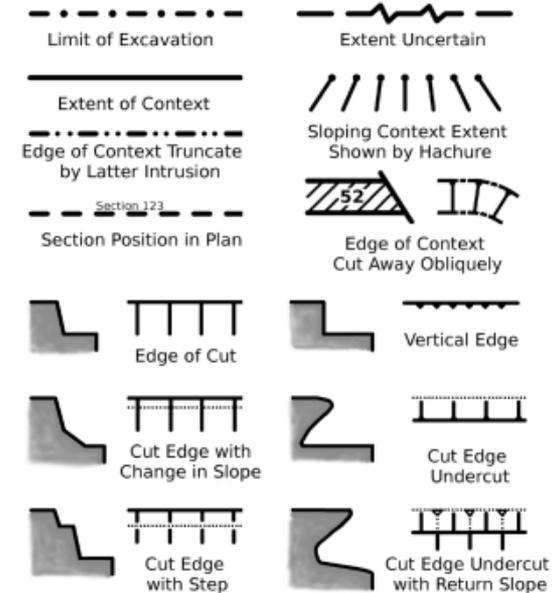
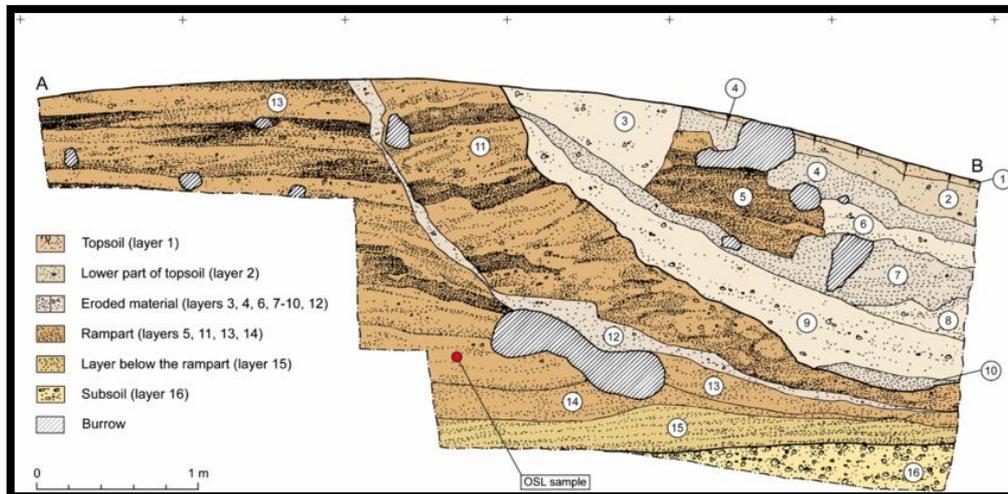


**IL 3D APPLICATO ALL'ANALISI ARCHEOLOGICA**

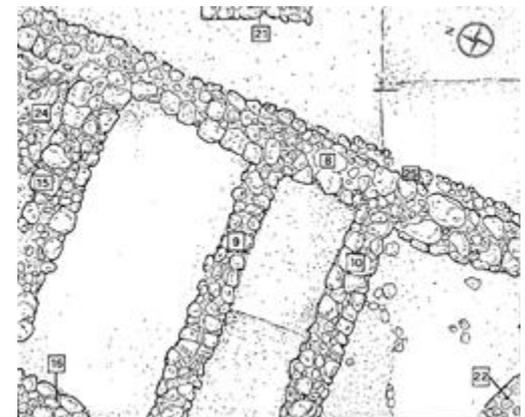
# DOCUMENTAZIONE



La documentazione canonica è bidimensionale: gli archeologi sono sempre stati educati a RIDURRE la realtà



## Convenzioni grafiche



3D: approccio diretto, non viziato da interpretazione personale

[Monte Avena 3D](#)

# Archeologia: scienza **DISTRUTTIVA**

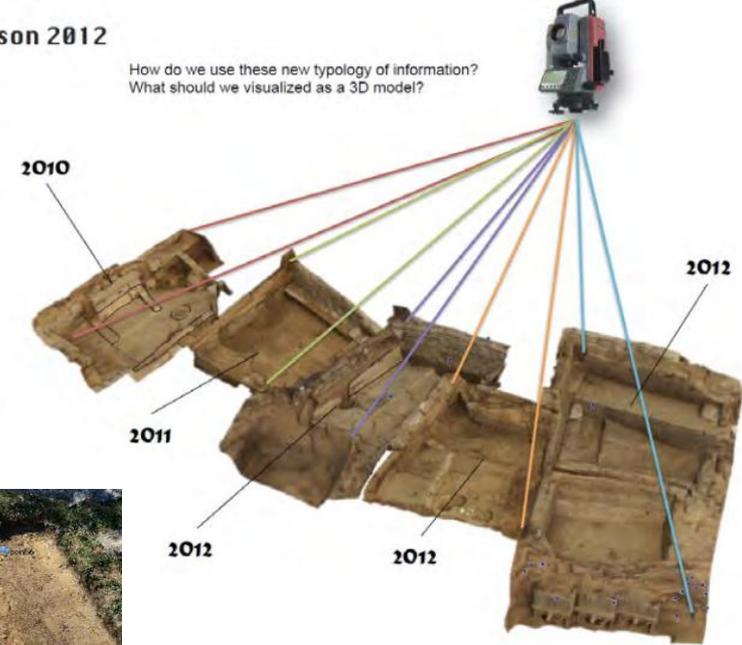
La documentazione deve essere:

- affidabile
- completa
- chiara
- realistica

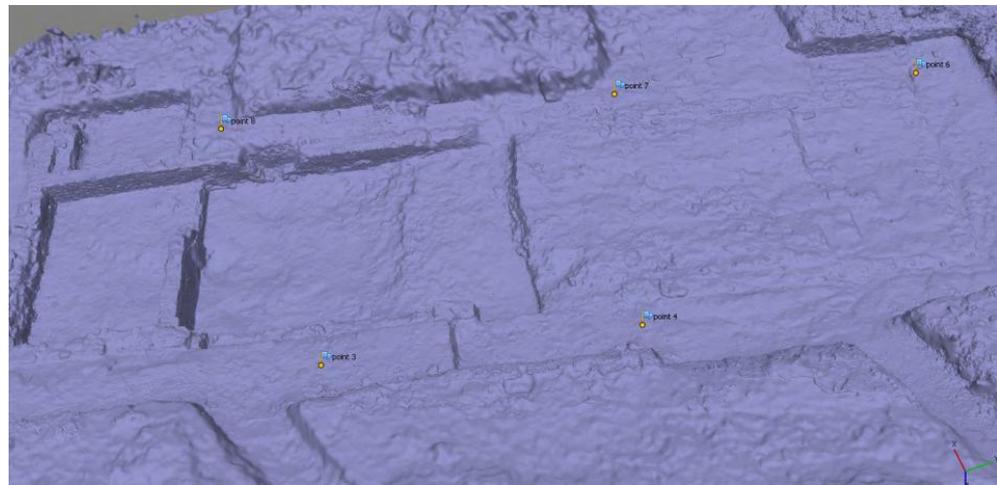


ison 2012

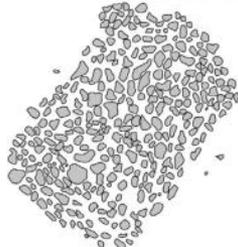
How do we use these new typology of information?  
What should we visualize as a 3D model?



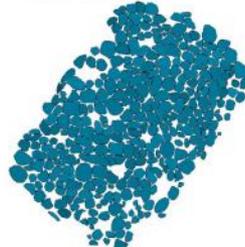
Serve l'interpretazione ma  
anche il dato oggettivo, quello  
che spesso manca una volta  
terminato lo scavo



Per questo Il 3D NON è un'alternativa ma serve a **COMPLEMENTARE** la documentazione canonica



**Traditional  
Plan Drawing**



**3D Drawing in  
Plan Perspective**

**Questione principale:  
SFRUTTARE IL 3D COME  
STRUMENTO ANALITICO**



- Facilità di diffusione:  
catalizzatore di attenzione  
e discussione scientifica

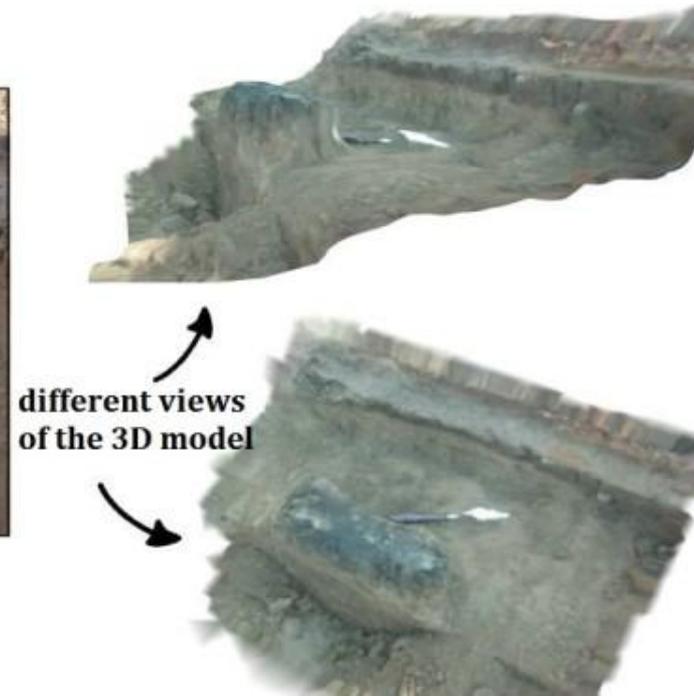


- Strumento interattivo

- Grande varietà di  
tecniche di acquisizione  
che si possono applicare  
a siti, paesaggi, reperti,  
ecc.



