LOW COST DIGITAL PHOTOGRAMMETRIC TECHNIQUES FOR THE DOCUMENTATION OF CULTURAL HERITAGE

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Cultural Heritage

Cultural Heritage geometric recording & documentation is extremely important and are included to the fundamental targets of UNESCO

Yet not much attention is paid especially in developing countries, where monuments of great value exist, due to other priorities: poverty reduction, infrastructure improvement

Need for Low Cost techniques

for the Geometric Recording of Historical Monuments

Geometric Recording of Cultural Monuments

- The geometric recording of a monument is the procedure of acquiring, processing, archiving and presenting data for the determination of the position and the actual present form, shape and size of a monument in 3D space at a given moment in time
- The geometric recording monitors the present condition of the monuments, as it has been formed through time and it is a necessary document for those would understand their past, as well as for those who provide for their future

Basic Principles of Geometric Recording

- Structural Interventions on the monument according to International Rules

  Application of non contact methods and techniques

  Recoverability of interventions

- Use of low cost methods and techniques appropriate for the Technical Specifications

  Documentation of monument - Field data collection

- Specialized needs according to the importance & shape of the monument and of the intervention that will be done

  Accuracy, Type & format of products

Specific requirements

for large scale monument surveys

- Complex objects
- High accuracy requirements
- Multitude of reference systems
- Extremely large "height" variations compared to the short measuring distances
- Demand for alternative - unconventional products
- Lack of standards - specifications

Sources of metric information

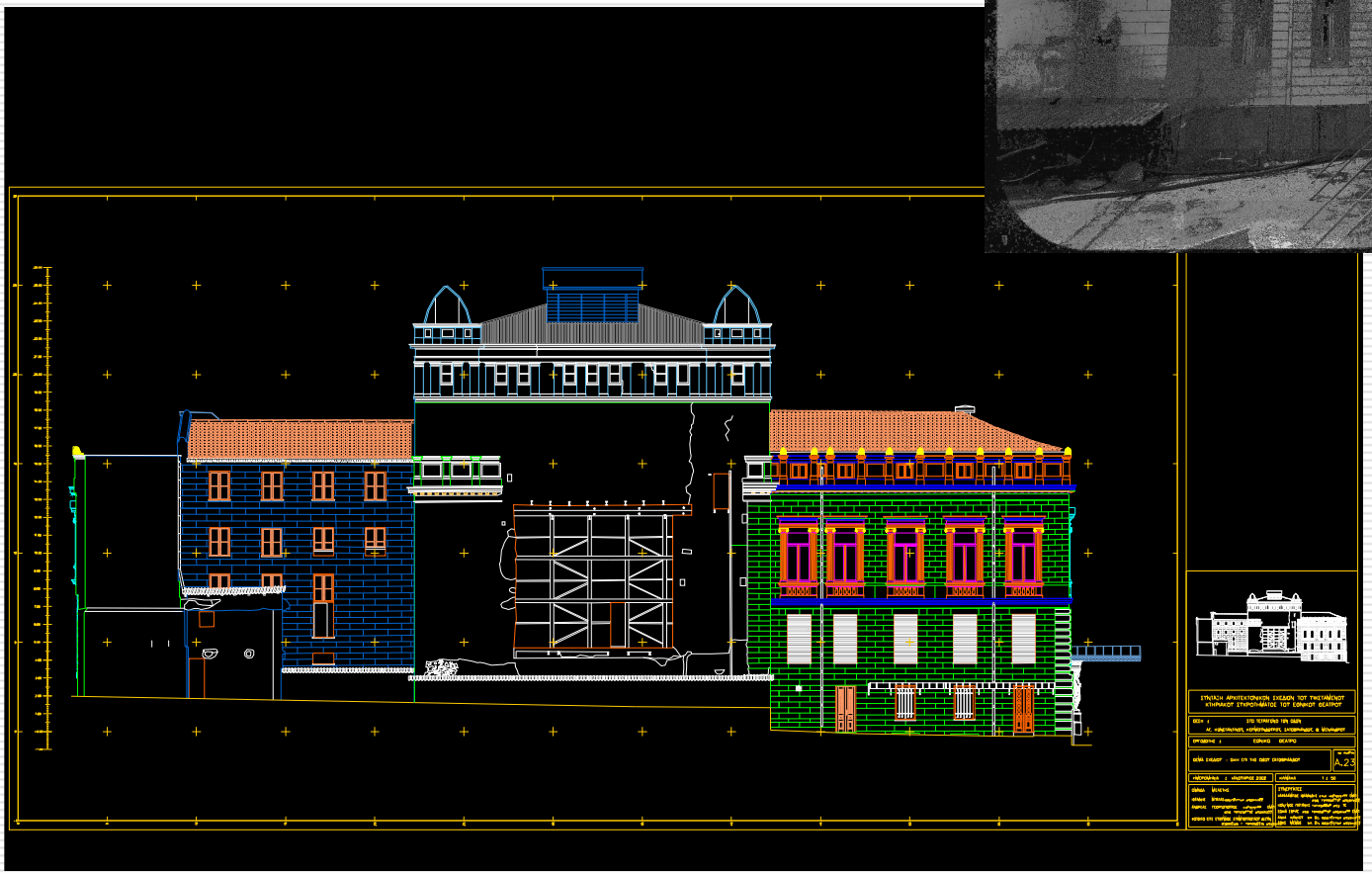
- Geodetic measurements
  - 3D point determination
- Photogrammetric data – procedures & products
  - Vector drawings (2D - 3D)
  - Raster products (2D)
  - Video sequences
- Terrestrial Laser scanning point clouds
  - Practically infinite number of 3D points

