Documentation, Visualization and Interpretation of Archaeological Sites in Kruger National Park
The Thulamela Case Study

Project Proposal

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Project Statement

This multi-phase project will document, present and interpret targeted archaeological and cultural heritage of Kruger National Park. Apart from our own academic research, our work will be developed in conjunction with scientists at KNP and serves both scholarly and general public audiences. Using scanning and digital technologies we will develop new techniques for recording and visualizing archaeological sites in conjunction with new pedagogical tools designed for a variety of audiences and stakeholders in and around KNP, in South Africa and internationally. The project has two related components with different time scales. First, the scanning and visual recording of the Iron Age site of Thulamela and its excavated finds, which will take place for 3 weeks during May-June 2004 and 2005. Second, an ethnographic study of the emergent cultural heritage policies and practices being developed at KNP and the various interest groups, including tourists who will directly benefit from these new initiatives. This will take place for two months over June-August period for the next five years. We have secured long-term funding from the National Science Foundation (US$2 million) and also the Institute for Social and Economic Research and Policy at Columbia University and the Mellon Foundation. We estimate that the costs for our team will be $23,000 for the 2004 field season. KNP will benefit in a number of important ways. This work directly enhances the planned interpretive center at Punda Maria, providing visual resources for the site and its artifacts and multiple interpretations of the site's history. Since security for some artifacts is an issue within the park, 3D visualization combined with a robust database of excavated objects and ethnographic research materials will provide an excellent alternative. We also will promote the significance of the site to a world-wide audience, highlighting the full spectrum of cultural and natural heritage at KNP. Our work will also enable various local stakeholders, such as the Venda, Shangaan, Iron Age archaeologists and KNP officials, to voice their interpretations and/or cultural connections with Thulamela. It will thus connect KNP to larger pool of tourists, students, schools, archaeologists, academic audiences and the general public in South Africa and abroad.

Work Procedure
We will conduct our fieldwork in two integrated phases. In the first phase, we will conduct documentation of the Thulamela and possibly Makhane sites in the Parfuri region of KNP. The second will consist of archival and ethnographic research conducted by project director Dr. Lynn Meskell. These individual phases will be broken down as follows:

PHASE 1

a. The recording of archaeological remains and cultural landscapes at Thulamela with both digital photography and videography.

We will conduct extensive photographic documentation of the site to be used for documentation, three-dimensional modeling of Thulamela, and the design elements of educational resources and outreach programs. All content will be made available through our high end augmented reality environment at Columbia University, at the interpretive center in Kruger National Park, and on the World Wide Web.

Our videographic documentation will focus on processional movements up to the site from the valley below and then wending through the site just as the ancient inhabitants would have experienced. Like the Shona people of Great Zimbabwe and the contemporary inhabitants of the nearby Venda kingdom, those visiting ancient Thulamela had to move along the correct track, one that was both functional for reasons of security and experiential, in the sense of engendering an embodied response of esteem and reverence to the chief. This rich historic and ethnographic information documenting the visitation customs will enable us to record these processionals with significant accuracy. The official route takes us up past the huge baobab tree at the base of the site, past the stone monolith and from the base of the walls, higher and higher to the enclosure of the chief and his court. We will focus on reconstructing the flow of movement, including the possible restrictions to that movement across the site, i.e. the logic of the site.

It will also be necessary to take a series of landscape videos around Thulamela from various vantage points: from the base of the valley, through the Niala forest below the site, at the ‘eye’ of the site (the primary lookout) and so on. These videos will complement our use of panoramic photography to capture similar view corridors.

We also have the unique opportunity to build on this ethnographic and historic information by conducting video interviews with Venda and Shangaan informants, communities who have their own specific claims to and interpretations of Thulamela and the material culture retrieved from the site. This dynamic relationship with contemporary stakeholders and the potential differences in interpretations is something that archaeologists have to constantly negotiate. We can represent this dynamism through ethnographic video. These materials will further stimulate dialogue amongst various groups, including scholars, tourists, parks service officials, school groups and diverse local communities, and through such dissemination, a wider cross-section of these communities will have access to information and in turn a say in the site's interpretations.

As with our photographic documentation, all video content will be used in advanced graphic environments on the Columbia campus, in the visitor center of Kruger National Park, and on the World Wide Web.

b. Site survey of Thulemela using total station and global positioning systems integrating all of our data into Kruger Park's existing geographic information system.

One of the priorities of KNP is to document archaeological sites according to the highest standards of the discipline. This survey will operate at three levels: total station recording of our work linking it to earlier excavations at the site; to the larger Geographic Information System of KNP; and the wider historical landscape of South Africa. We will record and survey Thulamela using a total station, since co-ordinates for the various enclosures, features and finds do not appear in the published excavation report. These data will be made available to KNP's existing Geographic Information System.

This survey will provide a more systematic base reference for the databasing of finds from the site as well. As it will not be possible to scan the entire site, this data will also be used to make simpler 3D models of the site made with computer aided design software to give an overall sense of the size and complexity of Thulamela.

