RECORDING CULTURAL HERITAGE IN 3-D

"Athena" Research and Innovation Center in Information, Communication and Knowledge Technologies

CULTURAL and EDUCATIONAL TECHNOLOGY INSTITUTE

Christodoulos Chamzas, Director

http://www.ceti.gr

The Cultural & Educational Technology Institute

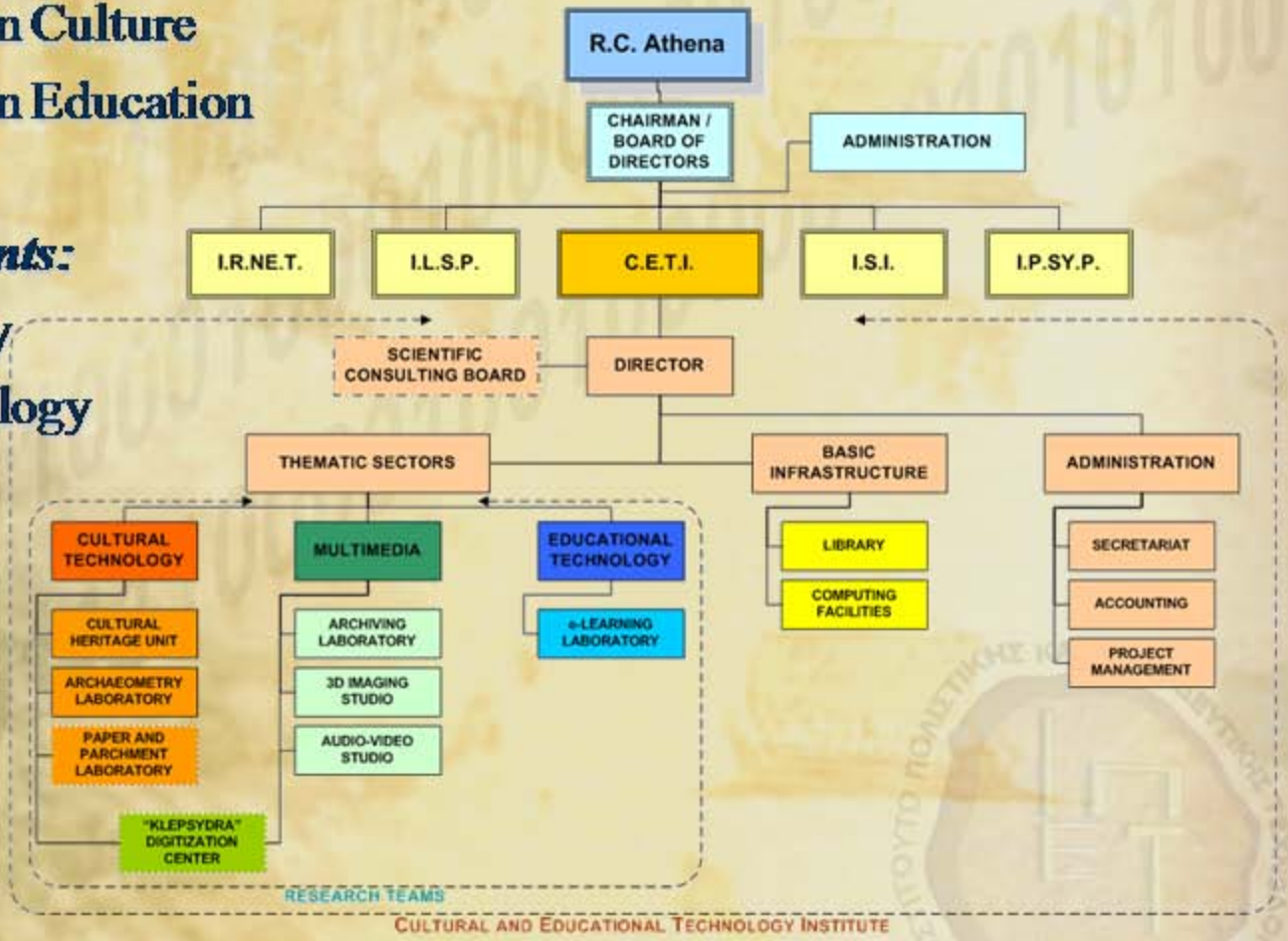
- *Xanthi, Thrace*
- *Founded 1998*
- *People from the Engineering Dept. D.U.Th.*
- *Under the Ministry of Development*
- *On November 2003, joined "R.C.Athena"*

PRINCIPAL OF OPERATION

The aim of the Cultural and Educational Technology Institute (C.E.T.I.) is the strengthening of research and technological activities and the application of new technologies to the sectors of humanitarian science and culture and to education.

The Cultural & Educational Technology Institute

- ***Main activities:***
  - New technologies in Culture
  - New technologies in Education
- ***Three R&D Departments:***
  - Cultural technology
  - Educational technology
  - Multimedia



ACTIVITIES

- ✓ *Study of ancient pottery and monuments of art dated from Antiquity to present*
- ✓ *Partial analysis of ceramics (dating and composition analysis)*
- ✓ ***3D scanning, archiving, retrieval and presentation of cultural objects, monuments and archaeological excavations***
- ✓ *Multimedia Databases MPEG7 compliant*
- ✓ *GIS system*
- ✓ *Content retrieval (Audio, Image, 3D)*
- ✓ *Adaptive e-learning environments, learning objects depositories and teleconferencing*

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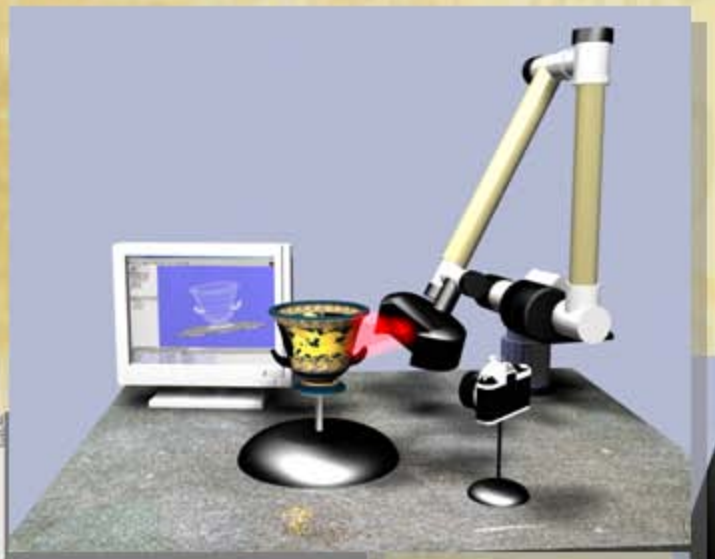
3D IMAGING LABORATORY

3-D REPRESENTATION and PLACES



INTERACTIVE OF OBJECTS via INTERNET

Serres, June 6, 2007

www.ipet.gr/3d_demo

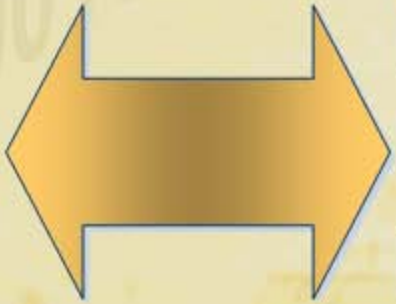
3D?

- *Why 3D?*
  - It is the way we see .
  - It is more natural
  - It provides a complete description of the objects
- ***Is it a mature technology?***
  - NO
- ***What is next?***
  - The feeling of touching them

Recording Cultural Heritage in 3D

Complete **three-dimensional (3D)** recording **of cultural content (objects, monuments, etc), is a multi-dimensional process:**

- **Digitization in 3D**
- **Processing & Storage of 3D data**
- **Archiving , Management & Retrieval of 3D data**
- **Visualization & Dissemination of 3D data**
- **Replication & Reproduction of 3D data**



- **Algorithms**
- **Hardware**
- **Software**

Processes involved in 3D digital recording

Recording Cultural Heritage in 3D

Digitization in 3D

- Processing & Storage of 3D data
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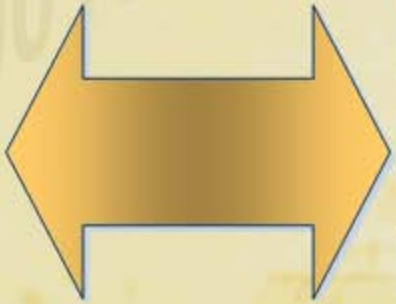

- Algorithms
- Hardware
- Software

Processes involved in 3D digital recording

Factors that influence the choice of a 3D digitization method and its results:

- Geometric complexity
- Size and position of subject
- Surface properties
  - Transparency
  - Reflectance
  - Diffraction
  - Color/texture
- Additional restrictions
  - Accessibility
  - Protection and security issues

Morphological complexity: *Size and shape*

Morphological complexity: *Level of detail*

Diversity of *raw materials*

3D Digitization

Technology solutions

Light waves
f=100 – 1000 THz

Passive techniques

- Shape from structured light
- Shape from silhouette
- Shape from stereo
- Shape from motion/video
- Shape from shading
- Shape from texture
- Shape from photometry
- Shape from focus/defocus
- Shape from shadow
- Photogrammetry
- Contact measurement systems

Active techniques

- Laser triangulation
- Time of flight & coherence of lasers

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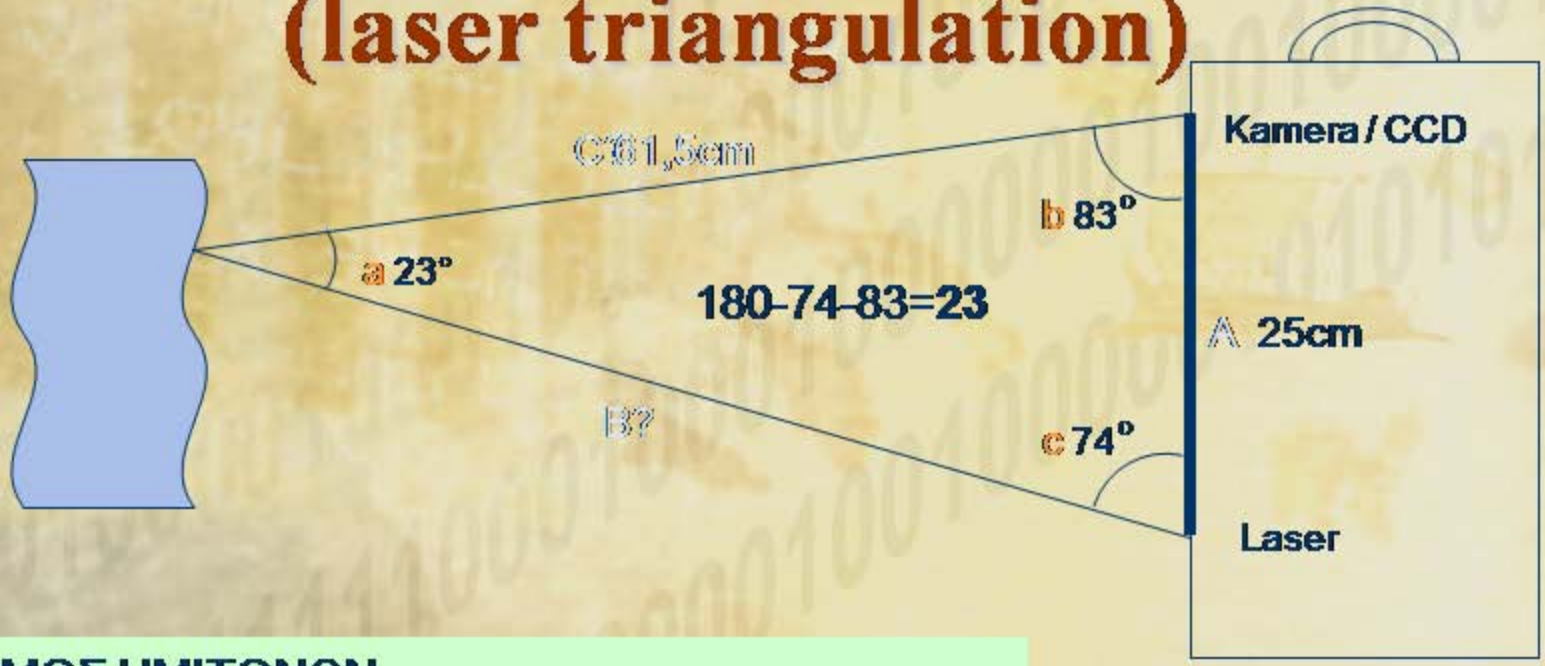
Measurement principe (laser triangulation)



ΝΟΜΟΣ ΗΜΙΤΟΝΩΝ

$$\frac{a}{\sin a} = \frac{b}{\sin b} = \frac{c}{\sin c}$$

$$c = \frac{25 \times \sin 74}{\sin 23} = 61{,}5cm$$

PUBLICATIONS

1. N. Tsirliganis, G. Pavlidis, A. Tsompanopoulos, D. Papadopoulou, Z. Loukou, E. Politou, K. Stavroglou, C. Chamzas, "Integrated Documentation of Cultural Heritage through 3D imaging and multimedia database", VAST2001: Virtual Reality, Archaeology and Cultural Heritage 28-30 November 2001, Glyfada, Athens, Greece
2. N. Tsirliganis, G. Pavlidis, A. Koutsoudis, E. Politou, A. Tsompanopoulos, K. Stavroglou, C. Chamzas, "New Ways in Digitization and Visualization of Cultural Objects", Proc. IEEE DSP 2002, Santorini, Greece, July 1-3, 2002
3. Pavlidis G., M. Lazaridou, F. Arnaoutoglou, C. Chamzas, "Best practices in archival and retrieval of 3D cultural information, Submitted to Journal of Cultural Heritage, Elsevier

3D Digitazition of Urban Areas

Based on photogrammetry and empirical methods (topographic measurements)

Reconstruction of part of the old town of Xanthi (high resolution)
Reconstruction of St. Barbara's springs of Drama (low resolution)

Reconstruction of part of the old town of Xanthi (video_demo)

PUBLICATIONS

1. Koutsoudis A., Arnaoutoglou F., "ON 3D RECONSTRUCTION OF THE OLD CITY OF XANTHI: A minimum budget approach to Virtual Touring based on Photogrammetry", ***Journal of Cultural Heritage, Elsevier***, Volume 8, Issue 1, January-March 2007, Pages 26-31

3D reconstruction of monuments

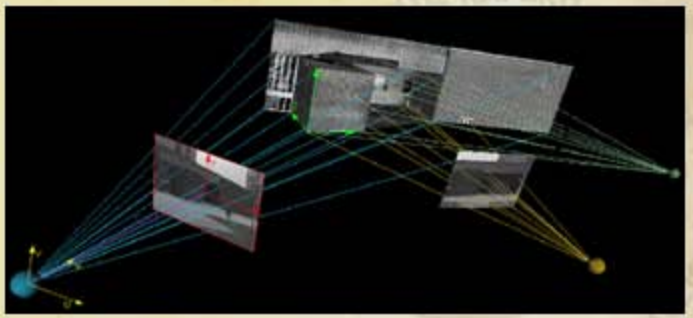
MANI: Methodology → a mixture of ***empirical method*** and ***photogrammetry***

Empirical method: Measurements of distances between characteristic points on the surface of the monument are taken (by hand).

Pros: simple, productive, portable and of low cost.
Cons: low accuracy and demanding in terms of time of physical presence near the monument

Photogrammetry: Common digital photos can be used, under suitable conditions, for measurements that can be of the scale of accuracy obtained by the topographic methods.

Pros: objective and reliable and can be aided by CAD software; relatively simple and has low cost; can be used for complex objects with high surface detail
Cons: has to be combined with topographical or empirical measurements; the obtained quality is a function of the time spent; since it is based on photos, there is a need for adequate space.



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Field work…

Actual monument

Αθηνά
Athena

EPISKOPI at Stavri

Serres, June 6, 2007

3D reconstruction

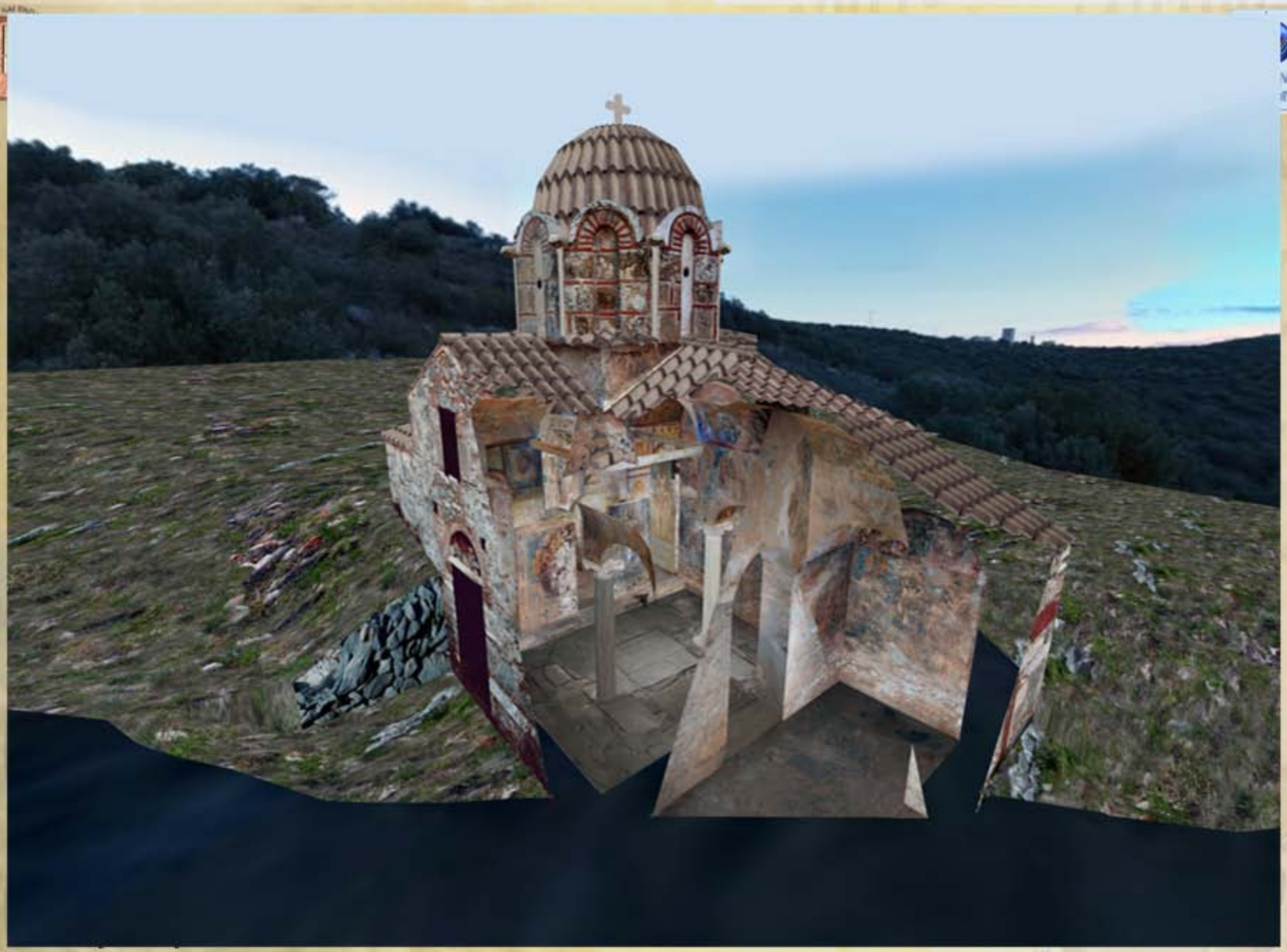
Actual monument

Αθηνά
Athena

AG.VASILIOS at Kelefa

Serres, June 6, 2007

3D reconstruction



Possible representations of the 3D model (outer & inner parts shown)

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DEMO of
3D reconstruction of monuments

Click on images to see VRML representations of the models

Video 1
Video 2
Video 3

Video 1
Video 2
Video 3
Video 4

PUBLICATIONS

1. Tsioukas V., Tsirliganis N., Pavlidis G., Arnaoutoglou F., Chamzas Ch., Mpakourou E., Mexia A., "Photogrammetic Modeling Of Byzantine Churches", CIPA 2005 - XX International Symposium, 26 Sept. - 1 Oct., 2005, Torino, Italy.
2. Pavlidis G., Tsirliganis N., Tsiafakis D., Arnaoutoglou F., Chamzas C., Tsoukas V., Mpakourou E., Mexia A., "3D digitization of monuments: the case of Mani 3-rd International Conference on Museology, Mytilene, 5-8 June 2006
3. Koutsoudis A., Arnaoutoglou F., Chamzas C., "On 3D reconstruction of the old city of Xanthi. A minimum budget approach to virtual touring based on photogrammetry", Journal of Cultural Heritage, Volume 8, Issue 1, January-March 2007, Pages 26-31

3D scanner

Towards a versatile, handheld scanning system

The idea

Usage of a setup with a video camera and a laser light projecting device (line pattern)

Combination of:

- Camera tracking → Provides coordinates of the camera position in the 3D space
- Laser triangulation → Provides coordinates on object surfaces relative to the camera

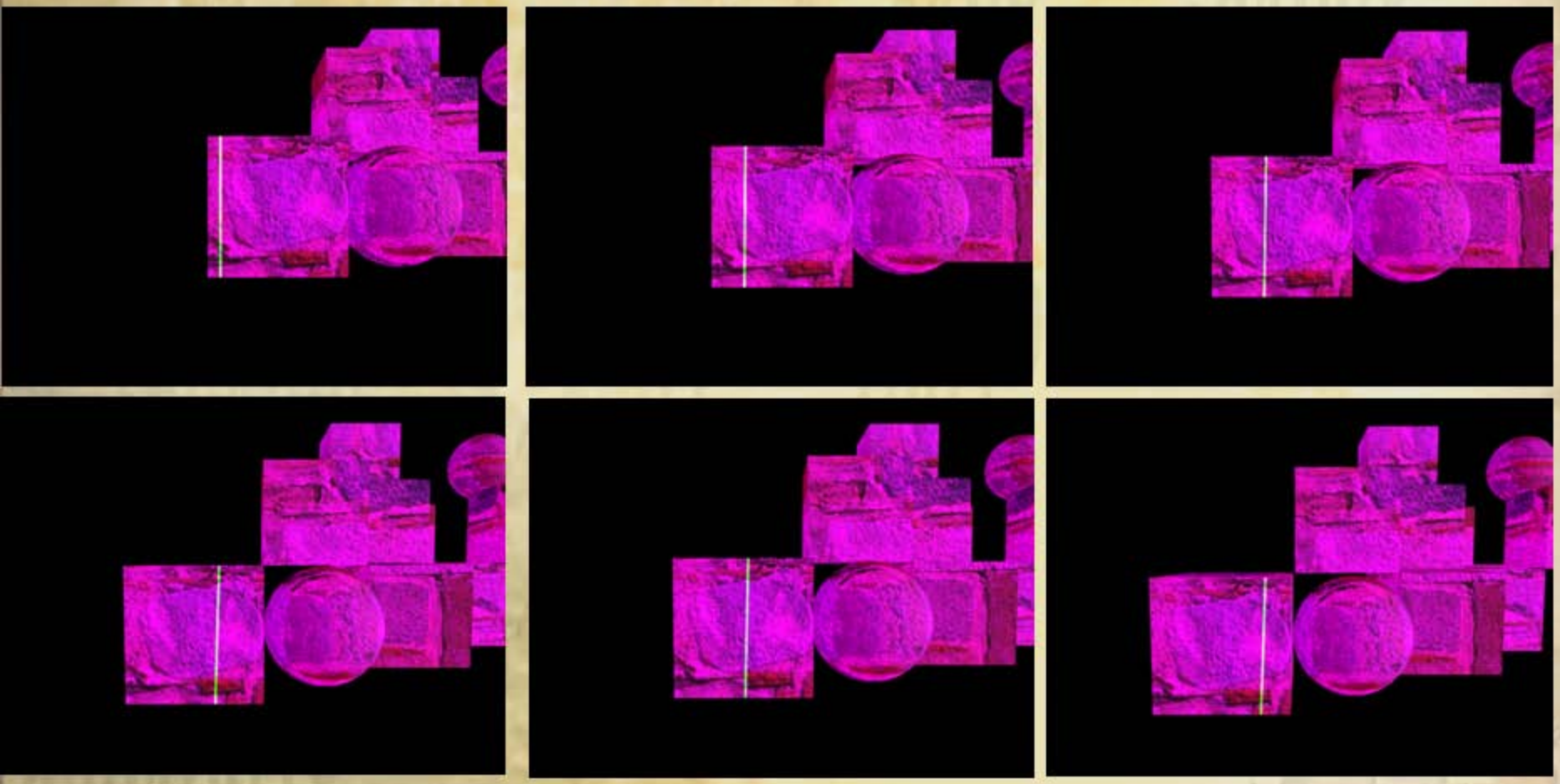
Versatility – the key idea:

- The system can use any kind of setup
  - from a high resolution camera and precise laser device with very high cost
  - to a web camera and a simple laser device with very low cost

Simplicity of usage

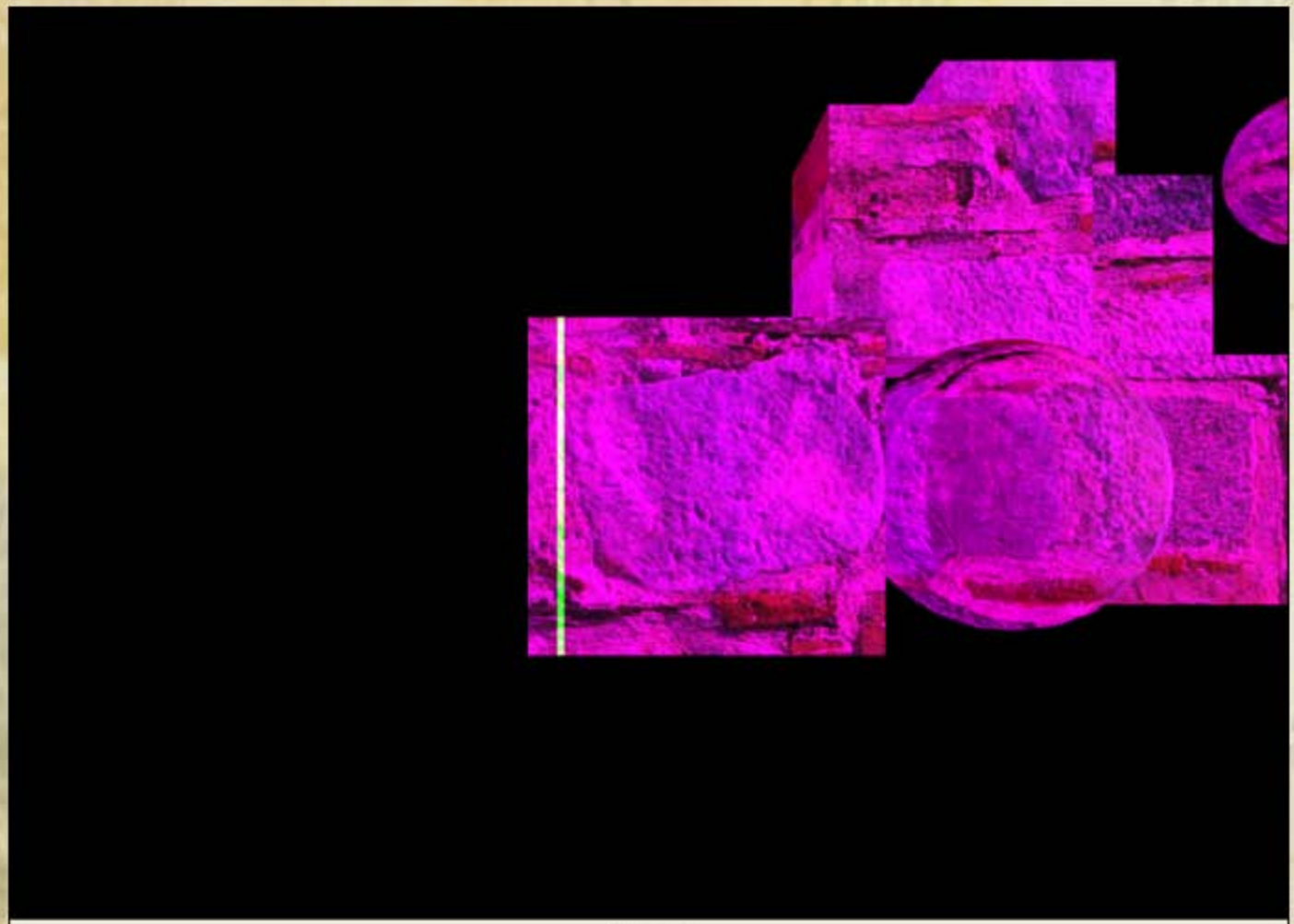
- Just use the setup to record a video of an object
- The whole process can be done offline (it is based on software)

Simulations with synthesized data



Sequence of six consecutive video frames (step 10 frames) from the test data set.
The green line is the laser projected on the object

The complete test video sequence

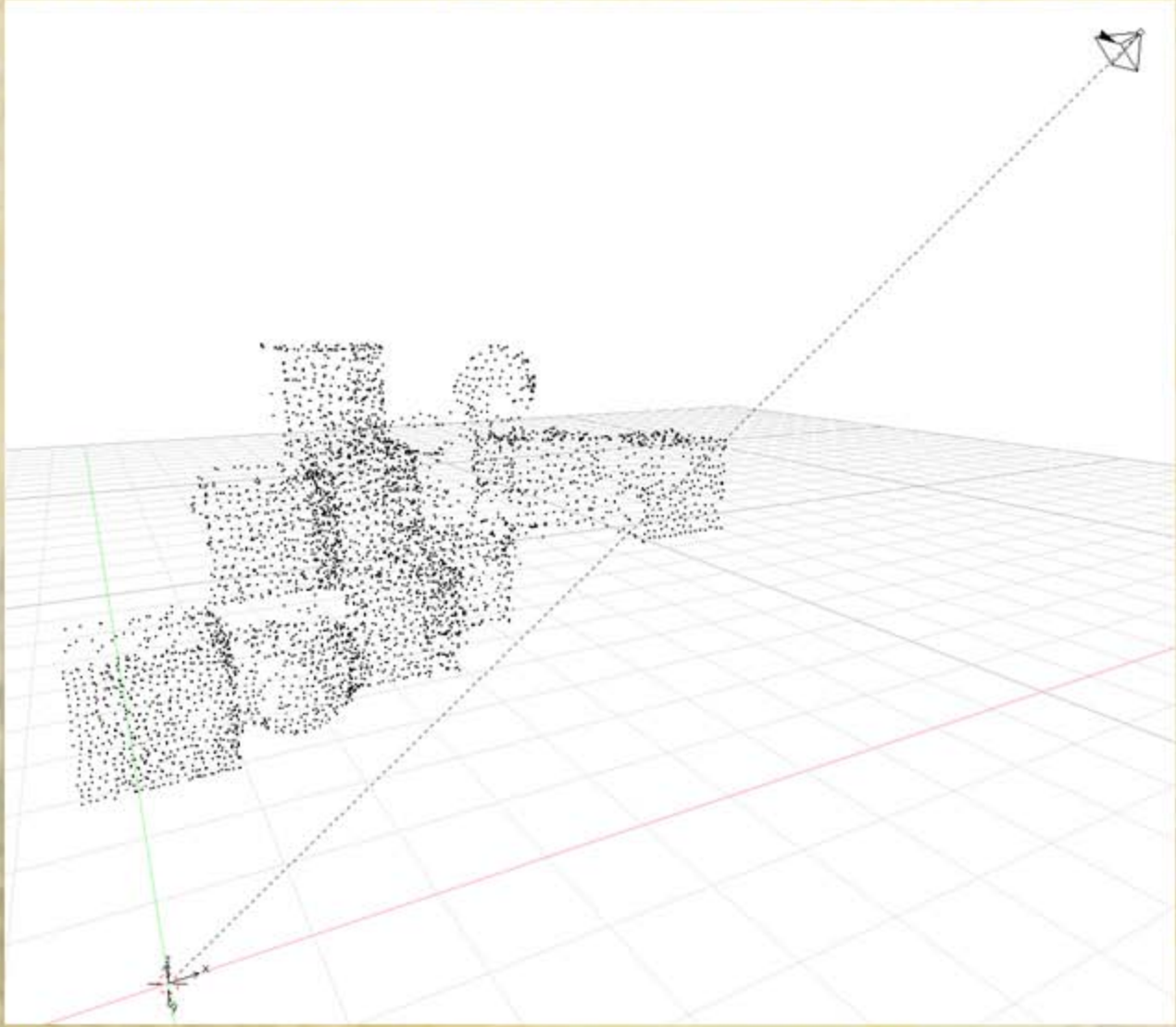


video.avi

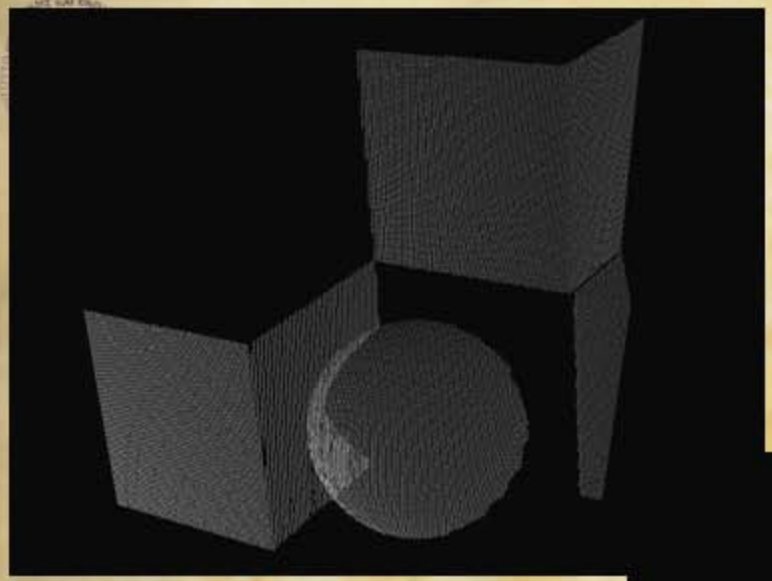
Click on image to play the video

Tracking with voodoo tracker developed by digi-lab, University of Hannover

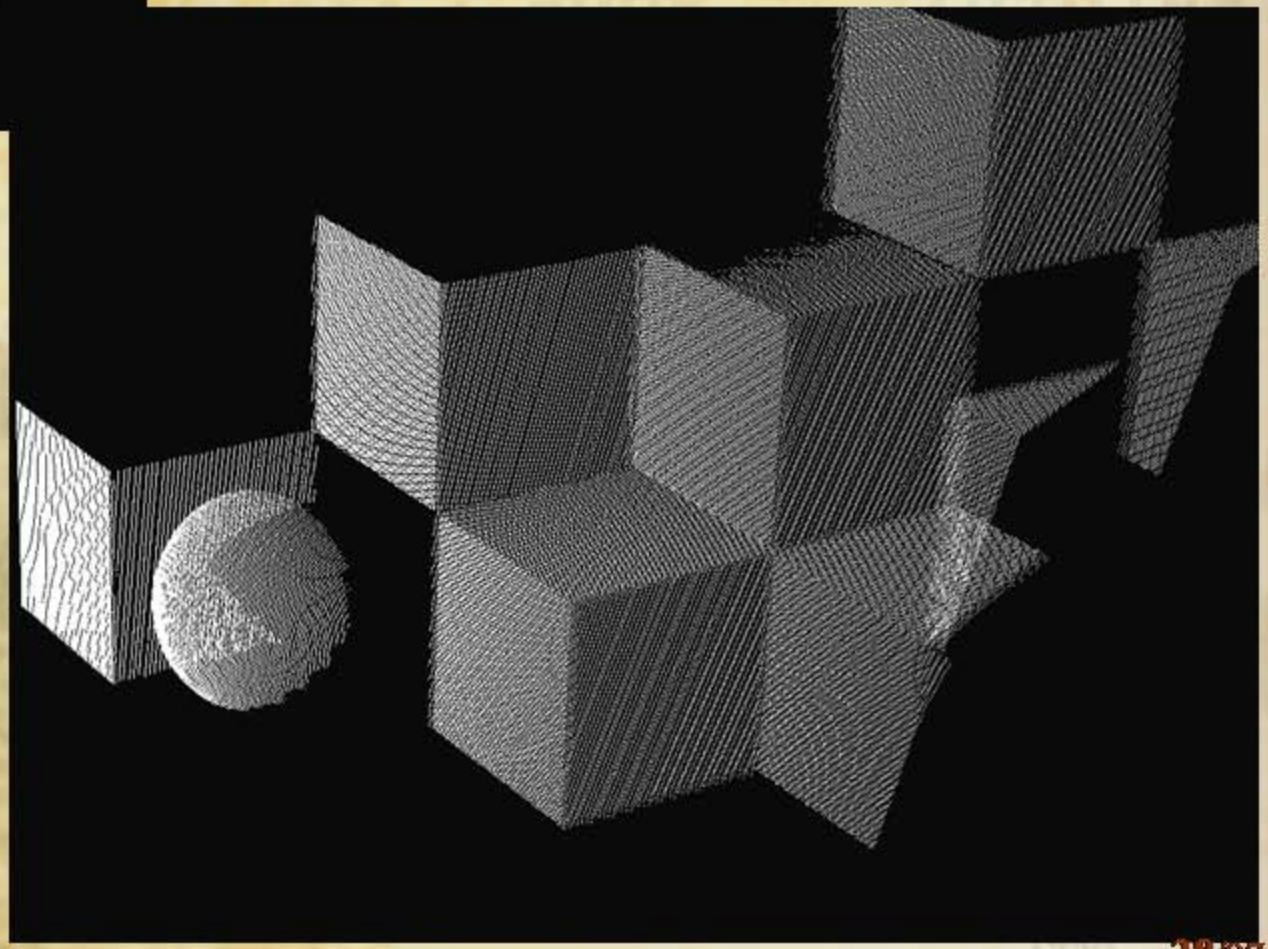
http://www.digilab.uni-hannover.de/docs/manual.html



Result of camera tracking (using voodoo on our test sequence): The camera path shown as dotted line. The dots on the surface of the objects correspond to control points used by the tracker during the process.



The reconstructed point cloud during the 3D scanning process



Click→
To see VRML

PUBLICATIONS

1. F. Arnaoutoglou, A. Koutsoudis, G. Pavlidis, V. Tsioukas, C. Chamzas, "Towards a versatile handheld 3D Laser Scanner ",The 7th International Symposium on Virtual Realitiy, Archaelogy and Cultural Heritage (VAST 2006),Nicosia, Cyprus, 30 October - 4 November, 2006, pp 7-12

Recording Cultural Heritage in 3D

- Digitization in 3D
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Processes involved in 3D digital recording

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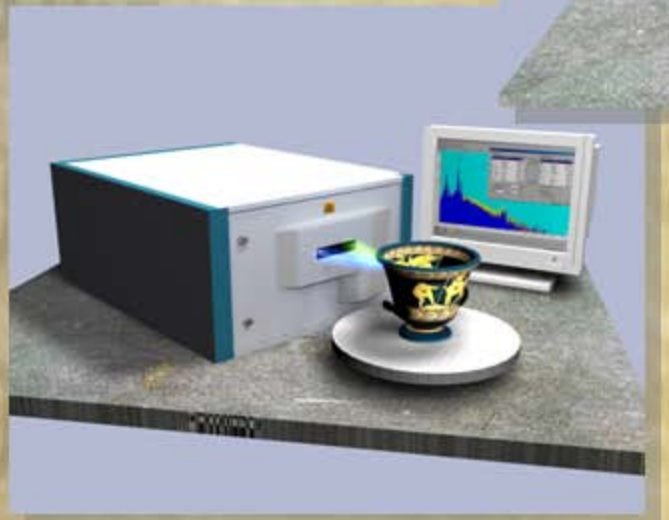
Digitization:

3D geometry & texture & Surface Properties



Technologies

Technologies used for designing and constructing a database system with extended search, visualization capabilities and the ability to deliver its multilingual content over the Internet

- MySQL: An SQL compliant relational database supporting Unicode content.
- MySQL-PHP, HTML: Extended database management system (DBMS)
- MySQL-PHP, HTML: Advanced user interface for local or remote database administration.
- MySQL-PHP, HTML, VRML, 3D-GIS Plug-in, Flash: Advanced user interface for database navigation and search over the Internet, supporting extended 3D visualizations
- Hi level programming: Special purpose software for on-site off-line input that supports Unicode content
- 3D Modeling/CAD: Usage of 3D software for virtual reconstructions
- GIS: Usage of GIS software for site reconstructions

Photo Scanning

Laser Scanner

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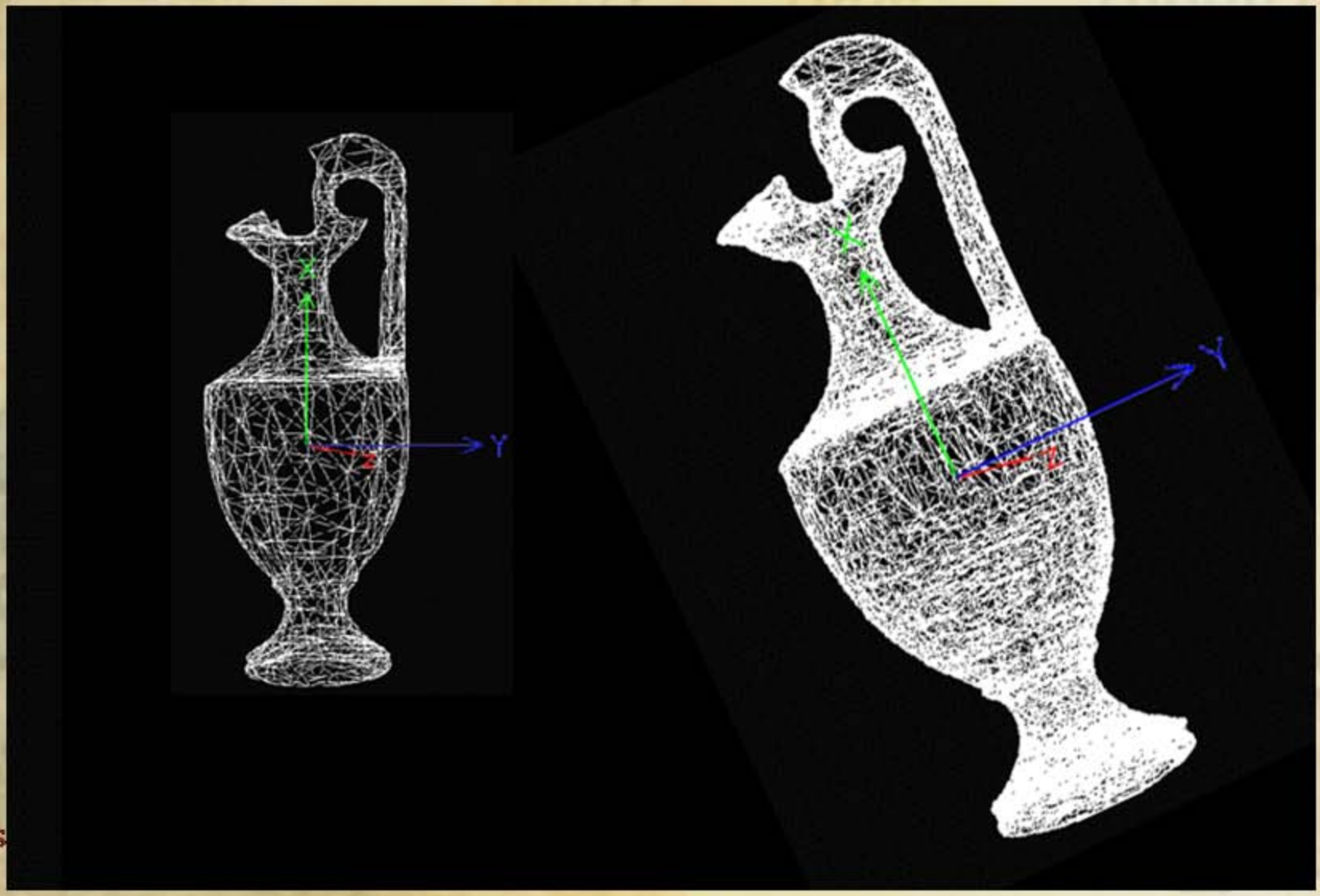
Photo Scanned object
(bad geometry registration)