Geometric Recording of Monuments

The geodetic and photogrammetric methods:

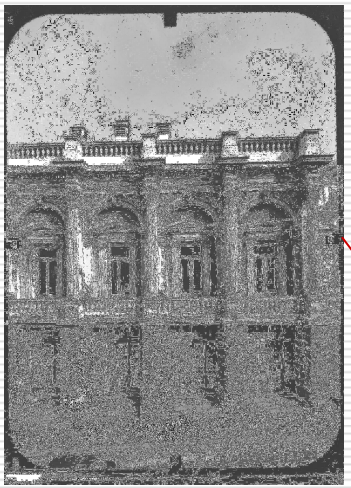
- Are based on direct measurements of lengths and angles either on the object itself or on images of it
- Determine 3D co-ordinates in a common reference system
- Ensure the specified and common accuracy
- Provide adaptability and flexibility, together with speed, security and efficiency
- Are cost effective, in the sense that they are the only ones capable of satisfying and meeting any specifications with the least possible cost and maximum possible benefit

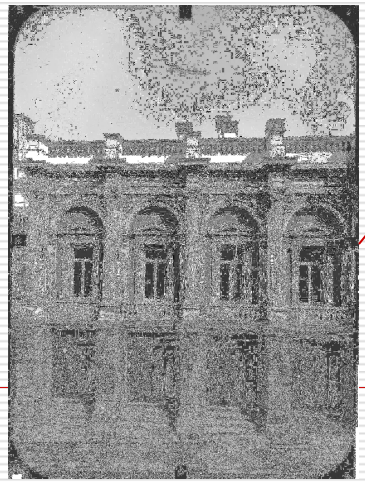
Digital Rectification

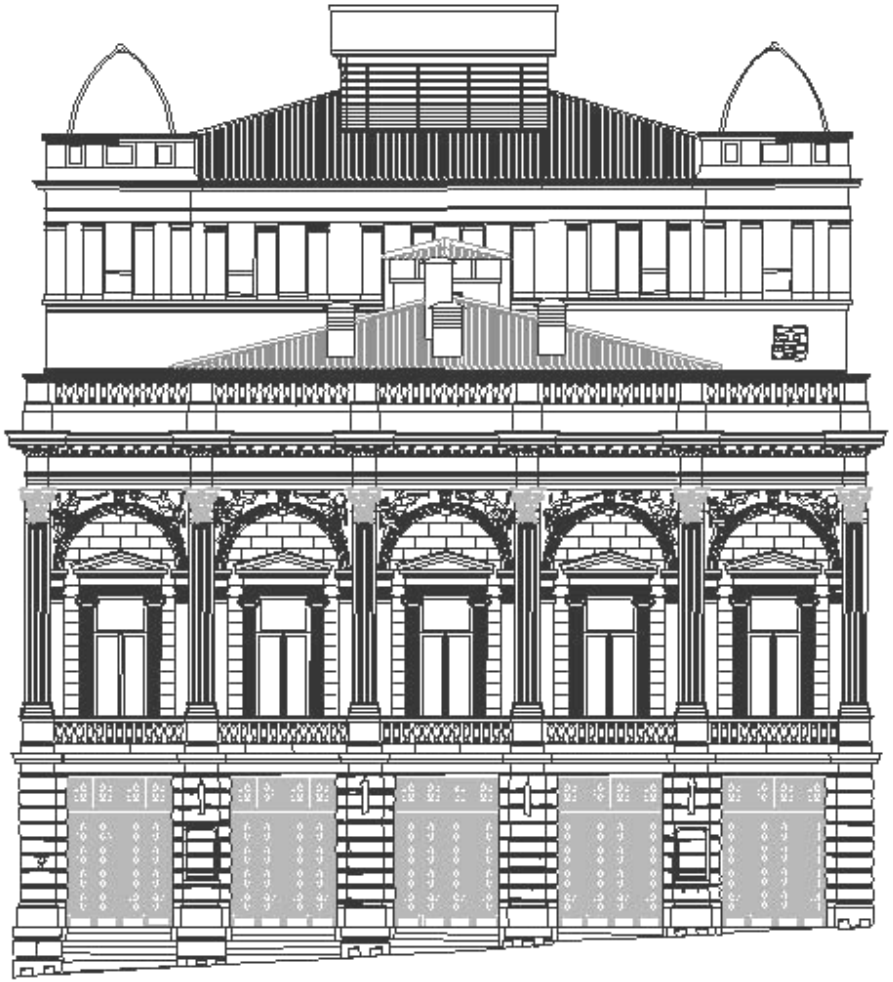


Orthophotography

Photogrammetric Stereo restitution



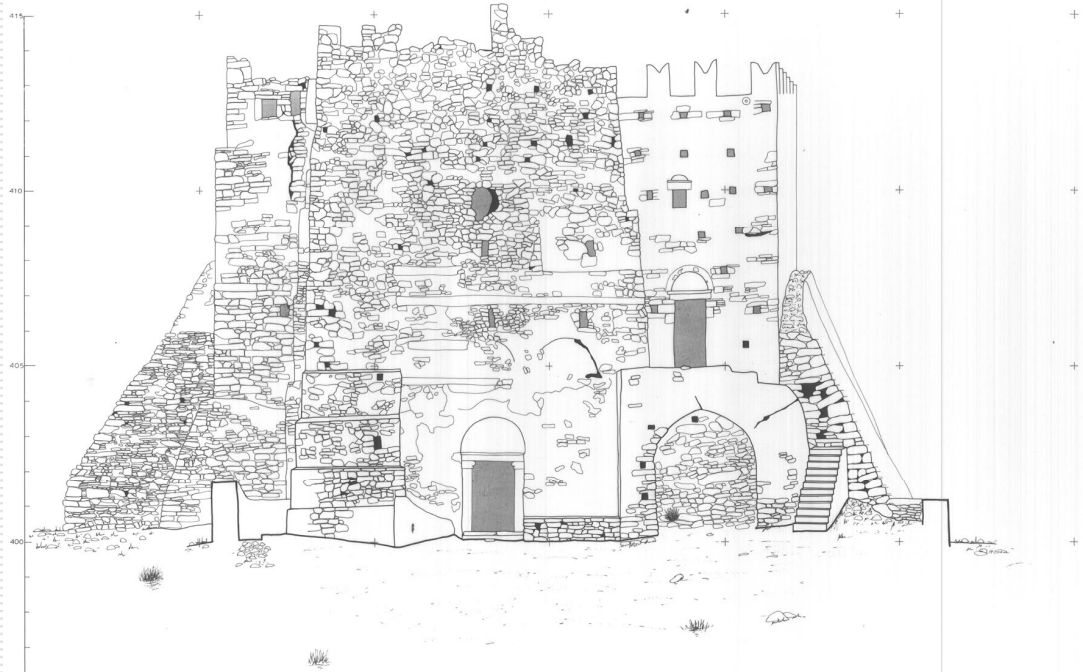




