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DIGITAL 3D ANALYSIS OF HISTORICAL TEXTILE FRAGMENT

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Abstract.
This paper presents and explores 3D techniques for analyzing historic textile fragment. The textile fragment piece examined throughout this paper originates from the English National Trust archive held in the collection at Claydon House. The aim is to utilize data collected with a combination of both 2D pattern software and state-of-the-art 3D technology to both recreate and reconstruct a compelling and 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.

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" (P.Volino, Magnenat- Thalman 2000 p.3-4). It is widely recognized that the accurate simulation of cloth is a highly specialized field demanding knowledge and understanding of several factors including a sound knowledge of fabric manufacturing technique, properties and modeling. There is limited knowledge that specifically looks at the relationship between historical textile fragment and digital 3D simulation. It appears there is no sound methodology linking the two practices.

"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" (Spence, Robb, Timmins, Chantler 2000, p.51-62). Independent to the software packages currently available to render 3D textiles is the requirement to input specific fabric measurements. These measurements are those which the computer relies upon to assign attributes specific to certain fabric types such as bend, tension and stretch. Testing within this paper concentrates on two analytical techniques however further apparatus will be later consulted to record a full range of tensile results. "Examples of these include Browzwear's fabric testing kit and Optitex's fabric testing utility. The fabric properties obtained vary depending on the system, but generally all devices include facilities for measuring tensile and bending properties." (Power, 2013 PP.423-439). Handling the complexities of such delicate historic textile fragments has brought its own challenges for exploration in both the physical restriction and new ways of working for the design practitioner.

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 fragment detail (decorative collar)
(Claydon House dated 1625c)

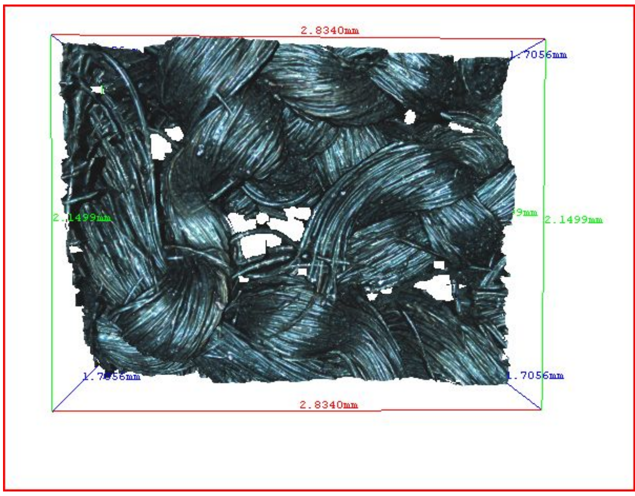
3.0 Analytical Techniques

The two techniques explored within this paper where chosen one for recorded success in textile analysis (IFM) and the other technique (CT) used perhaps more widely in the medical community rather than for textile analysis were chosen as its results, if successful, would give high resolution image stack data and video. 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

3.1 Experiment 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" (Breese, McCrone 1984) "Several texts describe microscopic techniques that can aid in the identification of fibers (McCrone et al.1978; Slayter and Slayter 1992) "(Jakes, 2000, p.45). 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 structure. Several settings were explored with different exposure times, magnification and contrast adjusted to gain optimum results on screen.



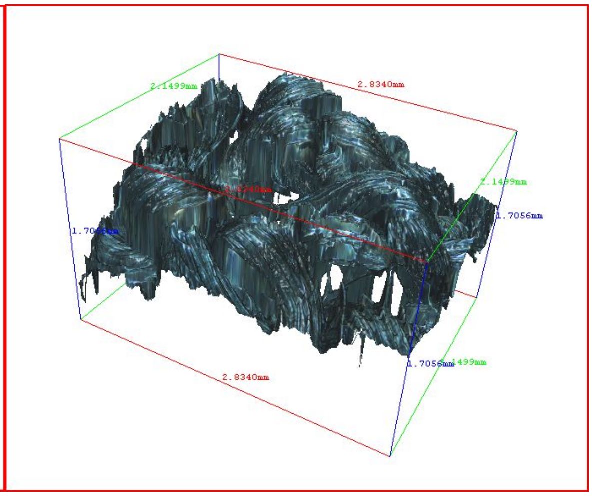


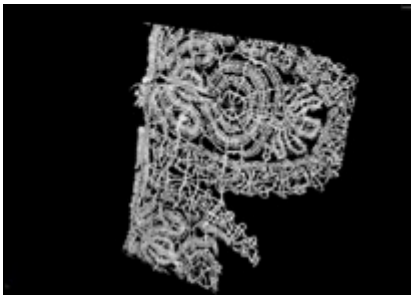
Fig.2: Linen lace structure at 10.00x Magnification 2.834mmx1.7056mm