**original photo**  
(from the archive)

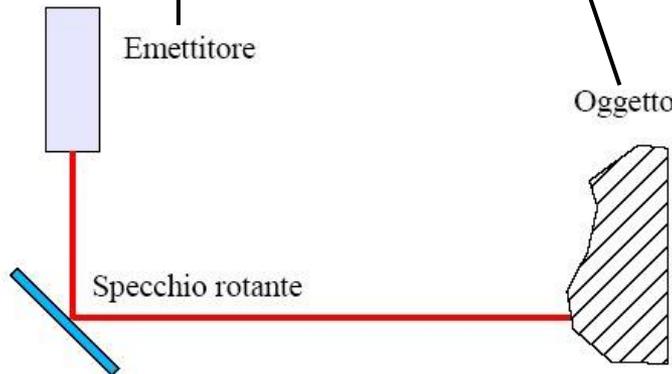


different views  
of the 3D model

# Tecnologie di acquisizione: il Laser Scanning

Emette fasci di radiazioni elettromagnetiche ad alta intensità (LUCE LASER)

Rileva la SUPERFICIE dell'oggetto in modo tridimensionale



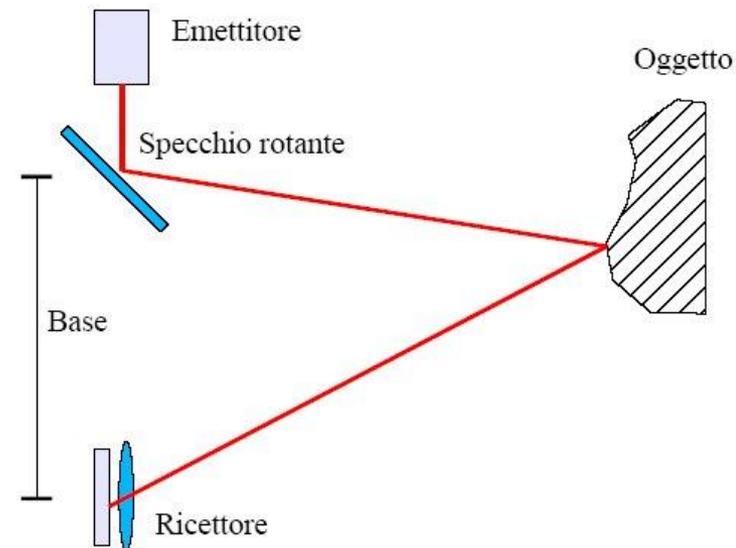
## 2) Laser Scanner triangolatori

- sulla base di angoli e distanze definite (base), grazie alle proprietà note dei triangoli si ottengono informazioni sull'oggetto



## 1) Laser Scanner distanziometri:

- Ad impulsi (misura i tempi trascorsi tra due impulsi o due treni d'onda)
- A misura di fase (misura lo sfasamento tra l'onda emessa e quella ricevuta)



## Strumentazione Laser Scanner 3D



- Sistemare lo strumento su un treppiede (deve ruotare intorno a un asse verticale e autolivellarsi)
- La penna laser deve poter ruotare attorno ad un asse orizzontale e misurare l'angolo tra raggio laser e piano orizzontale
- Misurare l'angolo tra il piano verticale e un asse orizzontale di riferimento
- Lo strumento deve poter fotografare l'intera zona che può essere colpita dal raggio laser
- Deve poter trasmettere le coordinate e la fotografia al computer

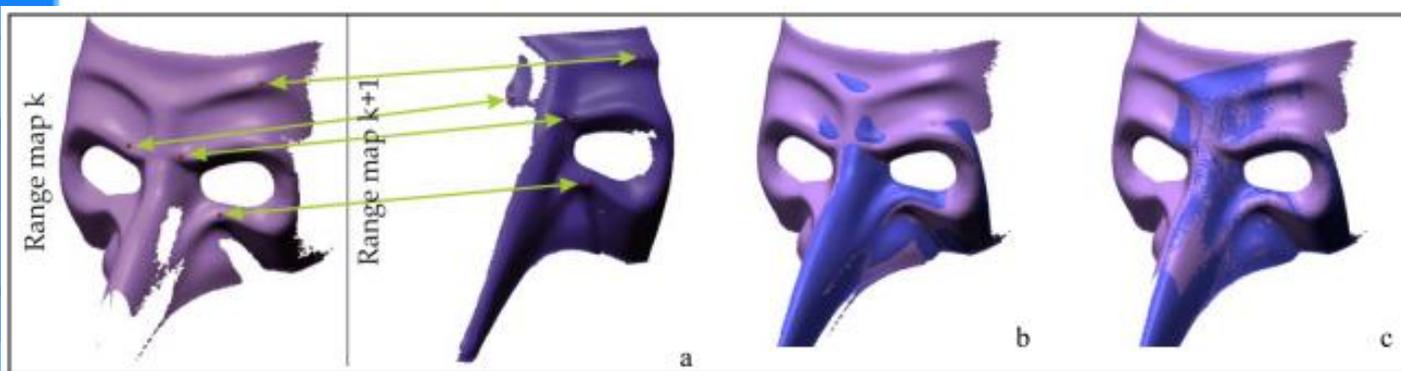


Figure 6. ICP alignment process: a) selection of corresponding points on two partially superimposed range maps; b) rough pre-alignment; c) accurate alignment after a few iterations

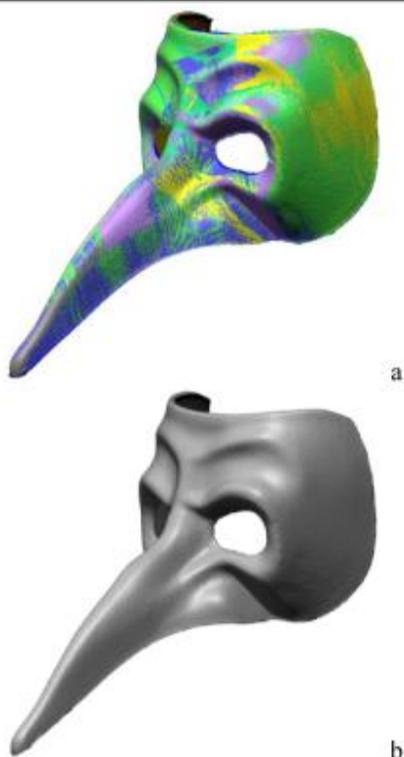


Figure 7. Mesh generation: a) set of ICP aligned range maps. Different colours indicate the individual range maps; b) merge of all range maps in a single polygonal mesh

Il laser scanner effettua scansioni in cui acquisisce un numero elevato di punti (**nuvola di punti**) sotto forma di coordinate xyz, arricchite opzionalmente con 3 informazioni di colori (Immagine in 2.5D). La geometria della superficie viene perciò acquisita in maniera automatica.

