When Data Becomes Information: Visualizing Archaeological Textiles

Hembo Pagi[1]

[1]Archaeological Computing Research Group, University of Southampton. United Kingdom.

Abstract

The main focus of this work is on web visualization technologies that could be applied to visualize archaeological textile data. The datasets used for the project contain more than seven thousand records of textile fragments. The web application *Textile Recorder & Visualizer* was created based on the *WordPress* publishing platform to maintain the records and provide the visual output of the data. Visualization introduces new possibilities into archaeological textile analyses. It also makes the data intellectually accessible for non-specialists. Working with multiple datasets brings up many interesting issues related to preliminary data collection and data standards. Well-defined and organized data help to produce more accurate visualizations and open new possibilities for collaborations. The project has clearly shown that there are always new ways to process and analyze archaeological data. Using web visualization techniques for that purpose was very successful and encourages continued work on that topic.

Keywords: *textiles, data visualization, web visualization, X3D, SVG*

1 Introduction

New technologies have made data collection and recording much less complicated than earlier—in a short time we can produce an enormous amount of archaeological data. The data used for this project consist of more than seven thousand textile finds. Handling big datasets with computers is not new in archaeology. In 1967 R. G. Chenhall[1] shared his experiences of describing artifacts for computer analysis. We have more than forty years of experience working with archaeological data, but sometimes we still record it as a if we were writing a fieldwork diary, without the proper structure.

This project is not about organizing data or finding new ways of implementing databases. Its main focus is on technologies to make alphanumeric textile data available through graphical representation in real time, both in two- (2D) and three-dimensions (3D). Improving recording standards for digital preservation and presentation of archaeological textiles will remain for future works. Visual interpretation creates the possibility of reviewing data at the time of recording and even more importantly, it provides new ways of analysis—visualization gives a better understanding of volumes, surfaces, and possibilities for visual comparison.

3D representations can be used as bases for further analysis and for more detailed reconstruction of fabrics. Visual interpretation of textiles also gives the opportunity for non-professionals and students to learn about textiles directly from the excavation data.

There are three main starting points for the project:

- It must be easily accessible, both physically, in terms of software—no expensive software should be required, and also intellectually—not all people can understand the weaving related terminology.
- A visualization approach was taken to turn data into meaningful information and to make it intellectually accessible.
- It is not reasonable to produce visualizations manually using traditional modeling methods for such a large dataset; the process has to be automated.

To meet all the goals, the best approach for the project is to create a web application. As the main focus of the project is in web visualization techniques and not creating a web database interface, *WordPress* is used as a framework for the application to make the development process easier. *WordPress* is a web publishing (originally blogging) platform where additional plugins can be added to extend the default functionality.

2 The Data

The primary dataset used for this work comes from the Quseir al-Qadim excavation in Egypt.[2] This was a collaborative project between researchers from several

[1] R. G. Chenhall, "The Description of Archaeological Data in Computer Language," *American Antiquity* 32 (1967): 161–167.

[2] David Peacock, *Myos Hormos-Quseir Al-Qadim: A Roman and Islamic Port Site: Interim Report* (Southampton: University of Southampton, 2008).

institutions, directed by the University of Southampton. There are more than two thousand textile finds recorded on the original excavation database, mainly from Roman and Islamic contexts.

The second dataset is also about Egyptian textiles but from earlier times. Several thousand textile fragments were found from Amarna Workmen's Village. The numerical database was created with the characteristics of almost 5000 specimens. The project ended in 2001 with the publication of a monograph[1] and the final database.[2]

Archaeological textiles are a rare type of artifact, and the majority of finds are very small fragments of the original textile. For example, a great number of Amarna Workmen's Village textile pieces were smaller than 10x20 cm.[3] Taking into account that the piece has been a part of a garment or even a sail, the artifact represents a very tiny sample of the original textile. This brings in a very important point of this project: all the visualizations represent only the recorded data, not an attempt to reconstruct the fabric, garment or other original item.

