Abstract

In modern archaeology large amounts of data are generated through the use of 3D laser scanners, photogrammetry, digital photography, remote sensing, computer vision and other forms of digital archiving process. For interpretation and visualization of data the archaeologists use a variety of specialized software tools (some open source), which can usually handle specific type of data at a time. These tools allow for stand-alone data decimation, analysis, visualization, archiving, and contextualization. In the end there is a lack of integration of tools in order to allow for comparison of different data sources. Majority of the tools also do not provide a straightforward way of sharing data within a large community of users and scholars.

Virtual reality offers flexible modality for visualization, exploration and interaction with spatial data. Shared virtual environments can provide remote user access to these data. The aim of the proposed Telimmersive framework (TeleArch) is to integrate different data sources and provide real-time interaction tools for remote collaboration of geographically distributed scholars. The framework also includes optional audio and video streaming technologies, which create a virtual presence of the remote user inside shared virtual space.

The primary goal of 3D collaborative research is to develop real-time interaction to access and manipulate 3D spatial data remotely by multiple participants. In Telimmersive archaeology the interpretation process is the result of embodied participatory activities whereas multiple users/actors construct a new digital
hermeneutics of archaeological research from the fieldwork to virtual reality communication. This cyberspace augments the possibilities to interpret measure, analyze, compare, illuminate and simulate digital archaeological models according to different research perspectives while sharing data in the same space.

First experiments of Teleimmersive archaeology are in progress between the University of California Merced, Berkeley and Davis with different case studies including the Neolithic site of Catalhoyuk (Turkey), the Chinese Western Han tombs and the Mayan city of Copan.
Overview

- Digital Hermeneutics in archaeology
- 3D Interpretation
- Simulation
- Data capturing – Case studies
- VR and collaborative systems
- Teleimmersion Archaeology
Hermeneutics

- The art, skill, theory, and philosophy of interpretation and understanding
  *The question is not so much what we understand as how we understand* (Johnsen, Olsen, 1992)

- Knowledge and context
- The historical or hermeneutic sciences deal with communication, understanding, meaning and action (cf. Patrik 1985)
- Digital hermeneutics deals with embodiment, enaction, interaction, feedback, immersivity, situated environments and cybernetic transmission
- Interpretation is a translation process
- New Research Questions

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Digital Archaeological Hermeneutics

**Simulation/Interaction**

**Interpretation**

**Data Processing**

**Knowledge**

**Validation**

**Data recording**

**Communication**

**Transmission**
Data

- Documentation
- Fieldwork
- Data entry
- Repositories
- Archives

Performance

- 3D modeling
- Simulation
- Interaction
- Embodiment
- Enaction

Interpretation

Cybernetic circle

Validation
Interaction
Feedback
Cultural transmission
Virtual Communities
Fieldwork
Data-entry
Processing
Interpretation
Enaction/embodiment
CASE STUDIES

3D-Digging at Catalho˘gyuk

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To interpret an archaeological excavation in 3D using advanced technologies for visualizing and interpreting structures, objects, artifacts and stratigraphic layers.

- In order to reach this goal all the fieldwork activities are based on 3D data recording by laser scanning, digital stereo cameras, digital photogrammetry, computer vision and remote sensing.
Purposes

• Preservation of the site. The fragile archaeological structures and remains of the site have to be documented in detail and with very sophisticated instruments before time and environmental factors can damage them.
• Reconstruction of all the excavated structures. Part of the site is open to visitors but it is very difficult to interpret the site in a comprehensive broader vision. The 3D documentation will display this content in a very innovative way and in different locations.
• Data recording of small size artifacts (figurines, pottery, artifacts).
• Experimental use of different integrated technologies and models. From the technological point of view the project could test the effect of different instruments and tools on the same case study.
• Stereo visualization of 3D data during the excavation. The use of portable stereo systems of visualization (video-projectors, 3D displays) on the excavations will involve the archaeologists to analyze daily the data recorded in stereo-vision.
• Use of virtual collaborative environments for interpreting data and testing the reconstructions.