Dopo la fase di ACQUISIZIONE c'è quella di **PROCESSING**:

- Allineamento visuali e nuvole di punti
- Generazione Mesh
- Editing e ottimizzazione Mesh
- Mapping della texture e visualizzazione (wireframe, shaded o texturizzato)

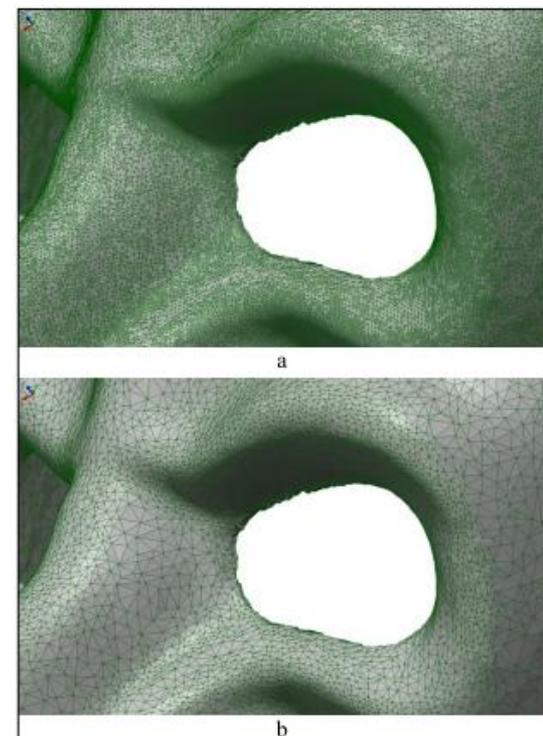


Figure 8. Mesh optimization: a) mesh with polygon sizes given by the range sensor resolution set-up (520,000 triangles); b) mesh simplified in order to keep the difference with the unsimplified one, below 50 µm. The polygon sizes vary dynamically according to the surface curvature and the mesh size drops down to 90,000 triangles

**Caso studio di digitalizzazione e acquisizione 3D di un sito archeologico:  
My-son (Vietnam)**



Tecnologia scelta: **Laser Scanner a onda continua**  
(triangolazione lavora meglio con piccoli oggetti e non lavora bene con la luce del sole)



- Alta precisione (2mm deviazione standard)
- Alta velocità (1 milione di punti al secondo)
- Comodità (5 kg di peso)

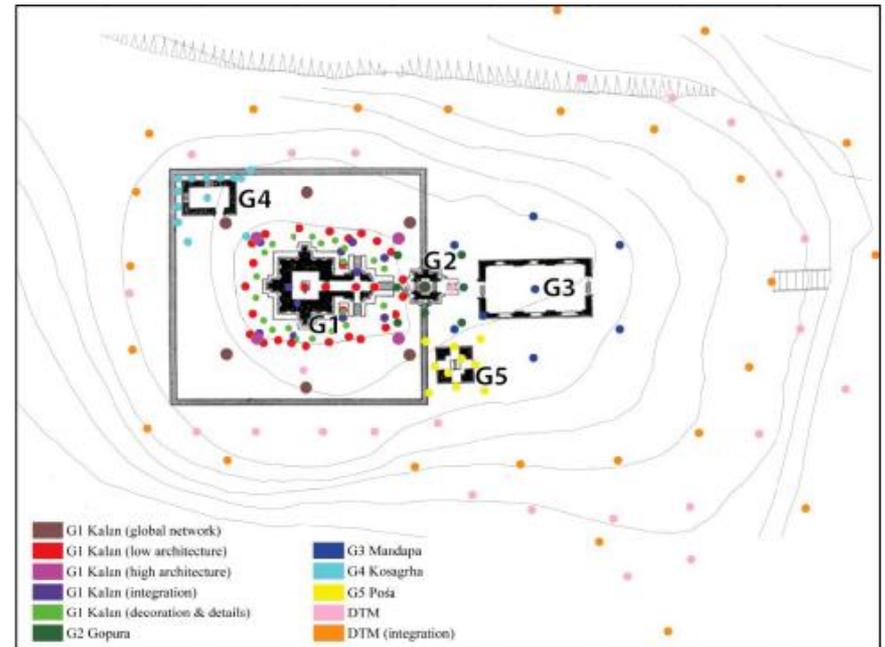


Figure 11. Map of the hill where the G Group is located within the My Son Area, with the scanner positions for acquiring different structures highlighted by colored dots

### 3D survey in 3 step:

- 1) Acquisizione di tutte le architetture in base alle diverse complessità
- 2) DTM senza elementi antropici e alberi (anche contesto circostante)
- 3) Acquisizione di alcuni manufatti archeologici

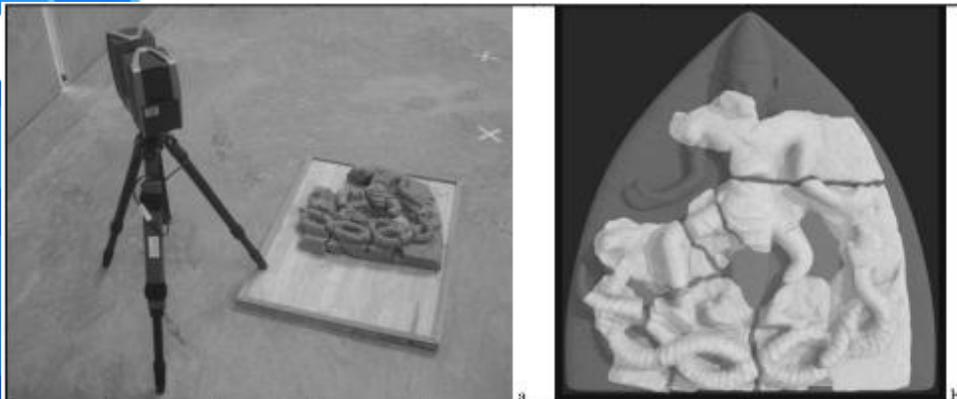


Figure 12. Sculpted tympanum representing Krishna dancing on the snakes, originally at the entrance of the kalan:  
a) 3D laser scanning in the “store room” of the museum; b) reality-based model from the 3D data

Table 2. Number of point clouds acquired at different resolution levels (first three columns), and total number of 3D points acquired during the whole 3D survey of the G Group and the related decorations (last column)

	Resolution			# points (x 10 <sup>6</sup> )
	Coarse	Medium	High	
G1 (Kalan)	7	43	22	126
G2 (Portal)	-	9	-	21
G3 (Assembly hall)	-	8	-	15
G4 (South building)	-	13	-	31
G5 (Pavilion for the foundation stone)	-	6	4	4
DTM	49	-	-	27
21 Finds	-	-	60	2
Total	56	79	86	226

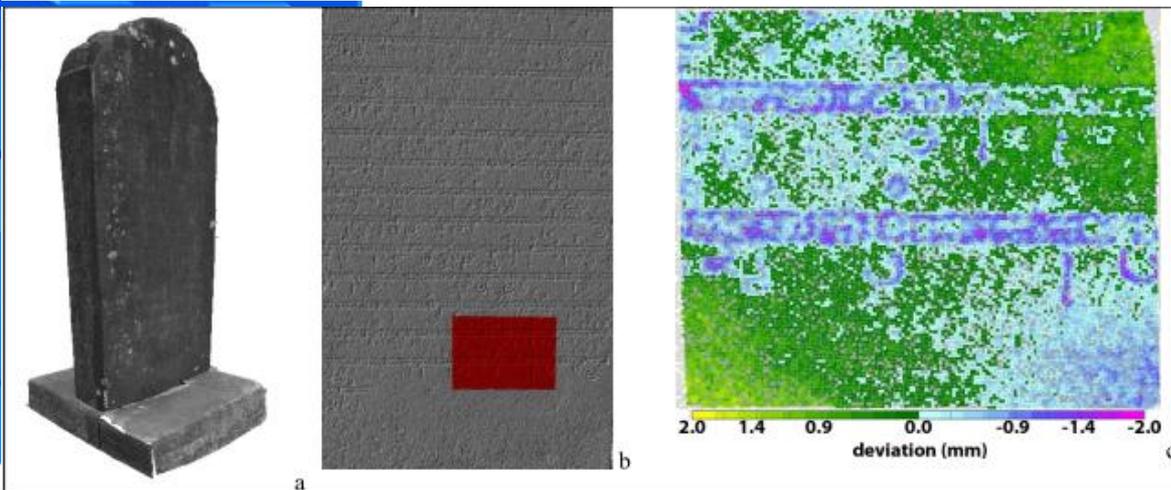


Figure 13. High resolution capture of the Foundation stone through SFM: a) texturized 3D model measured through a sequence of 24 images shot around the artifact; b) mesh model of the central part of the stone with a small area highlighted in red; c) color-coded deviations of the SFM acquired points from a best-fitting plane calculated on the red area of b), clearly showing a the nearly 2 mm carving on the stone

### Modellazione:

- 1) Pulizia dei dati e allineamento
- 2) Texturizzazione

### 4) Estesa campagna fotografica

(per proiezione della texture ma anche per dettaglio geometrico)