Including the site on the broader scale of the full park will provide information about flora, fauna, and the original environment and its changes over time. Likewise, since there are several socio-historical phases at the site, we will use this data to model historical landscape contexts as they change over time.

c. Panoramic photography (QuickTime Virtual Reality nodes) and three-dimensional renderings at Thulemela (Cyra Laser Scanning and Computer Aided Design software).

Rather than attempting to capture the entire site with the Cyrax scanner, we will focus on the key structures and spaces that will serve as the distribution points of multimedia content in our system.

First, we will scan the major architectural features to the north of the site. We know that the stonewall enclosures cluster according to rank in size and position (height and seclusion were the major features) and to the status of the inhabitants. These relationships are essential to representing the experience of the site. The enclosures are grouped around a central focal point, the court area, and are situated at the highest and most isolated part of the site. Non-walled areas of occupation surround the walled areas. This settlement pattern is significant in that it conforms to the those typically seen in Zimbabwe culture, where royal leaders are protected not only by walls but also by their subjects. Following Miller's system, enclosures 13, 14, 5—each approximately 10m in diameter—are particularly important. These are the enclosures that were excavated and yielded 'royal' burials and evidence of gold smelting.

Second, we plan to take panoramic photography from significant points to capture the rest of the site, including view corridors (significant landscapes that highlight historic trade routes, strategic defensive lookouts, etc.). These open areas of the site may also be the most conducive for potential remote sensing work.

Excavated objects will also be a priority in our modeling process. Prior to the field season, we will arrange access to the excavated objects now held at the Pretoria Museum. Even if we are to simply photography these object, the work will require special permission as several are highly valued gold artifacts. The use of additional equipment may demand additional paperwork.

d. Digital audio recordings of both environmental information and ethnographic interviews.

Most important here is the contextualization of the site in its immediate landscape. This would consist of recording environmental information, perhaps at different times of the day. We will also use audio for ethnographic interviews when videography proves difficult.

Phase 2

The proposed cultural and ethnographic phase will consist of approximately two months over the months of June, July and August each year. Research will take place, in the first instance, for a period spanning five years and will be conducted by Dr. Meskell.

Heritage assessment would involve a three-fold strategy including participation, visitation and interviewing, both within the park and outside. Participation entails involvement with government officials, KNP personnel, archaeologists, tourists and members of local communities in and around the park. Visitation means access to lodges and sites within KNP, some of which are privately run, as well as to archaeological sites, cultural and craft centers. Interviewing would take place with individuals, groups and representatives alike and would include those engaged in the business of heritage and tourism outside the borders of the park. Thus the project lies at the intersection of several significant domains: politics, nationalism, tourism, heritage, economics, development and indigeneity. Political rhetoric in South Africa currently positions tourism as an economic strategy for poverty relief and here 'heritage' provides the raw material: archaeology is clearly imbricated in these narratives (see Blundell 1996, 2002). This makes South Africa a unique research subject for archaeologists interested in contemporary politics (Hall 2000, 2001, Lewis-Williams 1995, Shepherd 2002) and significantly different to comparable settler societies such as Australia, New Zealand and the United States (Lilley 2000). More specifically, KNP is an optimum test site to analyze the machinations at international, national, and community levels since it effectively bridges global and local presentations of South African heritage and tourism. KNP is aware of the values of a diverse spectrum of heritage and cultural tourism, therefore a critical engagement with archaeology must be paramount. This critical study does not simply reside in the static nature of archaeological sites or objects, but at the intersection of living communities, global and national institutions, the forces of tourism, re-worked and narrativized pasts in the present, and the series of negotiations that are woven between them.

As an international researcher, Meskell hopes to play a two-fold role in the new social ecology program of Kruger National Park. First, I will act as an international archaeological expert and consultant on issues of heritage assessment, collaboration and presentation to a range of publics. Secondly, she will observe a range of negotiations between individuals, communities and organizations as they work towards a strategy of economic empowerment, nascent nation building and the presentation of a new South Africa to a burgeoning tourist industry. These creative potentials have been forged around the rhetoric of an African Renaissance, yet few have had the opportunity to assess its implementation on the ground. The objectives are to analyze the voices, values and identities at play in the new cultural imperatives that seek to revive, regenerate, and reconstruct. Kruger is actively seeking tourist feedback in written form and my own work would be another avenue to pursuing those goals in assessing visitor reception to developments in the park. Here relevant concerns are expressed over commercialization, additional entertainment, souvenir authenticity, exhibitions and edutainment that all add dimensionality to the tourist experience. Archaeology and cultural heritage are the vital but missing components of this ambitious reconceptualisation of Kruger National Park.

While access to KNP as a whole is desirable, Meskell envisages that the majority of her time would be spent in the southern third of the park. However, since Thulamela is a major research focus of the overall project and she will concentrate her efforts in the extreme north of KNP as well. Thus the majority of her research time will be split between Punda Maria and Skukuzu stations, with KNP personnel, consultants, researchers, tourists and so on. Such work will largely be conducted on foot (at major sites and camps) and in vehicles when accompanying tours. Here we would hope that the park would support this by authorizing travel and assistance in moving between stations in the extreme north of the park. We do not envisage off-road research unless called upon by KNP to assess archaeological sites, at which time we will request accompaniment of park personnel. Meskell would also require access to historic archives and up-to-date archaeological reports from KNP and most of these would be available at Skukuza.

