Digitisation, processing and visualisation of monuments within the 3D-ICONS framework

The case *of* Athena RC

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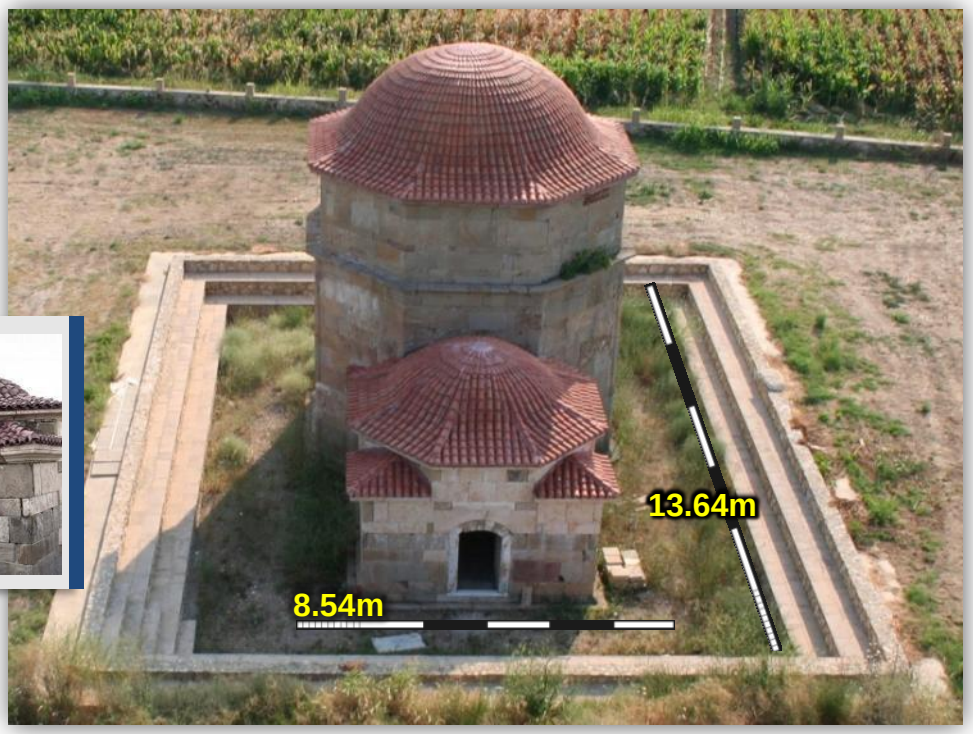
Major monuments promised to be delivered…

First Collection : Ottoman Monuments in Thrace, Greece

- **Kioutouklou Baba Bekctashic Teke**
  - Ottoman period (1354 - 1920)
  - Historical scheduled monument
  - Sidini, Xanthi, Greece
  - Funerary site - place of worship





Major monuments promised to be delivered…

Second Collection : Paleochristian and Byzantine Monuments in Northern Greece

- **Church of the Holy Apostles**
  - 14th Century
  - Included in Unesco's world heritage list
  - Located in the center of Thessaloniki
  - Still in service

Major monuments promised to be delivered…

Second Collection : Paleochristian and Byzantine Monuments in Northern Greece

- **Church of the Acheiropoietos**
  - 5th Century
  - Included in Unesco's world heritage list
  - Located in the center of Thessaloniki
  - Still in service
  - Major restoration of the interior mosaics

Major monuments promised to be delivered…

Second Collection : Paleochristian and Byzantine Monuments in Northern Greece

- **Church of St. George (Rotunda)**
  - 4th Century
  - Included in Unesco's world heritage list
  - Located in the center of Thessaloniki
  - High number of visitors on a daily basis

Major monuments promised to be delivered…

Third Collection : Monastic monuments of Northern Greece

- **Monastery of Panagia Kalamou in Xanthi**
  - Exists since 17th century
  - Major reconstruction/restoration in 20th cen.
  - Still in service
  - Probably the most morphologically complex