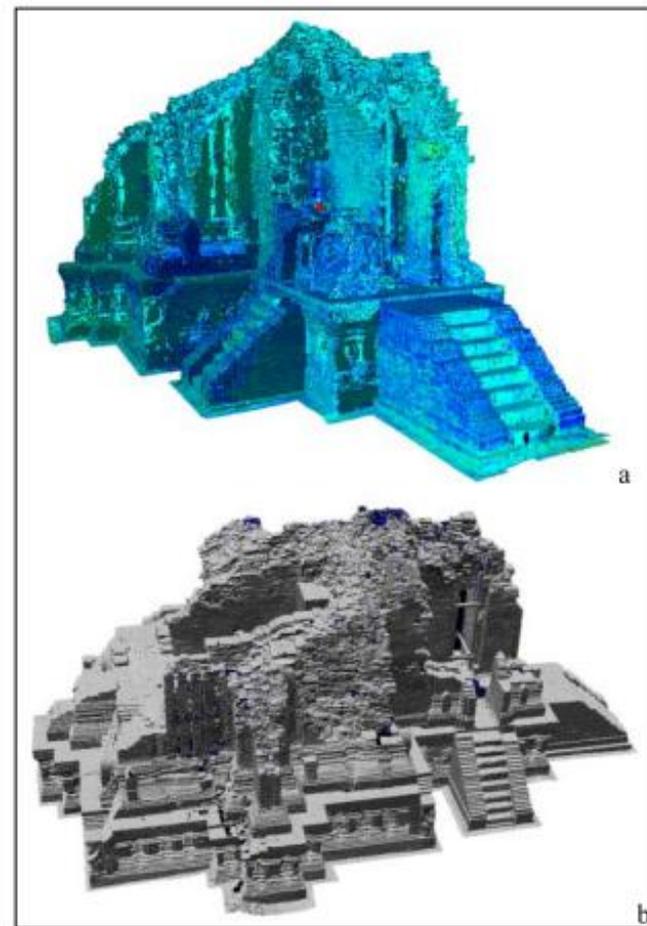


Figure 15 – a) Point cloud model of the Kalan cleaned and aligned in the same reference system; b) polygonal model of the Kalan with a decimated and watertight mesh

## II LIDAR

### (Light detection and ranging)

- Misura l'elevazione relativa della superficie del suolo
- Rivela la **MICROTOPOGRAFIA**
- Ricostruisce **paesaggi fossili**
- **Penetra la vegetazione**

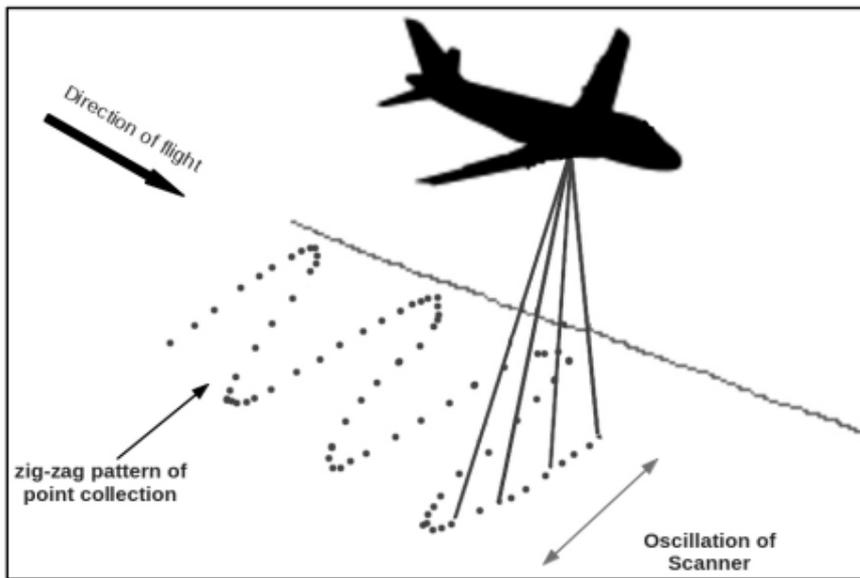


Figure 1. Demonstration and example of the zig-zag point distribution when ALS data are collected using an oscillating sensor

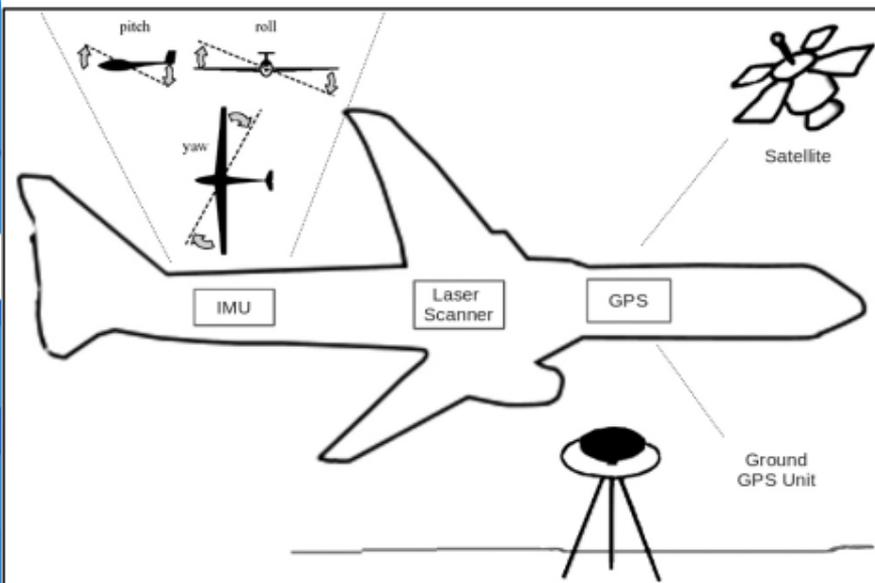


Figure 2. Schematic of the key components of the ALS system that enable accurate measurement of height and location

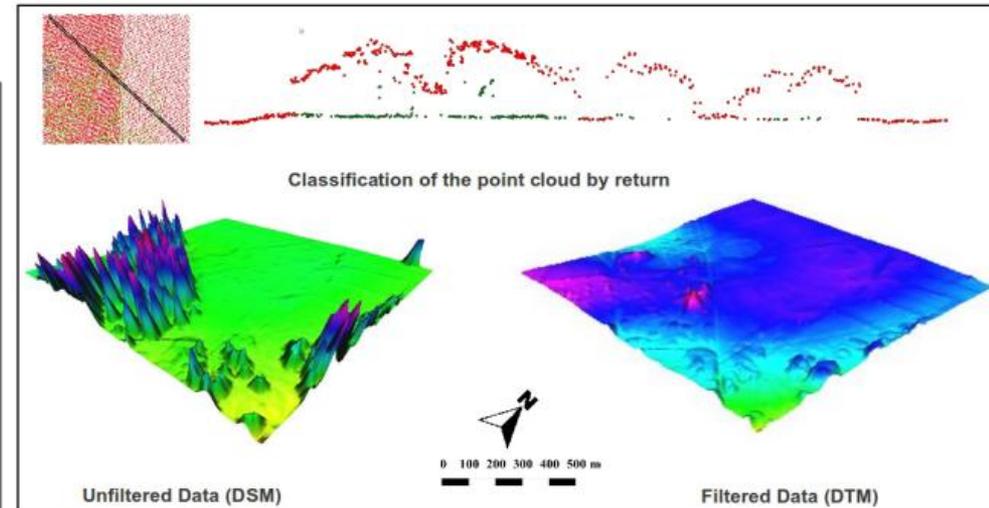


Figure 5. An example of classification of points based on return which forms the most basic method to filter non-terrain points from the DSM

Produce DEM/DSM e **DTM**

(il sensore registra ostacoli che riflettono parzialmente i fasci di luce, e per questo li può rimuovere)

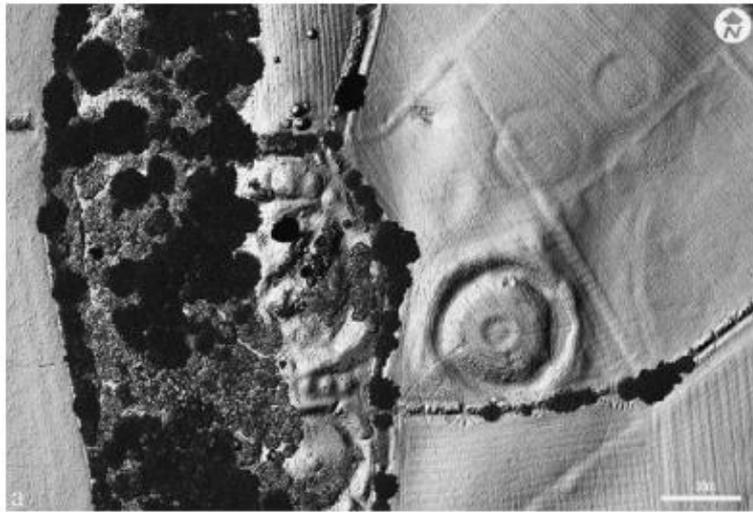


Fig. 4. Plan view of LiDAR generated DSM (a) and DTM (b) for northern section of the Hill of Tara, displaying the variable quality of microtopographic documentation beneath vegetation cover.

