the photosensitive layer directly, it is exposed through the transparent backing. The greyscale of the transparent film is translated into a relief. The lighter the film the higher the relief. As usual, the shadows are printed, therefore for exposure through the substrate, negatives

are used when relief on white paper should be printed. Positives were used for Woodburytype since the plate are flooded with pigmented gelatin which is then transferred to the paper. The shadows are the maxima of the gelatin relief. The exposure times are now much longer, about 20 min with an intensity of again 5 mW/cm^2 for UV light between 250 to 390 nm. After washing the plates were hardened for 15 min in sunlight.

a)

b)

Figure 3: a) CMY print, b) CMY print with relief

The plates were inked and printed following traditional hand printing methods. For photogravure linseed oil-based etching inks were applied generously and wiped off with a piece of cotton muslin, until the image was visible and clear. The plate was then mounted on a Polymetaal HPV 60 printing press, damp paper aligned with the plate and the plate/paper sandwich was compressed between the two rollers of the press. Since the printing plates were transparent, the 3 colour prints could be aligned by eye. Alternatively, pin registration can be used, that is the plates have to be aligned to each other and the paper is aligned with the plates by using a pin and tab system. The print was then dried. For the embossing the print was dampened again and then put through the press on the ink free embossing relief. The relief can be embossed straight after the colour printing but the disadvantage is that too much ink is then transferred from the fresh print onto the embossing plate, resulting in a loss of hue.

Printing spot colour with relief plates does not require an embossing step since the relief is of the different plates is embossed during the printing process. The disadvantage of this approach is a negative relief in the print.

Figure 3 demonstrates the subtle difference when the embossed relief is added to the print. The print conveys now the appearance of a frieze. Figure 3b) was recorded using a lockdown appropriate kit for reflectance transformation imaging kit.

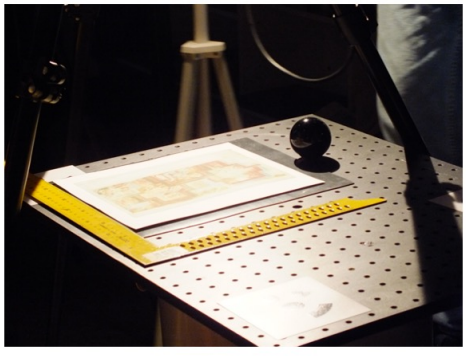
Reflectance transformation imaging of the prints

Reflectance Transformation Imaging is a technique that captures the surface shape and colour of opaque materials at per pixel level using traditional photographic techniques [16]. RTI images are produced by photographing an object several times from a fixed position but illuminating it from multiple angles.

To understand the relief produced with our method, the prints were captured with the highlight based RTI method described in [17].

The prints were placed on a flat table. A black reflective sphere positioned next to the print and within the field of view of the camera was used to calculate the positions of the light. The camera used was a Fujifilm X-T10 digital camera with a 16.3 MP APS-C sensor fitted with a 50mm lens providing a 35mm equivalent focal length. This was attached to a tripod and positioned perpendicular to the surface of the print. The light source used was a handheld flashlight (Power Flash PR400).

The various sequences of images were captured in a darken room. About forty-five images from different angles and positions were shot for each print. Images with harsh shadows were discarded as they can affect the surface normal reconstruction. The images were registered before processing to improve the alignment of the sequence as small movements of the camera or the tripod during the capture session can translate into blurry RTI images and hence, inaccurate surface normals. The alignment was done with the Fiji's plugin Linear stack alignment with SIFT [18] with subpixel accuracy. Processing was done with the open-access software developed by Cultural Heritage Imaging [19].



a)

b)

Figure 4: a) arrangement of print and black reflective sphere. b) snapshot of image recording

Conclusions

The reconstruction of the appearance of the Maya frieze of the Palace of the Stuccoes in Acancéh Yucatán is a test case to establish a new tool for the preservation, reconstruction and dissemination of archaeological artefacts. The process described here is not the creation of a replica, a technique well established and used in many museums, but to use 2.5D printing method to create the appearance of the object. The difference to a 2 dimensional photograph or drawing is that haptic qualities can be captured and moving shadows under different illuminations are made possible. The methods presented here are the first steps of research into a) what data has to be collected to have enough information to recreate the appearance of an artefact and b) what are the most effective printing methods to scale the print up or down and to adapt the print to different substrates without losing optical and haptic qualities.

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Susanne Klein is a physicist by training and has lived and worked in the UK since 1995, first as a Royal Society Research Associate at the University of Bristol, and then as a Senior Research Scientist at Hewlett Packard Labs Bristol. She has been appointed an EPSRC Manufacturing Fellowship at the Centre for Fine Print Research starting January 2018. She is working on the reinvention of old printing technologies, such as Woodburytype and Lippmann photograph.

Abigail Trujillo-Vazquez, is a research associate at the Centre for Fine Print Research and part of the Appearance Printing European Advance Research School (ApPEARS). She has a background in Physics and Art History, focused in optics and spectroscopy, Mesoamerican art and ceramics. In her PhD studies in Art and Design at the University of the West of England she is working on the development of printing methods and materials for recreating the material appearance of ancient art.

Xavier Aure is a Research Fellow at the Centre for Fine Print Research. His background is in conservation of paintings and decorative historic interiors. His PhD research investigated the use and applications of 2.5D and 3D technologies applied to the study, documentation and presentation of paintings. Currently, he is working on the development of affordable custom scanning systems to record surface texture information and material appearance for cultural heritage applications.

Carinna Parraman's understanding of 2.5D printing has evolved through her training in in fine art print-making. She is Professor of Design Colour and Printing and Director at the Centre for Fine Print Research, and has in-depth knowledge of traditional colour mixing, colour printing and photomechanical printing processes. She collaborates with many different sectors including industry, heritage and fine-art print.