Other archaeological experts may be involved with the larger framing of the project and be in residence for shorter periods of time. Dr. Thembi Russell from the Rock Art Research Institute, and possibly one or two graduate students from Columbia University (Lindsay Weiss) and the University of Witwatersrand. The main liaisons at the Rock Art Research Institute in Johannesburg would be Thembi Russell, Geoff Blundell and Ben Smith (Director of the Institute).

Major Milestones
The project objective of designing digital resources for both advanced academic research and more general educational outreach provides us with three milestones to work towards. In the first case, we will develop an augmented reality environment in the Computer Graphics and User Interface Laboratory on the Columbia University Campus by the end of the 2004-05 academic year. The idea is to create a scale three-dimensional model of the site with all finds and complementary ethnographic materials embedded in the visual resource. This multimedia "report" would serve as an archive while also enabling undergraduates students, graduate students and faculty researchers to examine a full range of annotated materials in a virtual context.

The second objective is to use individual multimedia objects—images, sound, video, three-dimensional modeling, computer aided design, and animation—for a learning environment on the World Wide Web. In this way we will ensure broad dissemination of our materials to anyone with access to the internet. This resource will be developed in parallel to our work in the Computer Graphics and User Interface Laboratory ensuring that all documentation and representational material will be modular and scalable for the use of a diverse user group.

The final milestone will consist of our work at the Punda Maria Visitor Center. This is a long term, collaborative objective between our research group and KNP personnel. We will develop didactic resources for the Center based on our efforts to complete our first two objectives, again taking advantage of modularity and scalability of the multimedia elements of our documentation materials. This resource will also be designed for a broad user group, but we will prioritize the immediate stakeholders at KNP and the socio-cultural particulars of South Africa in general. The basic strategy will follow that of our higher-end resource, but it will be designed for the particular hardware, facilities, and knowledge-base of our partners in KNP.

Project risk
Given funding resources, academic qualifications, partners in South Africa, and our several seasons of field testing our methodologies in Egypt and Sicily, we consider this to be a low risk project.

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Phase 1 will take place in the Parfuri Region of KNP at Thulamela and Makhane. We also request access to the excavated materials presently stored at the Pretoria Museum. The second phase will have two foci. The first will take place in Parfuri and the second in the area of Skukuza.

Background Information

Three-Dimensional Scanning

We are intrigued by the possibility of Thulamela serving as the nexus for introducing complex ideas from a variety of disciplines: mathematics, earth sciences, economics, geography, literature, languages, politics, and history. Our ability to model, visualize and analyze the site is at the center of this endeavor.

To date, we have focused on building our tools at a variety of sites discussed below. We believe the environment in KNP is an outstanding venue for us to fully test the entire complement of our technologies, and at the same time create a meaningful and valuable resource for park visitors and researchers.

1. Scanning and Modeling of Cultural Artifacts

We are interested in scanning many of the small artifacts associated with the site to create very accurate 3D models of these objects. These models can be used for a number of purposes, including visualizations on and off site, aids to researchers who need to examine the objects closely without needing to travel to their physical location, and re-creation of the physical objects using a 3-D rapid prototyping process. The Columbia robotics team has extensive experience in 3D modeling of this type. We have developed methods that will allow us to form accurate solid object models from just a few scans of the object (Reed and Allen, 2000; 1999). The method takes a small number of range images and builds a very accurate 3-D CAD model of an object. The method is an incremental one that interleaves a sensing operation that acquires and merges information into the model with a planning phase to determine the next sensor position or 'view.' The model acquisition system provides facilities for range image acquisition, solid model construction and model merging: both mesh surface and solid representations are used to build a model of the range data from each view, which is then merged with the model built from previous sensing operations. The planning system utilizes the resulting incomplete model to plan

Figure 1. Top: Object and 3D model created from range scans. Bottom: Three range scans with extrusions that when intersected from the solid model.

the next sensing operation by finding a sensor viewpoint that will improve the fidelity of the model and reduce the uncertainty caused by object occlusion (including self-occlusion). The scanning process uses a high resolution scanner (Shapegrabber: www.shapegrabber.com) that provides very accurate and dense sampling of the objects. Using our own software algorithms we are able to build models of objects that can be sent to a rapid protoyping machine to physically build the models. Figure 1 shows some objects, range scans, extrusions of each scan, and the final resulting model.