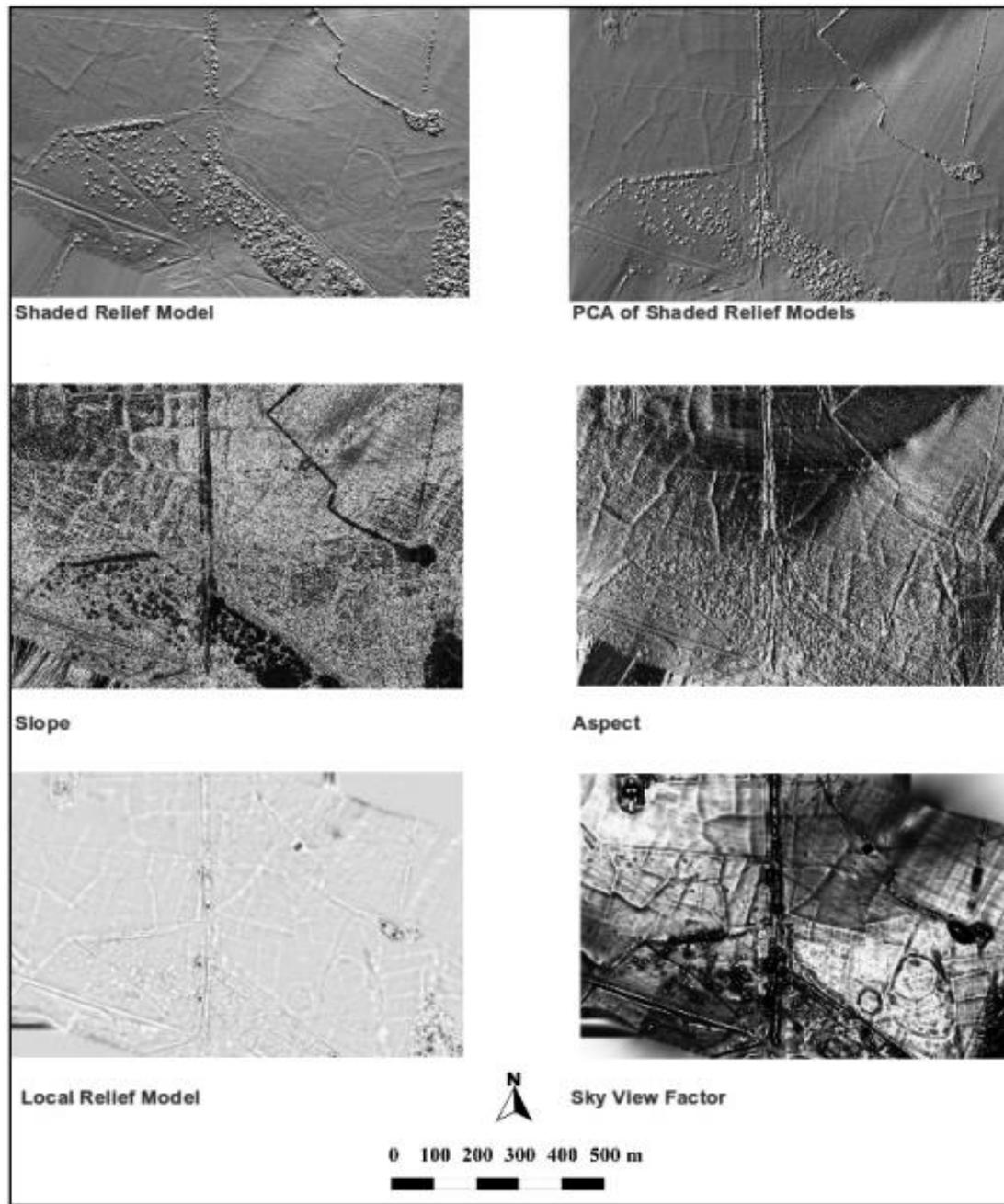


Figure 7. Comparison of visualisation techniques mentioned in this chapter

## Caso studio: sito di Caracol (Belize)

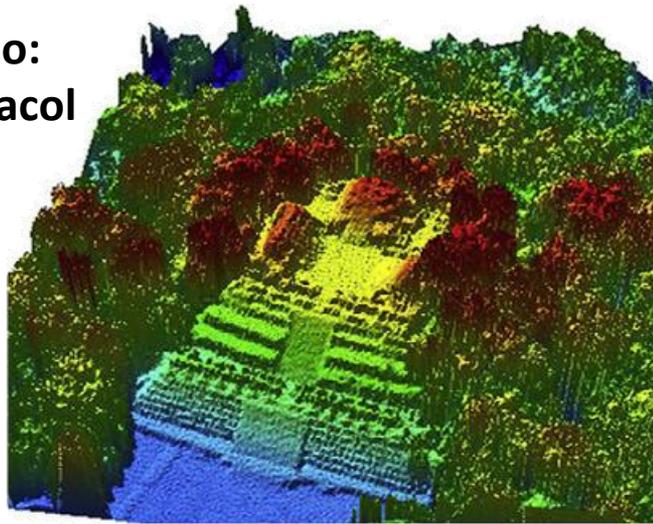
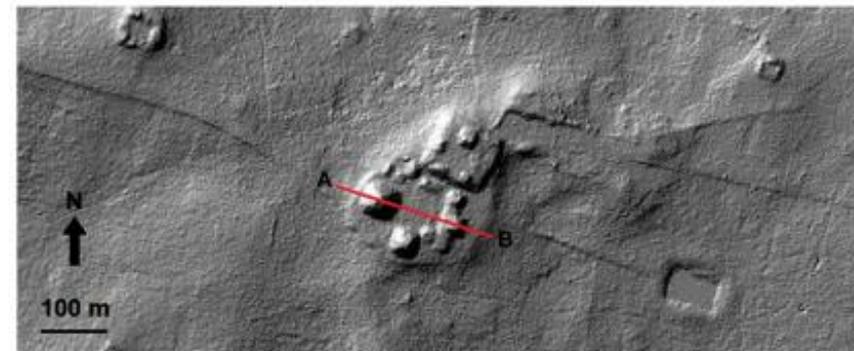
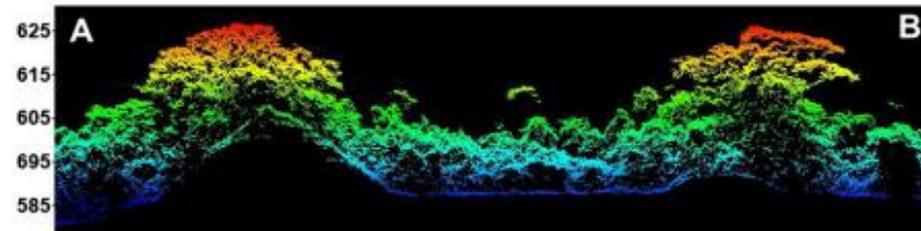


Fig. 5. Photograph and LiDAR imagery of "Caana," Caracol's main architectural complex; varying colors in the LiDAR data represent different elevations.

### Obiettivi

- Verificare effettiva funzionalità del LIDAR in aree boschive (2010)
- Verificare se l'intero altipiano Vaca (200 kmq) era organizzato entro un singolo sistema urbano



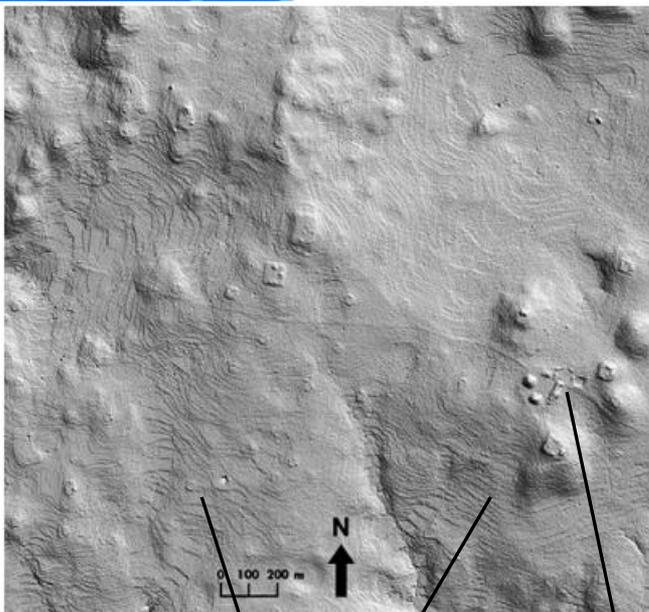


Fig. 8. LiDAR 2-D image of Ceiba Terminus showing an anthropomorphic landscape filled with constructed terraces.

terrazzamenti

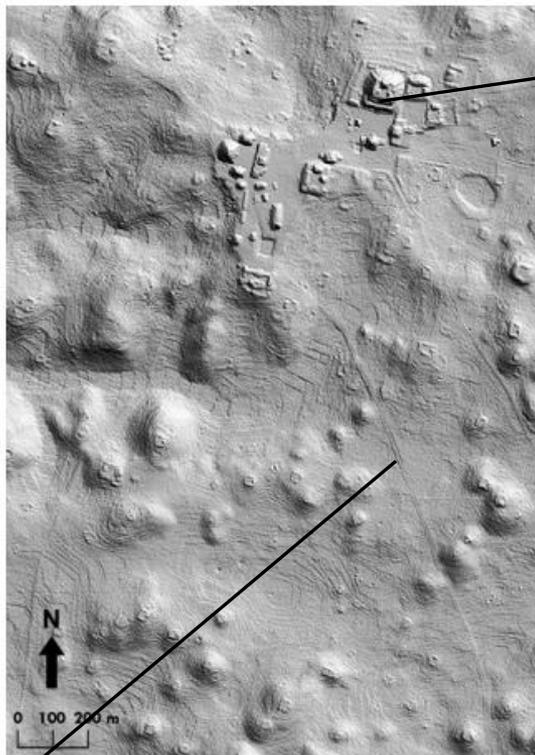


Fig. 6. LiDAR 2-D image of the Caracol epicenter.