X
Y
Z
X
Y
Z

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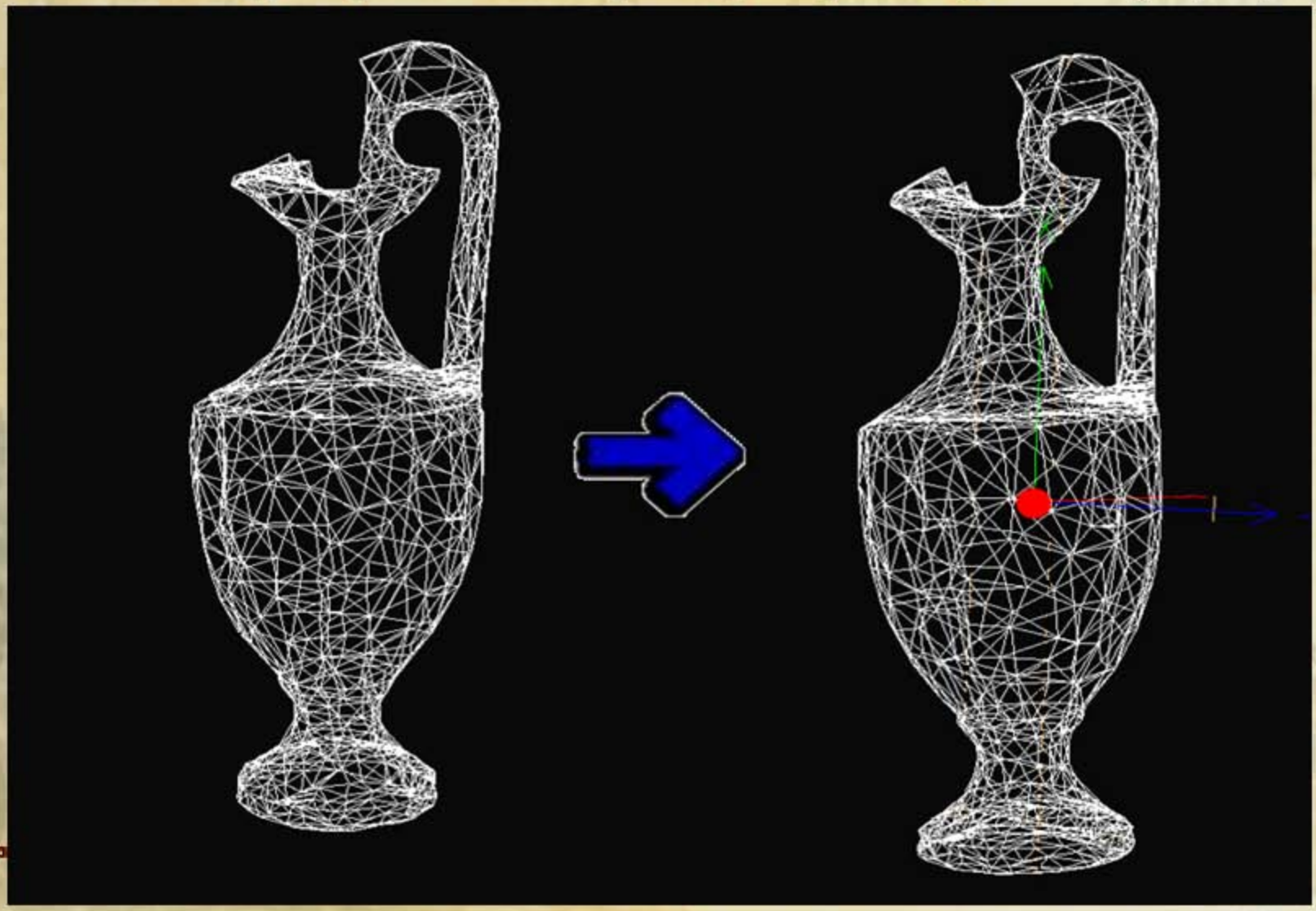
Ολίσθηση: κέντρο βάρους → (0,0,0)



Inertia Tensor – Ιδιοτιμές/Ιδιοδιανύσματα

Inertia Tensor

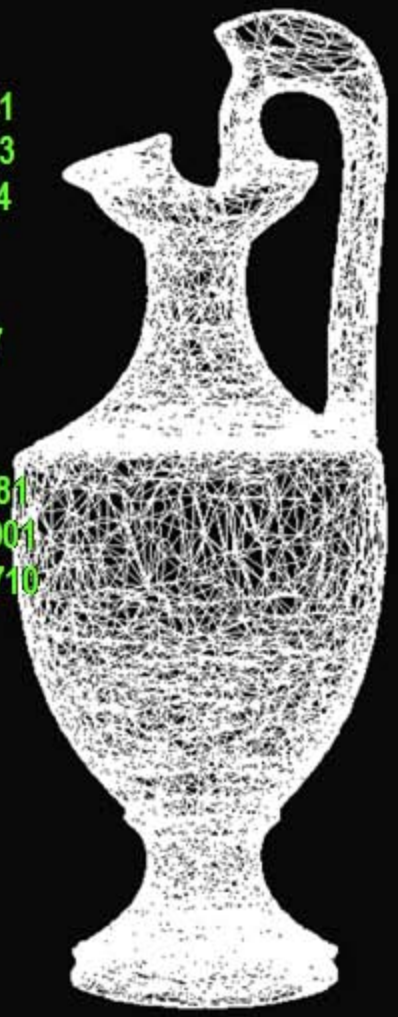
7.57798	-0.200833	-6.61341
-0.200833	6.35837	4.39283
-6.61341	4.39283	51.0104

EigenValues:

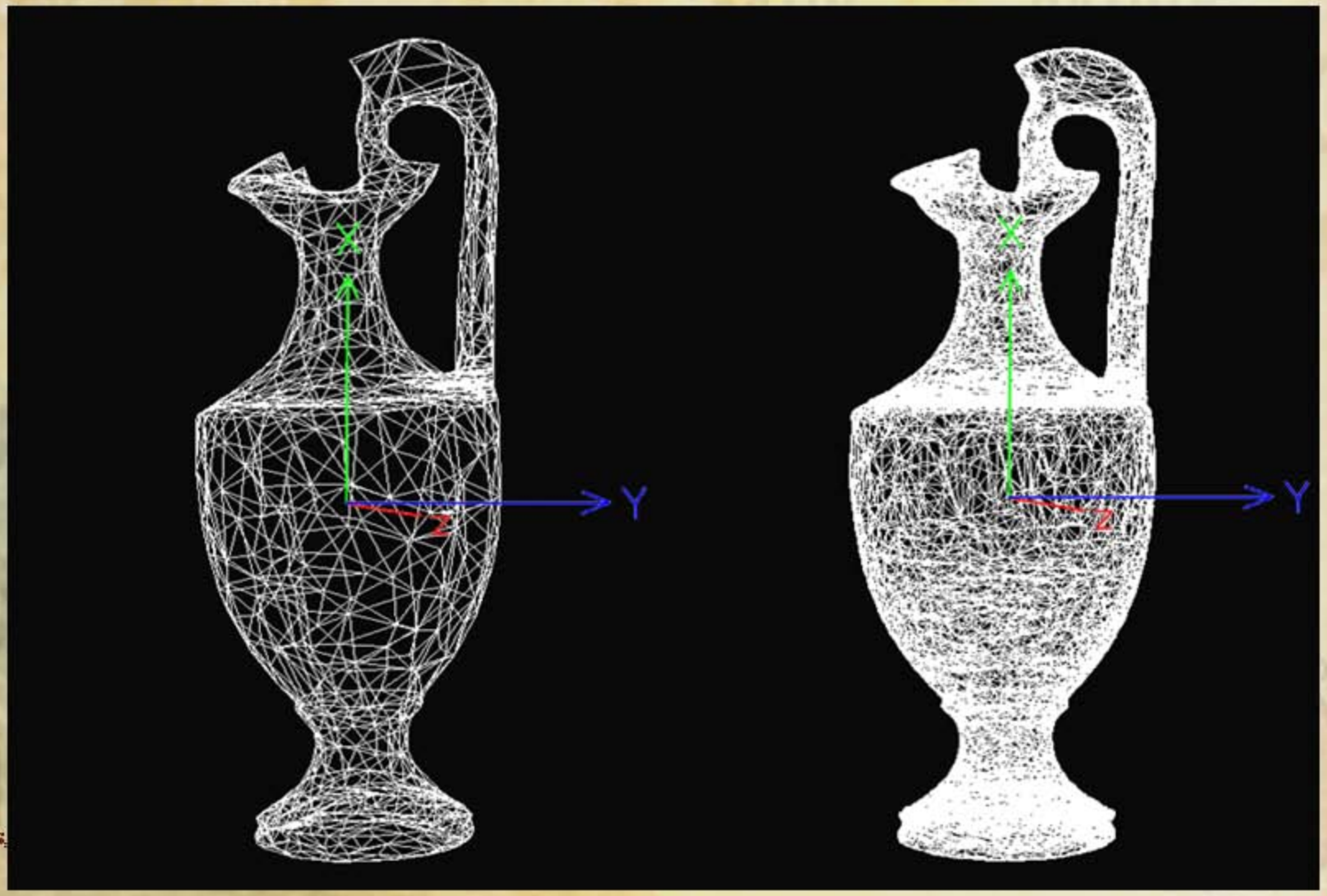
6.8215 5.71461 52.4107

EigenVectors:

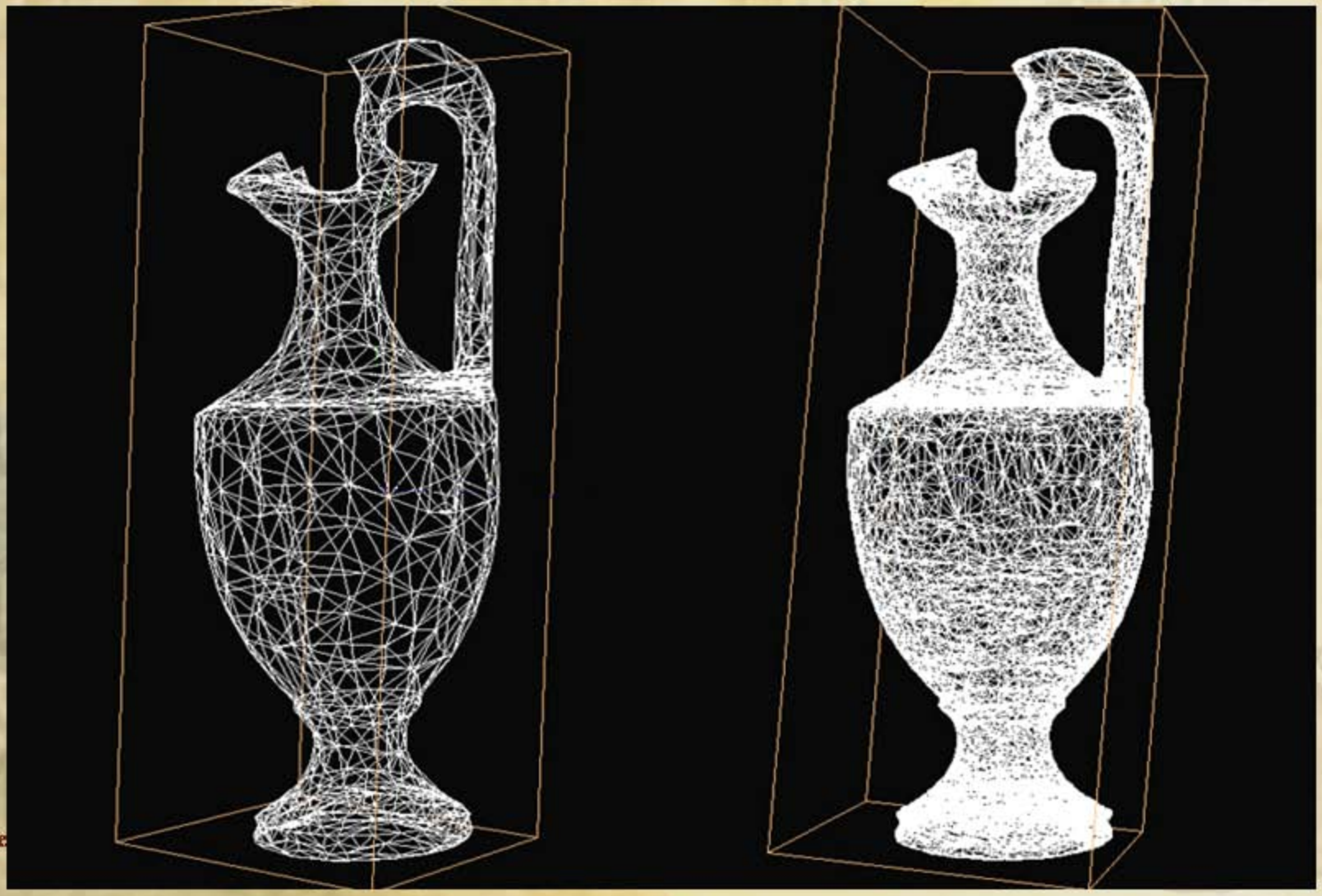
0.887794	-0.436308	-0.146481
0.451624	0.887169	0.0946901
0.088639	-0.150219	0.9846710



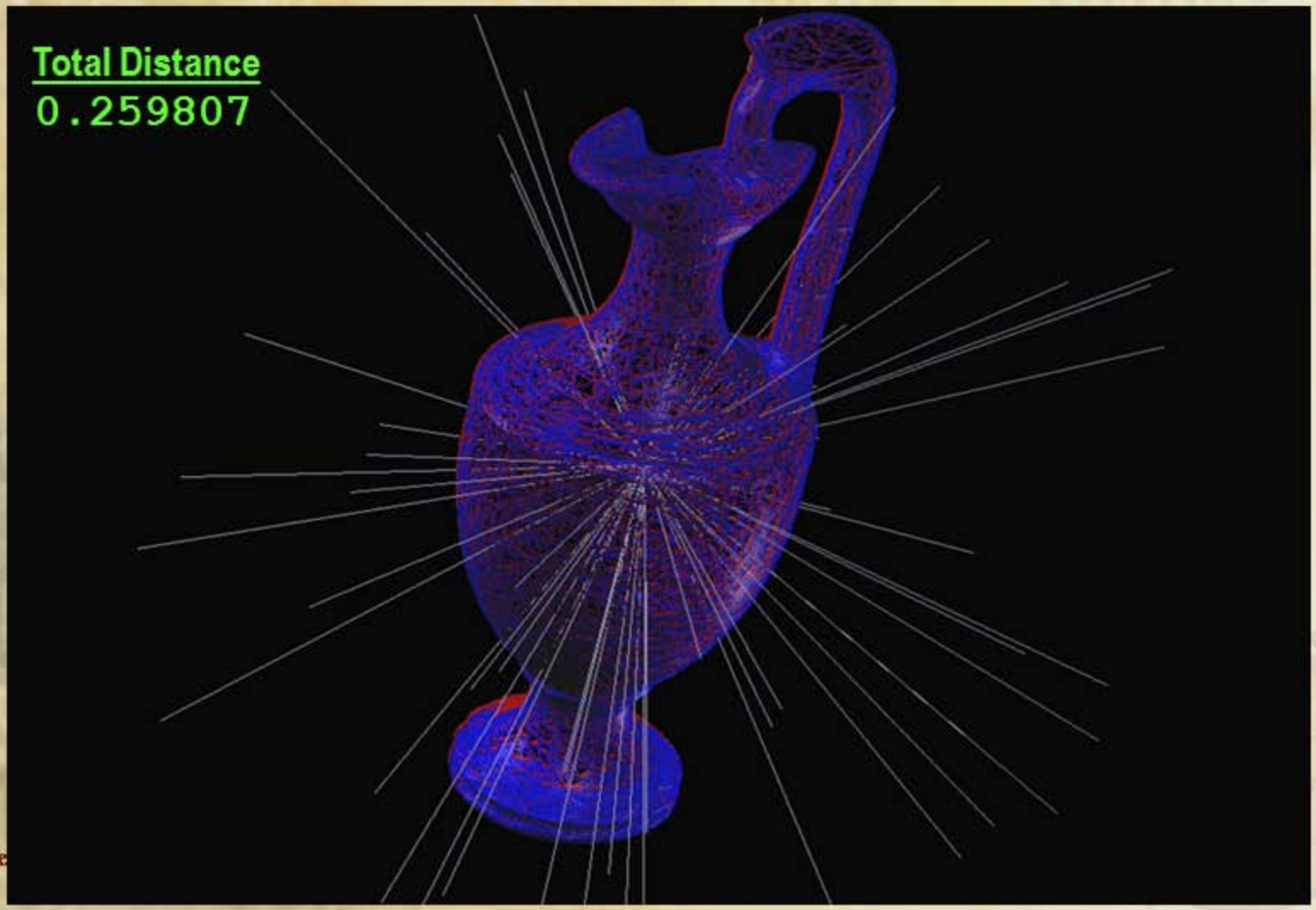
Προσανατολισμός (principal axes)



Scaling (bounding boxes)



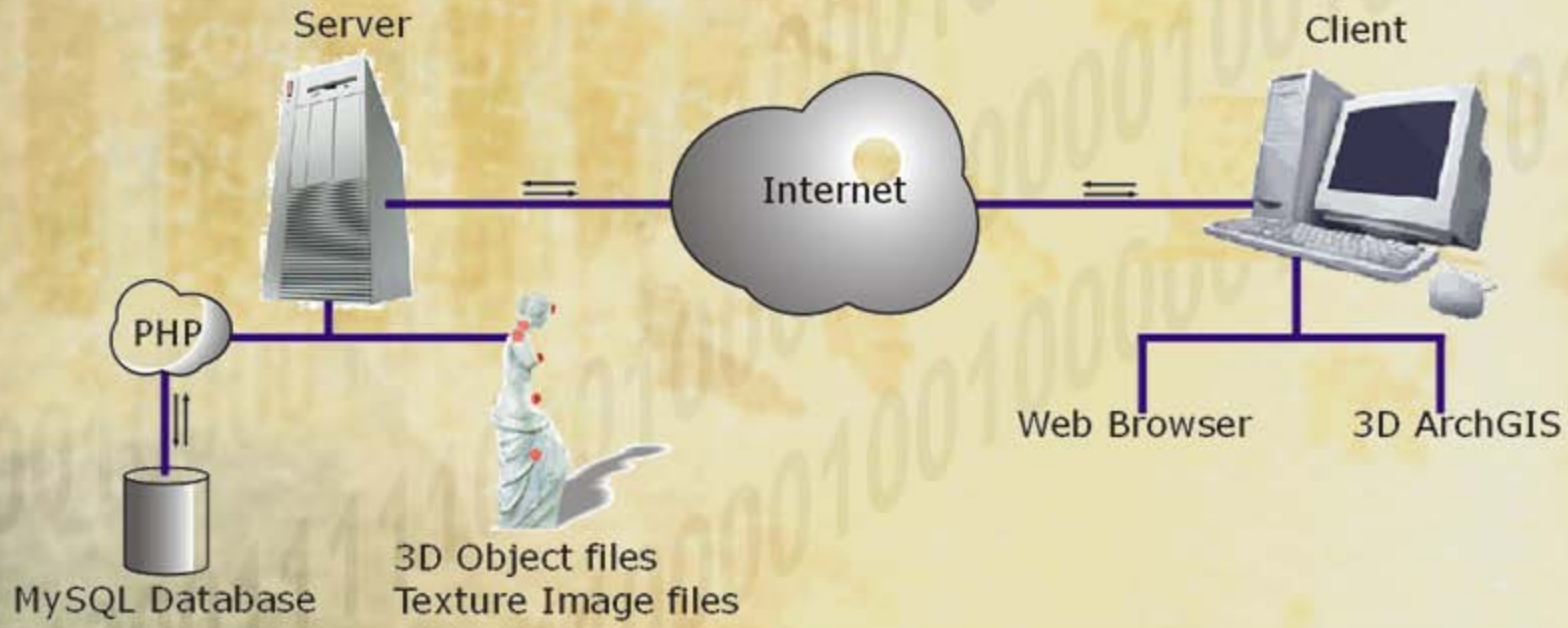
Μέτρηση της Απόστασης



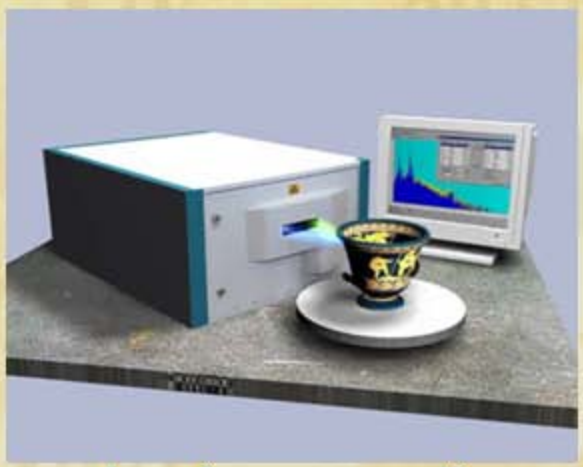
Εφαρμογή Υφής στο 2ο μοντέλο

3D OBJECTS WWW.CETI.GR/3d_demo

3D - GIS



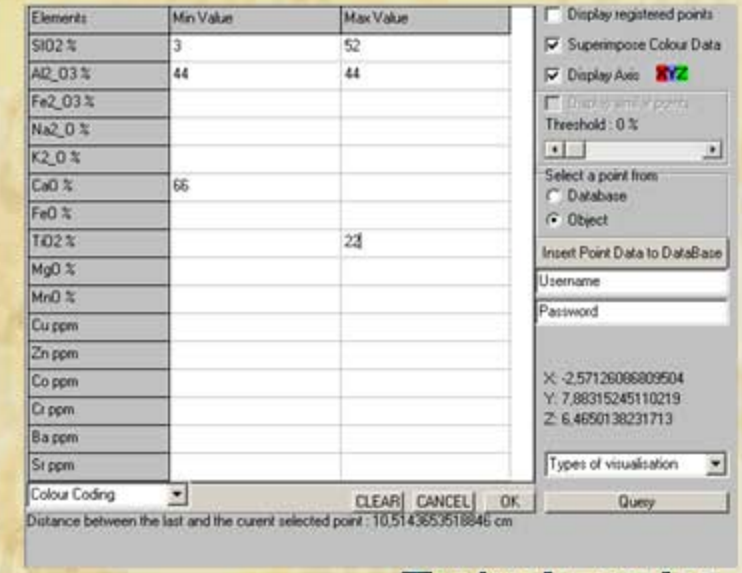
Technology framework for 3D archGIS system



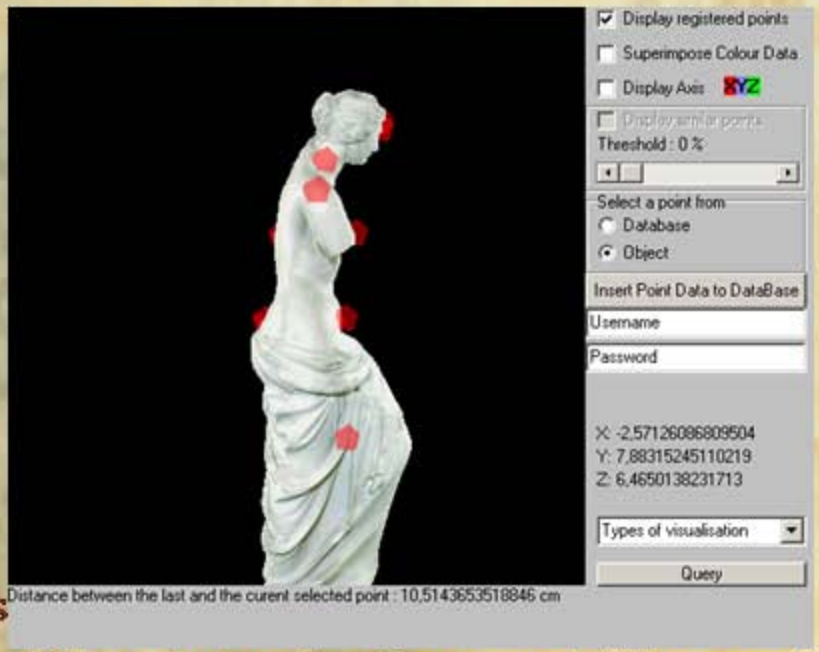
Acquisition of 3D geometry and surface properties