2. Large Scale Site Modeling

We will also create a model of Thulamela. Preserving cultural heritage and historic sites is an important issue, since these sites are subject to erosion, vandalism, and as long-lived artifacts, and have gone through many phases of construction, damage and repair. It is important to keep an accurate record of these sites using three-dimensional model building technology as they currently are, so preservationists can track changes, foresee structural problems, and allow a wider audience to ‘virtually’ see and tour these sites. Due to the complexity of these sites, building 3-D models is time consuming and difficult, usually involving much manual effort. Recently, the advent of new 3-D range scanning devices has provided new means to preserve these sites digitally, and to preserve the historic record by building accurate geometric and photorealistic 3-D models of these sites. This data provides some exciting possibilities for creating models, but at the cost of scaling up existing methods to handle the extremely large point sets created by these devices. This reinforces the need for automatic methods of registering, merging and abstracting the dense range data sets (Stamos and Allen, 2001; 2002). To create data-sets that can be turned into models, we are using a time-of-flight laser scanner (Cyrax 2500) to measure the distance to points on an object. Data from the scanner comprises point clouds, each point comprising four coordinates, x,y,z and a value representing the amplitude of the laser light reflected back to the scanner. This fourth coordinate, labeled RSV (Reflectance Strength Value) is a function of distance to the scanned surface, angle of the surface relative to the laser beam direction, and material properties of the surface. A scan of 1000 x 1000 points takes about 10 minutes. In order to acquire data describing an entire structure or site, multiple range scans must be taken from different locations which must be registered together correctly. Although the point clouds may be registered manually, it is very time consuming and error-prone. Each range scan can provide up to 1 million data points (see Fig. 2), and manually visualizing millions of small points and matching them is quite imprecise and difficult as the number of scans increases. We have used this method on two different cultural heritage sites. A comprehensive model of the Cathedral of St. Pierre in Beauvais, France has been constructed made up of data from all the scans (Allen et. al. 2003a; Allen et. al. 2003b). This Cathedral is on the world monument's fund most endangered list. The resulting model is very large, and visualizing the entire model can be difficult. Fig. 2 show the model from a number of views. For these models, 120 scans were registered on the inside of the cathedral, and 47 on the outside. The outside scans were registered automatically except for a small number (7) where a single extra point constraint were added manually to assist the automatic procedure in overcoming symmetries. The inside scans were first coarsely registered manually, before we developed our automatic methods, and were quite time consuming. We then ran our simultaneous ICP algorithm to substantially improve the registration. A 3-D video fly-through animation of the model is available at the website: www.cs.columbia.edu/~allen/BEAUVAIS.

3. Archaeological Site Modeling: Previous Work at Monte Polizzo

The team has previously conducted research at Monte Polizzo, Sicily as part of a Stanford University excavation headed by Dr. Ian Morris. Our goal was to digitally record the process of an archeological excavation in as much detail as we could. Archeology is a destructive process which requires that structures and findings, usually in the form of tools, pottery and bones, to be removed in order to continue. Our initial aim for this project was to capture the current state of the site on a daily basis using different type of sensors and to create an integrated 3D model of the site. This model would include geometry from laser range scans of the site and photometry from images and video. Our main research goal was to integrate these data sources into a viewable model and to record changes at the site as different layers were exposed. We used a Cyrax 2500 laser scanner to scan the site. Each scan created a point set of between 50K and 1000K points.

The team took over forty scans of the site, resulting in a very large model. Registration of the data sets is the most important technical challenge. For the surveying task to be successful, we adopted the coordinate system the Stanford team had been using. On the first day we established the necessary control points that would allow us to setup the surveying total station. Using special targets we placed in the scene, we could register each scan to the known control points. The targets can be recognized by the scanner, and this allows all scans to be part of a common coordinate system. We measured the target's location with the total station and took a low resolution 3D scan of it. We then identified and acquired the targets using this low resolution scan. Once acquired, the targets were removed from the scene and full resolution scan was taken. At the same time, an image was recorded with the digital camera. We had previously calibrated the digital camera with the scanner. This allowed us to take images of the scanned regions and know the exact transform that would allow us to texture map the images onto the 3-D scan surfaces, resulting in a photorealistic, viewable model. Upon returning to the U.S. after our field work, we have put together a model of the site. We are hoping to develop methods that will allow us to view parts of the model as needed rather than loading the entire model. Our equipment consisted of a Cyrax 2500 laser scanner, a Nikon D100 digital camera mounted on the scanner, a Leica TPS 700 total station and a laptop.