Vie di comunicazione

manufatti

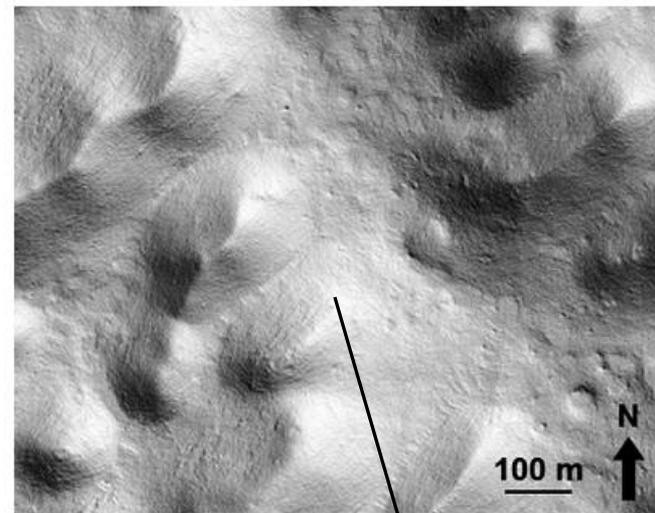


Fig. 10. A largely unmodified landscape from the southern part of the Caracol DEM.

Paesaggio naturale

Il **LIDAR** ha permesso di definire e riconoscere il sistema urbano di Caracol: città-giardino di 177 kmq all'interno di un paesaggio modificato dall'uomo

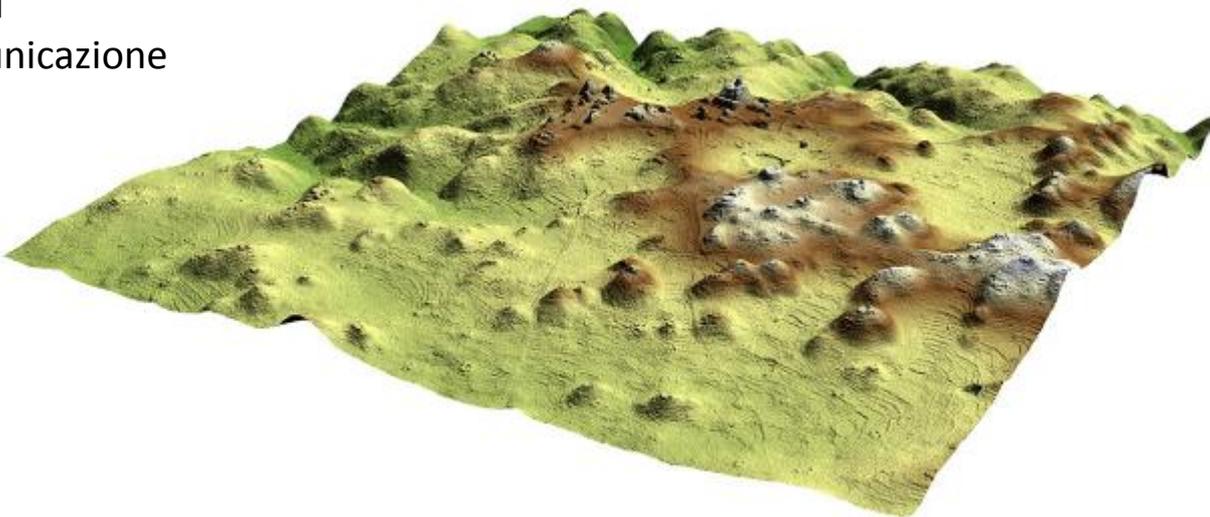


Fig. 7. LiDAR 2.5-D image of Caracol epicenter.

## Scanner a luce strutturata

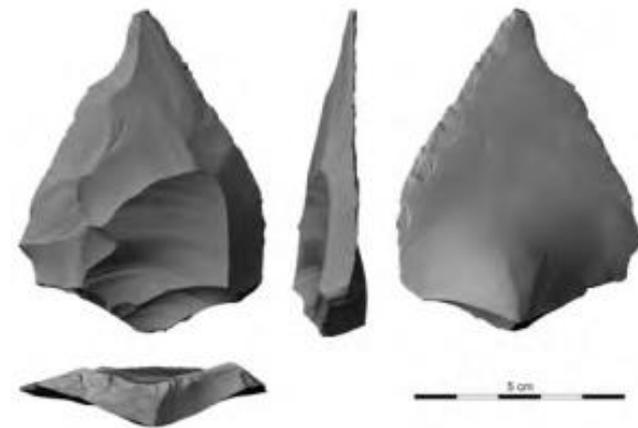


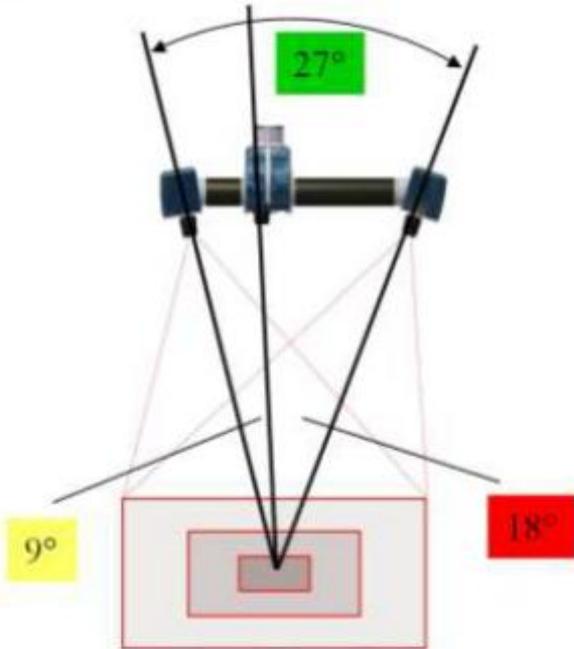
Fig. 4: Umm el Tlel: Surface scans of a stone tool; retouched Levallois point (© Neanderthal Museum)



Fig. 5: La Garma. Surface scan of a mobile art object; bear (© Museo de Prehistoria y Arqueología de Cantabria)



Fig. 6: La Garma: Surface scan of a mobile art object; ibex (© Museo de Prehistoria y Arqueología de Cantabria)



