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Scientists and artists partner to create virtual Petra

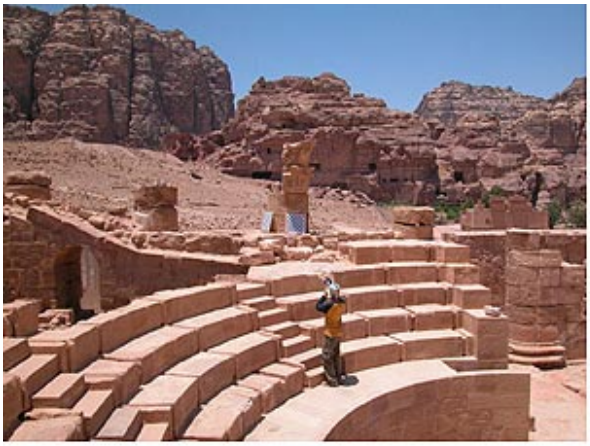
Digital technology electronically preserves the deteriorating temple and its artifacts.

by **Mary Jo Curtis**

Professor Martha Joukowsky has spent more than 10 years excavating the Great Temple of Petra, racing against time and the ravages of the desert to uncover the architecture and artifacts of the ancient Jordanian site.

Now, supported by a grant of more than $2 million from the National Science Foundation, Joukowsky and her students from the Center for Old World Archaeology and Art are receiving some unusual and innovative assistance from a team of scientists and artists. Together they are using technology to capture and restore aspects of Petra for future generations.

Led by principal investigators and Professors of Engineering David Cooper and Benjamin Kimia, a team comprised of Professor of Applied Mathematics David Mumford, Professor of Visual Art Richard Fishman, post-doctoral research associates Frederic Leymarie and Pierre-Louis Bazin, and New York University Professor of Computer Science and Mathematics Demetri Terzopoulos is collaborating with Joukowsky in a **multi-faceted project** that bridges research in the physical sciences and humanities.



Data recorded at the temple is later manipulated by a computer program to help analyze the site.

The group is building upon work begun three years ago with funding from an initial $1.25 million NSF grant. Cooper, Joukowsky, Kimia, Mumford, Assistant Professor of Computer Science David Laidlaw and then- graduate students Leymarie and Eileen Vote collaborated to digitally represent and manipulate two- and three-dimensional shapes from data recorded by laser range scanners and digital and video cameras ± and then apply those theories to archaeological site analysis.

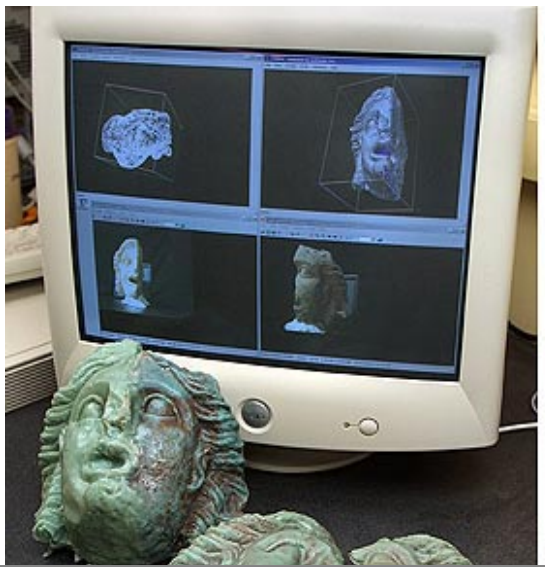
One dramatic result of that effort was the development of an immersive virtual reality rendering of the Great Temple in Brown's supercomputing lab, the Cave. In this second phase, the team will create a ªfish tankº virtual reality, that is, a desktop version that will be less expensive and more readily available to students and researchers.

ªThe Cave demonstrates the usefulness of this, but it needs to be more practical, so we're developing a prototype of that technology,º said Leymarie, the project manager.

During the decade Joukowsky and her colleagues have spent in Petra, they've unearthed more than 10,000 architectural fragments ± and nearly 326,000 cultural objects.

ªPetra is very rapidly eroding, so the team is eager to build accurate modelsº of what's there, said Cooper. ªSome of the geometry has been recorded pretty accurately with surveying equipment, but that's very time consuming. We want to do it with new techniques and get data faster and much cheaper with video and digital cameras , instead of long-range scanners, to make it more automated.º

Reconstructing pots from the thousands of excavated sherds may take anywhere from a few hours to a few days ± or may be impossible, Kimia noted. New computer programs, however, reassemble the puzzle-like pieces, offering mathematical probabilities for each potential match. Using various mathematical models, the team is also developing programs that can project how the original objects are likely to have looked ± even when only a few pieces are available.



ªYou can get a fair amount of information from an individual piece,º noted Cooper. The shapes ± eroded rectangles, spheres and cylinders, as well as the irregular and free-form ± provide rich data for developing shape theories.

That effort is enhanced by Fishman, who advised the scientists on the artistic process; he's now collaborating with them on digital virtual sculpting. Terzopoulos, a computer vision and animation specialist, was brought in to make inferences about the appearances of people and mammals of the period.

Masks constructed by Prof. Richard Fishman based on data provided by the computer program.

ªWith a 3-D reconstruction of the site, we want to have animated reconstructions of people and animals there ± and maybe eventually tie this to forensics, using bones from the site,º Cooper explained.

ªWe work on state-of-the-art multimedia trying to

make the computer do what the senses do automatically ± we want to make the computer perceive, to bring cognition into the process,º said Kimia.

ªIt's been a real synergistic effort,º Cooper said. ªIt looks as if these tools will be very powerful in helping archaeologists to extract more information from finds and make it easier to analyze these things ¼ this could really be a revolutionary contribution to archaeology.º

ªThe gains are immeasurable, both short term and long term,º agreed Joukowsky. ªI know our use of technology has improved learning.º

While there are a few similar projects elsewhere ± a team from Columbia is using earth-penetrating radar to scan sites beneath the surface in Egypt to identify potential digs, and another from Stanford is using scanning technology to reassemble an ancient 10-by-30-foot map of Rome ± the Brown scholars are pioneers, according to Cooper.

ªIn terms of automatically reassembling 3-D shapes from fragments, we are further along than anyone else in the world,º he said.

In addition to the archaeological applications, the project is aiding the development of a common language and understanding among the collaborators. Fishman sees his digital sculpting as a ªlink between arts, humanities and technology [that is] important for Brown and timely for education and the way society is moving.º

ªMany artists continually look for something that's unique to the time in which they're working, but many are put off by technology,º he said. ªFor most artists, this is not the way they visualize the world. ¼ This exposes me to things I don't know about, and it's important for us in the art department to expose students to this technology.º

Together, Kimia said, the team ªcan see things from different angles.º He believes it's important to bridge the gap between engineering and the humanities, as well as between engineering and medicine.

ªWe speak completely different languages, and we have to learn a lot to work in a common interface,º he said. ªI don't know too many others who do this. People have to have a vision of where this will go before they invest the energy.º

Ultimately, Cooper predicted, this technology will be available on a wide scale to the community and schools, where students can trade in their video games for an Indiana Jones fedora ªand feel like they're on a site ± and learn about mathematics at the same time.º

Said Joukowsky, ªThe greatest lesson I've learned is that creative thinking can achieve unimaginable results.º