

AC 2008-366: VIRTUAL PRESERVATION: A UNIQUE APPLIED RESEARCH PROJECT IN THE VIRGIN ISLANDS NATIONAL PARK

Karen Horton, University of Maine-Orono

Associate Professor of Mechanical Engineering Technology, University of Maine

Constance Holden, University of Maine at Augusta

Associate Professor of Developmental Mathematics, University of Maine at Augusta

Ken Wild, National Park Service

National Park Service Archeologist and Cultural Resource Manager, Virgin Islands National Park, St. John

Virtual Preservation: a Unique Applied Research Project in the Virgin Islands National Park

Abstract

Since 2003 students and faculty members at the University of Maine (UM) have participated in a unique partnership with the National Park Service (NPS) in the Virgin Islands National Park (the Park) on St. John. The Park contains ruins of over five hundred buildings that captured and enslaved Africans were forced to build, live in, and work in during the Danish colonial era from the late seventeenth- to the mid-nineteenth century. The ruins are overgrown by the jungle and not accessible by roads, and funding for preservation of this unique cultural resource is limited. As a result, the teams from Maine have engaged in an applied research service-learning project to "virtually preserve" the site of a sugar and rum factory on Leinster Bay using computer-aided design and close-range photogrammetry techniques. The applied research objective is to develop techniques to obtain accurate computer models of preservation sites to allow scholars and the public to "see" the sites in a three-dimensional sense. The project has involved both classes and travel to the Park. During spring terms students enrolled in courses to learn the required skills: taking and processing digital images, close-range photogrammetry processing, developing geographic information systems (GIS), and developing computer-aided design (CAD) models. Students were required to learn independently and through hands-on experience as expected of life-long learners. During the spring breaks faculty members and student interns traveled to the Park to work with a multidisciplinary team to take and process digital image and survey data at the site. Team members included professionals, graduate interns, and undergraduate interns from fields ranging from archeology to spatial information science. The interns observed first hand important sites of the brutal history of the Caribbean, and recognized the importance of preserving this unique cultural heritage. Interns participated in presentations describing the work and its importance to members of the public visiting the Park. Upon returning to classes after the break, the students continued to process the data collected. The results of their work from this ongoing project are available to the public on a web site.

Project Objectives

This is one of the first endeavors, initiated by the University of Maine, to try and save historic structures in the Virgin Islands National Park through computer graphics. Each year identifiable historic structures such as slave quarters, gravesites, bake ovens, wells, warehouses and great houses are being reduced to a pile of rocks and mortar due to weather and plant overgrowth. Since the Park constitutes over half of the island of St. John plus Hassel Island it essentially preserves the remains of the most complete (not impacted by development) representation of the Danish Colonial Period and Post-emancipation Era. Within the park ninety-eight percent of the historic resources are overgrown by jungle in the backcountry. Many of these threatened sites are incorporated within the park's seventeen National Register of Historic Places District and Site nominations and most of these structures are listed on the Park Service's List of Classified Structures. It has not been economically feasible to physically preserve these hundreds of significant historic structures. However, the National Park Service is mandated by law to preserve significant cultural heritage sites for future generations. The Park needs to document these historic sites before more data is lost.

The Park, as the client of this service-learning project, seeks a low-cost method to develop accurate three-dimensional computer models based on digital images of ruins and the terrain on which the ruins are located in order to “virtually preserve” the current state of the structures. The site at Leinster Bay is the initial test area. The desired result is a three-dimensional map with measurable spatial relationships between structures on the island that can be used for planning and interpretation. A GIS model accompanying the CAD model can provide historical, structural, and other information about the structures. Together these two models would allow historians, cultural preservationists, and the general public to better understand the remains as they stand alone and in relationship to all other historic sites across the park’s landscape. Such models can be built upon to help users understand what was at a given site, what it might have looked like, and how it operated and possibly changed through time. This method is expected to provide a unique and informative presentation of the history of St. John. The resulting computer files can be easily copied. The data and outcomes can be preserved on a durable medium, paper.

Three-dimensional modeling of cultural heritage sites has been taking place for many years, but developing low-cost methods suitable for public display is an ongoing area of research in the field.¹ No attempt to “recreate” the structures through computer modeling is envisioned because the project focuses on a virtual preservation of the structures as they currently exist, but the virtual preservation method provides the information required if funds were ever appropriated to restore the structures to the current state should they collapse.² Past preservation efforts in the Park included architectural drawings of the Leinster Bay factory site as shown in Figure 1. Other preservation efforts that have recently been carried out in the Park focus on locating and when possible identifying the hundreds of structures that are not accessible by roads or trails.³ The cultural preservation objective of the Park is to provide a comprehensive, publicly accessible three-dimensional computer model of the existing structures in their Park at their mapped locations with a corresponding significant body of easily accessible information about the structures.