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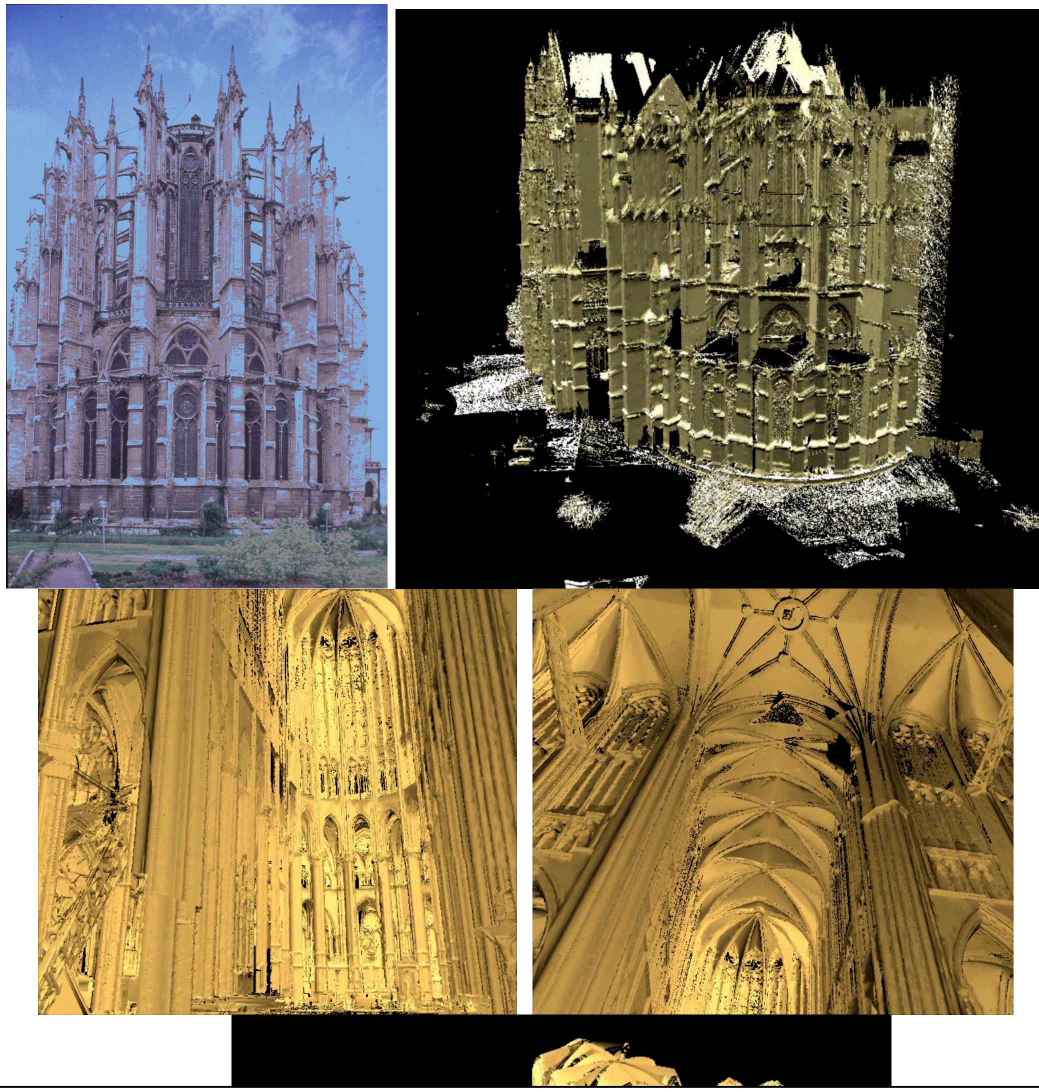

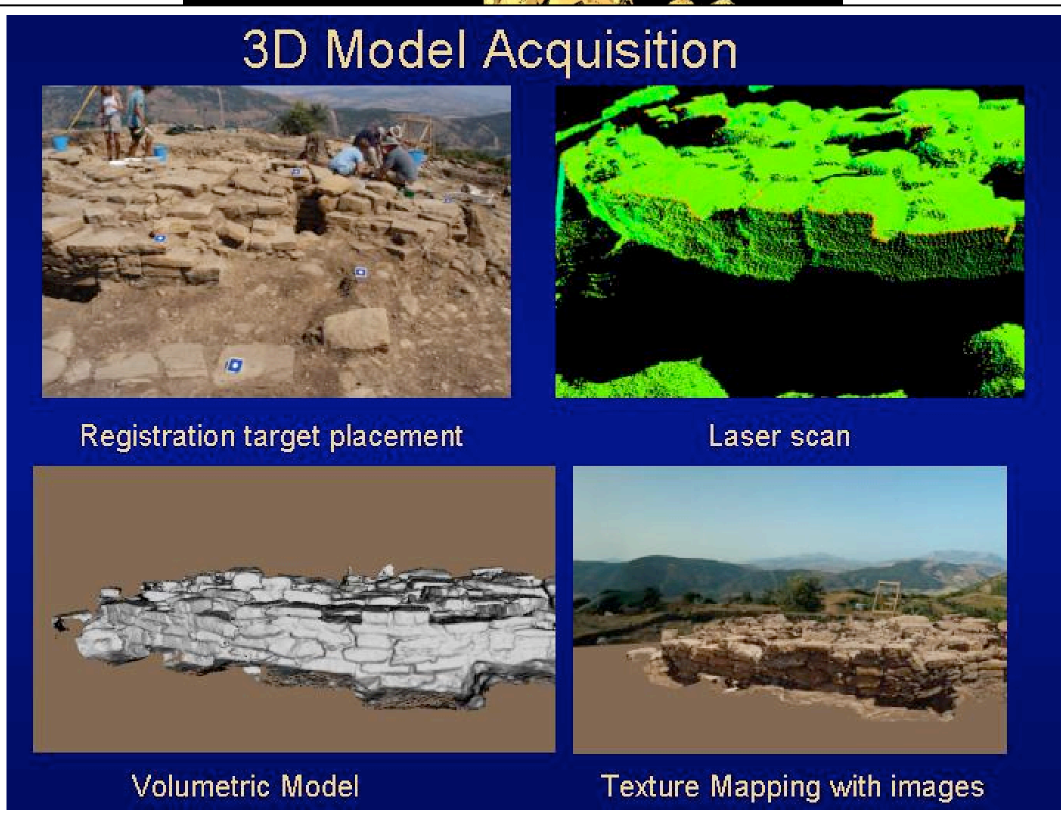
3D Model Acquisition
Registration target placement
Laser scan
Volumetric Model
Texture Mapping with images