Major monuments promised to be delivered…

Third Collection : Monastic monuments of Northern Greece

- **Monastery of Panagia Kosmosotira in Feres**
  - Founded in 1152
  - Build to be a miniature of Hagia Sofia

Aspects of the *conventional* pipeline being followed…

- **Divided into two main phases…**
- **Data Collection – Digitisation**
  - Terrestrial and aerial photoshooting
  - Also perform
    - Terrestrial TOF Laser Scanning →Partial capturing of monument's surfaces
    - Total station and empirical measurements (e.g. measuring tapes)
      - Target positioning, distances between strong features on monument's surface
- **Data Processing**
  - Structure from Motion / Multi-image dense stereo 3D reconstruction
  - Generation of primary model (Triangulated mesh)
  - Scale model → Based on laser scanning, total station, measurements data
  - Generation of lower resolution meshes
  - Export to *publish* file format – Use of a Web landing page
  - Generation of fly-around video sequences of monuments and details

Data collection equipment…

- **Terrestrial session**

  - Set of Samsung NX1000 compact DSLRs 20MP →*16mm* fixed zoom and *22mm-55mm* lenses
  - Set of tripods and custom variable height monopods
  - Optec Ilris 3^6D TOF laser scanner
  - Topcon GPT-3005N total station

- **Aerial session**

  UAV specs - Custom design and implementation by Aeroview.gr

  - Hexacopter – X frame arrangement (Diameter: *80cm*)
  - Naza-M controller board with GPS (Altitude hold, return home)
  - Payload capability 2Kg – Total Weight 4.7Kg
  - Flying time 15 minutes – Five cell 18.5Volt Li-Po
  - Two axis (Yaw, Roll) gimbal camera base
  - FPV – Telemetry functions (Viewpoint, altitude, battery's voltage)

Data collection approach…a.k.a. The shutter's nightmare

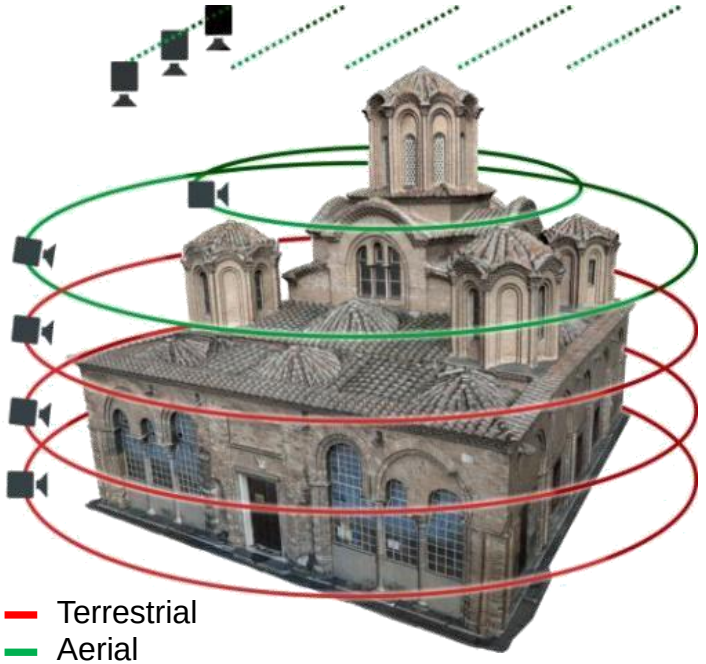
- **Primary method for all models**
  - SFM / Multi-image dense 3D reconstruction

- **Create multiple closed image sequences at different height levels around the monument**
  - Terrestrial (height range 1.50m – 6.00m using tripods, monopod)
  - Aerial (height range 7.00m – 40m e.g. Rotunda minaret)

- **Top aerial image sequences capture approach**
  - Low angle oblique
  - Vertical titled

- **Inevitable→ Additional image sequences to capture**
  - High morphological complexity areas with occlusions
  - Concavities
  - Details

- **No safe distance limit was introduced by the Ephorate!**
  - Allowed us to fly close to the monuments (some cases < 3m)