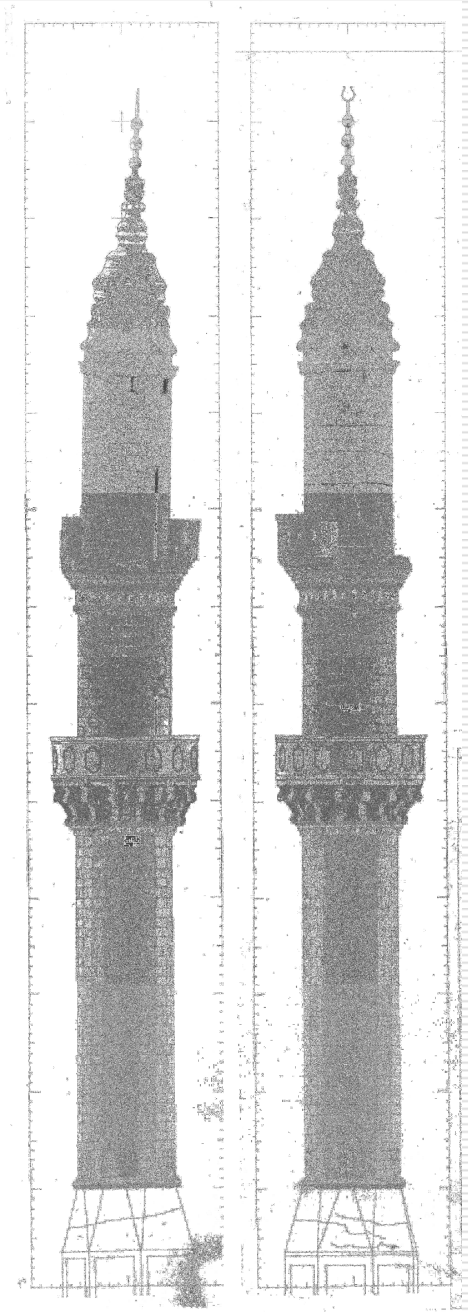
3D visualizations

Evolution of methods

1988
Analogue
2D Drawings completely by hand

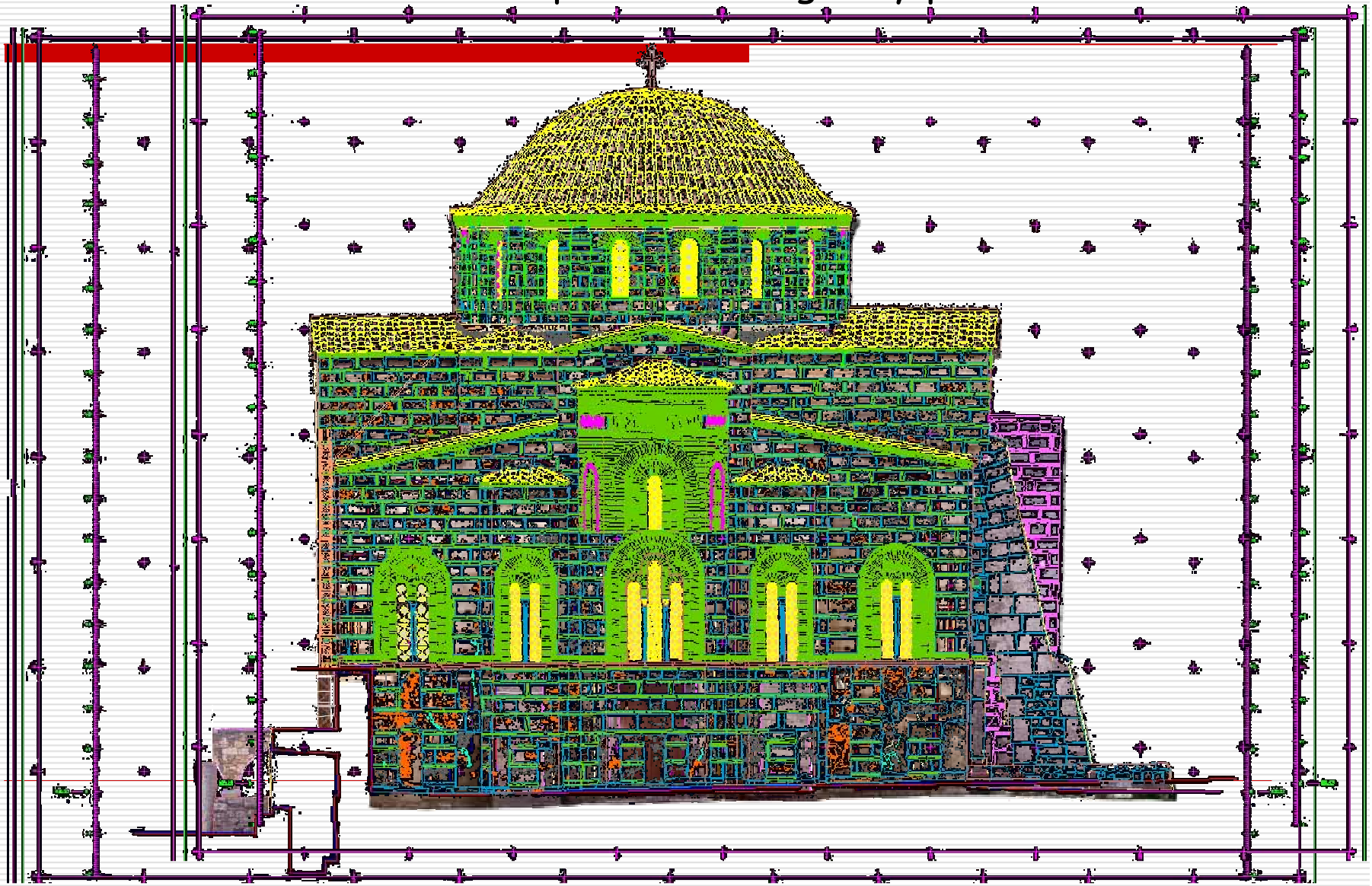


1992: Analytical 2D Drawings finished by hand



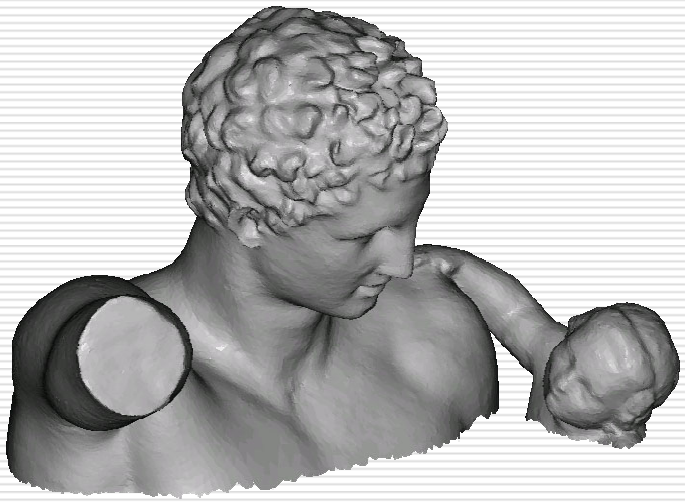
Evolution of methods