3 PREVIOUS WORKS ON DIGITAL WEAVING

There has been much work done on textile and cloth visualization. The focus has mainly been on the clothing industry, where Computer Aided Design (CAD) tools have made the design and production process much faster and more efficient. As retail is changing from the real world to the digital world, the garment industry is becoming interested in virtual try-on applications allowing users to see how the product might fit them.[4]

Chittaro and Covaglia's[5] work focused on technologies that enable cloth simulation in web 3D, using Virtual Reality Modeling Language (VRML), the predecessor of the X3D format. They had three goals: to develop a garment simulation engine, to define the cross-application data exchange format for the textile industry and to implement a tool, which can convert 2D CAD data into VRML models.

Kosek et al.[6] discuss the different ways of representing woven structures in VRML. They choose the *extrusion* approach for thread modeling. VRTex, the commercial software written partly by the same working group,[7] generates VRML output fabric based on textile description format defined by them.

Adabala et al.,[8] on the other hand, focus on real time visualization of woven cloth and realistic appearance optimization. Their method is implemented as a plugin for commercial 3D modeling software called Autodesk 3ds Max. The plugin allows the import of Weaving Information Files (WIF) into 3D models. The main focus is to accurately represent the dynamics of the cloth.

An interesting series of articles has been written about digital weaving by A. Glassner.[9] His main goal was to create a simple software tool for making patterns. In a similar manner to Smillie,[10] he built up his digital weaving algorithm to the basic drafts used by the weavers for setting up the loom. He developed his own weaving language based on commercial software called Painter to describe more complicated weaving processes.

As shown above, there are several publications about visualizing the textiles, but the present author has not come across any previous visualization work on archaeological textiles. All the papers cited contain aspects and ideas that were exploited in the project at some level. One might ask, what then makes this project so different?

[1] Barry J. Kemp et al., *The Ancient Textile Industry at Amarna* (London: Egypt Exploration Society, 2001).

[2] Barry J. Kemp, The Amarna Project, "Workmens' Village Textiles," www.amarnaproject.com/pages/recent_projects /material_culture/workmans.shtml.

[3] Barry J. Kemp et al., *The Ancient Textile Industry at Amarna*, 13.

[4] Luca Chittaro and Demis Corvaglia, "3D Virtual Clothing: from Garment Design to Web3D Visualization and Simulation," paper presented at the Eighth International Conference on 3D Web Technology, Saint Malo, France, March 9–12, 2003.

[5] Ibid.

[6] Miloslav Kosek, Tomas Mikolanda and Bohumila Koskova, "Ideal, Real and Virtual Textile Structure Modeling and Visualization," paper presented at the 3rd International Conference on Computer Graphics, Virtual Reality, Visualisation and Interaction in Africa, Stellenbosch, South Africa, November 3–5, 2004.

[7] Tomas Mikolanda, "VRTex—Virtual Reality Textiles," http://centrum.tul.cz/vrtex/.

[8] Neeharika Adabala et al., "Visualization of Woven Cloth," paper presented at the 14th Eurographics Workshop on Rendering, Leuven, Belgium, June 25–27, 2003; Neeharika Adabala et al., ""Real-time Rendering of Woven Clothes," paper presented at the ACM Symposium on Virtual Reality Software and Technology, Osaka, Japan, October 1–3, 2009.

[9] Andrew Glassner, "Digital Weaving, Part 1," *IEEE Computer Graphics and Applications* 22 (6) (December 2000): 108–118; "Digital Weaving, Part 2," *IEEE Computer Graphics and Applications* 23 (1) (2003): 77–90, "Digital Weaving, Part 3," *IEEE Computer Graphics and Applications* 23 (2) (April 2003): 80–88.

[10] Keith Smillie, "The Computer Construction of Weaving Designs," paper presented at the conference Share Knowledge Share Success, Toronto, Canada, 1997.

First, no proprietary software or formats are used in any phase of the project. Second, this project does not focus on garment simulation or any specific physical properties of textile. Finally, the quality (and quantity) of the input and the requirements for the output are very different. The works mentioned above use the industry standard WIF format as their data input format. This is the format designed for weaving machines to weave real fabrics. The data-model used for this project is much simpler, as well as the data itself. All the visualizations are mainly based only on three values: thread count per cm, thread diameter, and weave type. We are working with archaeological data, which is always incomplete!