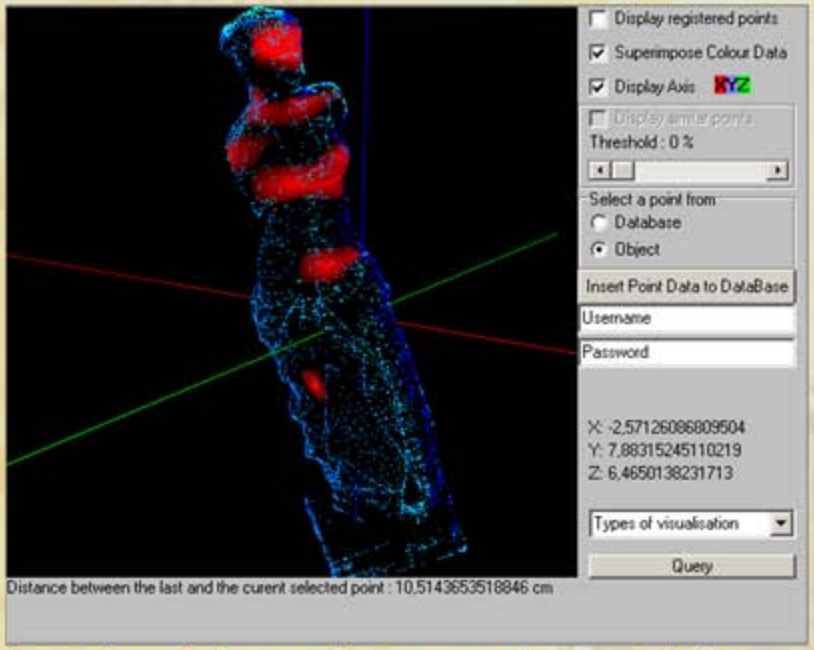
Screenshot of ActiveX plugin (➔MS-IE) developed in Delphi

Visual queries



Textual queries





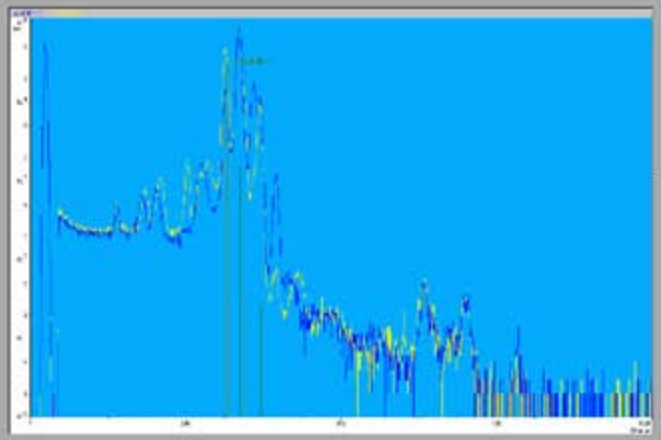
Different visualization capabilities: registered points, color mapping of data

afroditi, point number: 1

Chemical Analysis

- SIO2 % : 32
- Al2_O3 % : 15.41
- Fe2_O3 % : 3
- Na2_O % : 51.4
- K2_O % : 44.14
- CaO % : 14
- FeO % : 0
- TiO2 % : 0
- MgO % : 51
- MnO % : 3
- Cu ppm : 2323
- Zn ppm : 344
- Co ppm : 511
- Cr ppm : 412
- Ba ppm : 43
- Sr ppm : 133

Sample Position
3D X:-4 Y:11 Z:0
2D U:0 V:3



Display of detailed surface analysis

Elements	Value
SIO2 %	21
Al2_O3 %	13.32
Fe2_O3 %	23
Na2_O %	2
K2_O %	2
CaO %	1
FeO %	31
TiO2 %	41
MgO %	4
MnO %	1.12231
Cu ppm	3111
Zn ppm	231
Co ppm	12313
Cr ppm	122
Ba ppm	2222
Sr ppm	6783

Colour Coding

CLEAR CANCEL OK

Distance between the last and the curent selected point : 10.5143653518846 cm

Display registered points
Superimpose Colour Data
Display Axis XYZ
Threshold : 0 %
Select a point from
Database
Object
Insert Point Data to DataBase
Username
Password
X: -2.57126086809504
Y: 7.88315245110219
Z: 6.4650138231713
Types of visualisation
Query

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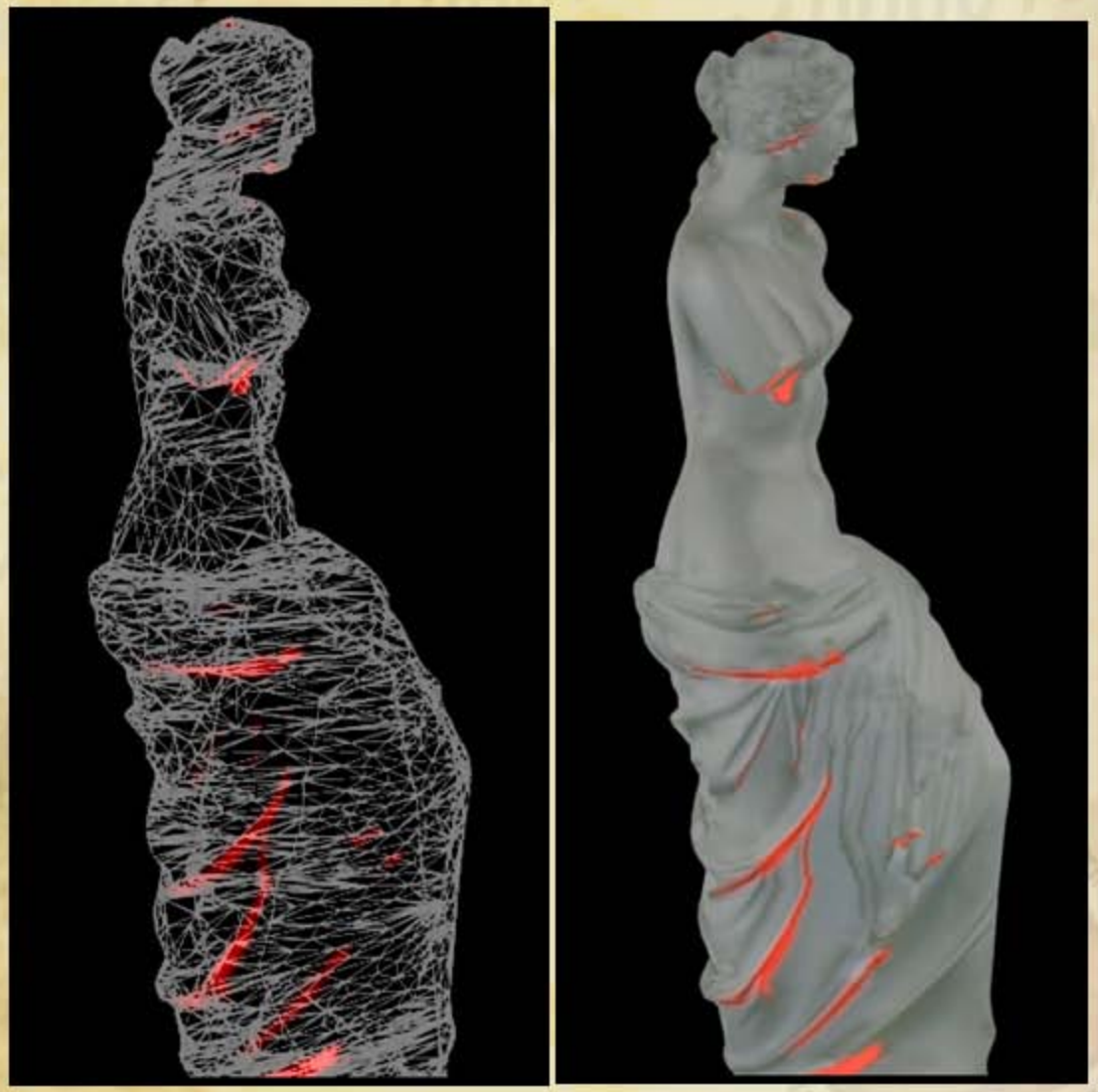
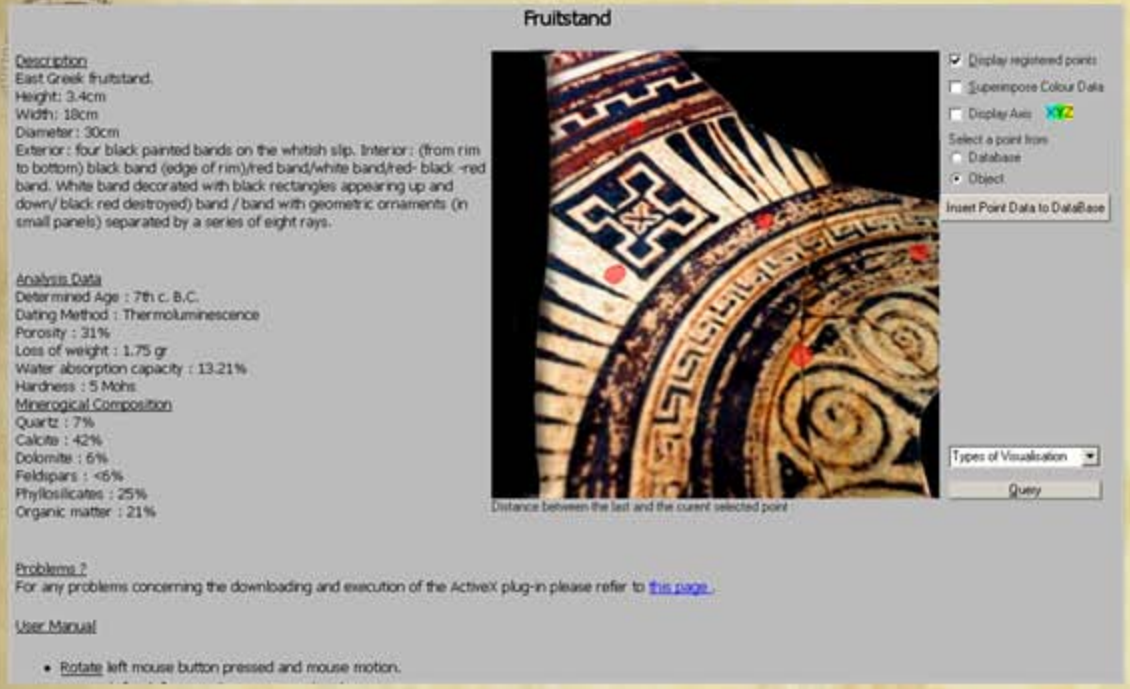
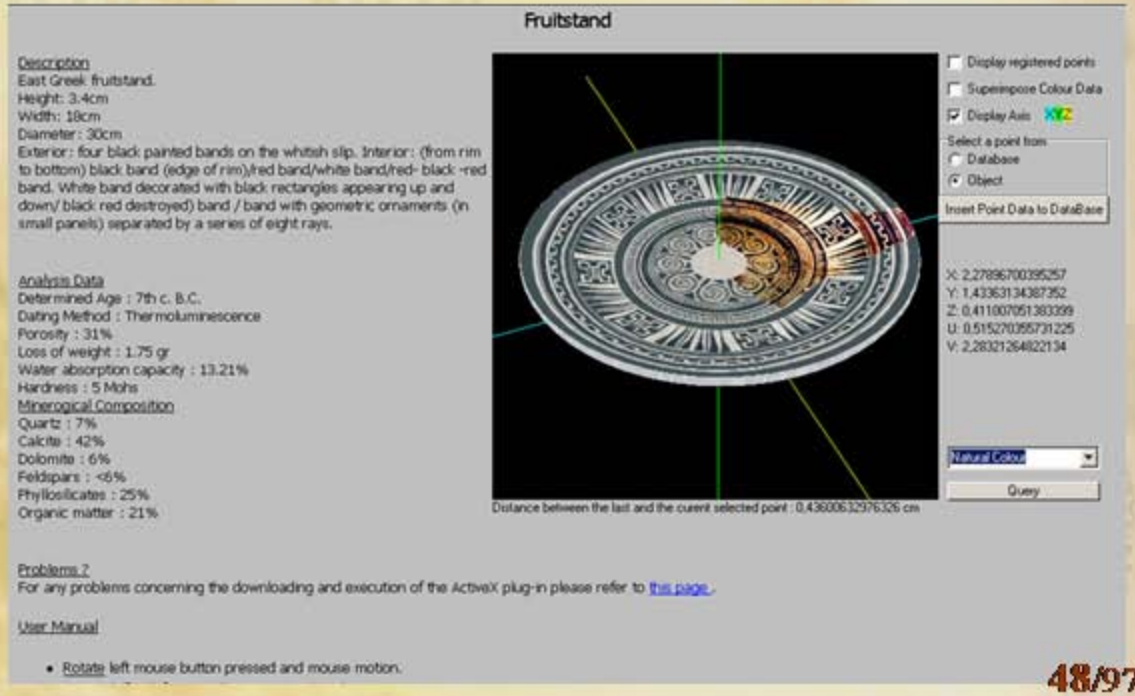
Data entry

3D GIS query?



Show the points where
Fe2O3
is more than 3%





Screenshots…

Demo needs to be in C:

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Demonstration…

3D data storage

Factors that influence the choice of a storage system:

- **Data access time**
- **Data transfer rate** to and from the computer memory
- **Multi-user** access
- Data storage **capacity**
- **Usage frequency**
- **Durability** of both the medium and the data
- **Conditions of storage and operation**
- **Cost** per unit of capacity

3D data storage

Happy Buddha

Triangles:	1.087.716
File Type	Size (Mb)
3ds	22
Lwo	27
Cob	38
Obj	38
Off	38
Ply	42
Peo	69
Raw	76
X	90
Wrl	125
Asc	130
Dxf	229

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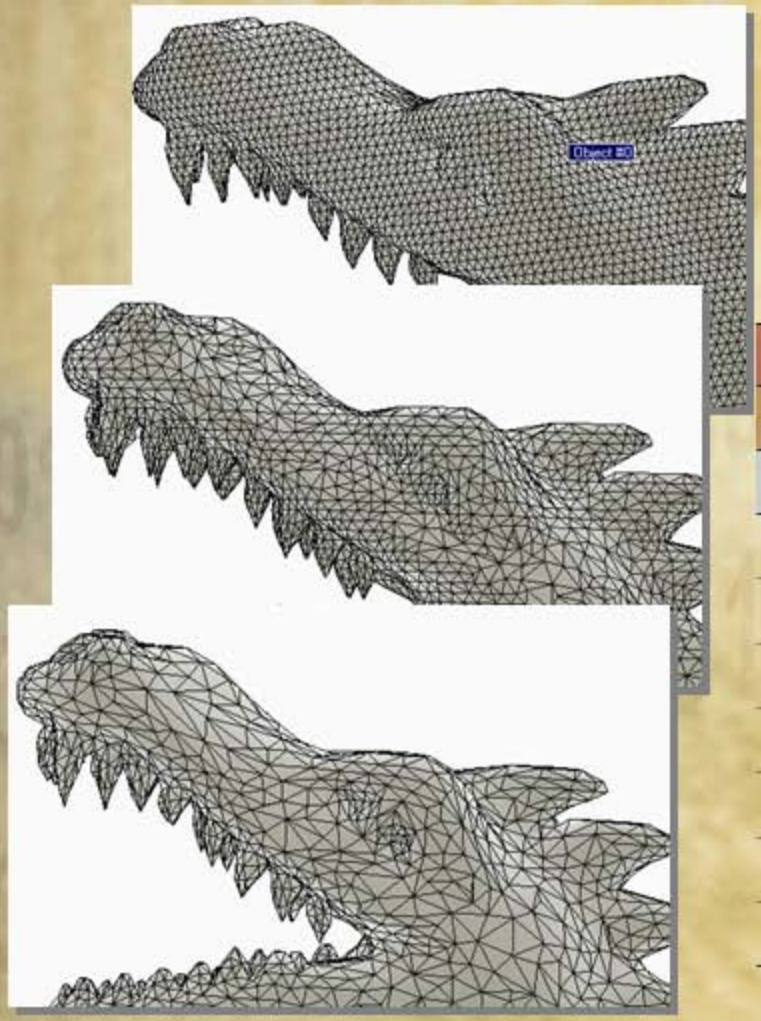
3D data storage



Geometry simplification and its implications in data storage requirements

Geometry	High	Medium	Low
Triangles	*108.588*	*54.294*	*10.859*
File	*Size(Mb)*	*Size(Mb)*	*Size(Mb)*
3ds	*2*	*1*	*0.2*
Off	*3*	*1.5*	*0.3*
Obj	*3.5*	*2*	*0.4*
X	*8*	*4*	*0.8*
Raw	*6.5*	*3.5*	*0.8*
Asc	*12*	*6*	*1.2*
Dxf	*23*	*11.5*	*2.3*

3D data storage

Metadata – categories:

- Data typed by the user that provide **information about the subject** (i.e. a description)
- **Managerial data**, to be used for version control, data type definition, etc
- Data providing **mathematical descriptions of features** that can be extracted from the 3D models and used for search by content
- **Watermarking** data

PUBLICATIONS

1. *Tsirliganis N., Pavlidis G., Koutsoudis A., Papadopoulou D., Tsompanopoulos A., Stavroglou K., Loukou Z., Chamzas C., " Archiving 3D Cultural Objects with surface pointwise data base information", First International Symposium on 3D Data Processing Visualization and Transmission (3DPVT 2002), June 19-21, 2002, in Padova, Italy*
2. *Nestor C. Tsirliganis, Fotis Arnaoutoglou, Anestis Koutsoudis, George Pavlidis, Christodoulos Chamzas, "3D-ArchGIS: Archiving Cultural Heritage in a 3D Multimedia Space", DigiCult.Info: A Newsletter on Digital Culture, December 2003, Issue 6, 6-10*
3. *Tsirliganis N., Pavlidis G., Koutsoudis A., Papadopoulou D., Tsompanopoulos A., Stavroglou K., Loukou Z., Chamzas C., "Archiving Cultural Objects in the 21st Century", Journal of Cultural Heritage, Volume 5, Issue 4, October-December 2004, Pages 379-384*

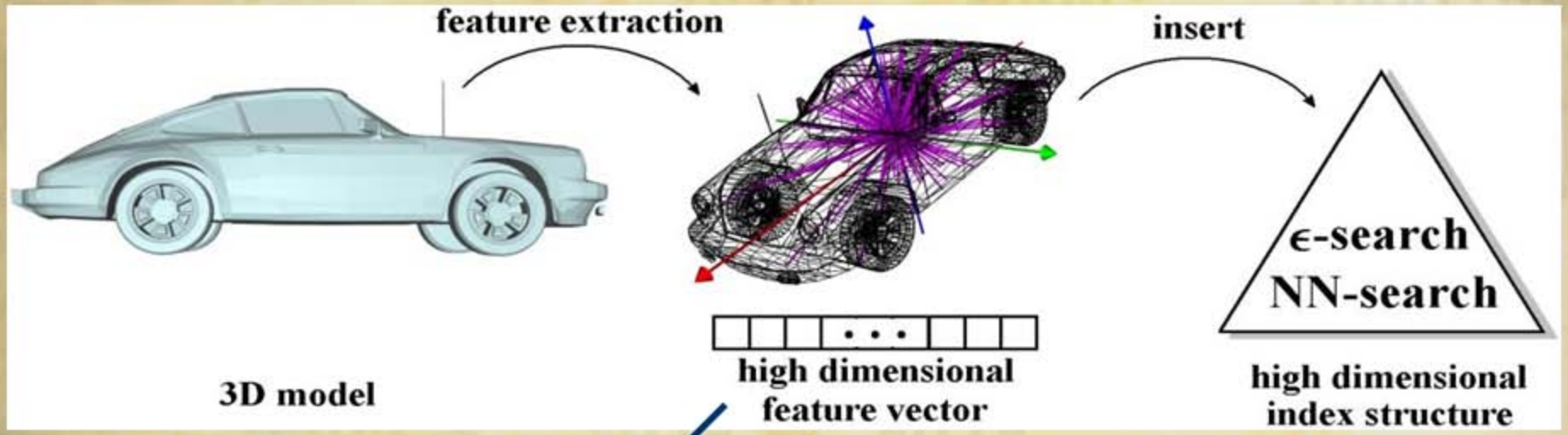
Recording Cultural Heritage in 3D

- Digitization in 3D
- Processing & Storage of 3D data
- **Archiving, Management & Retrieval of 3D data**
- Visualization & Dissemination of 3D data
- Replication & Reproduction of 3D data

Processes involved in 3D digital recording

Cultural & Educational Technology Institute
58 Tsimiski Street, [illegible] Xanthi, Hellas