Early Efforts 2003-2004

Faculty members at UM began this project with the Park in 2003. The project investigators obtained funds for use in 2004 from UM, the National Park Service, and the Friends of the Virgin Islands National Park. In the spring semester of 2004 Horton and Holden created a new course in the Mechanical Engineering Technology program, MET 220 CAD Modeling of Archeological Structures in which ten multi-disciplined students were enrolled. The course provided salary supplement through the Continuing Education Division of the University.² The first seven weeks of the course focused on computer-aided design skills based on MicroStation,⁴ the CAD software preferred by Wild, and GIS skills based on Arcview.⁵ During the two-week spring break Horton, Holden, and eight students traveled to the Park to take data for the project. The students were employed as paid interns for the Service, and Horton and Holden were volunteers. The building to be modeled is a cylindrical stone structure enclosing a well. Upon arrival it was covered with vines, which needed to be removed. Preservation was imperative because of the very deteriorated condition of one side, including a hole through the structure. The participants cleared brush from the well and other ruins including the sugar and rum factory, took physical measurements, took survey and global positioning system (GPS) data, took digital

images of the ruins, and began development of a MicroStation model of one of the buildings. Fortunately several other longer-term graduate and graduate student interns were working for Wild at the time and they also contributed to these efforts.

After returning to the University the class meetings resumed with students focusing independently on different aspects of the preservation project. Some students continued developing the MicroStation model of the structure of concern, some processed digital images using photo stitching software PTgui⁶ in order to apply the digital images to the model, others worked on a MicroStation terrain model to which the structural model could be applied, and others worked on a GIS model to catalog digital image data. A MicroStation model with applied images of one structure was posted on a web site, but the file size was over 16Mb and thus too large for easy downloading. While the results of this effort were promising, it was apparent that the method of developing a three-dimensional model of the ruins in MicroStation was unwieldy. However, Wild continued to be interested in developing the terrain model and locations of the ruins in MicroStation. Figure 2 shows the condition of the well structure and the model produced.