4 VISUALIZATION PROCESS

The most common workflow on an archaeological project leaves illustrating and reconstructing to the end, when excavation is finished and reports are being written.[1] Technology provides us with little more flexibility than Sorrell had to experience working with archaeologists as an illustrator more than three decades ago. The discussion below will explore the possibilities of visualizing archaeological data from the earliest preliminary recording phase.

Unless drawing a chart or a map, where a value usually corresponds to the length of the bar or a location in space, visualization always involves interpretation and guessing. In the context of archaeology there is never enough information available, therefore techniques for showing the missing data become important.[2] The aim of the visualization in my project is not to provide an accurate reconstruction of the textile fragment. It is an illustration or sketch, if you like, to "aid the imagination of the viewer just as they raise the questions," as Colin Renfrew put it.[3] His comment refers to archaeological reconstructions, but fits very well here: the outcome of the work presented here might aid the imagination (but it does not provide an explanation of the past) for the non textile-specialist and also serves as a tool for analyzing and raising questions for the specialist.

The accessibility of information sources has changed dramatically through the World Wide Web. As more and more archaeological datasets are made available on the web, we should think more about how we present our data to make them also understandable for the wider public. An image is worth a thousand words, as we know; therefore a web visualization approach was chosen to bring archaeological textiles closer to non-specialists.

Tony Parisi argues that a great mistake of web media is that graphics are mainly used for art rather than for visualizing information.[4] This project will try to change that trend.

Two formats were selected to present the project's data, Scalable Vector Graphics (SVG) for two-dimensional output and X3D, the successor of VRML, for the three-dimensional output. The following criteria were set for the graphics formats:

- Non-proprietary–open standard, royalty free, no cost of adoption;
- Easy to describe the interwoven threads;
- Modifiable by the scripting language;
- Supported by common browsers and/or open source client software is available.

4.1 2D VISUALIZATION IN SVG

Several archaeological projects have chosen SVG as their visual data delivery method.[5] Unlike the goal of this project, where visualizations are generated by the automated computer script, design tools like Adobe Illustrator and AutoCAD were used in the Wright and Durrand projects.

Visualizing textiles is an interesting task, as a 3D object will be represented in 2D. Walton and Eastwood[6] recommended dashed lines as one way to do it. In SVG there is an element called *path* with the property called *stroke-dasharray.* This lets us describe the properties of the line. A dash is defined with the value pairs, first value for the line, second for the gap. If only the one pair is defined, the same sequence is repeated. As the layout of the threads (position of gap) is not the same for every line, the offset must be calculated and added to *path* as *stroke-dashoffset* property. Knowing the thread count and the thread diameter, we can easily calculate the distance between threads. Finally, the weave type information, which is a repeatable pattern described as ones and zeroes, is combined with previous

[1]Alan Sorrell, *Reconstructing the Past* (London: Batsford Academic and Educational, 1981) 22.

[2]Karen M. Kensek, "Methods for Showing Missing Data, Multiple Alternatives, and Uncertainty in Reconstructions," http://csanet.org/newsletter/winter07/nlw07 02.html.

[3]Maurizio Forte and Alberto Siliotti, *Virtual Archaeology: Great Discoveries Brought to Life Through Virtual Reality* (London: Thames & Hudson, 1997) 7.

[4]Vladimir Geroimenko and Chaomei Chen, *Visualizing Information Using SVG and X3D: XML-Based Technologies for the XML-Based Web* (London: Springer, 2005) vii.

[5]Holly Wright, "Archaeological Vector Graphics and SVG: A case study from Cricklade," *Internet Archaeology* 20 (July 2006); Anne Durand et al., "Intra-site Level Cultural Heritage Documentation: Combination of Survey, Modeling and Imagery Data in a Web Information System." *Short papers from the Joint Event CIPA/VAST/EG/EuroMed* 30 (2006): 129–134.

[6]Penelope Walton and Gillian Eastwood, *A Brief Guide to the Cataloguing of Archaeological Textiles* (York: P. Walton, 1983) 13.

calculations and we can produce the line, where gaps leave the space for the intersecting thread (fig.1).