Database Development

As part of the larger project, Dr. Ross and his group have developed a novel query interface and database for archaeology. The query language allows users with some archaeological sophistication to pose exploratory queries over the database without having to be familiar with conventional query languages such as Standard Query Language. Previously, we used the system to provide a query interface for a dataset from an excavation in Memphis, Egypt.

We will also be able to demonstrate the system on other data sets. The South African project is particularly exciting because:

a) It would allow the database to tie in with other project activities that are also proposed for South Africa.

b) Our understanding is that there are numerous artifacts from the site whose data (descriptive data, images, where found, etc.) could be entered into the system.

When complete, we would be willing to share the software with appropriate personnel in South Africa, so that users could pose queries over the artifacts found at the site. Such a system could be made available in a presentation facility such as a museum, interpretive center or over the World Wide Web.

User Interface and Computer Graphics

1. Off-site (lab-based) collaborative augmented reality visualization system for use by archaeologists to interpret and analyze collected data.

Most of our visualization work will occur after our data collection field work experience at Thulamela. We propose to develop several different visualizations of the site, including ones that its emphasize history and development. We will utilize the 3D models developed from the CYRAX laser scans, photography, GPS surveys, and other available data, to create a detail 3D model of the site. Obtaining a 3D model is important for virtually recreating and visualizing the site in our lab at Columbia University. In conjunction with the 3D information, we will strive to integrate a detailed database of objects found on the site together with 3D models, pictures and drawings. That model will serve as a base for a collaborative augmented reality environment, which uses see-through head-worn displays to overlay synthesized imagery and sound with what users see and hear (Feiner 2002). The goal is to create an environment in which off-site archaeologists can visualize, interpret and analyze the site in detail. Our lab-based visualization would build on our previous and ongoing experience with data from Monte Polizzo in Sicily and the Cathedral of the St. John the Divine in New York.

Figure AR-SYSTEM. User's view of a virtual representation of the Monte Polizzo site in augmented reality. Users wear head-tracked, see-through, head-worn displays. Objects, such as the labeled pot, are represented either with a 3D model or with a picture if the model is not available. This image was rendered in real time through another tracked camera representing a second user's view.

From the laser range scans of the acropolis at the Monte Polizzo site (Figure MP), we meshed and texture-mapped a 3D model and created a complete "remote dig-site experience" in our lab's collaborative augmented reality visualization system. Our system, shown in part in Figure AR-SYSTEM, consists of multiple tracked user stations (consisting of a head-worn displays, gesture sensing gloves, headphones and a microphone), numerous portable displays, wall size display, as well as a projected interaction table surface (capable of detecting multiple users as well as multiple simultaneous touches). In this environment, the users can be completely immersed in the remote site via head-worn displays and therefore visualize the 3D structure as well as all the objects embedded in the environment, together with the panorama images presented in the background for a complete immersion experience. Users interact with our system by using natural gesture commands (such as pointing, dragging, and rotating), as well as voice commands combined into a seamless multimodal interaction that uses tracked volumes virtually attached to portions of the user's body (Olwal, Benko, and Feiner 2003; Kaiser et al. 2003). This environment is being developed to allow research on collaboration interactions and allow archaeological experts and students to use this system to perform analysis and interpretation of the available data.

Users wearing a head-tracked, see-through, head-worn display can explore a portion of the virtual dig site. They can view a 3D representation of the terrain as either a textured point cloud or a textured mesh. Small archaeological finds are placed around the dig site at the exact locations of their discovery, each labeled with its name and description. A 360-degree panorama, shown in Figure PANORAMA, recorded at the actual site, surrounds the model to provide an immersive virtual experience. As the user walks around the virtual site, she views a full-scale model of the terrain. She can inquire about situated objects through a combination of speech and, or navigate using a wireless mouse. Additional information about specific objects is available in the form of still images, movies, and textual descriptions that can be presented on the head-worn display.

Digital images, taken on site, make it possible for archaeologists to visualize the site's overall structure, as well as the geometry and texture of individual rocks, both those removed during the excavation and those still in place. Movies allow the archaeologists to witness excavation of objects and rocks, and other important activities. They also provide an invariable walkthrough perspective of the site, making it possible for the archaeologist to experience the excavation both visually and audibly through the eyes of the photographer. Archaeologists also have access to the textual database of information about the various trenches, objects and excavations on site. This information is available both in a tabular fashion in a fixed portion of the display, as well as in situ, labeling the objects found in the 3D environment.