Retrieval of 3D objects

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<?xml version="1.0" encoding="ISO-8859-1" ?>
- <Mpeg7 xmlns="http://www.mpeg7.org/2001/MPEG-7_Schema"
  xmlns:xsi="http://www.w3.org/2000/10/XMLSchema-instance">
  - <DescriptionUnit xsi:type="DescriptorCollectionType">
      <FileName>car5.xml</FileName>
    - <Descriptor xsi:type="Shape3DType">
        <numberOfBins>100</numberOfBins>
        <bitsPerBin>12</bitsPerBin>
        <Spectrum>0 1 2 6 4 29 5 30 8 10 8 11 14 14 36 18 20 24 32 65 57 83 83
          134 467 256 75 50 24 32 27 18 25 12 20 18 14 8 13 14 8 13 6 7 9 16 6 10
          7 8 11 7 8 8 9 6 6 6 9 9 10 11 12 12 13 20 15 20 28 26 40 44 44 72 100 66
          47 55 44 39 24 22 25 26 28 21 13 17 11 16 12 10 7 10 3 5 6 4 0
          2</Spectrum>
        <PlanarSurfaces>1111</PlanarSurfaces>
        <SingularSurfaces>21</SingularSurfaces>
      </Descriptor>
    - <Descriptor xsi:type="Perceptual3DShape">
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        <BitsPerAttribute>6</BitsPerAttribute>
        <IsAdjacent>1 0 0 1 1 0</IsAdjacent>
        <Volume>18 21 23 0</Volume>
        <Center_X>13 31 48 24</Center_X>
        <Center_Y>31 31 31 31</Center_Y>
        <Center_Z>31 31 31 33</Center_Z>
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        <Transform_3>32 32 28 31</Transform_3>
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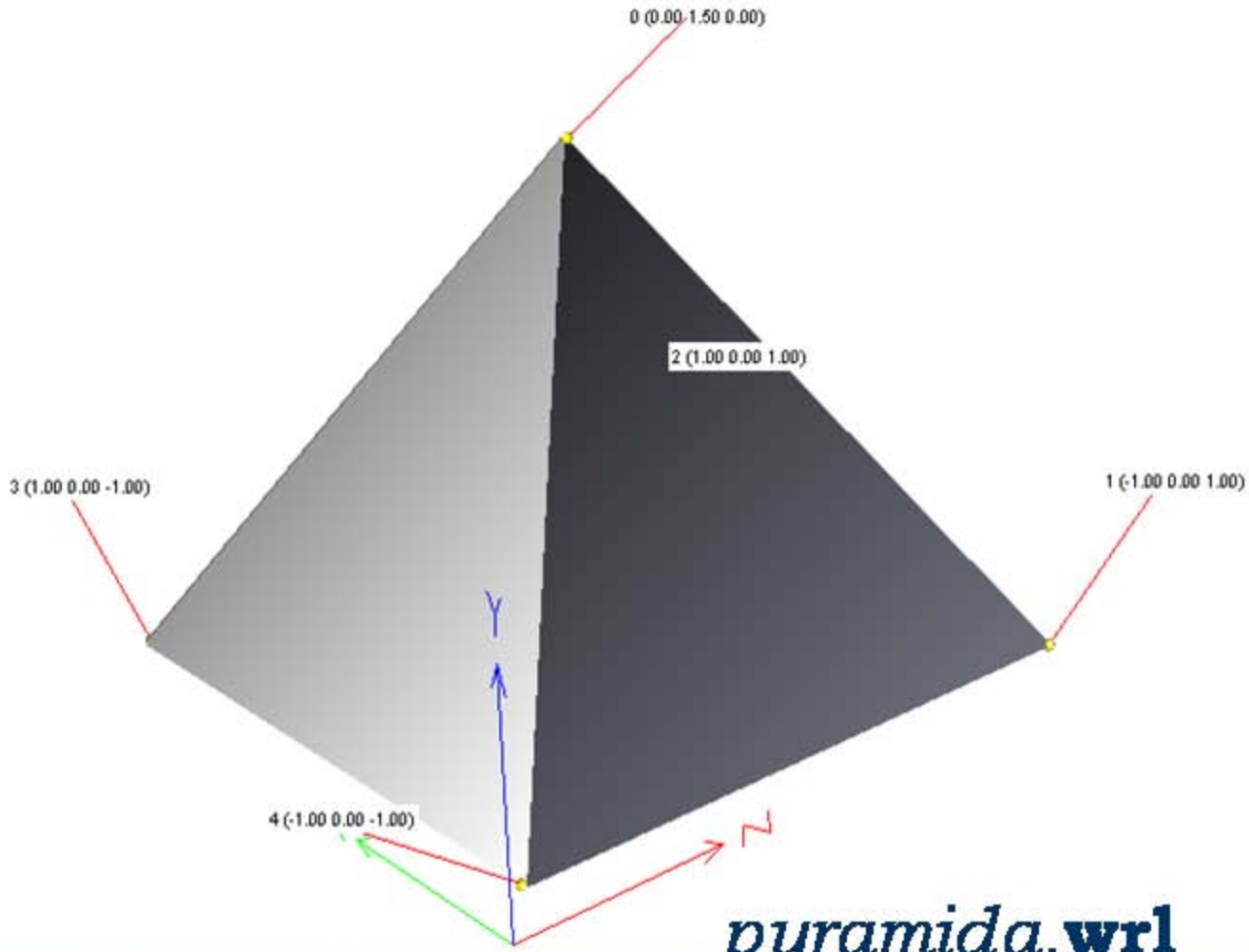
```


MPEG7 description

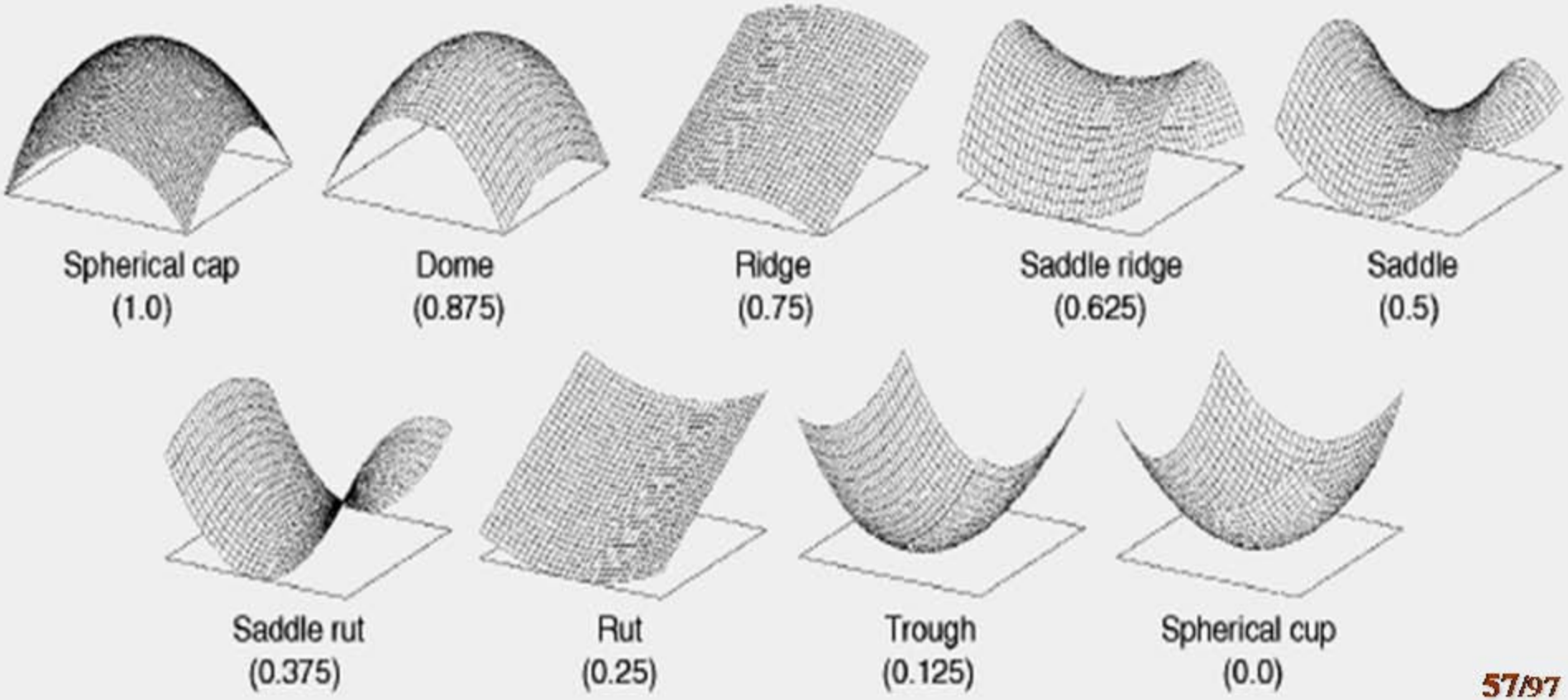
VRML (Virtual Reality Modeling Language) (example)

```
#VRML V2.0 utf8
Shape {
geometry IndexedFaceSet {
coordIndex [
0, 1, 2, -1,
0, 2, 3, -1,
0, 3, 4, -1,
0, 4, 1, -1,
1, 4, 3, 2
]
coord Coordinate {
point [
0.00 1.50 0.00,
-1.00 0.00 1.00,
1.00 0.00 1.00,
1.00 0.00 -1.00,
-1.00 0.00 -1.00
]
}}}
```



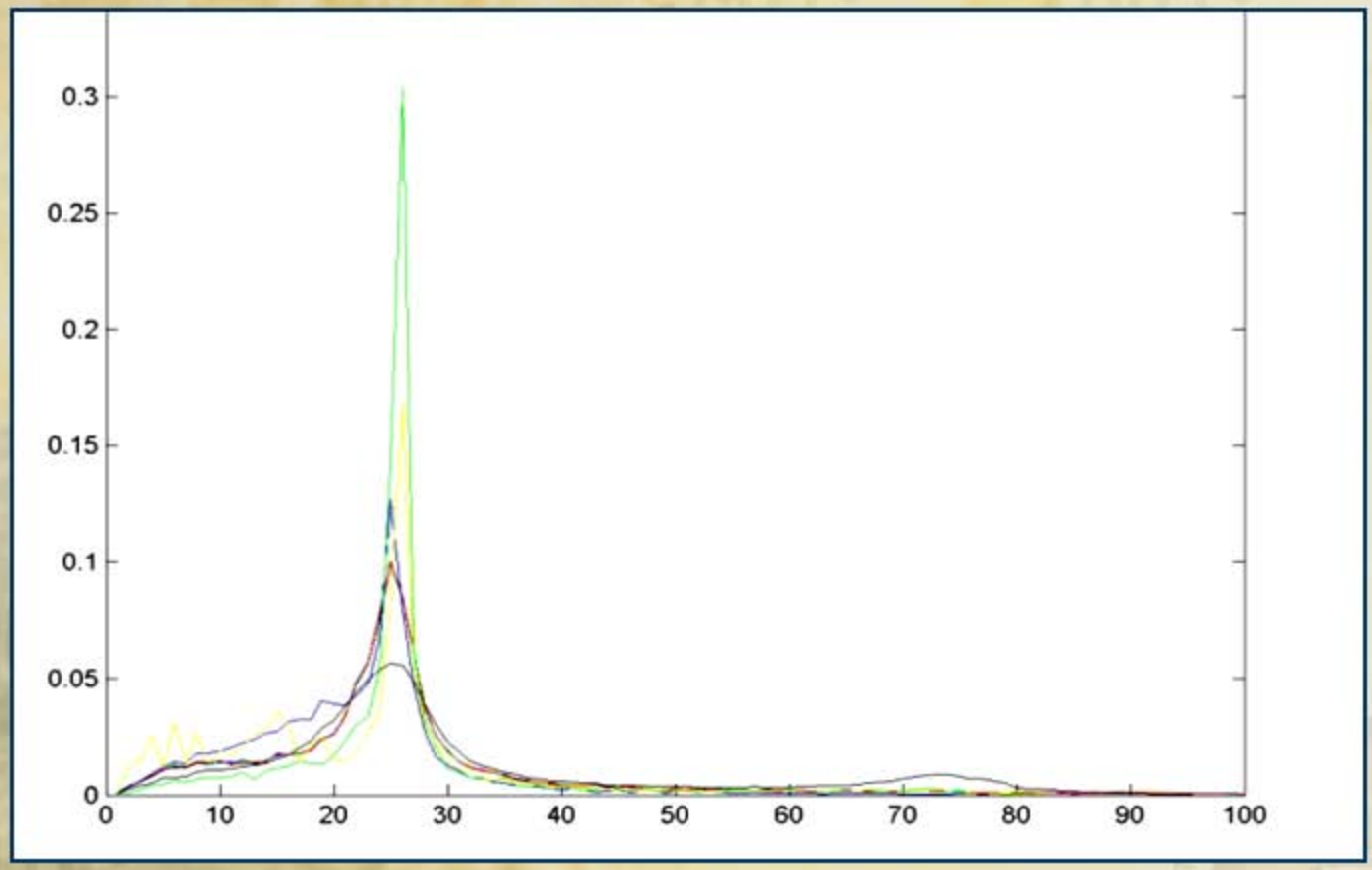
pyramida.wrl

Shape Index of Elementary 3D surfaces

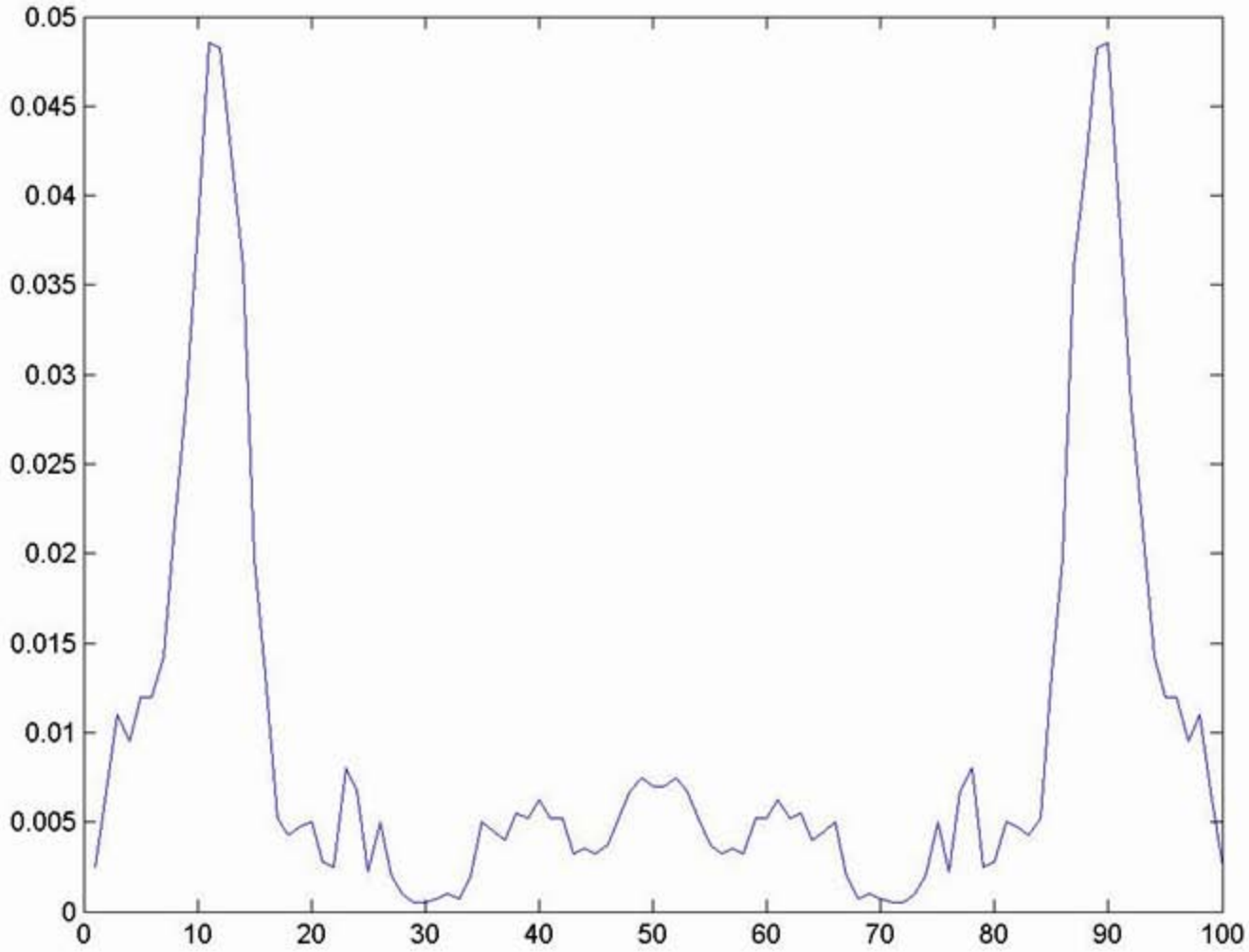


12 androids (example)

Example 1 Shape Spectum Histogram



Example 2


0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0
10
20
30
40
50
60
70
80
90
100

Xml Description


```
<?xml version="1.0" encoding="ISO-8859-1" ?>
<Mpeg7 xmlns="http://www.mpeg7.org/2001/MPEG-7_Schema"
xmlns:xsi="http://www.w3.org/2000/10/XMLSchema-instance">
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<FileName>CP_vase_1205_lr.xml</FileName>
<Descriptor xsi:type="Shape3DType">
<numberOfBins>100</numberOfBins>
<bitsPerBin>12</bitsPerBin>
<Spectrum>1 5 9 11 15 18 21 24 26 27 32 32 34 37 40 41 44 50 52 57 61
68 66 69 69 67 60 54 51 47 41 38 34 31 27 26 22 21 20 17 16 14 13 13
13 13 12 11 11 10 10 10 10 10 9 11 10 10 10 11 13 13 12 13 13 14 16
14 18 16 17 14 15 13 12 11 10 8 8 7 7 6 6 4 3 4 3 3 4 2 2 2 1 1 1 0 1 0 0
0</Spectrum>
<PlanarSurfaces>2047</PlanarSurfaces>
<SingularSurfaces>0</SingularSurfaces>
</Descriptor>DescriptionUnit></Mpeg7>
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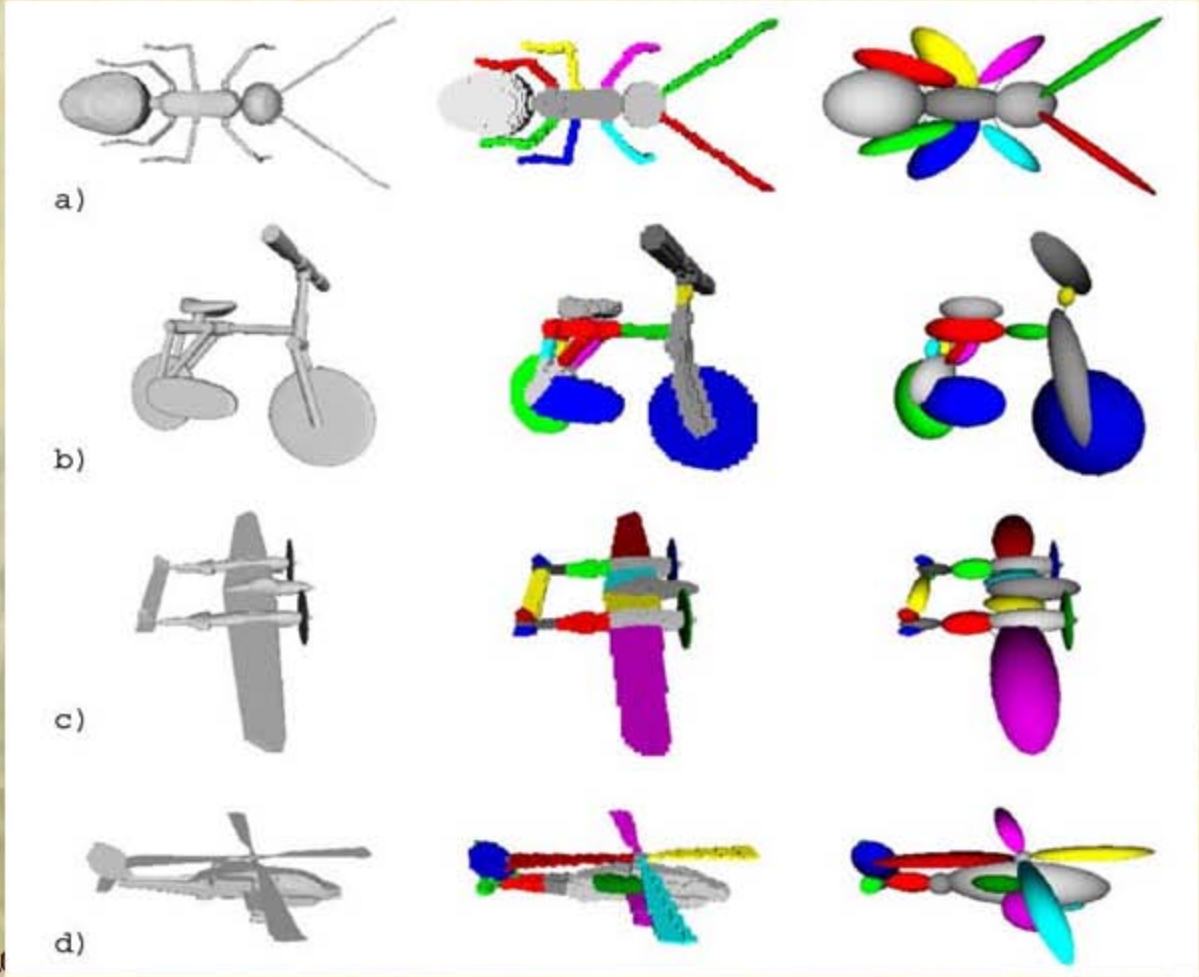
Perceptual 3D Shape Descriptor



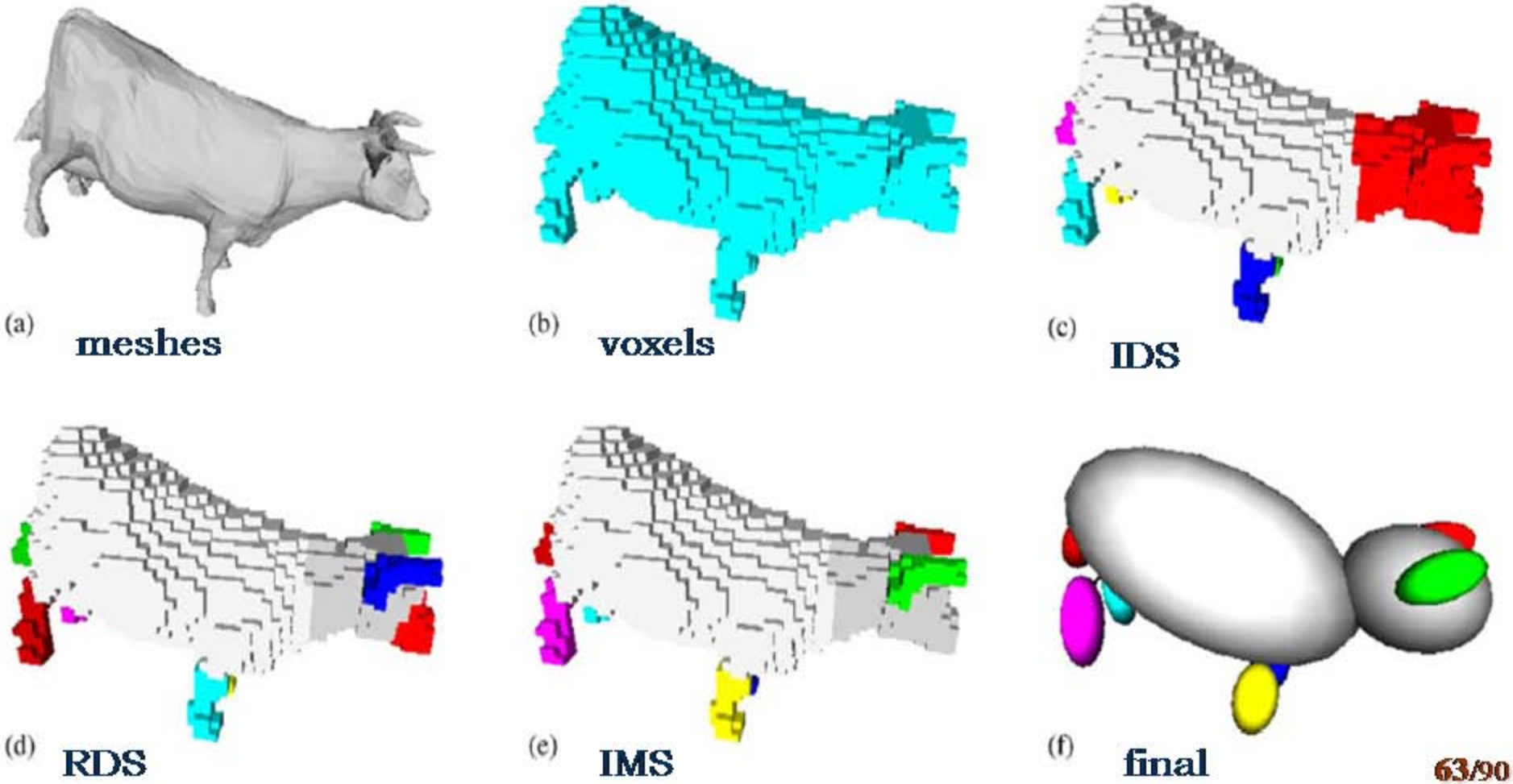
11 parts

14 parts

20 parts

20 parts

Pixels (2D) → Voxels (3D)