1999 3D Vector + 2D Raster products – digitally produced

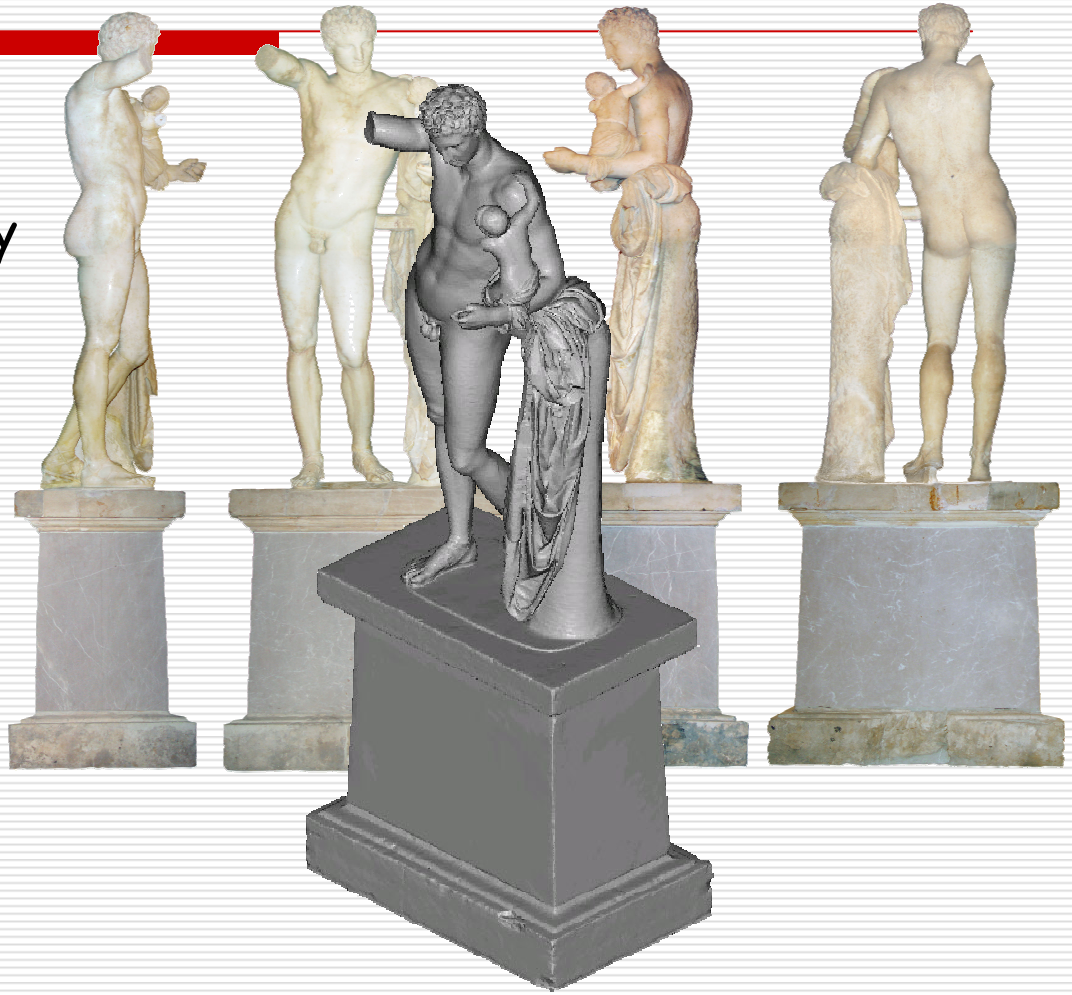


Evolution of methods

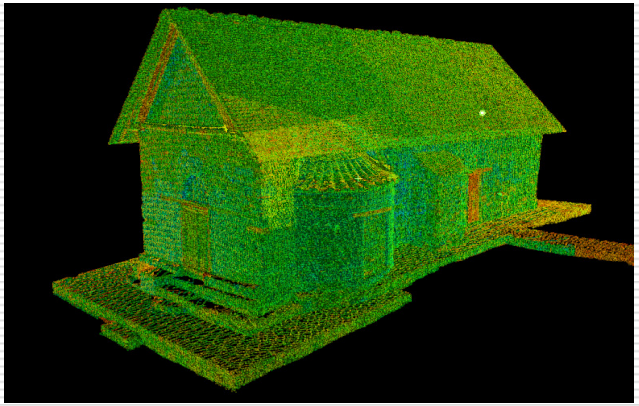
2004 orthophotos & 3D models
Fully digital
Combination of photogrammetry and laser scanning

