



Long Range Archaeological Laser Scanning

High Density Survey (HDS) & Data Distribution at Tiwanaku, Bolivia & Machu Picchu, Peru

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HDS using Optech Laser Scanner

- First year for High Density Survey (HDS) at Tiwanaku and Machu Picchu
 - **HDS**: Mapping methods that produce a dense set of three-dimensional data points across the surface of large (multi-hectare) sites
- Optech ILRIS 3D Laser Scanner
 - A *long-range*, TOF scanner used for scanning large structures or entire landscapes
 - Performance Range: 3 - 1500 meters
 - Data Sample Rate: 2000 points/sec

Significance of Long Range Scanning

- **Characterization of archaeological sites**
 - Much work is done with relatively small investigations (e.g. 1x2m excavation)
 - However, considerable information results from recording a high level of detail over larger areas
 - a scale of data that reflects human activities
 - c.f. Kvamme (2003) *American Antiquity* paper re: geophysical investigations and "landscape" archaeology

Scan Methodology for Long Range Scanning

- High distant vantage point
 - allows for the acquisition of substantial coverage in relatively few scans
- Multiple scan angles
 - compensates for "laser shadows" in scans
- Increased scan resolution = Exponential increase in scan time
 - critical balance must be evaluated for each project

Innovmetric's Polyworks software suite

- Polyworks Specifications

- Multiple scan alignment
- Polygonal mesh generation
- Geo-referencing
- Data measurements, feature extraction, primitive fitting, GD&T objects
- Hole filling, edge reconstruction, noise reduction



Tiwanaku, Bolivia

- Pre-Incan site, 500-900 AD



Scanning Objectives

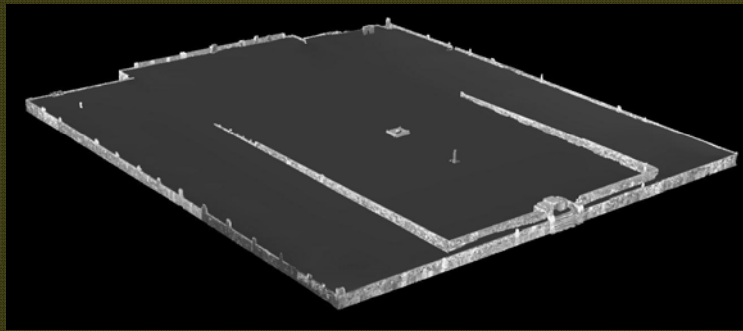
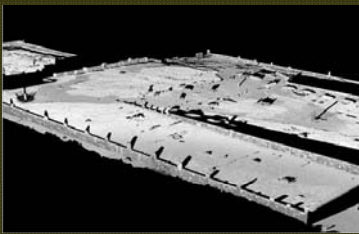
- Scan monumental architecture
 - Kalasasaya, Putuni, and Semi-subterranean temple
 - Resolution: 1 - 3cm
- Scan other areas of interest
 - Stone monoliths, survey area, excavation trench
 - Resolution: .5 - 3cm



Tiwanaku Scan Results

Kalასasaya

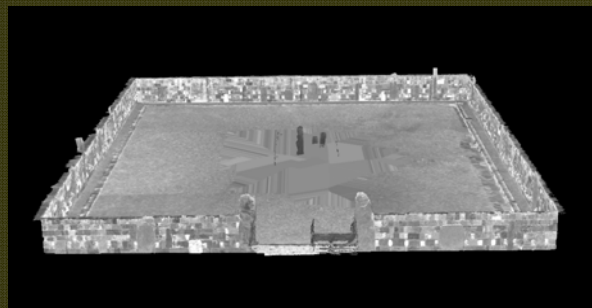
- Largest of structures (120 x 130 m)
- Scan Resolution: 3 cm
- 4 days scanning
- 110 scans
- > 15 million points
- > 1 million in mesh