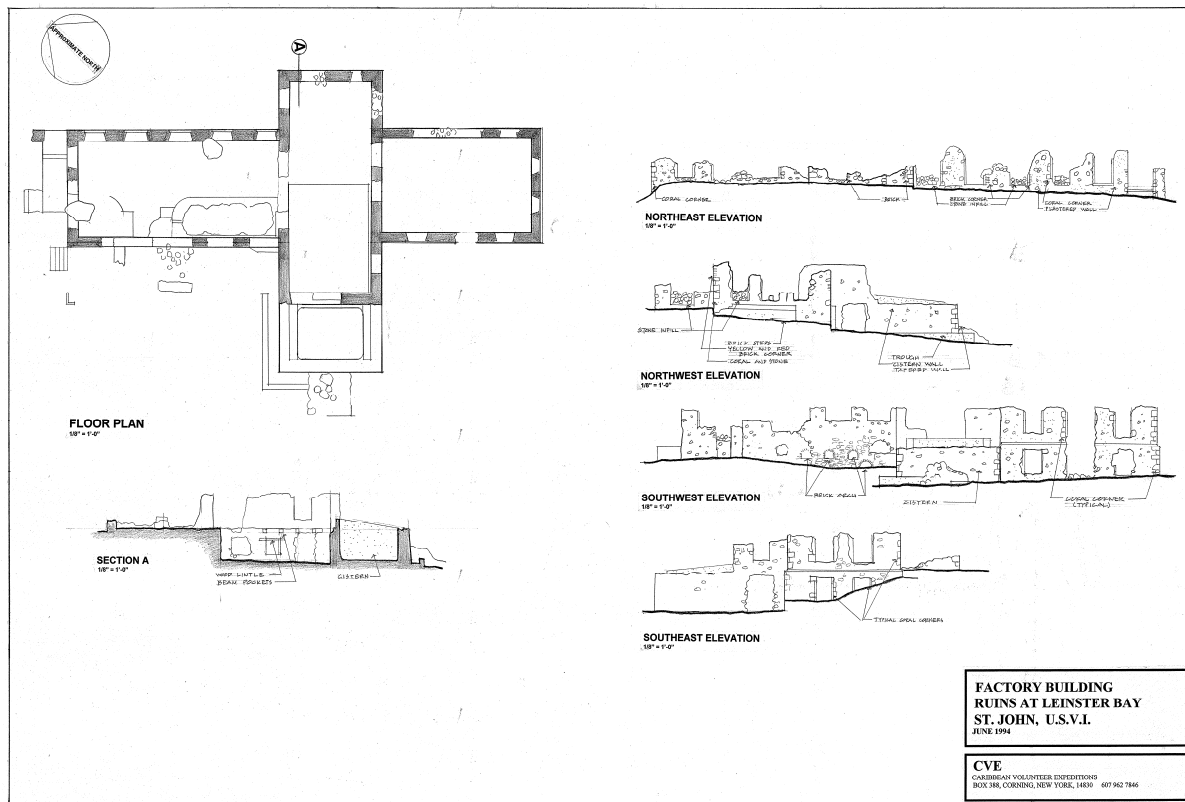


Figure 1. An architectural drawing of the factory building at Leinster Bay



Figure 2. A stone structure over a well at Leinster Bay and the MicroStation model

Subsequent Efforts 2005-2006

Horton continued researching alternative methods for computer modeling of structural ruins using digital images. She identified the close-range photogrammetry software PhotoModeler⁷ based on reports of other virtual preservation projects. In addition, successful use of the software for less complex projects with a similar student population had been reported.⁸ Horton then successfully sought UM funding and obtained licenses of PhotoModeler. She and Holden worked on learning the basics of using this close-range photogrammetry software and determined that it would be suitable and manageable for students to learn and use to continue the virtual preservation project. An ongoing student project could be one low-cost method of developing the virtual preservation model. In 2005 Horton successfully sought funds through the Friends of the Virgin Islands National Park from the Virgin Islands Humanities Council (VIHC) for travel and internships in order to continue the project.

In the spring of 2006 Horton offered a new independent study course MET 320 Virtual Preservation to three students to continue with the work. The students independently learned to take appropriate digital images to use with PhotoModeler, learned how to process the digital images in PhotoModeler to build three-dimensional models, and demonstrated basic proficiency with the software in modeling buildings. Again during the two-week spring break the principal investigators traveled with five students to the Park. The three students developing the three-dimensional computer models of the ruins took the specific digital images required in order to model the original well building again, as well as to model a more complicated, multi-room sugar and rum factory. The challenges in taking data were similar to those of 2003. There were trees that still needed to be removed from two rooms of the factory, and in some areas the closeness of the brush, even after application of a chain saw, prohibited optimal digital photography. The relative sun location and the cloud cover were constantly changing the lighting conditions of the digital images. Digital images had to be taken from a variety of angles and heights, including from a ladder and sometimes from on top of the ruins themselves in order to obtain the necessary views. The interns used significant ingenuity to obtain the appropriate data. The other two of the five interns took additional GPS and survey data in order to refine the

existing terrain model of the area. Again longer term graduate and graduate student interns as well as other Park personnel were available to assist with the tasks.

Upon return to the University, the three students enrolled in MET 320 completed models in PhotoModeler of the well building and individual rooms in the factory. Horton continued the work by modeling the remaining rooms and merging the several room models into a single model of a multi-room building. Similarly Holden continued to develop the GIS terrain data for use in a future CAD model of the local terrain that will also have applied to it CAD data of the ruin derived from the existing PhotoModeler model. Both of the outcomes were exported into MicroStation, the CAD software preferred by Wild. This effort has resulted to date in a unique three-dimensional model of the ruins of the sugar and rum factory that can be viewed and manipulated using the virtual reality modeling language (VRML) viewer Cortona⁹ at a UM web page.¹⁰ Figure 3 shows a photograph of a section of the sugar and rum factory ruin and the resulting PhotoModeler outcome of the section. In Figure 4 the PhotoModeler view of the entire factory is visible.