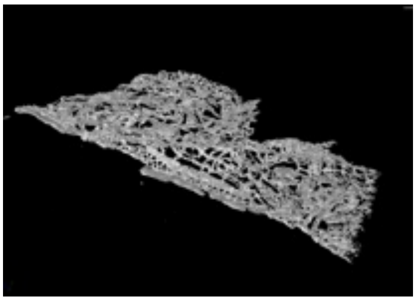
Fig.3: Linen lace structure at 10.00x Magnification (Side view) 2.834mmx1.7056mm

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.

3.2 Experiment 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" (Parnas, Wevers, Verpoest, 2005, pp. 1920-30). "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." (Geet, 2001) 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.





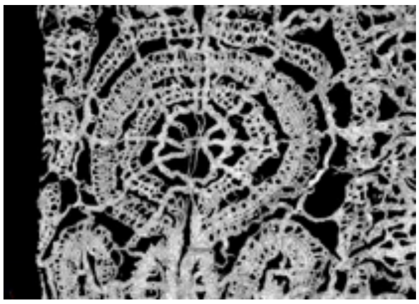


Fig.4: Front view of decorative collar (fig4)

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.

4.0 Discussion

Constructing not only a 3D visualization but also perhaps 3D printed prototype would result in wider accessibility for the general public to textile fragments that currently remain only in archives. As current research has identified even in a era of digital advancement, current 3D software packages can often assume the specific range of parameters to portray complex fabric structures, hence the 3D simulations are not always realistic. Perhaps a reason behind the difference in current assumed simulation data is that it is aimed at film and gaming communities, here designers are required to develop cloth simulation which look appropriate for their own outcome so visually flawless rather than historically accurate. Current simulation software often has a range of assumed fabric properties based on modern day cloth types, these cloth files are often complete repeats without areas of degradation, rot or dye variability. "Impressive results however have been reported in recent research in visualization of knitwear" (Zhong et al. 2000 Cited in Adabala et al. 2003 P.41-47). Techniques to represent complex knit patterns have been developed. Relatively less work has been done in the area of woven or embroidered clothes. "More recently Glassner has discussed the richness of patterns possible by using the ideas from weaving" (Glassner, 2003 P.77-90 Cited in Adabala et al. 2003 P.41-47). For the purposes of this PhD study accurate and true representation of both the surface and structure of the textile fragment would need to be developed for each unique archive piece. Several stages of modeling would need to be successful in order for an accurate and 'real' 3D visualization:

- Representing the pattern/ weave/ embroidery
- Modeling the structure of the thread which may have an element of decay
- Modeling the fabric dye and overall colour variation

A range of software currently exists which would take the above scan imagery into 3D reconstruction, 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." (Wang, Genc, 2012). The methodology of converting CT algorithm to generate geometry is an exciting area for future research within the textile remit and will be examined within this PhD research.

5.0 Conclusion

Research has shown the potential of microspectroscopy and computerized tomography scan to examine both structure and fibre of historic textile fragment. 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.

Handling the complexities of such delicate historic textile fragments has brought its own challenges throughout the research. The physical handling of the fragment meant following standard conservation practice; using scanning apparatus for the very minimum amount of time, avoiding cross contamination and handling with gloves. Overall the fragment levels of deterioration meant that upon touch the iron oxide dust transferred and handling was difficult particularly when trying to position for CT scanning. In addition to the physical challenges of working with historic textiles are the challenges which meet the textile designer who may not always have conservation at the forefront of their thought process. Putting notions of the 'perfect' structure and design away, the task instead here for the designer is to use all practice based knowledge to reconstruct with authenticity and accuracy. Where a textile falls apart the urge to reach for the sewing box must be avoided as here the true skills are to be digital.

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