XML Descriptor


```
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<Mpeg7 xmlns = "urn:mpeg:mpeg7:schema:2001" xmlns:xsi
        "http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation =
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        "DescriptorCollectionType"><Descriptor xsi:type = "Perceptual3DShape">
<Descriptor xsi:type = "Perceptual3DShape"><numberOfNodes>4</numberOfNod
<BitsPerAttribute>6</BitsPerAttribute>
<IsAdjacent>1 1 1 0 0 0 </IsAdjacent>
<Volume>47 2 6 6 </Volume>
<Center_X>34 5 31 31 </Center_X>
<Center_Y>31 31 20 42 </Center_Y>
<Center_Z>31 31 31 31 </Center_Z>
<Transform_1>63 62 39 24 </Transform_1>
<Transform_2>32 32 63 63 </Transform_2>
<Transform_3>29 40 32 31 </Transform_3>
<Transform_4>32 23 62 62 </Transform_4>
<Transform_5>63 32 24 39 </Transform_5>
<Transform_6>32 62 29 29 </Transform_6>
<Variance_X>26 6 16 16 </Variance_X>
<Variance_Y>3 3 6 6 </Variance_Y>
<Variance_Z>3 2 2 2 </Variance_Z>
<Convexity>53 41 28 28 </Convexity>
</Descriptor></DescriptionUnit></Mpeg7>
```

111000 →
1 1 1
0 0
0

http://195.251.3.13:81/mpeg7

CONNECT

Address http://195.251.3.13/mpeg7/

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Overview of MPEG-7 Audio

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Recording Cultural Heritage in 3D

- Digitization in 3D
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- Visualization & Dissemination of 3D data
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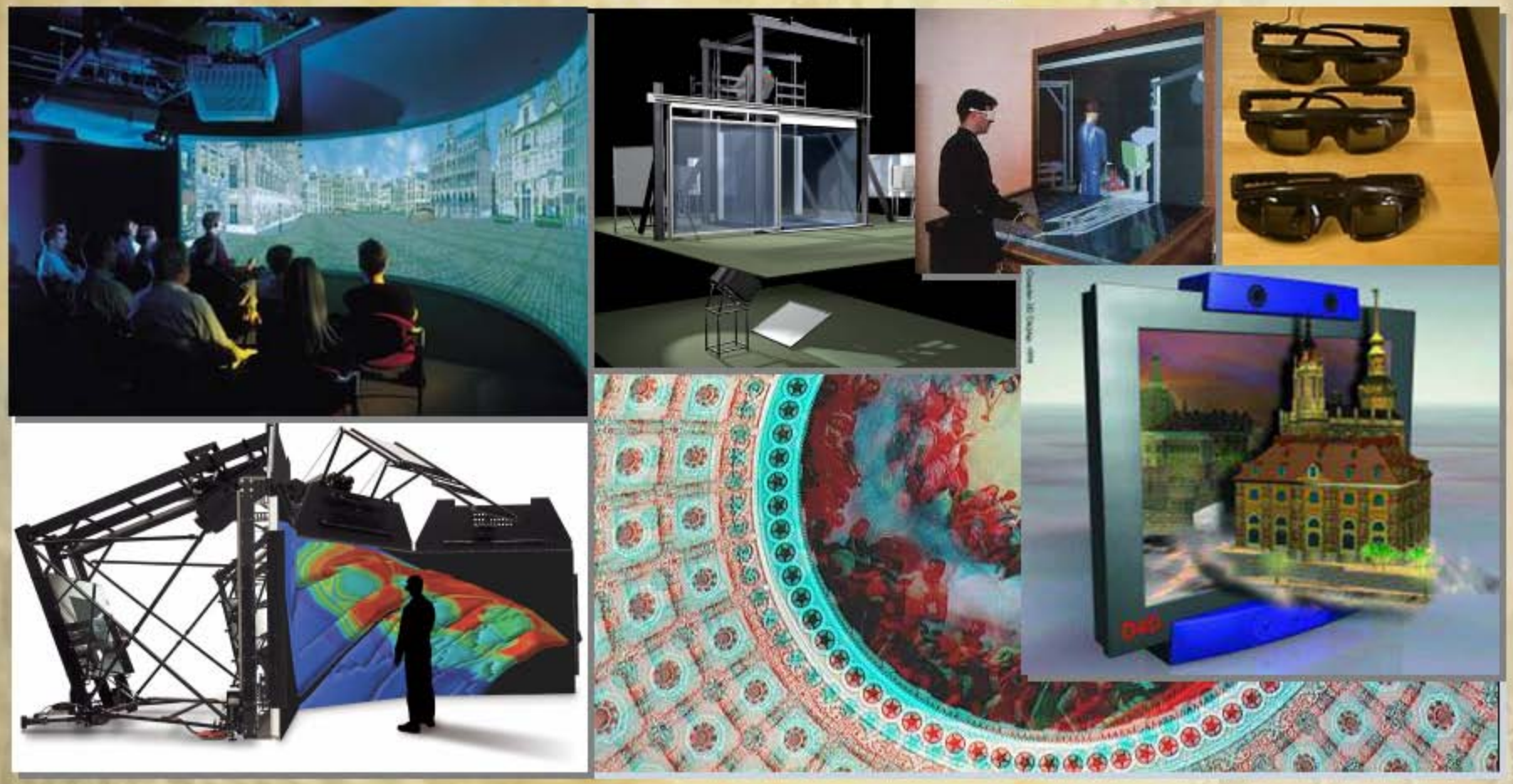
Processes involved in 3D digital recording

3D data visualization/projection

Factors that influence the choice of a 3D visualization device:

- Number of **concurrent spectators**
- Possibility or demand for **stereoscopic visualization**
- Level of user **interactivity**

3D data visualization/projection



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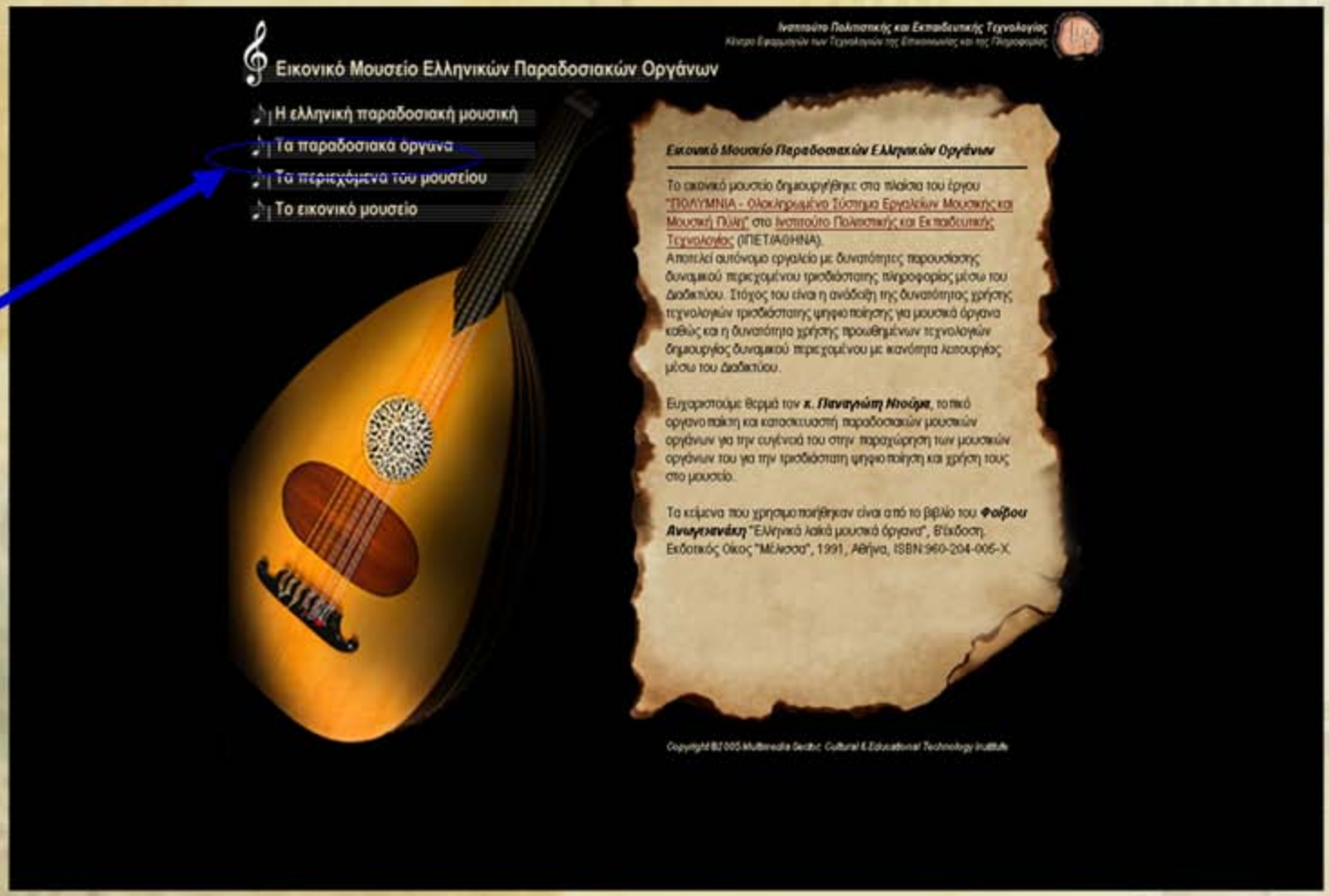
DYNAMIC VIRTUAL MUSEUM OF MUSICAL INSTRUMENTS



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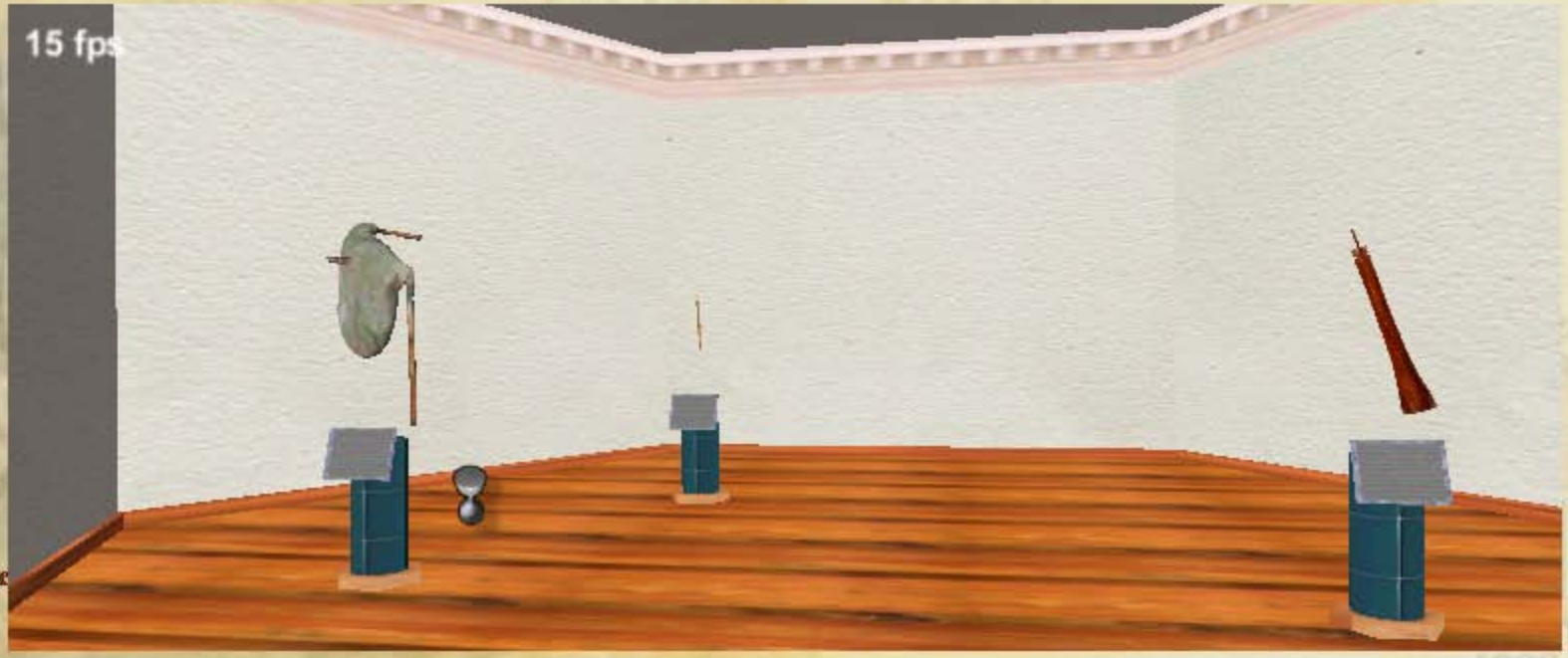
http://www.ipet.gr/momi

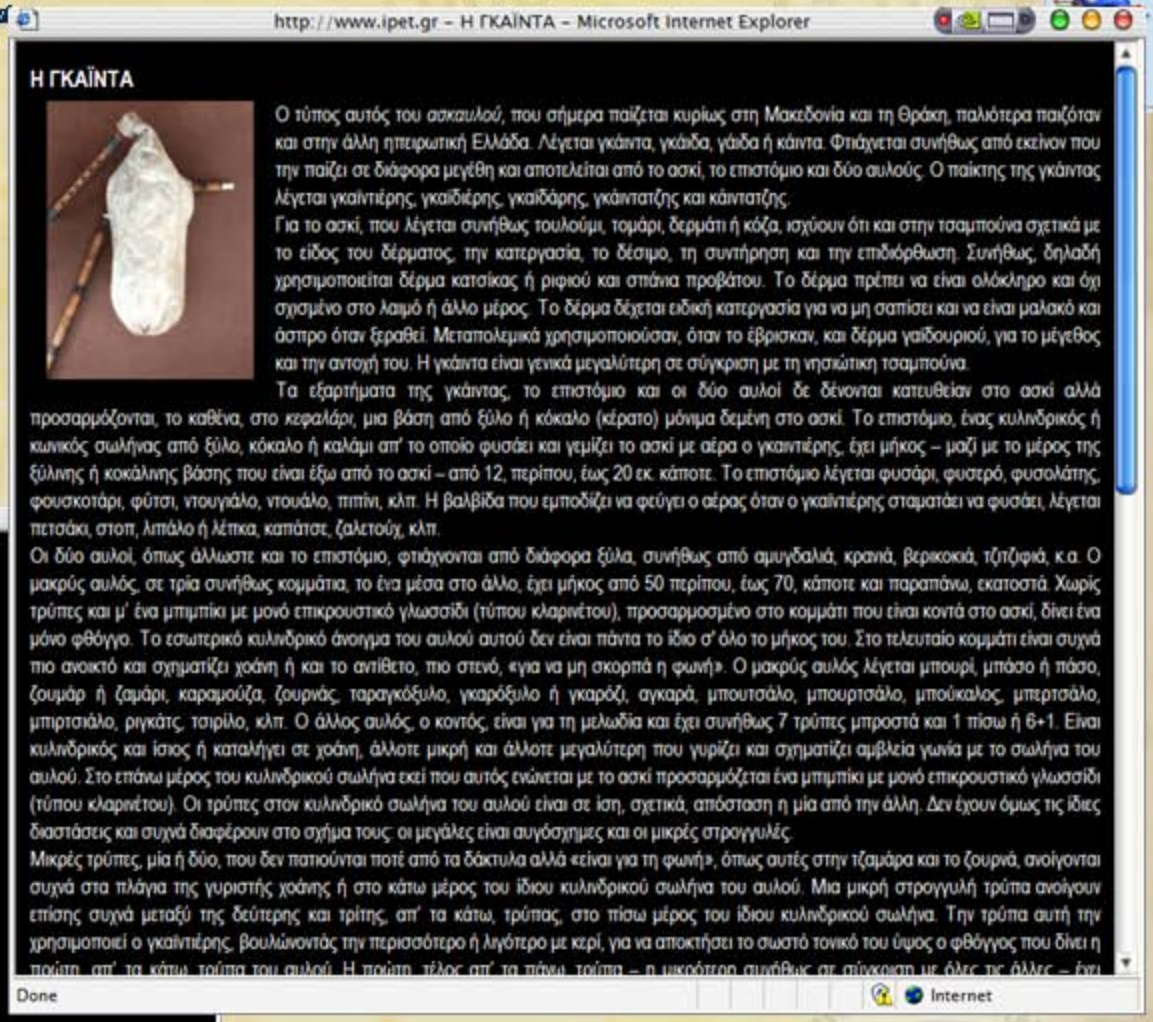
15 fps
ΕΓΧΟΡΔΑ
ΚΡΟΥΣΤΑ

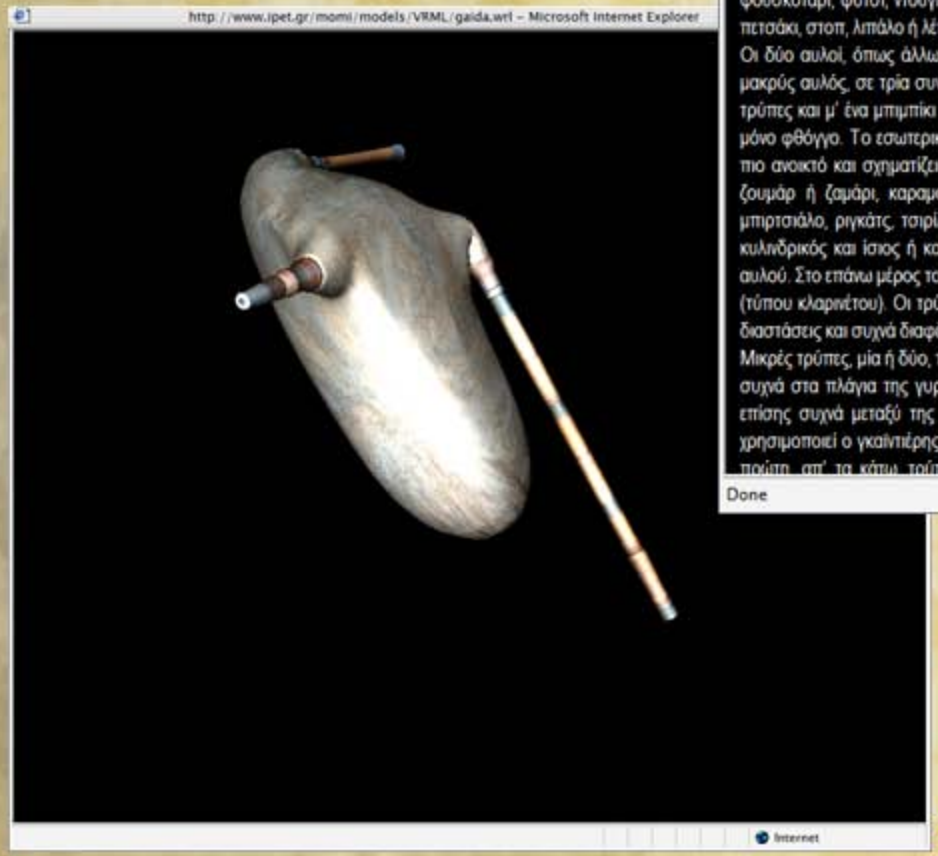
15 fps
ΚΡΟΥΣΤΑ

14 fps


15 fps

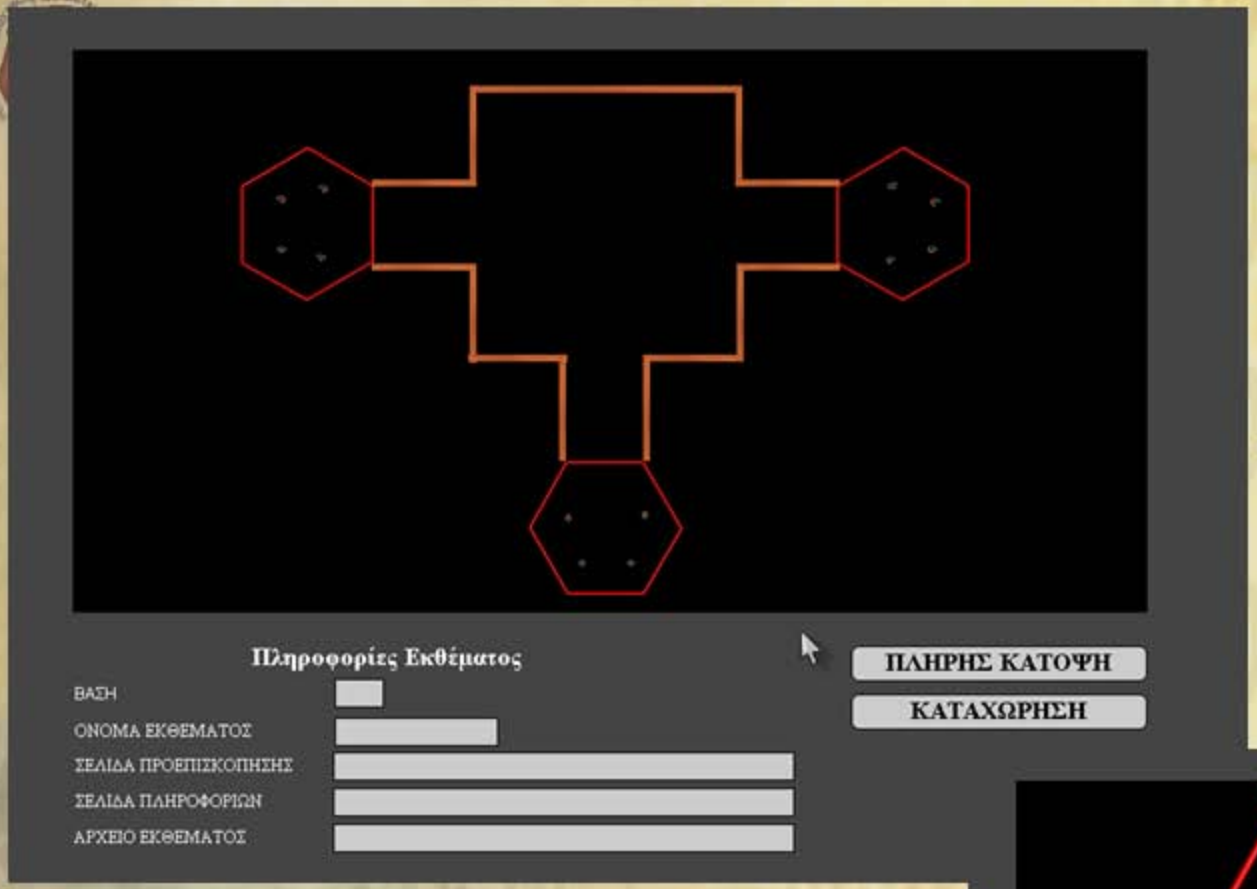
Clicking on a screen under an instrument pops-up the information page