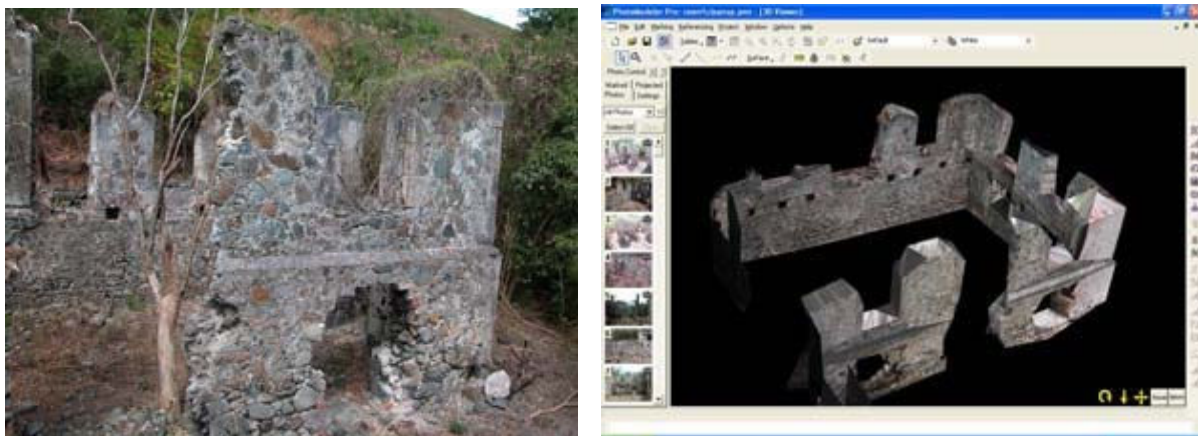


Figure 3. A portion of the sugar and rum factory ruin and the PhotoModeler model

Educational Objectives

Horton and Holden each hold full-time teaching appointments and were interested in providing unique educational opportunities for students involved in the project as they produced results that could be useful to the Park in attaining its objectives. The NPS also has a mission to provide training opportunities for future cultural preservationists. The principal investigators sought to assure that the coursework and on-site project offered opportunities for the following educational objectives:

1. Students will learn and apply technical skills independently.
2. Students will apply technical skills to new problems through applied research.
3. Students will travel to a location with significant cultural differences from their home setting.
4. Students will apply technical skills to a social need.

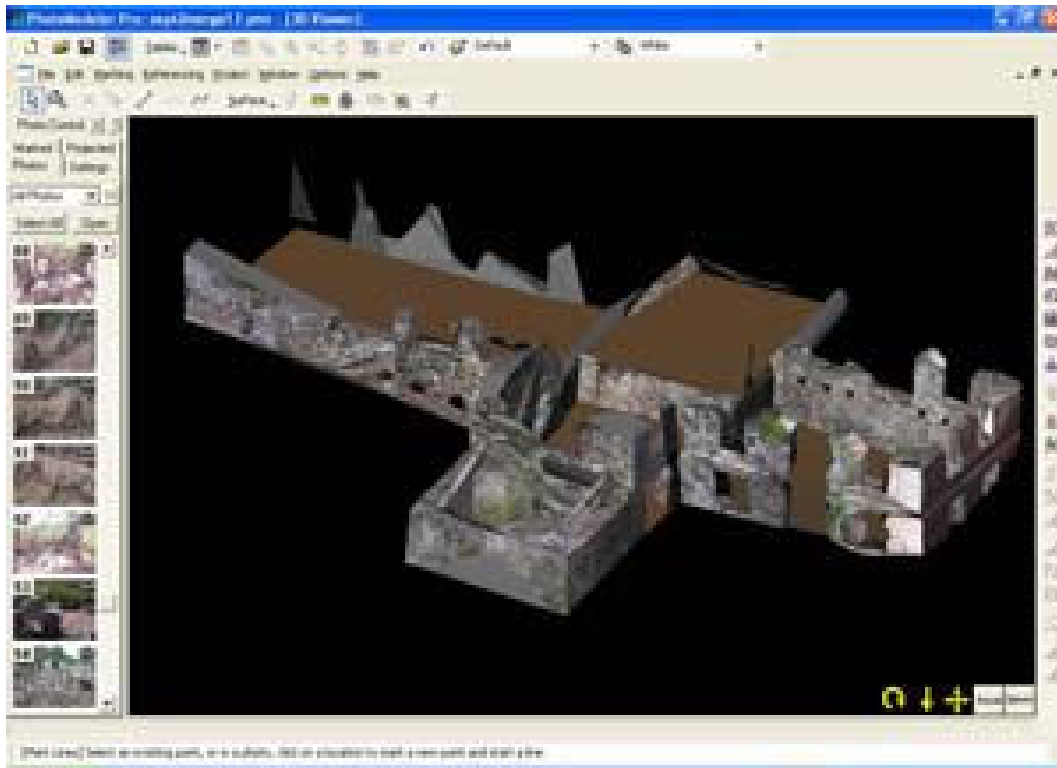


Figure 4. A view of the entire factory is visible in the PhotoModeler viewer. A number of site photographs used to create the view can be seen on the left panel.