If we have a textile with stripes, which have a different thread count and thread diameter from the rest of the fabric, we need to describe the whole repeatable pattern. The same applies also to more complicated weave structures—the more complexity we have the more we need to describe.

SVG gives us also the possibility to create the bump maps, usually a grayscale or black and white image in which color values are interpreted as the height properties for the object. When applied to the object it creates an illusion of 3D without changing the actual geometry of the source.

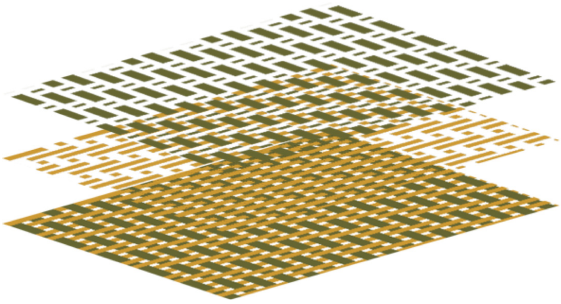

Figure 1. *Warp and weft threads in 2D view.*

4.2 3D Visualization in X3D

3D visualization is not new in archaeology. It is widely used for representing a particular building or monument, more rarely for artifacts and landscapes. 3D visualizations produced in this project have mostly illustrative purposes. As images are generated by the computer script based on database entries, they lack artistic touches. However, those images can be processed further or used as a base for material or garment creation using any 3D content creations tools.

Several approaches can be used to visualize the interwoven threads in X3D. We know the diameter of the thread and we calculated the sequence of the dash pattern already for the SVG output. Using those values we can calculate the coordinates relatively easily. As the *polyline2D* element has neither thickness property nor can textures be applied, *extrusion* element was used to describe the thread.

Two main properties are defined: first the *cross section*, which contains the coordinates for the yarn shape (in this case a circle) creation, and the *spine* property, which defines the path along which the cross-section will be extruded. A similar approach was also used by Kosek et al. for their ideal model[1] for fabric visualization.

The sequence of the dash pattern calculated for SVG cannot be applied directly. For example, if thread goes under more than one intersecting thread (twill weave for example), the dash values representing the visible line have to be interpreted differently (see fig. 2). Similar to SVG, the calculations are done for the minimal repetitive pattern of the textile structure and then repeated as many times as needed for the required output. The spine length gives the length to the visualized pattern and therefore the full length has to be calculated before outputting the image.

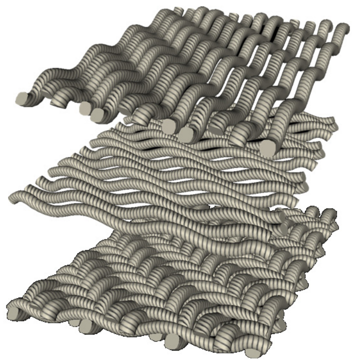

Figure 2. *Warp and weft threads in 3D view.*

The 3D world gives us the possibility to use textures for creating the illusion of twisted fibers. Both datasets have spin direction (S or Z) and tightness of the twist (also called spin angle) recorded. If spin and spin angle exist, the image texture is applied to the thread to give a more realistic impression at the close-up view (see fig. 2).

5 Textile Recorder & Visualizer

Generally, in archaeology the most important thing is to record what we are doing and what we have found. Interpretation comes after that and this may be done by different people. This project is about providing a tool for both recording and interpreting the data, for specialists and non-specialists. The *Textile Recorder & Visualizer* web application was created for archaeological textile management and visualization purposes. Its main function is to help in cataloguing textile finds in an intuitive user interface with the focus on visual interpretation of the data. Visualization techniques discussed previously are now brought together with the real datasets.

The application's functionality can be divided into two parts: the data-recording interface for the specialists and the public website for all the users who are interested in the topic.

[1]Miloslav Kosek, et al. (p. 286 n6).

5.1 DATA MANAGEMENT INTERFACE

Recorder is the core element of the package, allowing users to manage textile data, including adding, editing, removing, and visualizing the records.