Data collection challenges

Terrestrial Photoshooting Sessions

- **People**
  - Respect visitors → In many occasions had to stop collection phase
  - Inform personnel about our work and what we are doing
  - Politely avoid long conversations with *drunken scholars*

- **Accessing the monument from all viewpoints needed**
  - Where not possible →Tried airborne instead

- **Weather conditions**
  - Trying to perform image collection always on cloudy days (Overcast)
  - Absence of strong shadows – Overall similar lighting conditions
  - Good for simulating different lighting conditions

Data collection challenges

Aerial Photoshooting Sessions

- **Wind gusts**
  - Reduce total flying time
  - Hard to automatically keep a safe distance from target → GPS slow response
  - Dictates full-manual navigation

- **Environment - Monuments morphology**
  - Difficulty to keep the UAV in pilot's line-of-sight
  - Need for pilot's continuous movement to keep L-O-S
  - Flight plan complexity related to morphological complexity

- **Birds…especially seagulls and crows**
  - Flying around the UVA to scare it
  - Sometimes…even try attacking the UAV!!!

Data Processing…software and hardware

Software arsenal

- **Primary 3D model generation software**
  - Agisoft PhotoScan Professional edition

- **Mesh processing, analysis and video generation**
  - Meshlab, Blender, Arius 3D Pointstream Editor, Cloud Compare, X-normal, InstantReality aopt tool

Hardware arsenal

- **6 x PC systems for data processing**
  - 3 x 64GB , 2 x 32GB , 1 x 96GB RAM
  - 4 x Intel i7 4-cores, 1 x 6-cores
  - ATI Radeon R9 280X, Geforce GTX 580
  - Microsoft Windows 7 Pro 64 bit

Data Processing…some numbers

Total number of images per project and some indication for processing times

- Kioutouklou Baba Bekctashic Teke → 1.000 images
- Church of the Holy Apostles → 4.100
- Church of the Acheiropoietos → 5.000
- Church of St. George (Rotunda) → 9.200

  Alignment duration: ~190 hours (10.000 points per image) Intel i7 6-core 3.4Ghz, ATI Radeon R9 200
- Monastery of Panagia Kalamou → 9.000
- Monastery of Panagia Kosmosotira → 4.000

Data Processing challenges

- **Long processing times**
  - Image alignment and dense stereo reconstruction →Extremely demanding CPU/GPU/RAM
  - Hard to automatically keep a safe distance from target → GPS slow response
    - Dictates full-manual navigation of UAV
  - Not as immediate as viewing data from a scanner

- **Exploit Agisoft Photoscan's Python scripting support**
  - Perform dense stereo in multiple small regions
  - Able to get higher resolution results with less memory requirements

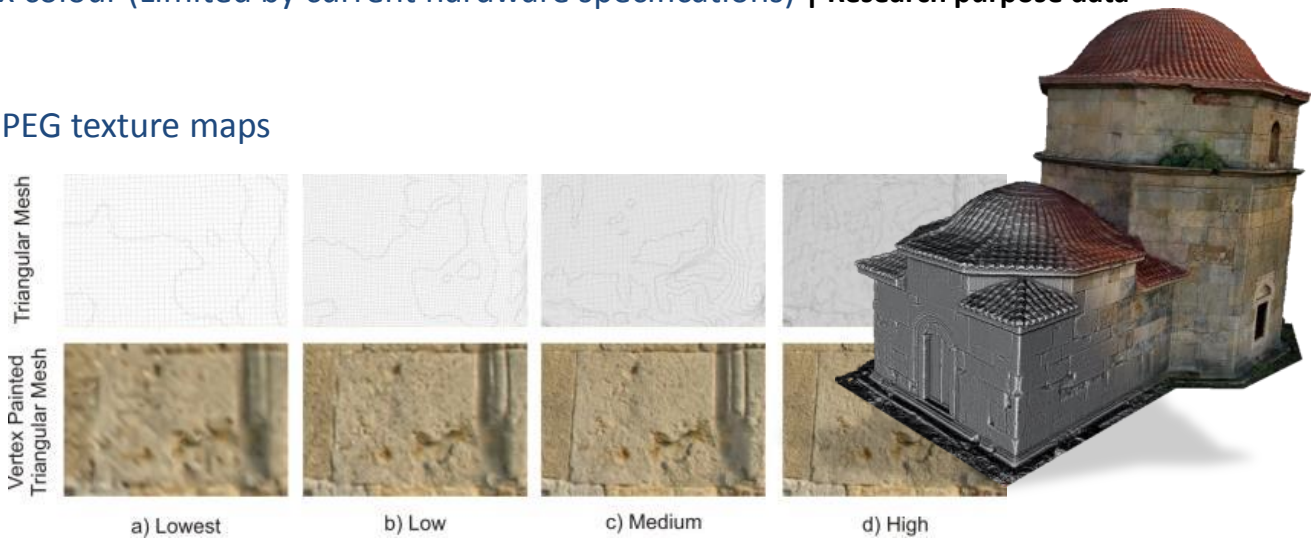
- **Still unable to get the best out of the image sequences**
  - Big data handling-visualisation inability using current hardware and software