Students Learned and Applied Technical Skills Independently

In the 2004 course MET 220 CAD Modeling of Archeological Structures students received traditional instruction in the basic methods which they would apply to the problem: CAD and GIS processing. However, while the faculty members helped coordinate the work of the interns on site, they were responsible for project completion. This offered opportunities for leadership, for students to learn on-site to take, organize and store appropriate digital images, to use surveying and GPS equipment, take and store associated data, to take on-site measurements for use in a CAD model, and to attempt the development of computer models from the data taken. One of the challenges students faced immediately was the lack of familiarity the principal investigators had with the site, with the techniques to apply, with the technical standards to apply (“get the model as good as possible” is not a typical technical standard), and with the actual technical techniques including the optimal use of the digital camera, the specific GPS unit, and the digital imaging software. This offered students unique opportunities to try techniques themselves with limited specific direction. Students from the colleges of Engineering , Liberal Arts, Education, and Natural Sciences, Forestry and Agriculture with diverse experiences learned together in the class. Each student contributed to a thorough report of the project to the National Park Service. Through this independent learning students expressed strong ownership of the results.¹¹

In the 2006 course MET 320 Virtual Preservation students learned to take appropriate digital images and process them in PhotoModeler independently using the training materials provided with the software. While they were guided with weekly meetings with Horton which sometimes

focused on carrying out specific techniques, the majority of their learning was independent. Guidance was provided through independent study contracts specifying expected outcomes. The student interns and principal investigators worked together to gather data on-site. These students then independently applied the close-range photogrammetry software to this very unique and complicated set of digital images.

Students Applied Technical Skills to New Problems Through Applied Research

One of the most interesting lessons for students participating on this project is that first attempts at applying new techniques are not always as successful as hoped. For example, while one building was virtually preserved in 2003, the technique used will not be repeated because it is too cumbersome. This required the principal investigators and the undergraduates to explore together other low-cost methods that could be productively applied to preserve the important cultural heritage site at Leinster Bay.

Horton worked with librarians at the Fogler Library at the University of Maine to identify a more appropriate method for performing the virtual preservation that would provide the digital image based three-dimensional CAD model sought by the Park. Articles in journals reporting on cultural heritage methods outlined a variety of methods, with the most practical identified as PhotoModeler. One student participated in both of the special classes and worked as an intern on both projects and thus experienced the technique development process first-hand.

As a result of this project the principal investigators determined that undergraduate engineering and engineering technology students are able to learn and apply necessary elements of the photogrammetry techniques fairly quickly. The cost of hiring undergraduate student interns to perform the labor-intensive taking and processing of digital images is relatively low. General improvements in project planning to make the process more efficient are now sought. Improvements in using the digital camera and digital image processing techniques to obtain more color control in the set of digital images due to varying sun and shade conditions is required in the future. Similarly while student interns can learn to apply the necessary skills for the collection of survey and GPS data and the processing of the data into a GIS, there are remaining data-collection organizational processes that can be improved.

Students Traveled to a Location with Significant Cultural Differences from Their Home Setting

The student interns who traveled to St. John were all white and from the U.S. northeast. In 2004 and 2006 interns read documents about the history of St. John and the history of the site on which they would be working. They visited with Wild a restored sugar factory at Annaberg, which offered a glimpse of the brutal conditions faced by the captured Africans forced to work there. The student interns working on the site at Leinster Bay frequently commented about the life the people working at the sugar and rum factory must have faced. Some of the people living on the island today are descendents of that era.

Student interns were housed in tents at a tourist campground on the beach at Cinnamon Bay. They shopped and did business in the town of Cruz Bay, where they interacted with residents with historical roots on St. John or other local islands, residents who had recently come to the

islands from the continental U.S., and tourists. They were able to see for themselves the differences in the culture of the residents of African origin with historical island roots compared to residents from the mainland, and tourists. The impact of geographic isolation (St. John is about 20 square miles and 20 minutes from St. Thomas by ferry) on the lifestyle was evident from events such as occasional power outages and limited access to high-speed internet service. Even differences in the evening locales preferred by local residents and tourists were evident.

Students Applied Technical Skills to a Social Need

Engineering in general involves the application of mathematical and scientific principles to practical applications to benefit humanity. Students were able to participate in the application of engineering techniques to cultural preservation. These students had the opportunity to read about and see on-site the history of a unique cultural heritage site. This offered the opportunity for on-site discussion of the outcome of the local history on the current population including financial issues and issues related to maintaining the island identity.