We hope to create a much richer experience for Thulamela by using digital representations of the objects that were found and potential recreations of the housing structures that could be manipulated and repositioned to be used in analysis of the Thulamela settlement. We intend to develop such a system and have it be used as part of the expert evaluation and as a tool for discussion and interpretation. We will further extend this work by developing interaction techniques to facilitate easy and tangible interactions in and across all our available displays.

In our previous project on Cathedral of St. John the Divine, we have been working with experts to identify differences between its architectural drawings and the current state of the building to be able to highlight the changes. We have created a detailed 3D model of the entire choir section of the cathedral and plan to use that model together with existing laser range scans in both our lab-based system and an on-site augmented reality experience that would show both experts and visitors these differences.

From this project, we would utilize our experience in modeling and interactive augmented reality presentations (storytelling) to construct similar presentations for the Thulamela site. We are especially interested in developing settlement simulations in which we could add and manipulate simulated structures on top of the actual model of the Thulamela site. That could provide a significant benefit to studying the socioeconomic aspects of the Thulamela settlement and could also be used to illustrate to the users how the ruling social hierarchy used the geography of the terrain to express their class, power, and status.

Related Work
Archaeologists currently use various kinds of written documentation, sketches, diagrams, and photographs to document the physical state of a dig site while it is being excavated. While there are many standards or guidelines for recording the state of the dig site during excavation, their main focus is to record and archive the data, rather than visualize it. To visualize the data, most archaeologists currently rely on geographic information systems (GIS), such as ESRI's ArcGIS [4] suite of software. Recently, INTRISIS [5] has extended some capabilities of standard GIS systems and functions as a plug-in for ArcGIS. Additionally, standard computer-aided design (CAD) systems, such as AutoCAD [2], are often used for modeling and reconstruction, and are both costly and time-consuming. While both GIS and CAD contain 3D visualization capabilities, most of those systems tend to present layered 2D maps or coarse topographical terrain maps with embedded objects, sketches, and pictures. However, additional multimedia, such as audio, video, 3D high-resolution terrain scans, and panoramas, as well as detailed object models, are currently not supported.

Several research groups have explored immersive 3D visualization for archaeology. For example, the ARCHAVE project [1] was developed for use in a CAVE [3]. It consists of a human-modeled environment embedded with virtual icons representing various types of finds and has been used to determine patterns and trends of the objects found on site, rather than a highly detailed computer generated model containing high-resolution textures for a more accurate representation of the actual site, as in our system. Gaitatzes et al. [6] present various VR environments for visualizing temples and public buildings in ancient Greece. Immobile users visualize an archaeological site on the stationary Immersadesk™ or the ReaCTor™, whereas in our system, users can physically walk around the life-sized dig site to explore different angles of the virtual world.

2. On-site wearable collaborative visualization/annotation system designed for the task of collecting of pictures, sounds, and videos,

On-site, we are interested in building on our previous experience in developing outdoor augmented reality systems (Feiner et al. 97; Hoellerer et al. 99; Guven and Feiner 2003) to create a collaborative system for researchers to be able to record, store and compare the data about the site in real-time without the use of a stationary system. We plan to use a hybrid tracking system (based upon GPS, inertial orientation sensor, and dead-reckoning) with a new version of our backpack-based augmented reality system to explore collaboration between several users in the field collecting and organizing data (see Figure BACKPACK-AR). This system would be capable of taking pictures, sounds and movies captured with their position and orientation, to create a rich dataset that can later be used in off-site visualizations. Potentially, a simple image morphing based walkthrough could be constructed without the need for complex geometry.

Figure MP: On top of Monte Polizzo: members of our team record exact 3D coordinates using a total station surveying instrument (upper left), capture video of an excavation using a digital camera (lower left), and scan a portion of the dig site using the Cyrax range scanner (right).

Figure PANORAMA: To complete the virtual reality experience, a 360 degree panorama is placed around the model in our virtual reality visualization system. The series of photographs used to create the panorama were taken from the center of the dig site on top of Monte Polizzo.

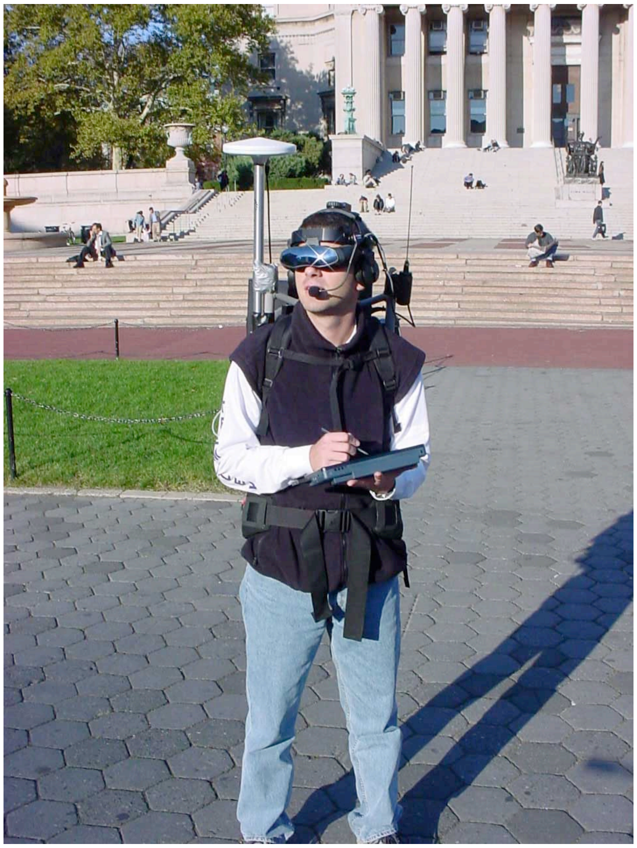

Figure BACKPACK-AR. Current version of our back-based mobile augmented reality system, using see-through head-worn display and hand-held display, and hybrid tracking based on GPS, inertial orientation, and dead-reckoning.