Tiwanaku Scan Results

Semi-Subterranean Temple

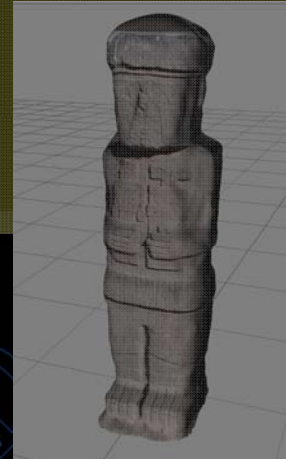
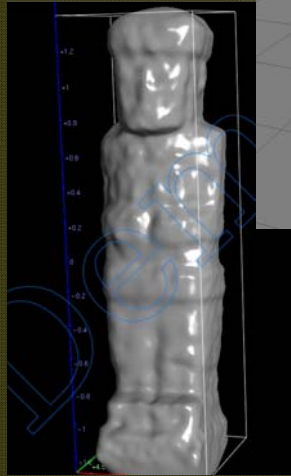
- Structure w/carved stone heads
- Scan Resolution: 1 cm, 2 mm
- 1 day scanning
- 8 scans collected
- 5 million points
- 2 million in mesh model



Tiwanaku Scan Results

Poncé monolith

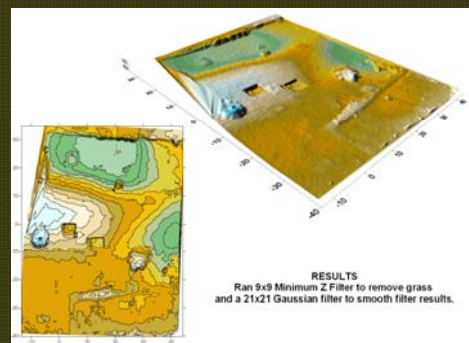
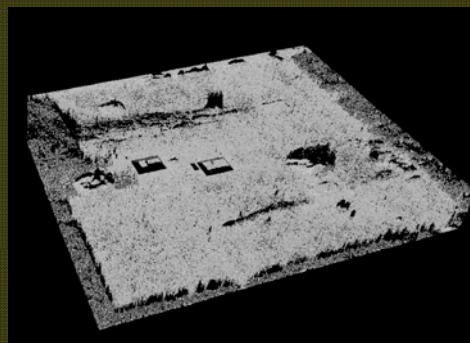
- Important stone monolith
- Scan Resolution: 5 mm
- ½ day scanning
- 6 scans
- > 500,000 points
- > 50,000 mesh model



Tiwanaku Scan Results

Survey Area

- Area survey by GPR (Ground penetrating radar)
- Scan Resolution: 1 cm
- 2.5 hours scanning
- 1 scan collected
- 10 million points

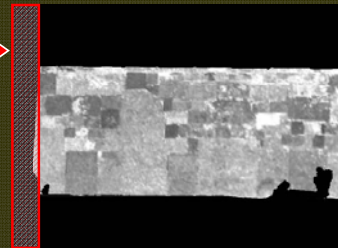


Tiwanaku Scan Summary

- Considerations
 - Parallax issue with close range scans
 - Limited resolution with detailed objects
- Summary
 - > 200 scans collected
 - 75 million points
 - 9 days of scanning

