Calvert, Sophie, Ryall, Helen, Power, Jess and Bills, Paul J.

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DIGITAL 3D RECONSTRUCTION OF HISTORICAL TEXTILE FRAGMENT

Sophie Calvert [1], Dr.Helen Ryall, [1] Dr.Jess Power,[1] Dr.Paul Bills[2]

[1]School of Art, Design and Architecture, University of Huddersfield, Yorkshire, England

[2]School of Computing & Engineering, University of Huddersfield, Yorkshire, England

Abstract.
This paper presents a new methodology for reproducing historic fragment in 3D with realistic behaviour, providing users with a feel for the fragment detailing. The fragment piece originates from the English National Trust archive held in the collection at Claydon House. The aim is to utilize a combination of both 2D pattern software and state-of-the-art 3D technology to recreate a compelling and a highly realistic representation of historic fragment. The process starts with investigation of the textile construction. Textile fragments will be incomplete and/or have a level of deterioration therefore various recording techniques are to be explored. A combination of both photography and 3D scanning technology will be utilized throughout the methodology to accurately record the digital data. The equipment setting will be analyzed in order to produce an accurate working method. This paper forming part of a larger study, will specifically focus on the methodology for recording data from one fragment piece.
Keywords: Historic, 3D fragment, render, virtual, scanning

1.0 Introduction

For a number of years, more actively since the 1980's, the study of digital cloth motion and simulation has been studied by both industry specialists and academia as previous papers have summarized; The complexities in realizing a textile with a high degree of deformation characteristic has been a challenge to researchers since the 1980s. There has been some cross fertilization between textile engineering and computer graphics modeling methods; this encourages the employment of a multidisciplinary approach to cloth modeling research [1]. There is limited knowledge which specifically looks at the relationship between historical textile fragment and digital 3D simulation. It appears there is no sound methodology linking the two practices. Textiles are among the most perishable artifacts, even the smallest textile specimens are of value to understanding production technology and cultural significance. [2]. Until recent years photorealistic textiles could only be rendered using tracing software. However with the accessibility of graphics cards from companies such as Nvidia and ATI a range of software can now provide real-time per pixel shading. The advanced rendering features of these cards allows software to be developed which uses the photometrically acquired bump and albedo maps to provide real-time visualization under user-controlled illumination, pose and flex [3]. It is expected that the data collected will be explored in a number of phases specifically focusing on translating 2D data into 3D output, this includes creating a highly compelling and accurate 3D representation of textile fragment. This will involve devising specific algorithm data as well as fully analyzing preset algorithm of current textile 3D specialist software. The first phase here focuses on collecting data using a range of analytical techniques which will inform the overall 3D content, 2D surface, structure and constituent elements further adding to the historical context of the fragment. This paper presents the methodology and findings from the first phase of the research and suggesting tracks for future exploration.

2.0 Identifying the historic textile fragment

Textile fragments used for examination in this paper are loaned from the English National Trust archives at Claydon House, Buckinghamshire, England. The piece selected for the pilot study dates back to 1625c. Figure 1 fragment is a linen needlepoint reticella lace decorative collar, rows of button whole stitches build up the design. The fragment is of importance for conservation as the dye process used causes rapid deterioration eventually fully breaking down the fibers to dust particles.

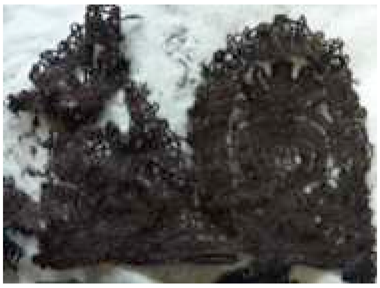


Fig.1: Textile fragments (decorative collar), (Claydon House dated 1625c)

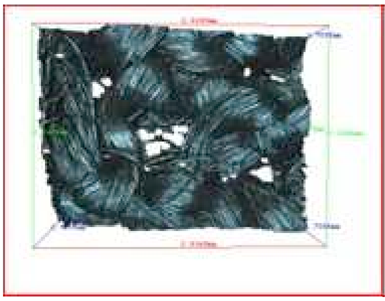
3.0 Analytical Techniques

Analytical methods are introduced with respect to analyzing textile fibers, structures and dye technique and provide examples of the data derived from each of these methods:

- optical 3D Infinite Focus Microscope Interferometer (IFM) to determine structure
- computerized tomography scan (CT) to analysis overall 3D structure
- X-Ray Florescence (XRF) for elemental analysis

3.1 Infinite Focus Microscopy (IFM)

Surface measurements for the work detailed here were carried out using an Alicona IFM (Infinite Focus Microscope), subsequently referred to here as the ‘IFM’. Objective lenses providing small depth of focus combine with vertical scanning for the capture of point height and true colour data from a surface using the variation of focus principle. The system differs from many other optical surface measurement instruments in that surfaces with large slope angles or complex texture can be measured. This is possible as the system is not limited to surface illumination by optical axial rays and hence surface slope angle is not dictated by objective numerical aperture. As IFM is not limited to the use of axially light this also allows for the measurement of dull and dark materials that are beyond the capability of many more conventional surface measurement techniques. Optical microscopy has been the mainstay of fiber analysis for study of both modern and archeological textiles. The microscopic examination of fibers mounted in an appropriate medium is often sufficient to establish the identity of modern commercial fibers [4] Several texts describe microscopic techniques that can aid in the identification of fibers (McCrone et al.1978; Slayter and Slayter 1992) [5]. It was envisaged that the textile weave structure could be examined in greater detail giving a three dimensional view. If possible individual yarns could be studied looking at breakage and areas of structural weakness within the textile. Several settings were explored with different exposure times, magnification and contrast adjusted to gain optimum results on screen.



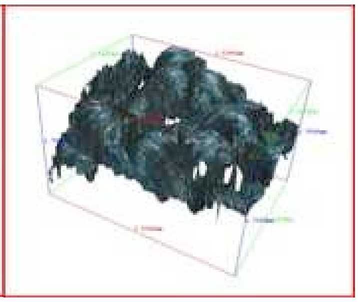
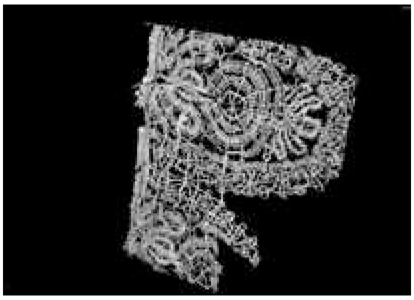


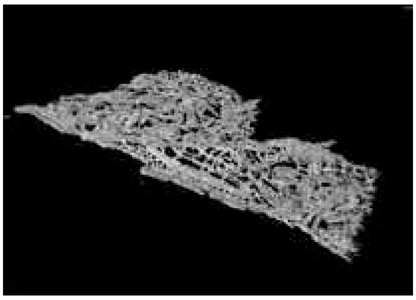
Fig.2: Linen lace structure at 10.00x Magnification 2.834mmx1.7056mm **Fig.3:** Linen lace structure at 10.00x Magnification (Side view) 2.834mmx1.7056mm

The linen lace has larger areas of deterioration which has permeated through all layers. With magnification set to x50 also using the ring light it was possible to view individual fibres in detail. Microspectroscopic analyses of the samples confirmed the identification of the fibers sources as protein and cellulose.

3.2 Computerized tomography scan (CT)

Many techniques exist to determine yarn architecture, especially in a small volume, but X-ray Computed tomography (CT) is perhaps the most widely available technique capable of quickly imaging a representative volume. X-ray CT has of course been used for many years to image biological features for medical purposes [6]. More recently, X-ray sources with the capability to focus the X-ray beam to 10-micron spot sizes have given rise to X-ray micro- CT, which has dramatically improved spatial resolution relative to traditional X-ray CT. [7] X-Ray imaging fragile textiles requires much experimentation to achieve the desired settings prior and post scanning process. The instrument used in this study was a Nikon Metrology XTH 225 micro-CT scanner, with a Tungsten X-ray target and Perkin-Elmer detector. Scans were taken at 40 kV and 185 μA with an exposure time of 708ms resulting in a 5 μm spot size. No hard filtration was used. Each scan contained 1583 frames which were then reconstructed using Nikon Metrology's proprietary software. All rendering and subsequent analysis was performed in VG StudioMax 2.1 and surface determination was optimized manually.