3. Internet-based portal with some 3D models of the site and some of our archaeological analysis available online for visitors around the world.

Some of the models, conclusions, and interpretations will be integrated into both our offsite lab-located system and our onsite portal (www.learn.columbia.edu/nsf). We will transfer some of our models in Macromedia Flash or record movies with recorder narratives to highlight some of our research and some of our interpretation.

Visual media may prove to be a vital tool in opening dialogue between diverse groups of stakeholders on a more concrete level. Given the 11 official languages of South Africa and the diverse communities and identities under negotiation, we consider central the role of visually based media within outreach and education. Multi-media presentation and visual models then function as an integral tool by which non-specialists may express their ideas, especially when tempered by a consideration of social and cultural practices and the existing technological infrastructure. What is more, creating a role for community members in the actual design project enhances their position in the project.

It is our objective to engage the potential of the interpretation and design process within the post-apartheid social milieu while also introducing a relevant, cost effective set of computer aided design, geographic information systems, and visualization resources on the World Wide Web to our partners. The intention is not to supersede local individuals and their vital knowledge — an act that would go against the very principles of heritage conservation — but to provide better options for documenting and representing our work with these stakeholders. These efforts will provide a powerful tool that gives people voice and agency in their connections to the past and its resonances for the future. This is key in both the representation of archaeology as well as the teaching of heritage values and strategies at a university level. We are thus training a new generation of heritage planners and archaeologists.

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Archaeological and Anthropological Research

Kruger National Park is an international icon that represents the remarkable natural heritage of South Africa. For over a century the unique flora and fauna of the park has invited protection and conservation, institutionalized under a government mandate formalized by Paul Kruger himself. While enormous efforts have been undertaken to protect, study and present South African natural heritage in KNP, the concomitant cultural heritage of the park has received comparatively little attention. Mounting pressure in the new South Africa for cultural expression of the African Renaissance has resulted in the promotion of Kruger sites such as Thulamela, an outstanding archaeological site that has become a nascent focus for education, community participation and economic empowerment. Yet on recent calculation KNP could yield over 1000 archaeological sites within its boundaries, from Stone Age tool scatters to impressive rock art. Many now recognize that it is now timely to engage in a renewed archaeological investment in the park that might include GIS mapping of previously or newly identified sites, reassessment of current site presentation and a detailed analysis of cultural heritage and its presentation to various stakeholders and publics. Meshing archaeological and ethnographic field practice offers one of the clearest avenues to addressing these concerns and draws on the expertise of scholars at the Rock Art Institute (University of the Witwatersrand) and in the Department of Anthropology (Columbia University, New York).

KNP is a unique national site with a complex political history that has recently come under scrutiny (Bunn 2001, Carruthers 1995). Yet given this history, deeply implicated in the consolidation of Afrikaner nationalism, new developments from within suggest a new climate of inclusivity and empowerment encapsulated in the motto Its mine, Its Yours (also translated in Tsonga). Social ecology, traditionally defined as the co-evolutionary interaction between social and natural systems that ultimately highlighted the social contributors to environmental crisis, has now been reconfigured. The notion that ecological problems arise from deep-seated social problems undermines human societies, specifically in impoverished contexts such as South Africa, whereas new movements encompass ecological, cultural and socio-economic dimensions within a conservation framework. At KNP social ecology is tacitly aimed at empowerment, education and encouraging communities to embrace conservation ethics. My own work dovetails nicely with these explicit calls for interdisciplinarity, community participation and educational outreach. Quite clearly, archaeology is the missing component in the current social ecology plan for KNP. Part of the new environment of dialogue and partnership must include an historic and cultural component as central. As South African politicians and intellectuals have repeatedly declared, the past is key in redressing the ills of the apartheid regime and crucial to the creation and sedimentation of identity in the present: it is neither fixed nor complete, but open to a series of creative reworkings (Meskell 1998, 2002a, 2002b). This process has obvious socio-economic interventions whether the economic imperatives of craft production, land claims (de Villiers 1999), human rights issues or intellectual property concerns: all of which KNP has some experience of, or undoubtedly will in the near future. In creating bridges, both physical and symbolic, an understanding of the material substrate of identity is necessary in the vital process of identity constitution and maintenance. 'Visible and invisible fences of the past' — a phrase taken directly from KNP's new social ecology statement, is particularly apt to my proposed research into the connectivity between past and present.

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