Technologies

• Time of flight scanners
• Optical scanners
• Computer vision
Catalhuyuk (East Mound, B87, 2010)

Scanners
Processing: F. Galeazzi

Trimble: time of flight scanner
Optical Scanners in Lab

Exhibit: 3D Archaeology at Catalhuyuk, Stanford, 2011
Photos for image modeling (Catalhuyuk, Turkey)
B89, Image modeling (130 photos)

B89, Image modeling (with stratigraphic units)
B77, Image modeling (140 photos)
Technologies 2012

- Time of phase laser scanner Faro Focus 3D
- Optical Scanner Nextengine
- Tablet PC Motion Computing
- Wireless Simcard SimEye
- Gigapan Set
- 2 Digital cameras Canon, 400D, EOS 60D
- Stereo camera Fujitsu 3D
- Infrared camera Flyr
- 6 laptops

News 2012

- More computer vision and more teams involved
- Standardization of all the procedures
- Burials
- More fast and efficient 3D laser scanning (122,000 / 244,000 / 488,000 / 976,000 points/sec)
- GIS compatibility (in-out)
- All the data daily aligned, georeferenced and ready
- 3D Sketching in PDF format
3D Sketching

- Bench
- Hearth
- Altar

The structure was found in a context, not covered completely by the unit 1860. This feature seems to have a circular shape and some texture.
2012/11/19

2D DRAWINGS BY CAD ON ORTHOPHOTO

INFRARED CAMERA ON B80
Geophysical survey

Processing by K. Strutt

3D Scanning of microlayers (Unit 19835, B89)

Model made by A. Asaro
DEM by Laser Scanning (300k points)
What after?

• Query, comparisons and analyses of data
• Distribution and communication of data
• Reconstruction
• Simulation
• What’s more? Performing models, data in collaborative environments
• Virtual performance

Tele-immersion Lab, Hearst Memorial Mining Building, UC Berkeley
Aims of this Work

- Build a shared virtual environment to allow for virtual fieldwork activities through 3D teleimmersion
- Register and integrate different 3D and other data sources in the same space
- Provide communication platform for real-time interaction of multiple users through audio and 3D/2D video

Teleimmersion

- Tele-immersion connects remote users through a shared virtual environment
- Users are captured in real-time using stereo cameras to obtain their 3D avatar (captured as 3D mesh)
- Geometry of the real world is preserved and mapped into virtual environment
Teleimmersion System

Real-time 3D reconstruction

3D Video Capture

Diagram flow of the 3D reconstruction algorithm from point of image capture to transmission through TCP/IP. Intermediate and final results of the real-time 3D reconstruction include mesh, calculated depth-map, depth-map after post-processing, and rendering in virtual environment without and with texture mapping.
Virtual Tools

- **Navigation Tools** → navigation through 3D space
- **Graphic User Interface Tools** → interaction with menus
- **Draggers** → moving and rotation objects
- **Screen Locators** → rendering manipulation (e.g. mesh vs. texture)
- **Annotation Tools** → marking and communicating interesting features to others
- **Pointing Tools** → laser pointer, flashlight etc. used to point at interesting features
An international, collaborative project involving computer experts, archaeologists, architectural historians, and cultural heritage managers who are seeking how to reinvent how we integrate 3D objects, virtual reality environments, and GIS maps in a single, open-source web environment for use in research and teaching on ancient architecture.

Start-Up Level 2 Grant - Prototype Development: to develop a prototype of a GIS-based, web-interface database (3D Web GIS) of ancient architecture that can curate, search, and compare digital objects (such as drawings, maps, diagrams, text, photographs, and video), but also highly accurate 3D scans of sculpture and 3D architectural models in a virtual environment.

www.acmesal.edu
Virtual Museum of the Western Han Dynasty
UCM, Xi’an Jiaotong University
five stereo camera clusters
CONCLUSIONS

• Simulation and not visualization is the core
• Knowledge is by interaction (the information comes from the feedback)
• Knowledge distributed and augmented by collaborative environments (playing with the data)
• Teleimmersive Technologies create hybrid cyberspaces of simulation, interaction and reconstruction: networks of “minds at work” (new knowledge)
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THANK YOU!

謝謝