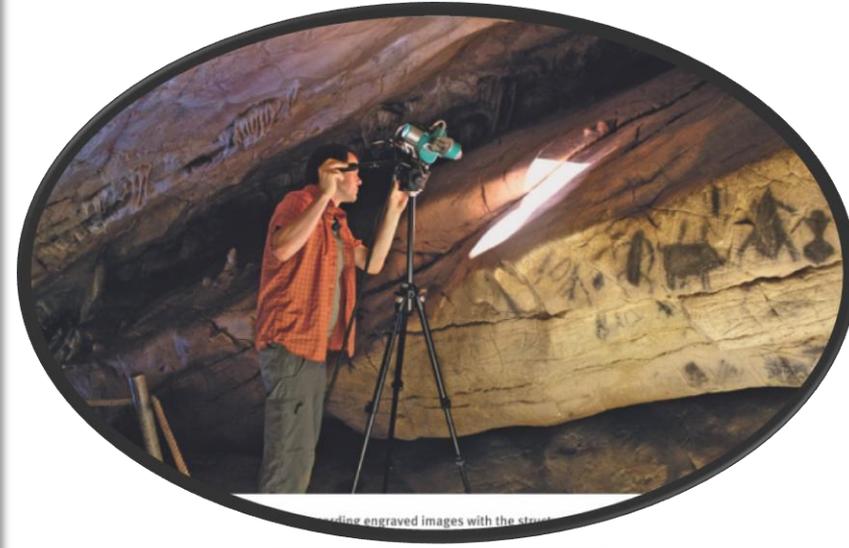
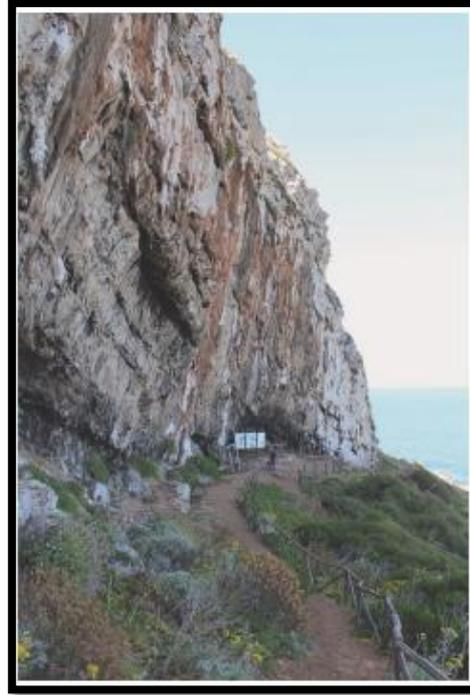
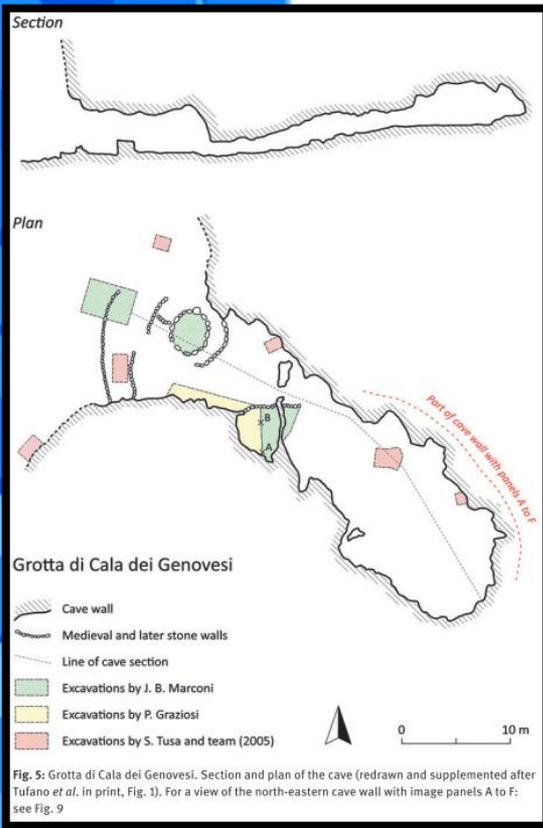
- Sistema della triangolazione

- Particolarmente adatto all'analisi degli oggetti

Figure 2: Asymmetrical 2-camera setup.

Sebastiano Tusa, Gianpiero di Maida, Andreas Pastoors, Henny Piezonka, Gerd-Christian Weniger, Thomas Terberger

# The Grotta di Cala dei Genovesi – new studies on the Ice Age cave art on Sicily



107 scansioni per 13 mq di superficie



Fig. 9: Grotta di Cala dei Genovesi, north-eastern cave wall. Above: sketch with subdivision of geological units and image panels; below: panoramic photo with location of image panels B to F (drawing: H. Piezonka; photo: G. di Maida and T. Terberger)

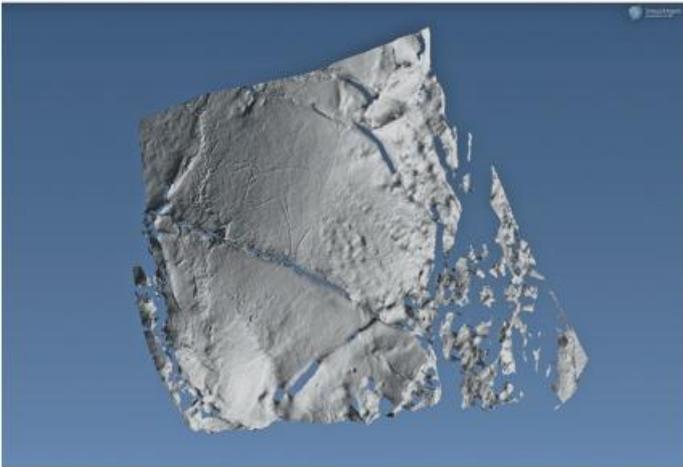
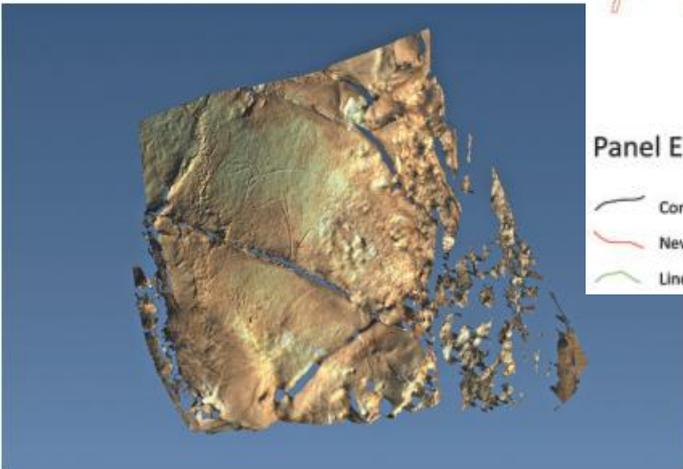
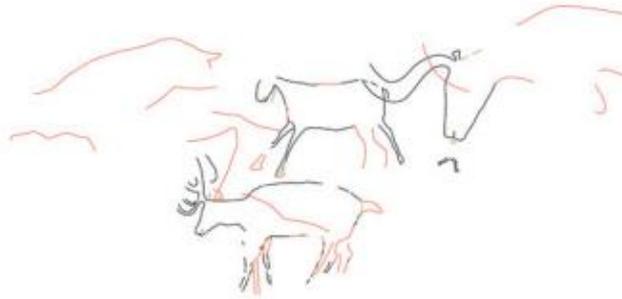


Fig. 11: Grotta di Cala dei Genovesi. Digital 3D model of aurochs in panel G generated by the structured light scanner; above: with colour information (Image: A. Pastoors)



Panel E

-  Confirmed lines
-  New lines
-  Lines not found

0 30 cm



**Sovrapposizione** vecchia + nuova documentazione:

- Linee di nuovi animali
- Linee che completano vecchi animali o figure umane
- Linee e gruppi di linee schematici

-Problemi di conservazione?

Panel F

-  Confirmed lines
-  New lines
-  Lines not found

24



0 30 cm

Reference/Source	Humans	Bovids	Equids	Cervids	Felines	Unident.	Total
Graziosi 1956	4	7	8	5		1	25
Graziosi 1962	4	9 (+2)	12 (+4)	6 (+1)	1 (+1)	2 (+1)	34
Graziosi 1973				(+1)			
Survey June 2012	4	13 (+4)	12	8 (+1)	(-1)	1 (-1)	38

# THE STONE AGE MEETS THE DIGITAL AGE

Exploring the Application of Digital, Three-Dimensional Technologies for the Study of Lithic Artifacts

SURF Conference Panel Session 6A

By: Nicole Lang

Mentor: Dr. Lisa Maher, Anthropology

### I. Introduction

It broke! It was 19,000 years old and it broke (figure 1)! I will not name the undergraduate anthropology student at UC Berkeley who destroyed any possibility of studying an irreplaceable lithic artifact in its original form. Luckily, before it broke, I made a high-resolution, accurate, three-dimensional replica of the lithic that can be studied (figure 2). New media and digital tools offer us the ability to experience virtually reconstructed historic sites and cultural material.<sup>1</sup> It was only a matter of time before archaeologists saw the potential that 3D technologies offer for cultural heritage preservation and artifact analysis.

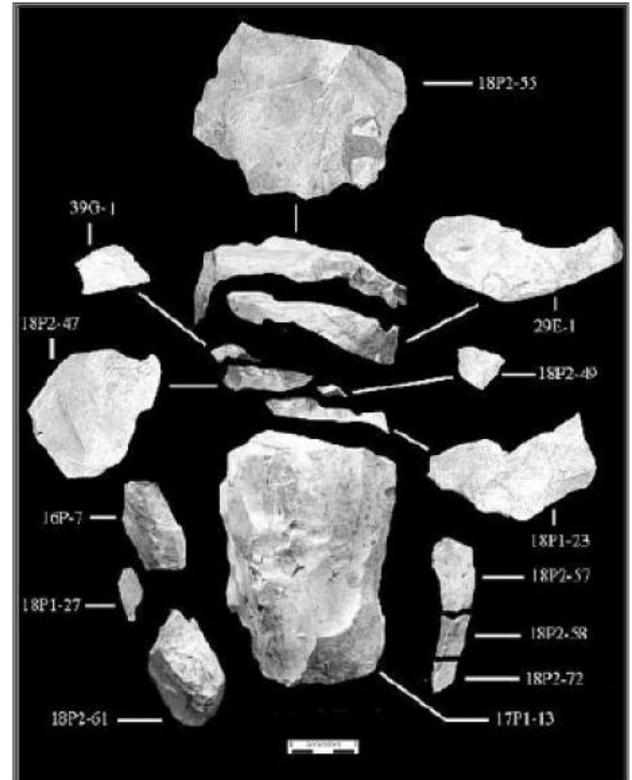


Figure 3. Photographic representation of lithic refitting. Source: <http://www.texasbeyondhistory.net/pavoreal/paleoindian.html>

- Salvaguarda la **preservabilità** del pezzo
- Modo nuovo di **interazione** con il materiale
- Didattica e analisi attraverso la **stampa 3D**

# Extracting Scar and Ridge Features from 3D-scanned Lithic Artifacts

Eitan Richardson<sup>1)</sup>, Leore Grosman<sup>2)</sup>, Uzy Smilansky<sup>2)</sup> and Michael Werman<sup>1)</sup>

Nuove opportunità analitiche?