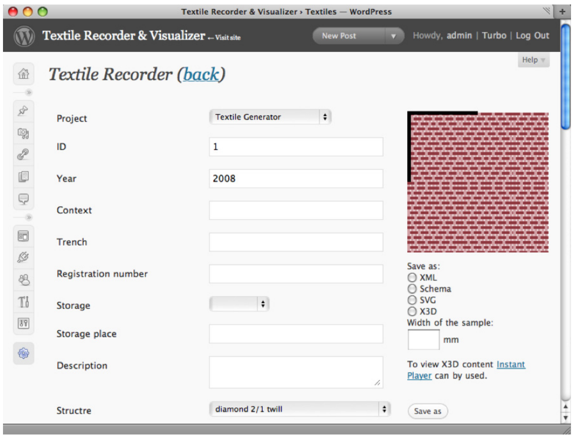

Figure 3. *Screenshot of the edit view.*

The data manipulation is handled from the *edit view* (fig. 3), which is displayed when the user selects the item from the list or when adding the new entry. This page is not only for editing; it also displays the visual output—visualization of the data is displayed in SVG format. Users can also download the data in other formats: a textual format such as a XML-file or graphical formats such as a SVG- and X3D-file.

Data manipulation functionality is not the main focus of the project. What makes it unique is its visualization capabilities. *Image Browser* opens totally new ways to browse the textile dataset. All the records that can be visualized are listed as an image gallery (fig. 4). One of the project experiments was to apply Hammarlund's visual grouping method to computer-generated images.[1] For example, the user can sort records by textile density and thickness. Other sorting and analyzing filters can be easily added to take advantage of the visual data.

The application also allows the user to produce visualizations without adding data into the current database. Where the external dataset is in one or more different formats, transformation rules can be provided in XSLT-format (Transformations Style-Sheets transforming XML documents into other XML documents). By this method data can also be aggregated and queried very easily.

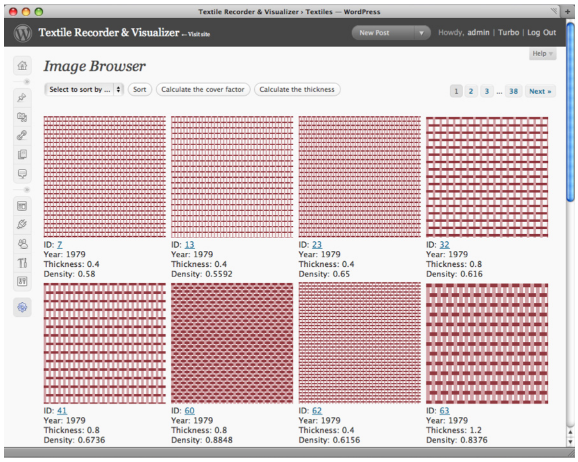

Figure 4. *Screenshot of Image Browser.*

5.2 PUBLIC WEBSITE

Textile Recorder & Visualizer is not only a tool for specialists; it also provides public access to datasets in both the traditional (textual) way and through the visualizations. Being part of the Word Press blogging/publishing platform, it is easy to combine the recorded information and reports, news about the excavation or textile-documenting project.

The public site has all the same functionalities as the recording interface except the recording function. For the non-professional user, visual browsing capabilities provide an interesting way to learn about the textiles. It is easier to remember the weave structures having visualized them, which could also give us a different understanding of the textiles.[2] Also, all the data are visually comparable at the same scale, which can be adjusted.

6 CONCLUSIONS

The main goal of the project is to test the web visualization techniques suitable for visualizing archaeological textiles in two- and three-dimensional graphics. The project clearly demonstrates the potential of the approach taken when working with archaeological textile data.

Typically, producing a graphical representation of the artifact or building involves a lot of research and data interpretation. Often there is not enough information and some "educated guesses" have to be made. In that case, issues like transparency of the decision-making process and presentation of uncertainty[3] become very

[1]Lena Hammarlund, "Handicraft Knowledge Applied to Archaeological Textiles," *The Nordic Textile Journal* (2005): 87–119.

[2]Fiona Handley, email message to author, October 12, 2008.

[3]Karen M. Kensek, "A Survey of Methods for Showing Missing Data, Multiple Alternatives, and Uncertainty in Reconstructions," http://csanet.org/newsletter/winter07/nlw0702.html.

crucial. The graphical outcome of this project is 100% data-driven. If the required information for visualization is missing, no graphical output is produced. Visual representation of textile data is not an attempt to reconstruct textiles or garments, but rather to provide an illustration and a tool for interpretation.