Data Processing…

- **Producing different resolution models**
  - Photoscan → Meshlab (>mesh simplification) → Blender (>UV unwrap) → PhotoScan (Texture Mapping)

- **End up with four different mesh complexity levels**
  - Low Res: <100K facets with 1024^2 pixels texture map **| Mobile devices & low bandwidth connections**
  - Medium Res: <300K facets with 4096^2 **| Average PCs**
  - High Res: aprox. 1M facets with 8192^2 **| High end PCs**
  - Raw : >20M facets with vertex colour (Limited by current hardware specifications) **| Research purpose data**

- **Output formats**
  - Fist three levels as X3D with JPEG texture maps
  - Raw in binary PLY format



On landing pages…

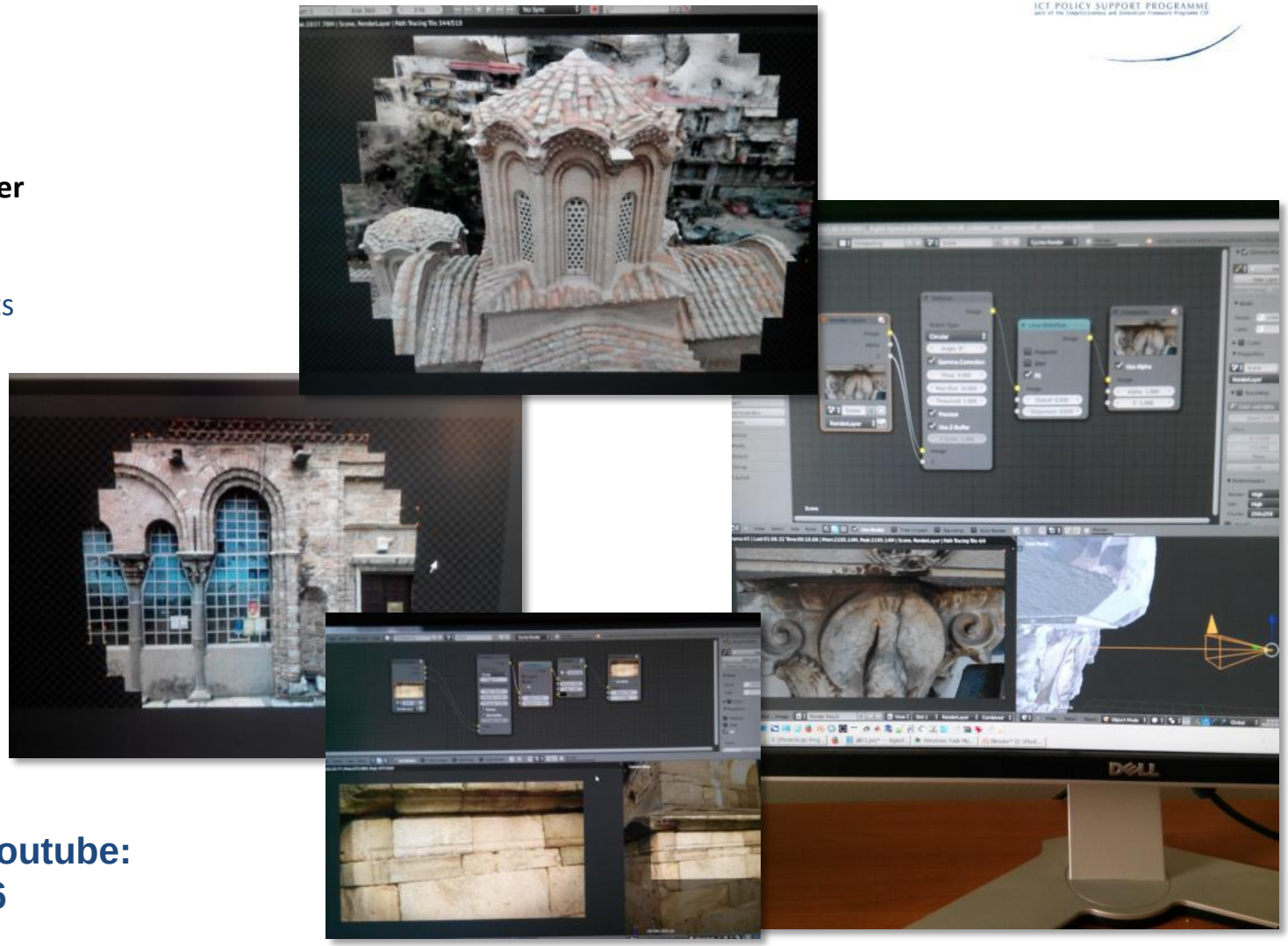
- **Some features**
  - Use WebGL/X3DOM javascript as a viewer
  - Show 3D models in a wide range of platforms
    - IOS8 supports x3dom
- **Turntable navigation mode**
  - Prevent users accessing unwanted viewpoints
- **Attempted an application-like flavour**
  - iframes & tabs technologies

3D-ICONS Portal:
http://3dicons.ceti.gr

Cheat mode URL:
http://goo.gl/Q1GNyr

On video sequences…

- **Rendered using Blender**
  - Cycles renderer
  - Depth of field effects
  - Barrel distortion
  - Colour aberration
  - Vignette
  - 1080p