Area in photo
missing from scan

Parallax issue between
scanner and internal camera



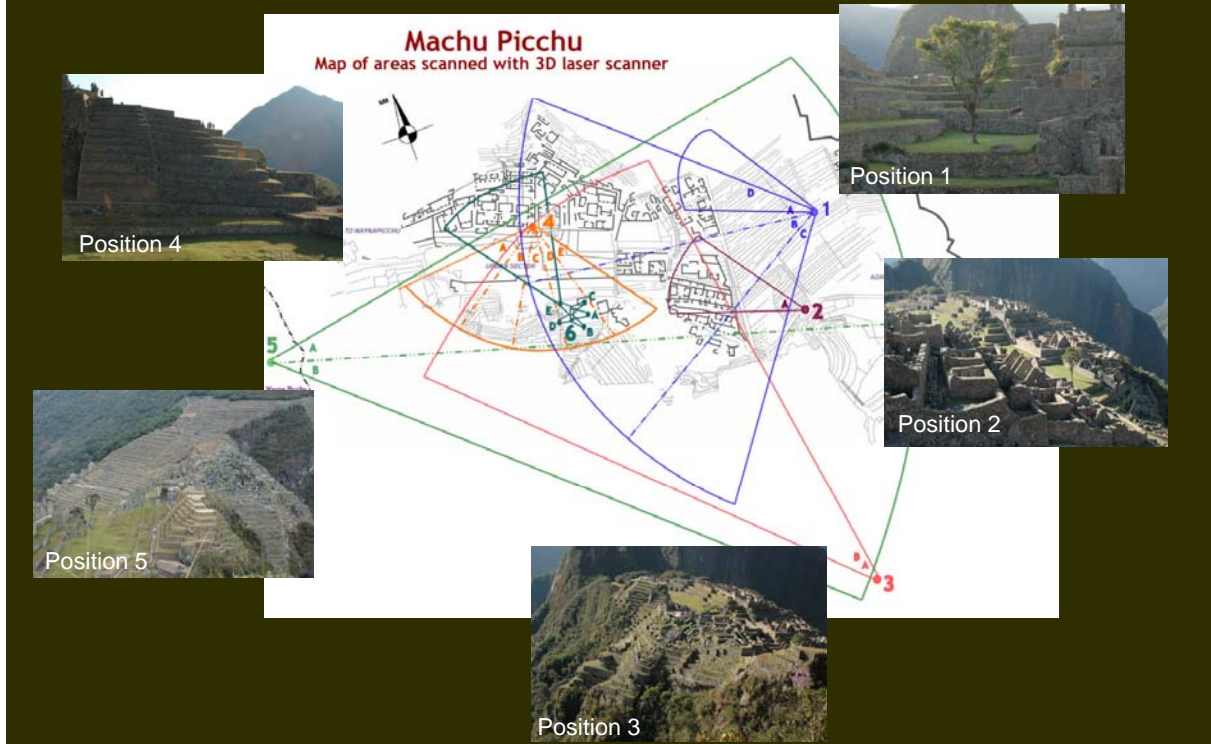
Machu Picchu, Peru

- Legendary 'lost city' of the Inca



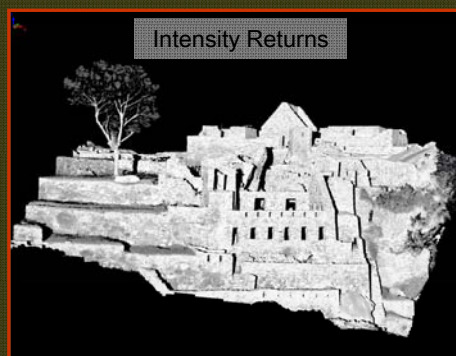
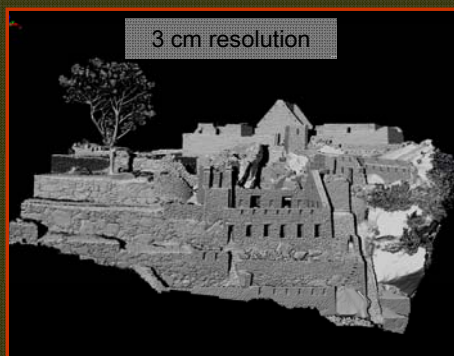
- Scanning Objectives
 - Scan entire site
 - Scan special interest areas
 - Huayna Picchu
 - Temple area