Feedback given by the textile specialists and archaeologists emphasizes the importance of this kind of visualization work both from the textile specialist's and an educational point of view. After all, visualizations are produced without any additional effort from user's side.

Deeper research into how closely computer-generated images match the real textiles will remain for future work; however, the implementation of the visual grouping method introduced by Hammarlund[1] is the first move in that direction. Textiles are grouped by their visual properties like thickness and density. Combining the visual database with her methodology will bring the results into a photo-gallery style interface (see fig. 4) making it more informative and easier to review the query results. Even if the real textile record and computer generated image do not match perfectly, the visual output still helps us to understand the textiles in a different way.

Another goal of the project is to make archaeological data intellectually accessible through visualizations. For the business world, turning data into useful information has been the key issue for decades. In archaeology, many recorded datasets remain useless for non-specialists if the data are not presented in terms that everyone can understand. For example *Textile Recorder & Visualizer*'s *Image Browser* (fig. 5) lets users browse the database content visually. And as we all know, images are worth a thousand words—providing a computer generated on-demand visualization makes the textile data easily understandable (see fig. 6 and fig. 7). Without any archaeological or textile-industry knowledge, users can differentiate patterns and fabric density.

This is in many ways a learning project, constituting first steps towards a digital archaeological textile management and research tool. The results of the project encourage further work with the archaeological textile data to improve the digital documenting standards for archaeological textiles for the purpose of visualizing, archiving, and analyzing.

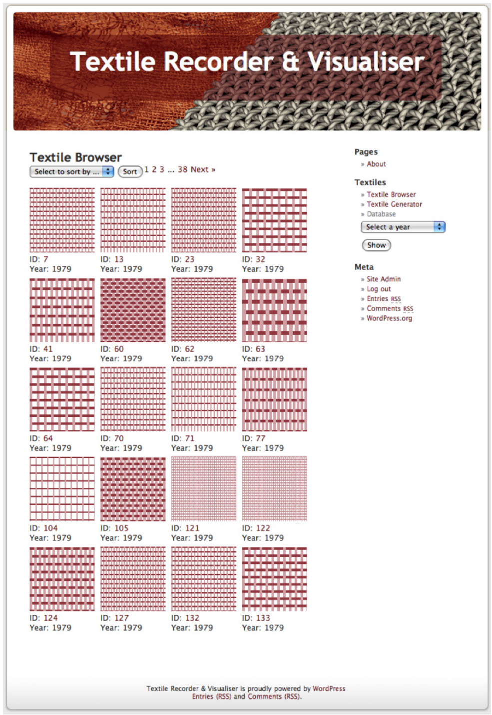

Figure 5. *Screenshot of Textile Browser.*

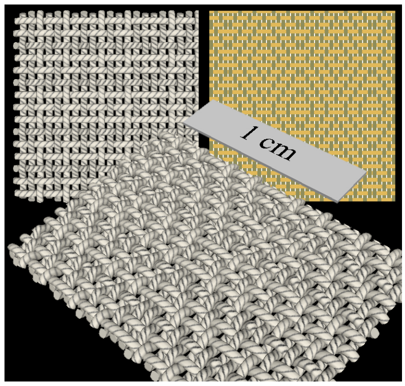

Figure 6. *Textile fragment with diamond 2/1 twill weave.*

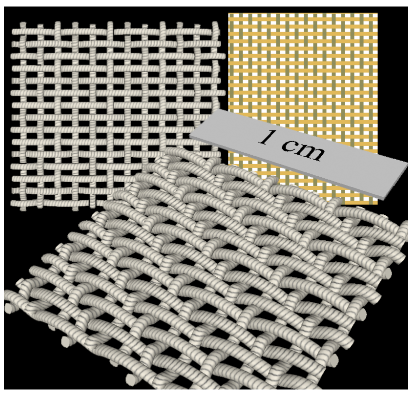

Figure 7. *Textile fragment with twill 2/1 weave.*

[1]Lena Hammarlund (p. 289 n1).