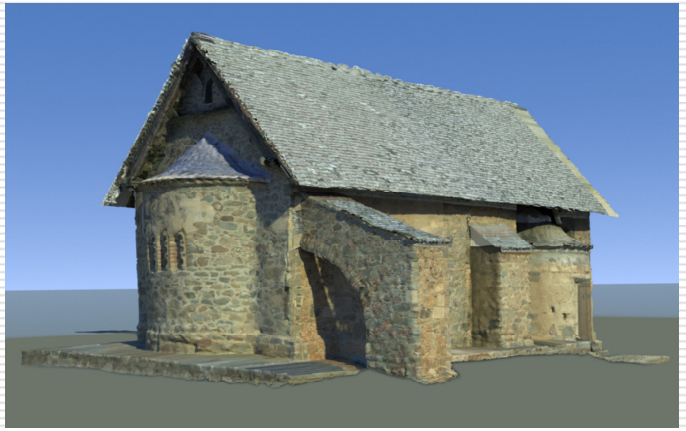


Detail of the 3D model



Evolution of methods





2006 3D solid models using terrestrial laser scanning - fully digital & automated

Cost & time consuming procedures – Specialized equipment & staff

Low cost techniques

Contemporary digital photogrammertic techniques:

Speedy & affordable solutions for the geometric documentation of monuments

Raster products / 3D models

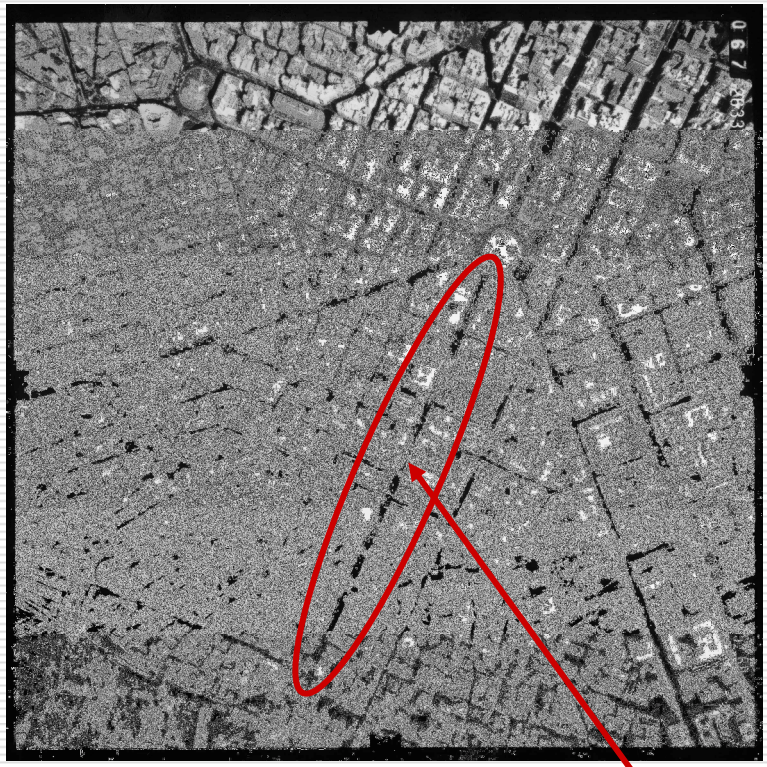
- High resolution digital cameras — Cheap / Easy to use
- Topometric measurements — No control points
- Photogrammetric software — No need of special knowledge & equipment

Alternative photogrammetric procedures

- **Photogrammetric rectification**
  - Orthophoto-mosaics of flat surfaces
- **Multi-image management with bundle adjustment algorithm**
  - Orthophotos & 3D textured models of complex historic buildings

Orthophoto-mosaics of building facades

Historic center of Athens, Greece



Aerial photography

View from GoogleEarth

Athinas street

Horizontal plan of Athinas st.