Machu Picchu Scan Map



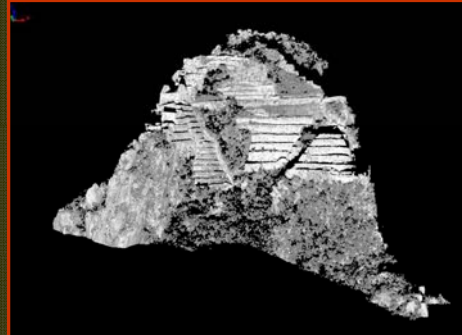
Machu Picchu Scan Results

- Entire Site
 - 12 total scans
 - Scan Resolution: 3 - 20cm
 - Approximate Site Dimensions: 300 x 700 m



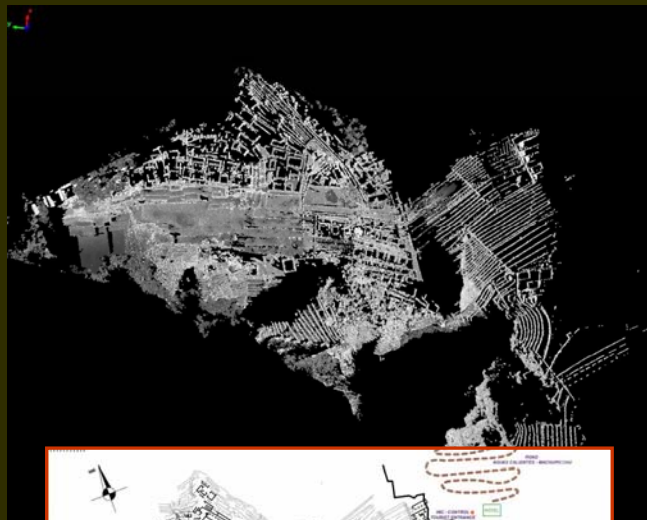
Machu Picchu Scan Results

- Huayna Picchu
 - 2 scans
 - 3 cm resolution
 - 500 meters from scanner



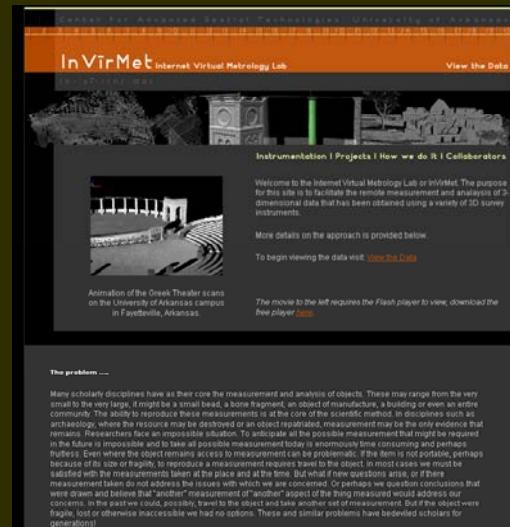
Machu Picchu Scan Summary

- Considerations
 - Scanning at night
- Summary
 - 25 scans collected
 - > 75 million points
 - 4 nights of scanning



Data distribution

- Multiple parties interested in viewing the data/ conducting research
 - University of Pennsylvania
 - Instituto Nacional de Cultura Cusco
 - CAST
- Data sharing via the WWW



<http://www.cast.uark.edu/invirmet>

IMView and InVirMet

- InVirMet (*Internet Virtual Metrology Lab*): Web site hosted by CAST that contains 3D data sets from scanning projects
<http://www.cast.uark.edu/invirmet>
- IMView: Free 3D data viewer by Polyworks
- IMView for download from InVirMet website
 - View and manipulate data in 3D
 - Perform interactive measurements on the data
 - Distance, Angle, Bearing, etc...

Conclusions/Future Work

- Optech was well suited for long range HDS at Tiwanaku and Machu Picchu
- Re-scan more detailed architecture with close range scanner in 2006 at Tiwanaku
- Work with other companies to provide more 3D formats to increase data distribution efforts

Acknowledgments



Questions

- Contacts

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