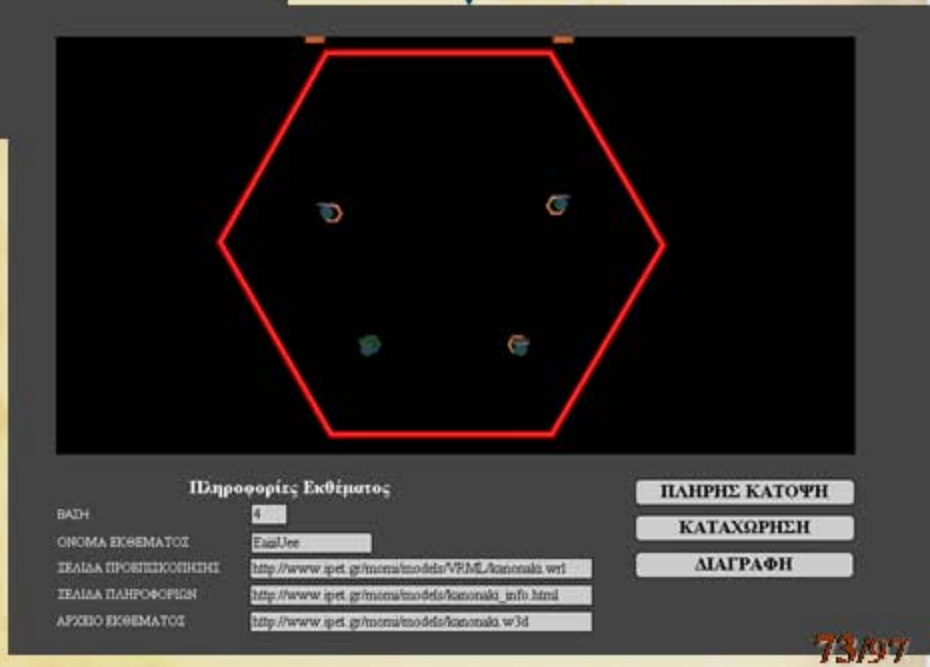
←
Clicking on an instrument pops-up a full scale VRML models

See an example instrument VRML model



Clicking a dot zooms to corresponding room and loads data

Online administration



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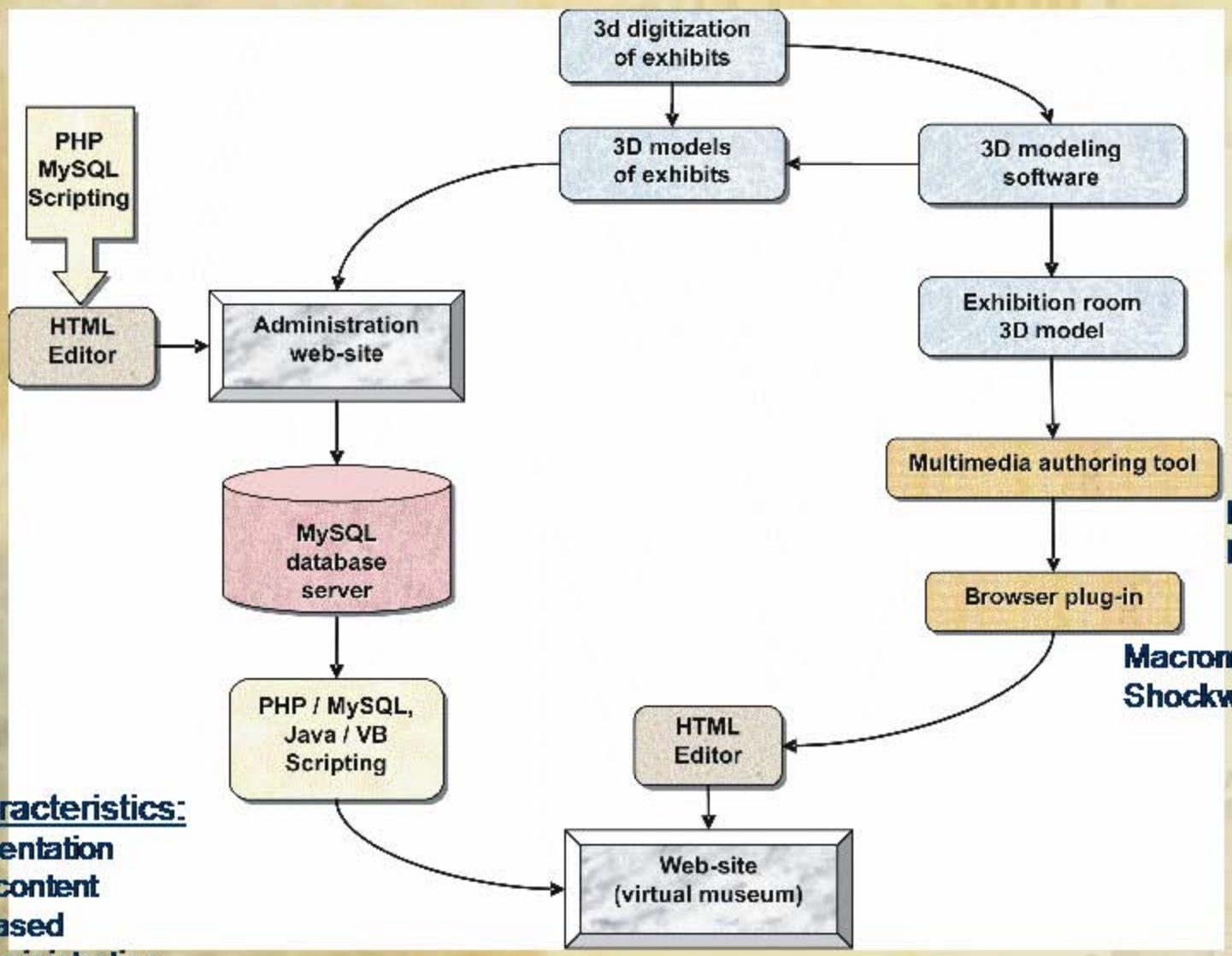
Current implementation supports this museum design
Up to 12 exhibits



Macromedia Director

Macromedia Shockwave3D

Main Characteristics:

- 3D representation
- Dynamic content
- Internet based
- Online administration

Process cycle: from digitization to the museum

PUBLICATIONS

1. *Pavlidis G., Tsiafakis D, Arnaoutoglou F., Chamzas C., Provopoulos G., Chatzopoulos S., "MOMI: A dynamic and internet-based 3D virtual museum of musical instruments", 3-rd International Conference on Museology", Mytilene, 5-8 June 2006*

Recording Cultural Heritage in 3D

Digitization in 3D

Processing & Storage of 3D data

Archiving, Management & Retrieval of 3D data

Visualization & Dissemination of 3D data

Replication & Reproduction of 3D data

Algorithms

Hardware

Software

Processes involved in 3D digital recording

3D data replication/reproduction

- Production of multiple digital replicas
  - Multiple replica production devices
    - CD ROMs
    - DVD ROMs

- Physical object reproduction
  - 3D printing/plotting/milling devices
    - Material deposition devices
    - Stereo-lithography devices

"Digitization And Archiving of Archaeological Sites"
The Karabournaki Case

- *Remains of a settlement including harbor and cemeteries*
- *Late Bronze Age to the Roman times*
- *Flourished during Archaic times (7th-6th cent.)*

Motivation: Definition of the problem

Archaeology is based on systematic collection and analysis of data through excavation and other forms of field-work.

- ***Recording***
- ***Management***
- ***Visualization***
- ***Dissemination***

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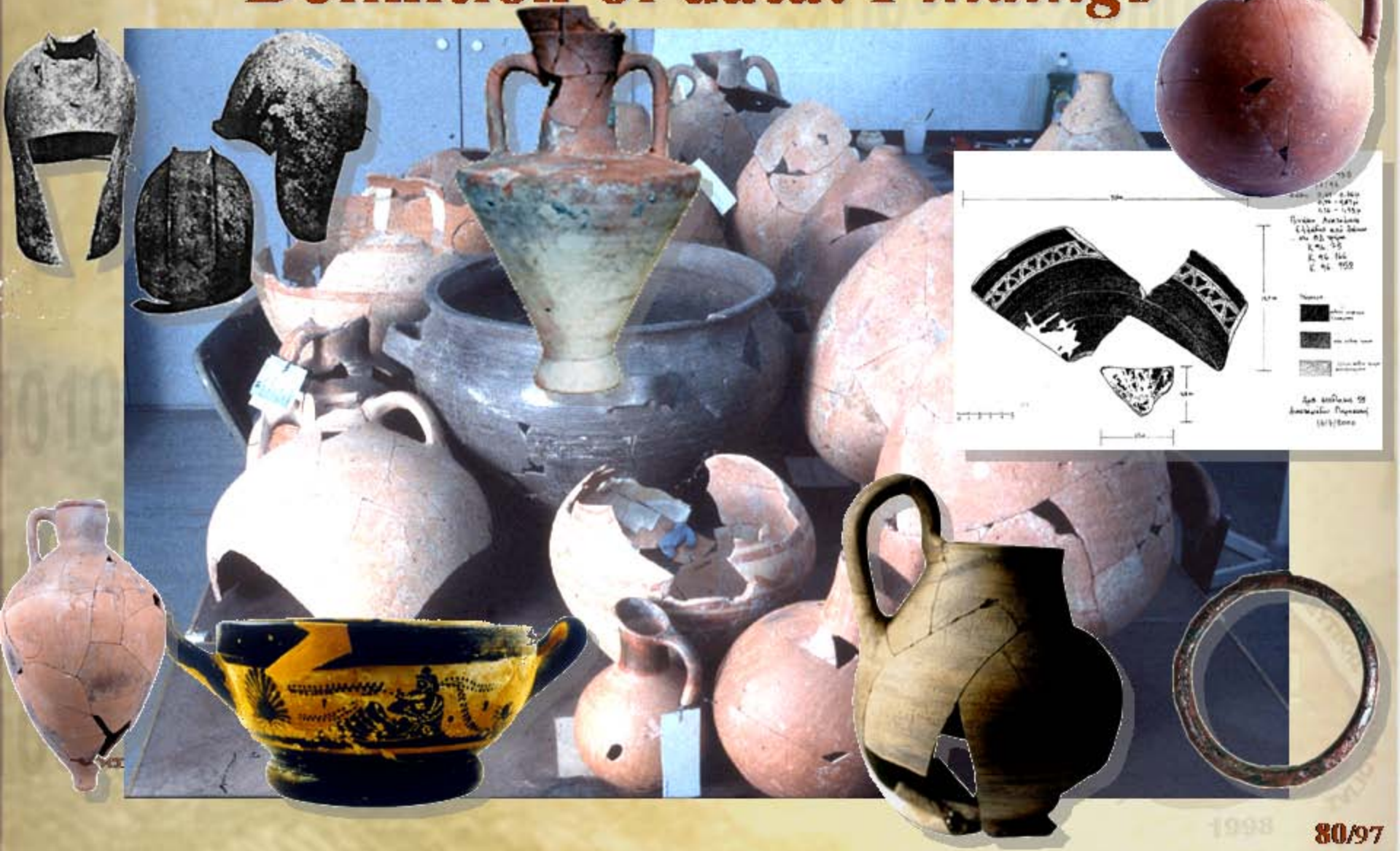
Definition of data: *Findings*



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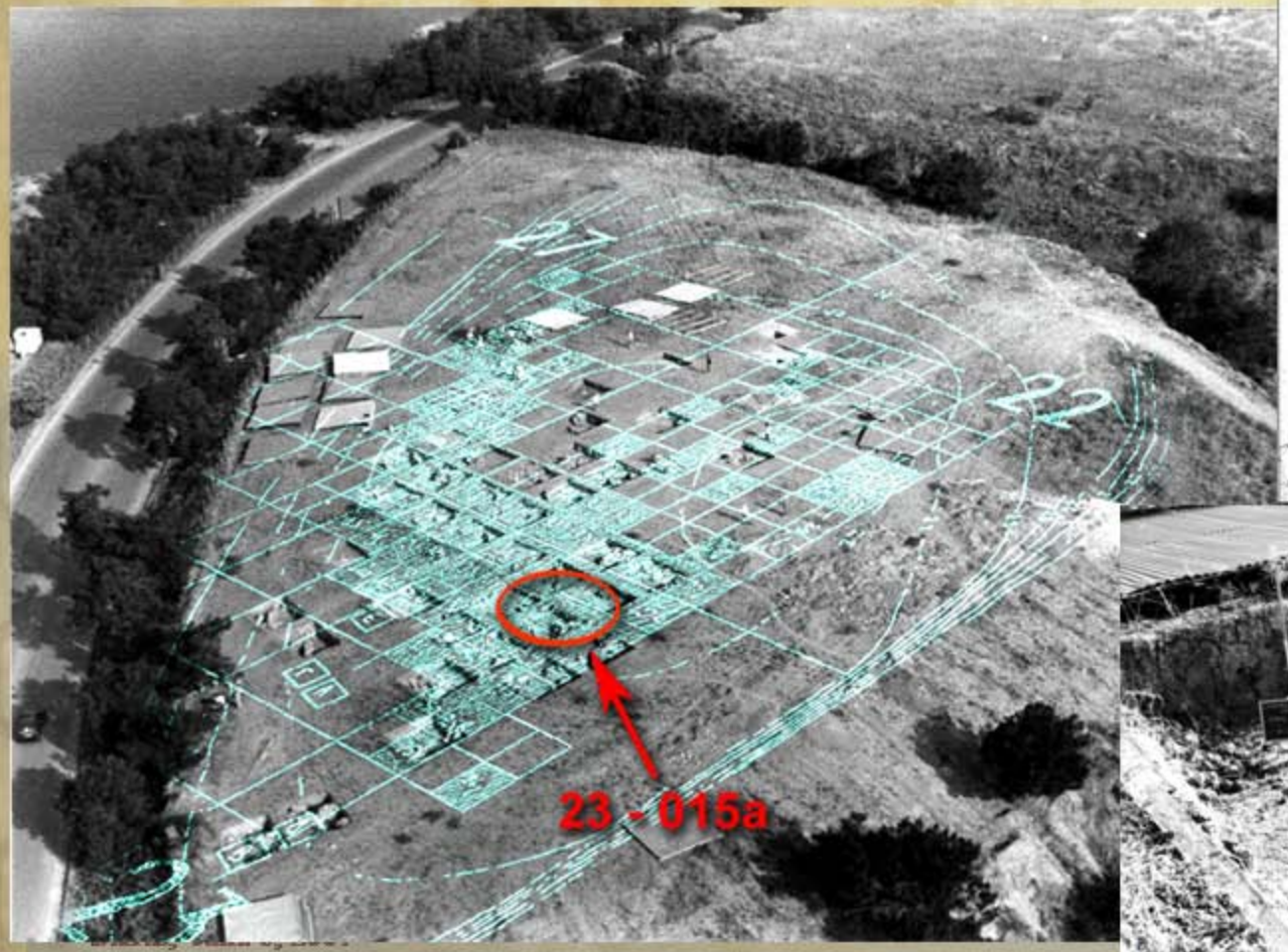
Definition of data: *Trenches*



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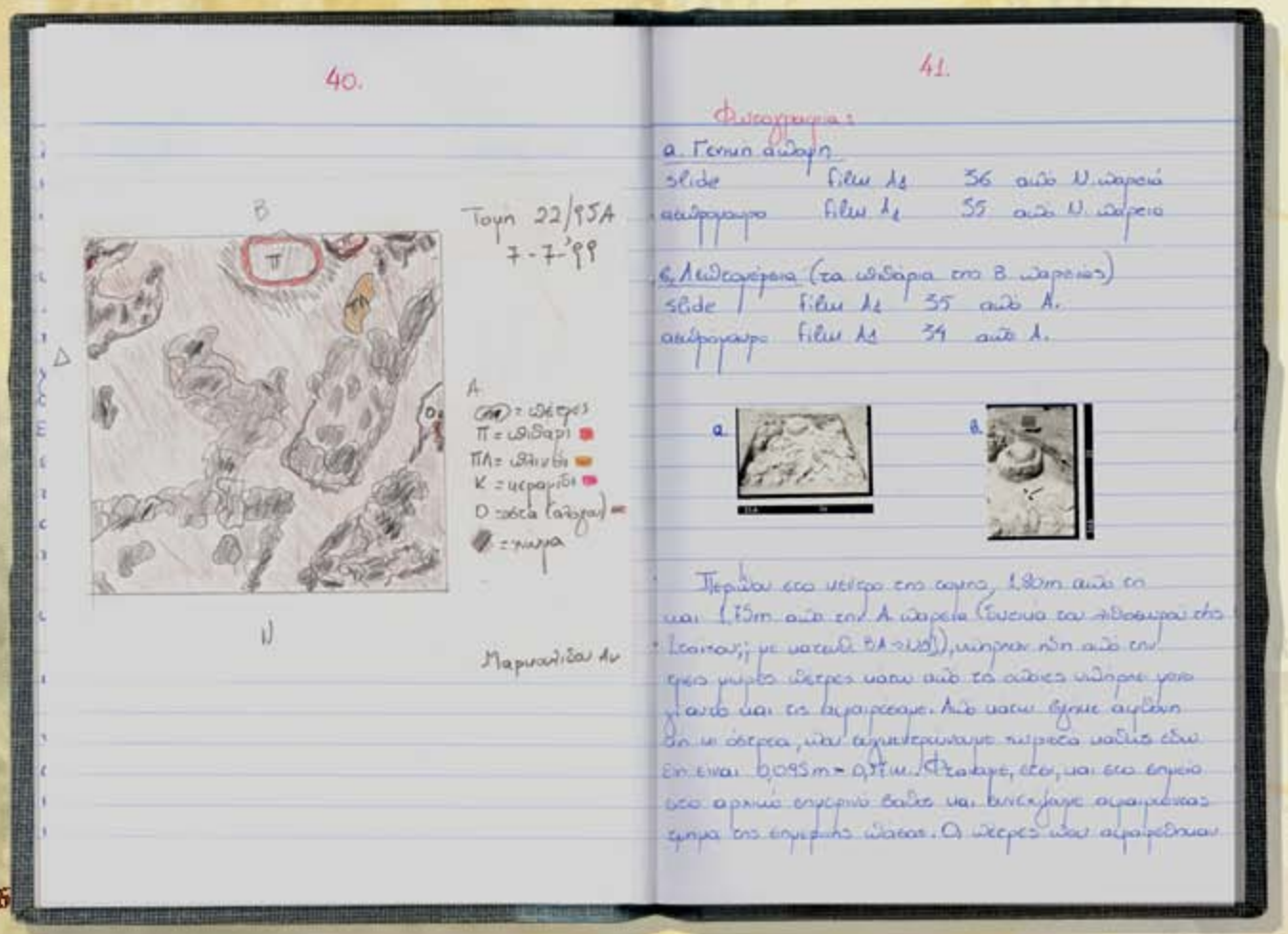
Definition of data: *Excavation Notes*



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"Digitization And Archiving of Archaeological Sites"
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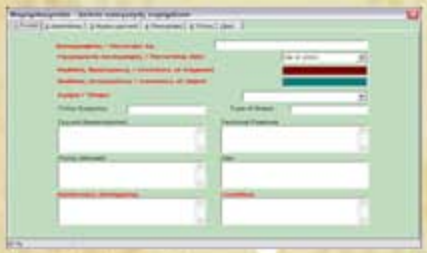

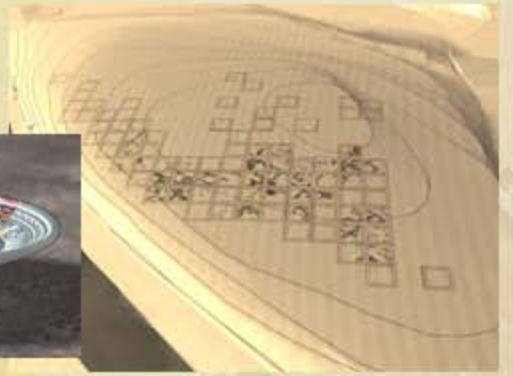

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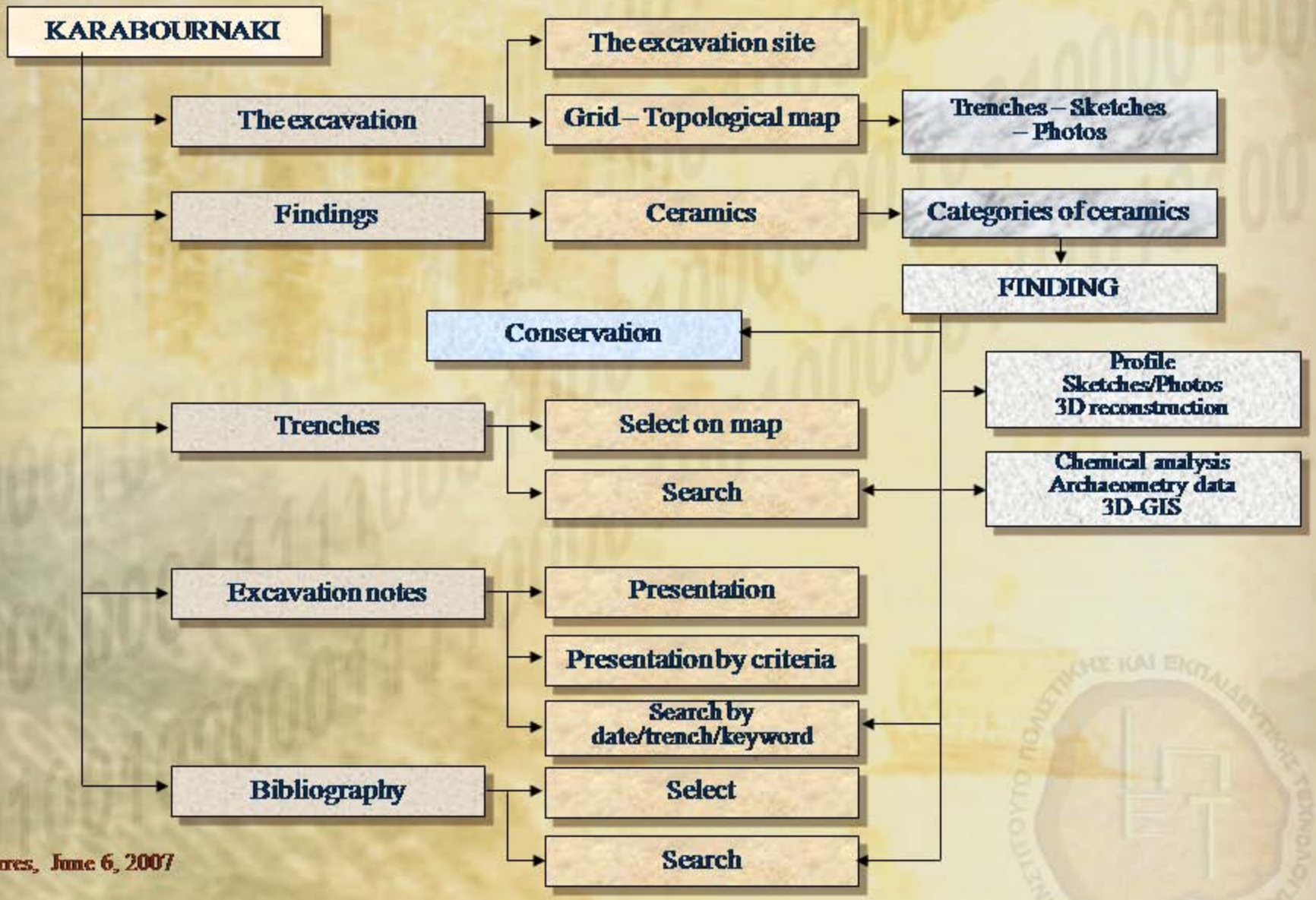
Data structure