Video Channel on Youtube:
http://goo.gl/eNIAH6

What is next…

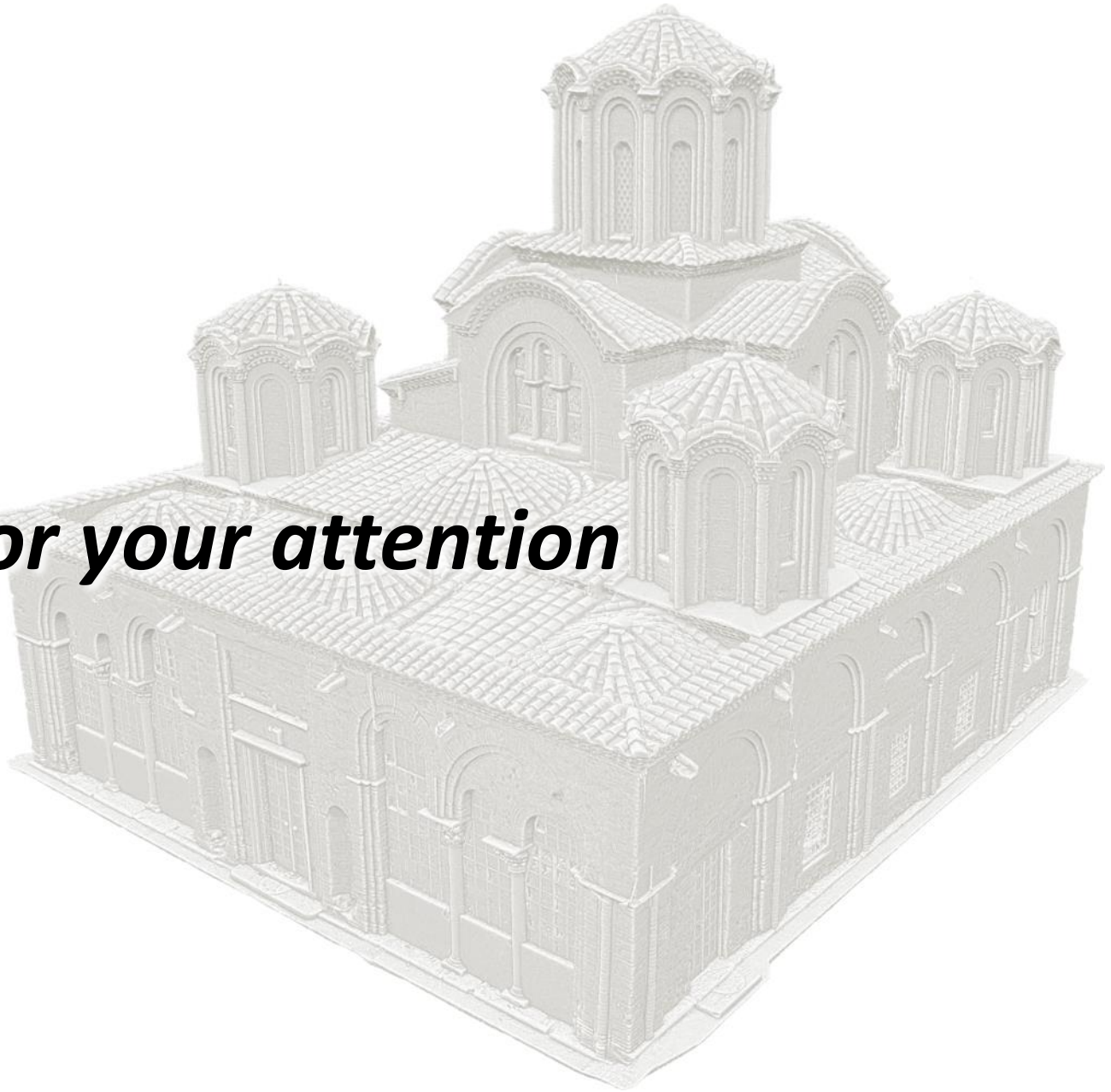
- **Complete the generation of the primary 3D models for the remaining of the monuments**
  - Looking forward for the new Agisoft Photoscan version that supports network processing
- **Update current high resolution models**
  - Use of binary X3D encoding and progressive download
- **Generate orthophotos of monument's facades → Digital resources**
- **Stick to metadata generation and ingestion targets**
- **If time!!!Work on a custom WebGL/ThreeJS based viewer in order to exploit**
  - Tessellation displacement mapping
  - Low complexity mesh / High geometry details presented through shaders

Some related papers…

- *A. Koutsoudis, B. Vidmar, G. Ioannakis, F. Arnaoutoglou, G. Pavlidis, C. Chamzas,* ***Multi-Image 3D Reconstruction Data Evaluation****, Journal of Cultural Heritage, Volume 15, Issue 1, January–February 2014, Pages 73–79.*

- *F. Remondino, F. Menna, A. Koutsoudis, C. Chamzas, S. El-Hakim,* ***Design and implement a reality-based 3D digitisation and modelling project****, International Congress on Digital Heritage, 28 Oct - 01 Nov, Marseille, France, 2013.*

- *A. Koutsoudis, B. Vidmar, F. Arnaoutoglou,* ***Performance Evaluation of a Multi-Image 3D Reconstruction Software on a Low-Feature Artefact****, Journal of Archaeological Science, Vol. 40 (12),December 2013, pp.4450-4456.*



Thank you for your attention