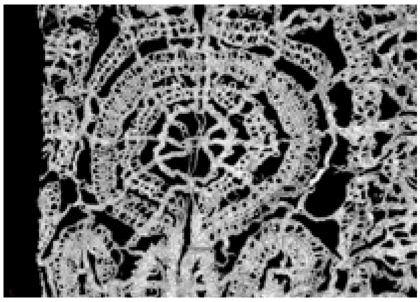


Fig.4: Front view of decorative collar (fig4) **Fig.5:** Cross sectional view, decorative collar **Fig 6 :** Detailed view, decorative collar

After configuring the apparatus for some time to the required parameters stated above, the outcome resolution and detail far exceeded expectation. When examining the image data both in the cross sectional views and in the volume rendering, a certain amount of noise was observed on the surface. This was addressed by adding filters in VG StudioMax 2.1. The image stack and data collected from the CT scan pictured above in figures 4,5,6 was of such high quality this could be used in future research for 3D modeling purposes. Constructing not only the 3D visualization but perhaps also a 3D printed prototype would result in wider accessibility to textile fragments which currently remain only in archives. A range of software currently exist which would take this 2D imagery into 3D reconstruction, commercial software including: MATLAB, Rhinoceros, ANSYS. Although here the 3D scan data is developed as STL format with no information about surface which are used in NURBS surfaces. To generate IGES files from this data reverse engineering software could be consulted such as Simpleware, MIMICS, AMIRA. Most software support polygon mesh and point cloud data to create, render and animate with no limits on complexity or size. The ability to automatically convert any 3D image dataset into high quality meshes is becoming the new modus operandi for reverse engineering. New tools for image-based modeling have been demonstrated, improving the ease of generating meshes for computational mechanics and opening up areas of research that would not be possible otherwise. [8] The methodology of converting CT algorithm to generate geometry is an exciting area for future research within the textile remit.

3.3 X-Ray Florescence (XRF)

Identification of colourants contained in historical textiles elucidates the history of dying technology, is necessary for the documentation of the artworks, may be decisive for the development of effective and appropriate conservation strategies and it is a challenging task for analytical chemists, mainly because; (a) very low amounts of samples are typically extracted from authentic artworks. (b) Degradation of dyes developed because of ageing effects and/or use of the historical object may complicate their identification. (c) In most cases, mixtures of colouring materials were used by the dyers to obtain the desirable hues [9]. Qualitative and semi-quantitative X-ray fluorescence measurements were performed on different areas of the textile fragments 40 kV for 90s, using a commercially available Bruker ARTAX 400 XRF spectrometer (Bruker AXS Microanalysis GmbH, Berlin, Germany) equipped with a Rh tube and a 650 μm collimator. The beam was focused on the different areas of interest in real-time using the camera attached to the spectrometer. Elemental spectra showed the constituent elements of both figure 1.

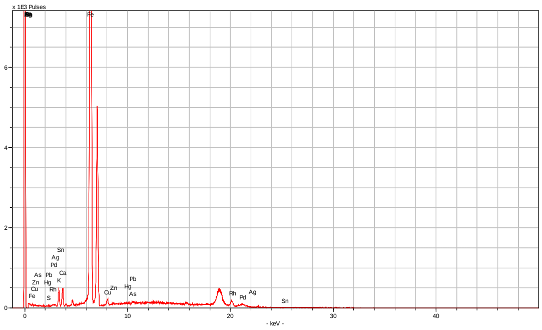


Fig7: TXRF spectrum of the textile fragment (linen)

The findings demonstrated the predicted high levels of iron confirming these metal oxides where used as mordants. Figure 7 concluded that high levels of Tin where found, with low level traces of Potassium and Calcium. Potash (Potassium carbonate) and Calcium were both commonly used to balance the PH of the dyebath.

4.0 Conclusion

Research has shown the potential of microspectroscopy, computerized tomography scan and X-ray Florescence technology for analyzing dyes, structure and fibre of historic textile fragment. Further work could be performed on other textiles within archives from different geographic region or different historic periods. These tools serve to non- destructively unlock the detail and context held in delicate textile fragments of which in time will fully disintegrate. Using the visual data gained from the CT and IFM, future research will focus on algorithm output, including those used to define specific material attribute and motion. Several textile specific specialist software will be utilized in the next stage of this research.

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