2D Digitization/3D reconstruction: Fruit stand

3D reconstruction process overview

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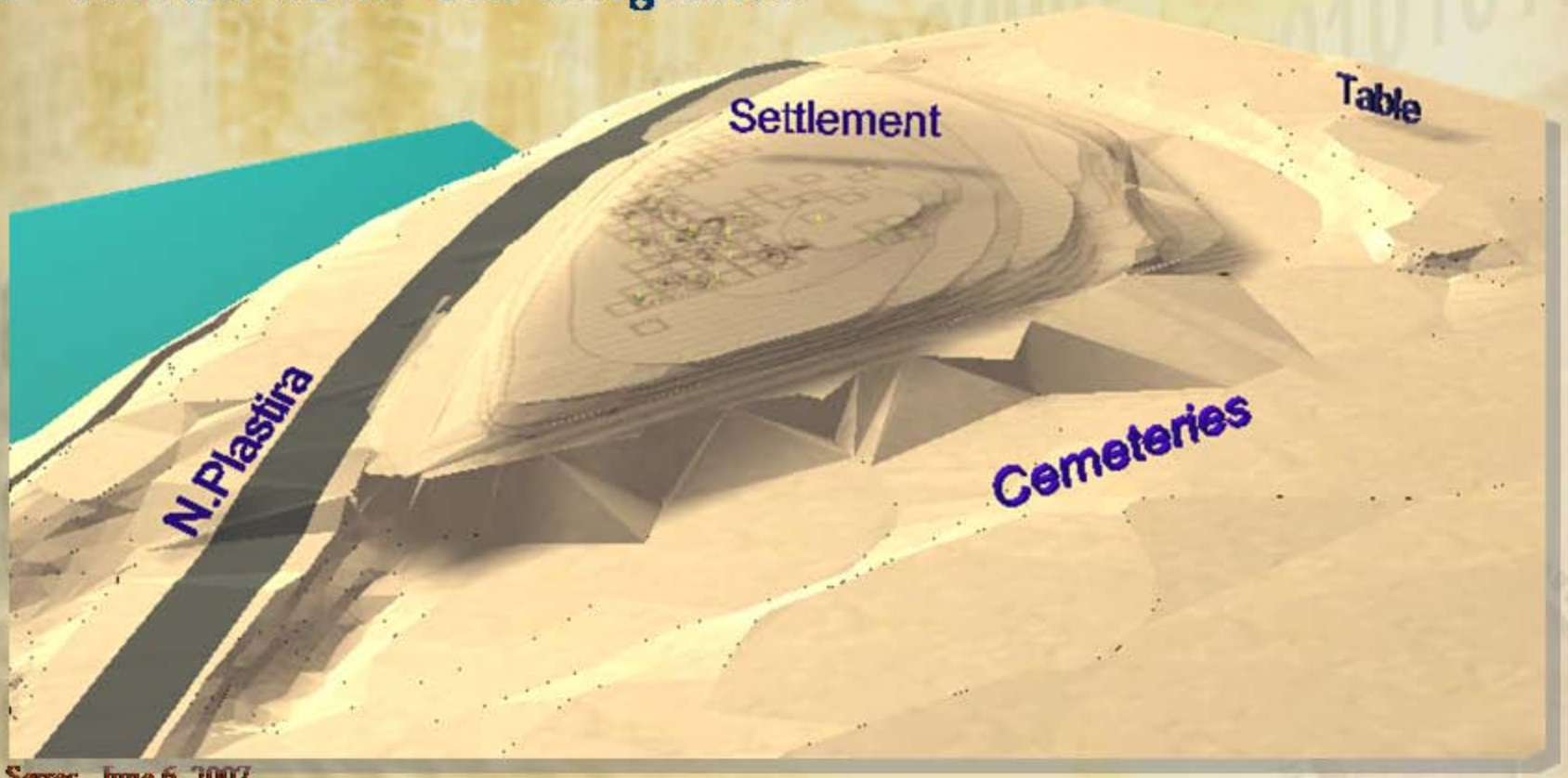
DEMO 3D

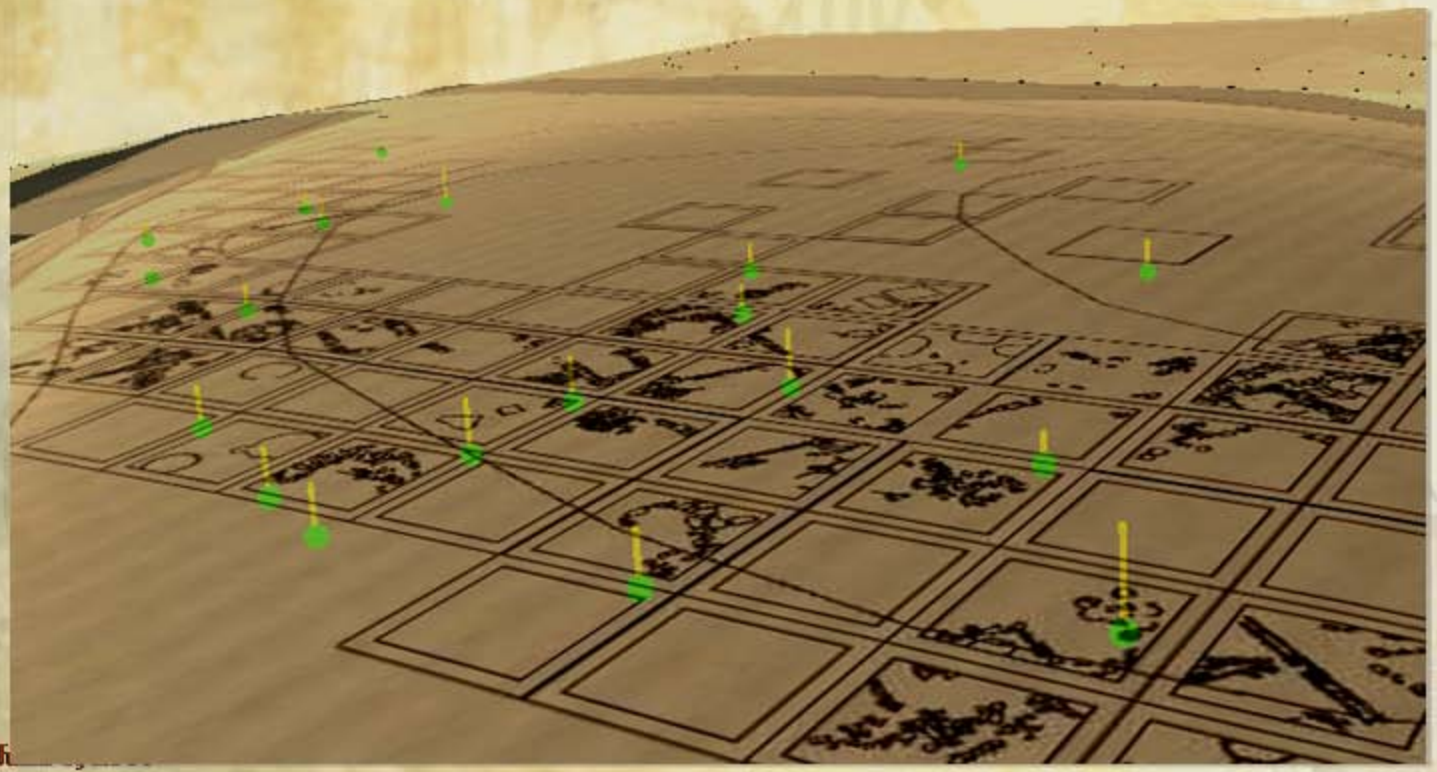
GIS representations

- *Current work: GIS integration*



GIS representations

GIS based query in 3d space (East Greek pottery)



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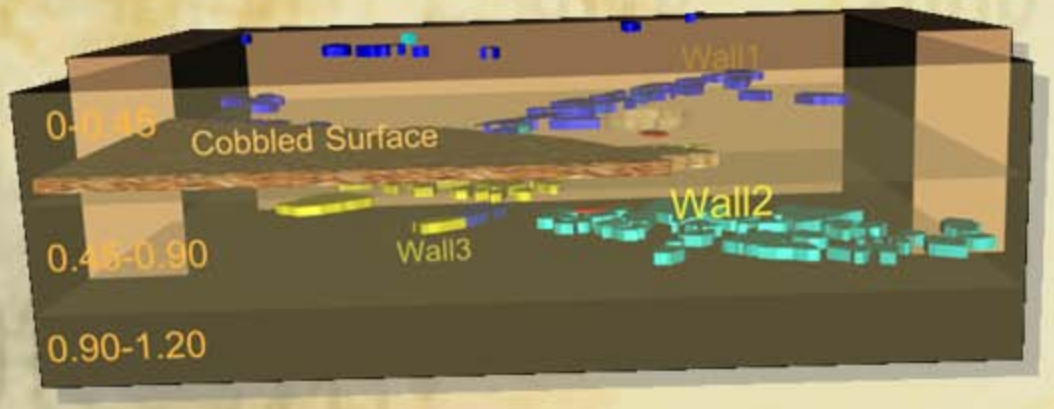
DEMO 3D

GIS representations



PUBLICATIONS

1. *D. Tsiafaki, A. Tsompanopoulos, G. Pavlidis, D. Papadopoulou, N. Tsirliganis, V. Evangelidis, C. Chamzas, "Archiving Cultural Objects in the 21-st century:Pottery from Karabournaki", XVI International Congress of Classical Archaelogy, 23-26 August 2003, Harvard University, Boston, U.S.A.*
2. *D. Tsiafakis, N. Tsirliganis, G. Pavlidis, V. Evangelidis, C. Chamzas, , "Karabournaki-Recording the Past: the Digitization of an Archaeological Site", EVA 2004:Conference of Electronic Imaging and the Visual Arts, March 29-April2, 2004, Florence, Italy.*

Conclusions

3D digitization is a** multi-dimensional process, **that depends upon the** **nature of the subject** **as well as the** **purpose of its application.

3D digitization involves:

- Digitization
- Storage
- Archiving & Management
- Retrieval
- Visualization
- Replication/Reproduction

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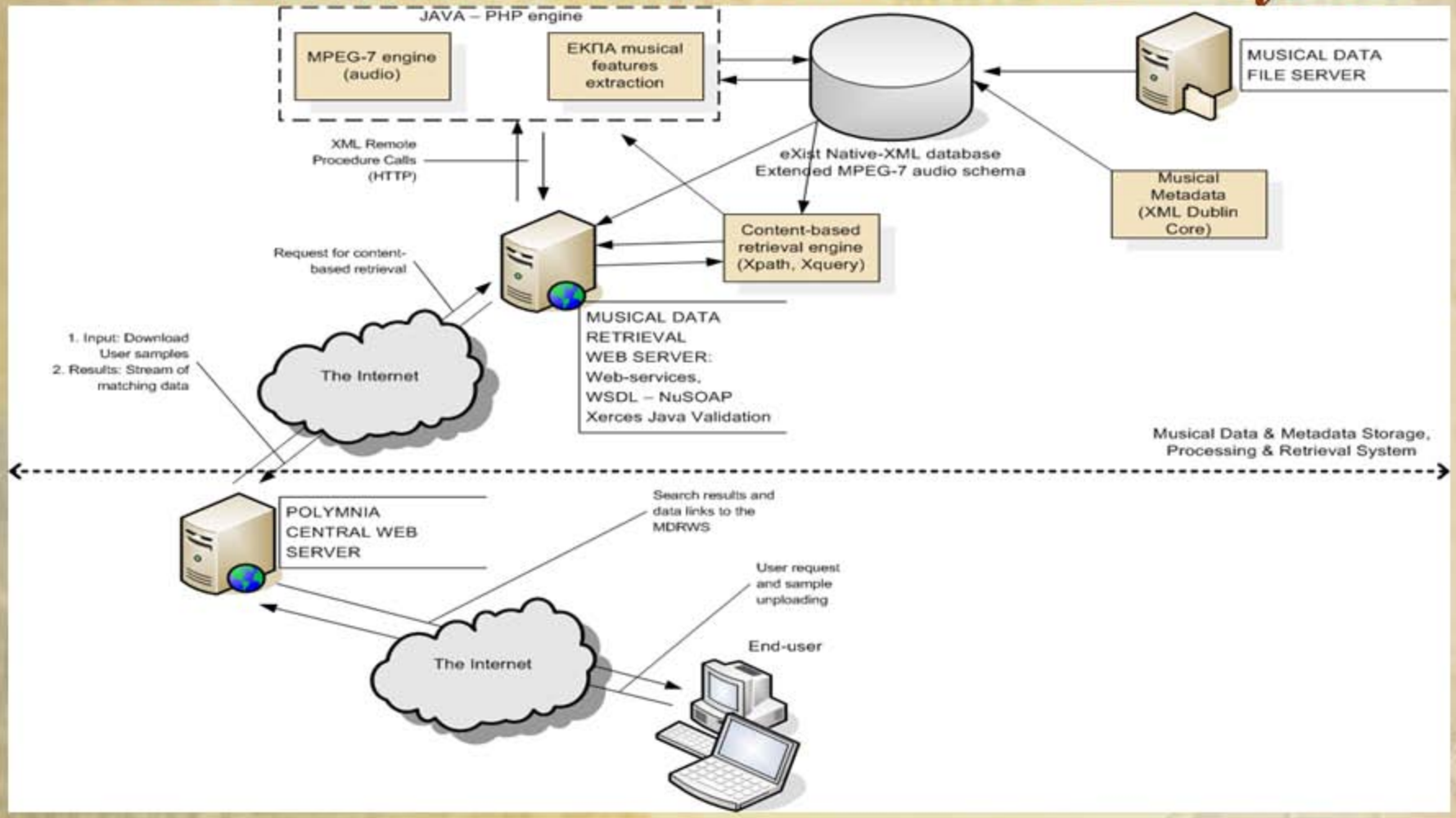
AUDIO-VIDEO LABORATORY

Specialized Audio and Video Systems

Serres, June 6, 2007

Traditional Greek Music Content Retrieval System



http://195.251.3.13/mpeg7

Address http://195.251.3.13/mpeg7/

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Overview of MPEG-7 Audio

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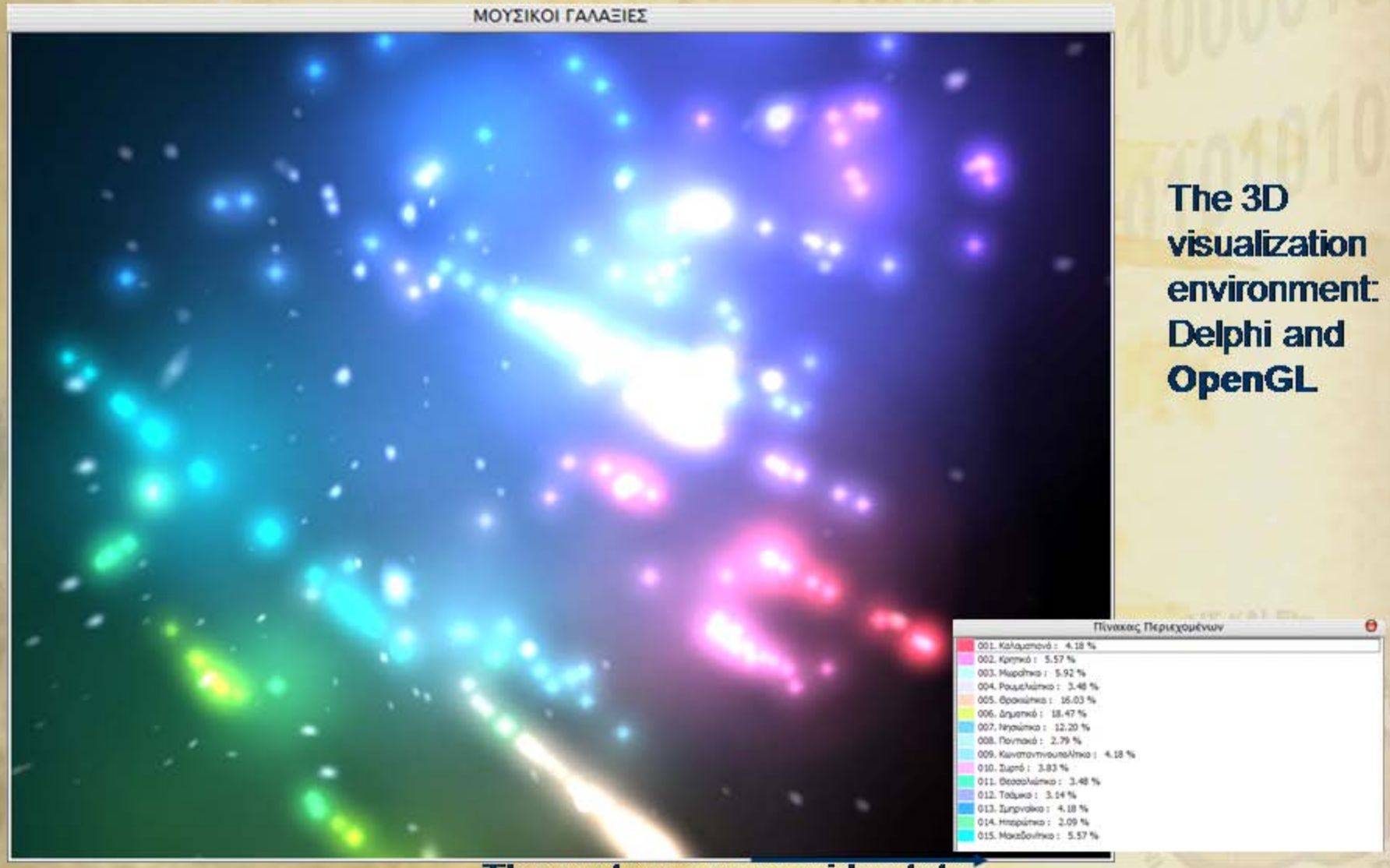
Traditional Greek Music Genre Classification and Visualization System



The 3D visualization environment: Delphi and OpenGL

The system can provide stats

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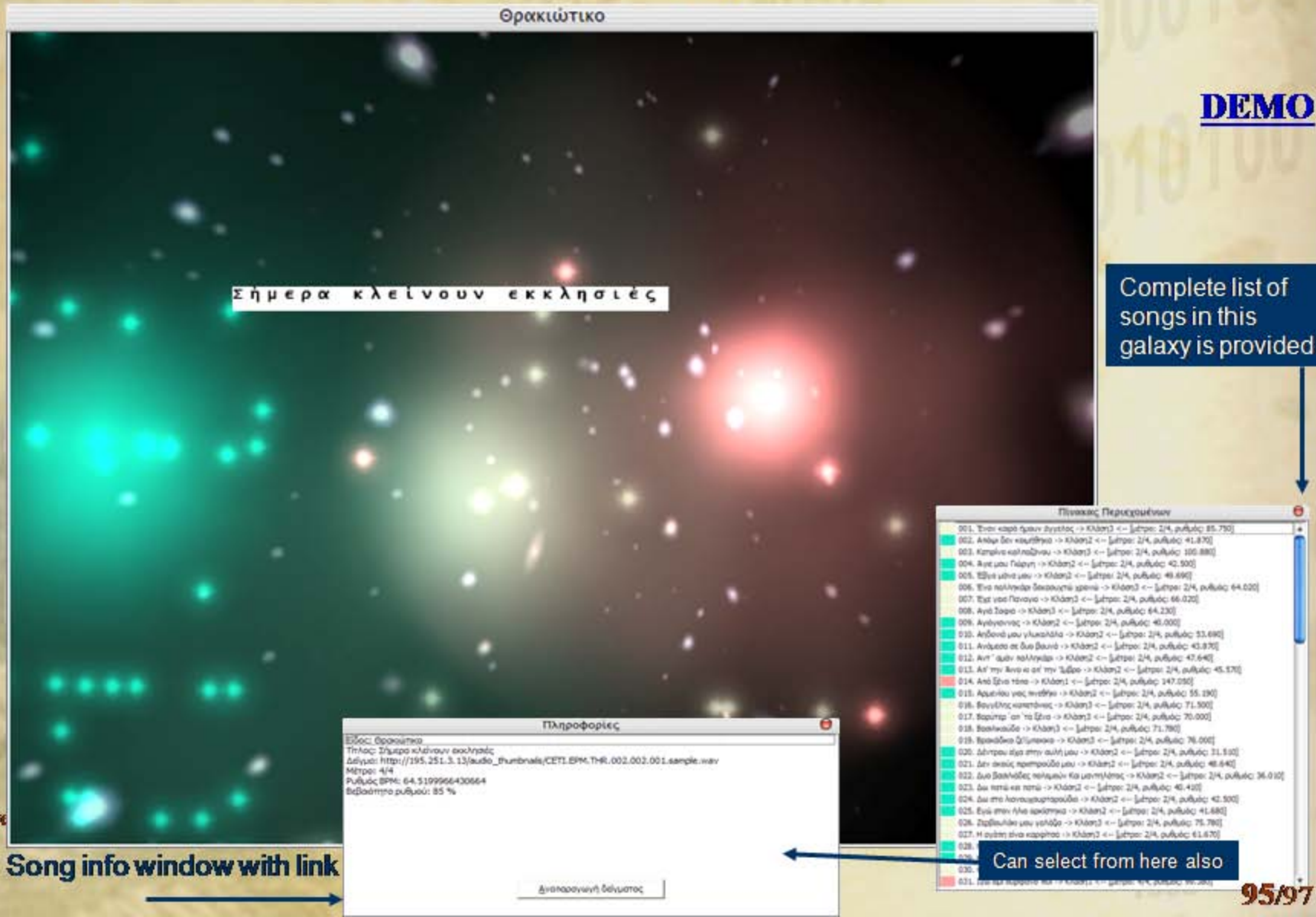
The galaxy-scale of the visualization: each planet is a song and there is a link on it to its data and sample URL for playback. The bright stars without links on them are the planetary system's "suns" (i.e. the clusters' centroids)

DEMO



Complete list of songs in this galaxy is provided

Can select from here also

Song info window with link

PUBLICATIONS

1. Pavlidis G., Tsiafakis D, Arnaoutoglou F., Balla K., Chamzas C., Pikrakis A., "Musical Universe", 3-rd International Conference on Museology", Mytilene, 5-8 June 2006
2. Tsekeridou S., Kokonozi A., Stavroglou K., Chamzas C., "MPEG-7 based metadata extrensins for traditional Greek Music Retrieval", MRCS Conference, Instanbul Turkey, 11-13 September 2006 (Lecture Notes in Computer Science, Multimedia Content Representation Classification and Security, Volume 4105, 2006, Springer Berlin / Heidelberg, pp 426-433)
3. Koutsoudis A., Arnaoutoglou F., Pavlidis G., Chamzas C.,"3D content-based visualization of databases", International Conference on Knowledge Generation, Communication and Management, Orlando, Florida, U.S.A. July 8-11, 2007

END

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