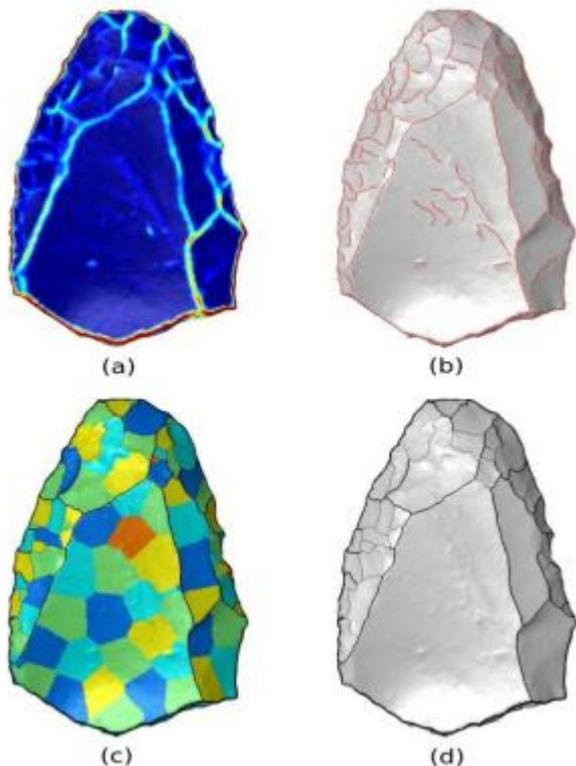


Figure 3: Intermediate steps results. (a) Estimated maximum principal curvature (b) Detected ridge lines (c) Geodesic clustering (segments indicated by colors) and post-merging (indicated by black borders). (d) The final scar-ridges after graph-cut optimization

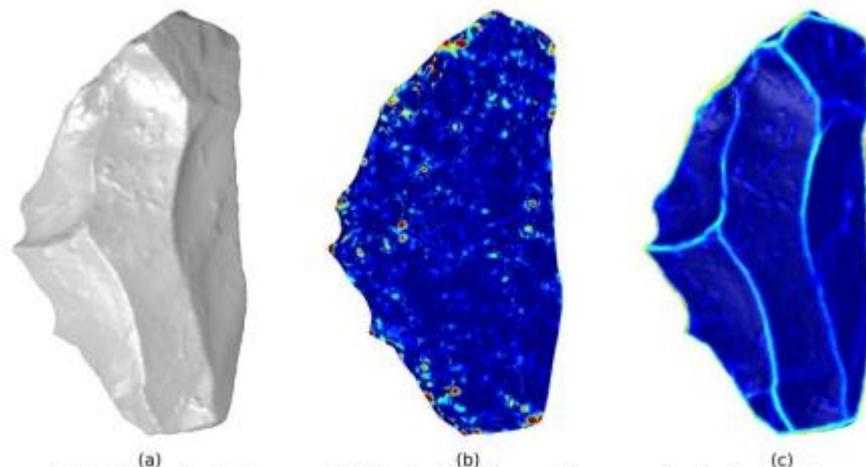


Figure 4: (a) The original scanned object. (b) The minimum principal curvature value  $-k_2$  (not informative for detecting the ridges.) (c) The maximum principal curvature value  $-k_1$ .

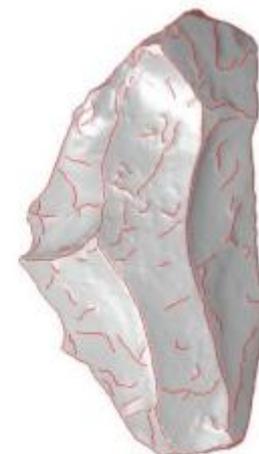


Figure 5: Detected curvature ridges.

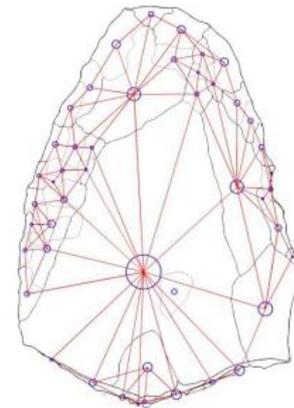
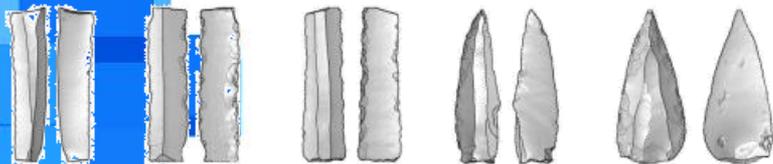


Figure 9: Lithic artifact represented as an adjacency graph of the scars. Size of the scar nodes in the drawing (blue circles) is proportional to the diameter of the scar. Edges (red) connect adjacent scars. The edges connecting to main scar on the back of the object are not shown.

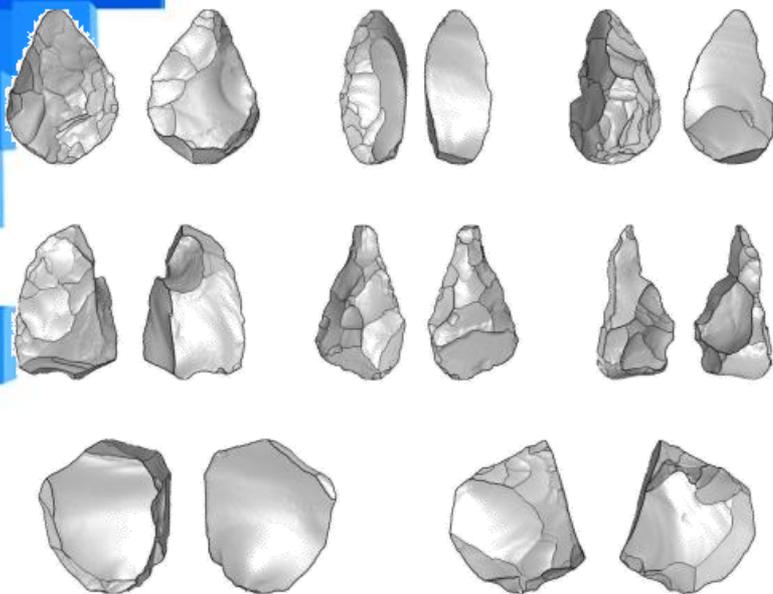


Figure 10: Scar segmentation results.

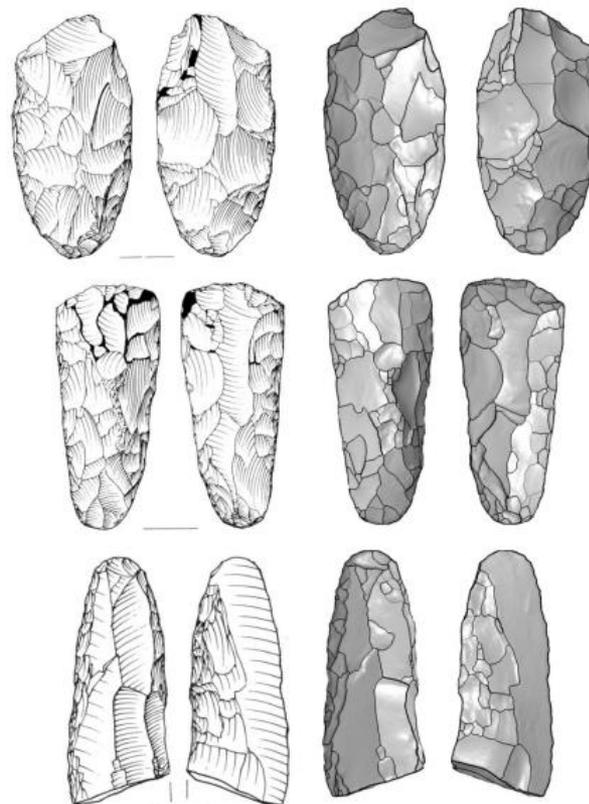


Figure 11: Segmentation results compared to traditional hand drawings (our results shown on the right.) Tools are from the Neolithic site of Abu-Gosh, excavated by Ianir Milevski, Drawn by Leonid Zeiger, Israel Antiquity Authority.