The VIHC notes as one of its goals and objectives: “Encourage the development of source materials which will enrich the base of information relating to Virgin Islands cultural history.”¹² In accordance with the granting requirements, principal investigators and students made two public presentations of the work being completed: one on-site, demonstrating the application of the technique at the ruins themselves, and the other at the Archeology Laboratory at Cinnamon Bay in the Park, demonstrating the close-range photogrammetry results to that point. The public presentation at the Leinster Bay factory site is shown in Figure 5.



Figure 5. Wild introduces the virtual preservation project at the Leinster Bay site.

The VICH defines the Humanities: “The humanities explore what it means to be human, through history, literature, folklife studies, cultural anthropology, archaeology, philosophy, ethics, comparative religion, law, and the history and criticism of the arts.”¹² The notion of applying engineering to explore what it means to be human was new to the students involved in this unique project.

Conclusions

The principal investigators and the students who have worked on the virtual preservation project in the Virgin Islands National Park have demonstrated that a relatively low-cost method of collecting and processing digital images using close-range photogrammetry software can be used to develop three-dimensional models of ruins of buildings that can be viewed by the public and processed in computer-aided design software. Undergraduate engineering and engineering technology students are capable of learning to apply the necessary techniques. The principal investigators must still guide the collection and processing of the data, and must complete some tasks still under development. In the future it might be possible to develop a course of study that would incorporate all necessary skills so that knowledgeable interns could take positions of several months in the Park supporting this unique virtual preservation project.

Acknowledgements

The authors acknowledge the financial support for this project provided by the University of Maine through the School of Engineering Technology, the 2003 Faculty Research Fund Committee, and the Division of Lifelong Learning; the National Park Service; the Friends of the Virgin Islands National Park; the Virgin Islands Humanities Council.

¹ Anestis Koutsoudis, Fotis Arnaoutoglou and Christodoulos Chamzas, "On 3D reconstruction of the old city of Xanthi. A minimum budget approach to virtual touring based on photogrammetry." *Journal of Cultural Heritage, Volume 8, Issue 1, January-March 2007*: 26-31.

² Karen J. Horton, Constance Holden, Ken Wild, Service Learning in the U. S. Virgin Islands National Park: A Virtual Preservation Project, *Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition*, American Society for Engineering Education, 2005, http://www.asee.org/acPapers/2005-743_Final.pdf (accessed Jan. 17, 2008).

³ Maxwell school of Syracuse University Anthropology Department Field School, Archaeological Survey and Historic Site GIS, St. John, United States Virgin Islands, <http://www.maxwell.syr.edu/anthro/archfield/virginislands/index.asp> (accessed Jan. 17, 2008).

⁴ MicroStation, Bentley Systems, Incorporated, <http://www.bentley.com/en-US/Products/> (accessed Jan. 18, 2008).

⁵ Arcview, ERSI GIS and Mapping Software, <http://www.esri.com/software/arcgis/arcview/about/features.html> (accessed Jan. 18, 2008).

⁶ PTgui: Create high quality panoramic images, <http://www.ptgui.com/> (accessed Jan. 18, 2008).

⁷ PhotoModeler, Eos Systems, <http://www.photomodeler.com/index.htm> (accessed Jan. 18, 2008).

⁸ Jack Leifer, "A Close-Range Photogrammetry Laboratory Activity for Mechanical Engineering Undergraduates," *November 5-8, 2003, Boulder, CO* 33rd ASEE/IEEE Frontiers in Education Conference, <http://fie.engrng.pitt.edu/fie2003/papers/1105.pdf> (accessed Jan. 17, 2008).

⁹ "Cortona VRML Client," Parallel Graphics, Jan. 18, 2008, <http://www.parallelgraphics.com/products/cortona/> (accessed Jan. 18, 2008).

¹⁰ "Virtual Preservation of Colonial Structures," University of Maine Mechanical Engineering Technology, September 4, 2006, <http://www.umaine.edu/set/met/ViginIslandModels.htm> (accessed Jan. 18, 2008).

¹¹ Nick Houtman, "Reengineering the Past: UMaine students use digital modeling to virtually rebuild the 18th-century plantation ruins," *UMaine Today January-February 2005*, <http://www.umainetoday.umaine.edu/Issues/v5i1/engineering.html> (accessed Jan. 18, 2008).

¹² Virgin Islands Humanities Council: About VIHC, <http://www.vihumanities.org/about.htm> (accessed Jan. 17, 2008).