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BIBLIOGRAPHY

Adabala, Neeharika, Nadia Magnenat-Thalmann, and Guangzheng Fei. "Visualization of Woven Cloth." Paper presented at the 14th Eurographics Workshop on Rendering, Leuven, Belgium, June 25–27, 2003.

Adabala, Neeharika, Nadia Magnenat-Thalmann, and Guangzheng Fei. "Real-time Rendering of Woven Clothes." Paper presented at ACM Symposium on Virtual Reality Software and Technology, Osaka, Japan, October 1–3, 2003.

Chenhall, R. G. "The Description of Archaeological Data in Computer Language." *American Antiquity* 32 (1967): 161–167.

Chittaro, Luca, and Demis Corvaglia. "3D Virtual Clothing: From Garment Design to Web3D Visualization and Simulation." Paper Presented at the Eighth International Conference on 3D Web Technology, Saint Malo, France, March 9–12, 2003.

Durand, Anne, Pierre Drap, Elise Meyer, Pierre Grussenmeyer, and Jean-Pierre Perrin. "Intra-site Level Cultural Heritage Documentation: Combination of Survey, Modeling and Imagery Data in a Web Information System." *Short papers from the joint event CIPA/VAST/EG/EuroMed* 30 (2006): 129–134.

Forte, Maurizio, and Alberto Siliotti. *Virtual Archaeology: Great Discoveries Brought to Life Through Virtual Reality*. London: Thames & Hudson, 1997.

Geroimenko, Vladimir, and Chaomei Chen. *Visualizing Information Using SVG and X3D: XML-Based Technologies for the XML-Based Web*. London: Springer, 2005.

Glassner, Andrew. "Digital Weaving, Part 1." *IEEE Computer Graphics and Applications* 22 (6) (2002): 108–118.

Glassner, Andrew. "Digital Weaving, Part 2." *IEEE Computer Graphics and Applications* 23 (1) (2003): 77–90.

Glassner, Andrew. "Digital Weaving, Part 3." *IEEE Computer Graphics and Applications* 23 (2) (2003): 80–83.

Hammarlund, Lena. "Handicraft Knowledge Applied to Archaeological Textiles." *The Nordic Textile Journal* (2005): 87–119.

Kemp, Barry J. "Workmens' Village Textiles." Amarna Project, 2008. www.amarnaproject.com/pages/recent_ projects/material_culture/workmans.shtml (accessed June 1, 2009).

Kemp, Barry J., Gillian Vogelsang-Eastwood, Andrew Boyce, and Egypt Exploration Society. *The Ancient Textile Industry at Amarna*. London: Egypt Exploration Society, 2001.

Kensek, Karen M. "A Survey of Methods for Showing Missing Data, Multiple Alternatives, and Uncertainty in Reconstructions." *CSA Newsletter*, 2007. http://csanet.org/newsletter/winter07/nlw0702.html (accessed June 1, 2009).

Kosek, Miloslav, Tomas Mikolanda, and Bohumila Koskova. "Ideal, Real and Virtual Textile Structure Modeling and Visualization." Paper Presented at the 3rd International Conference on Computer Graphics, Virtual Reality, Visualisation and Interaction in Africa, Stellenbosch, South Africa, November 3–5, 2004.

Mikolanda, Tomas. "VRTex-Virtual Reality Textiles." http://centrum.tul.cz/vrtex/ (accessed June 1, 2009).

Peacock, David. *Myos Hormos-Quseir Al-Qadim: A Roman and Islamic Port Site: Interim Report*. Southampton: University of Southampton, 2008.

Smillie, Keith. "The Computer Construction of Weaving Designs," paper presented at the Conference Share Knowledge Share Success, Toronto, Canada, 1997.

Sorrell, Alan. *Reconstructing the Past*. London: Batsford Academic and Educational, 1981.

Walton, Penelope, and Gillian Eastwood. *A Brief Guide to the Cataloguing of Archaeological Textiles*. York: P. Walton, 1983.

Wright, Holly. "Archaeological Vector Graphics and SVG: A Case Study from Cricklade." *Internet Archaeology* 20 (July 2006). http://intarch.ac.uk/journal/issue20/wright_index.html.