Target of the project:

Creation of a unified mosaic at a scale of 1:200, to be use for architectural interventions and restoration of the building facades - No high accuracy demands

Ortho-images of building facades

- Several high buildings – Relatively narrow street
- Commercial/crowded street Difficulties in entering the buildings
- 63 buildings on both sides of the street
- Short deadline for the creation of the mosaics

Simple **photogrammetric rectification** technique

Problems & Advantages using rectification process

Misalignment of the parapets and the balconies: Acceptable accord to the Technical Specifications

- Distance measurements
- Easy image acquisition for the higher parts that cannot be seen from the ground

Orthophoto-mosaics of the facades (1)

Facades of the buildings along one side of the street

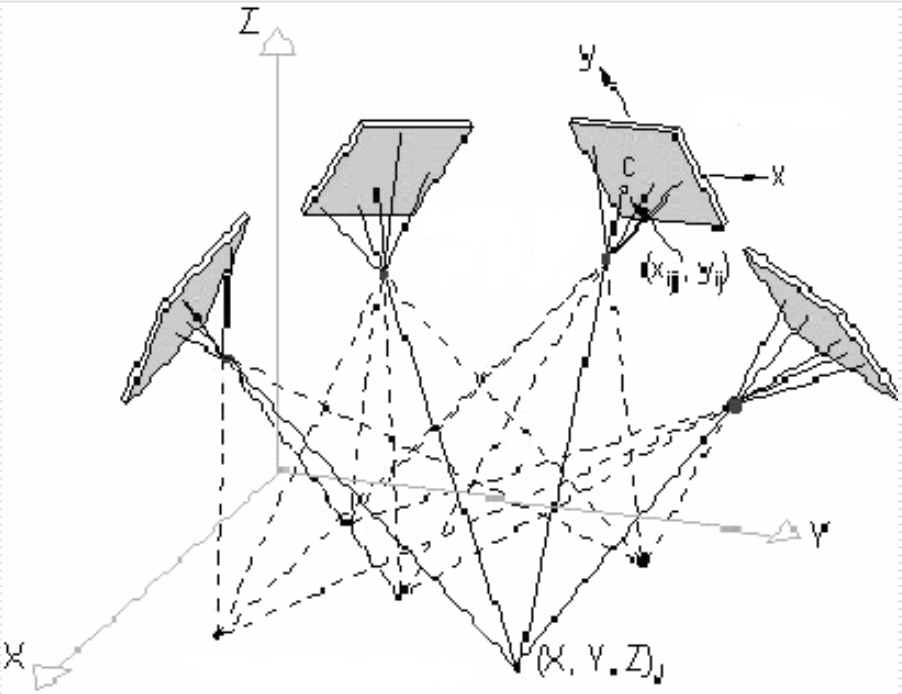
Orthophoto-mosaics of the facades (2)

Facades of the buildings along the other side of the street

Multi-image management with bundle adjustment

Bundle adjustment method using monoscopic measurements of homologue points on more than two overlapping images :

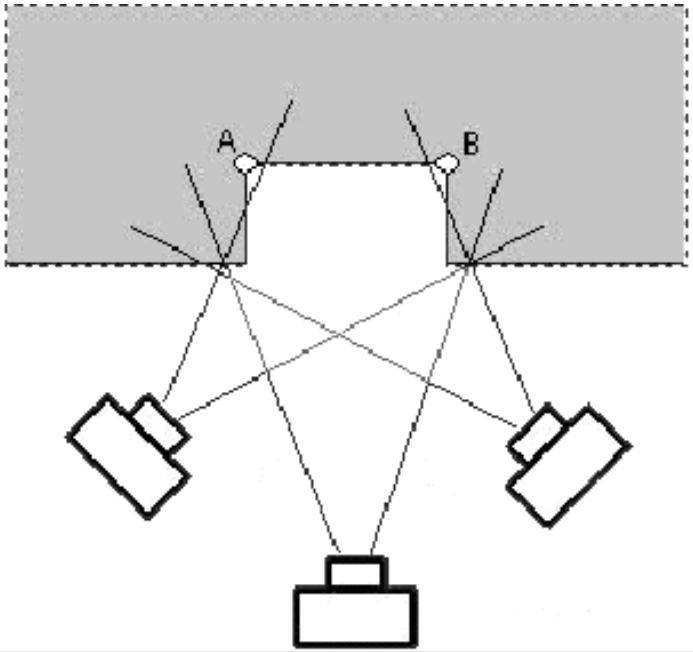
Simultaneous determination of the exterior orientation of the images and of the geodetic co-ordinations of object's characteristic points



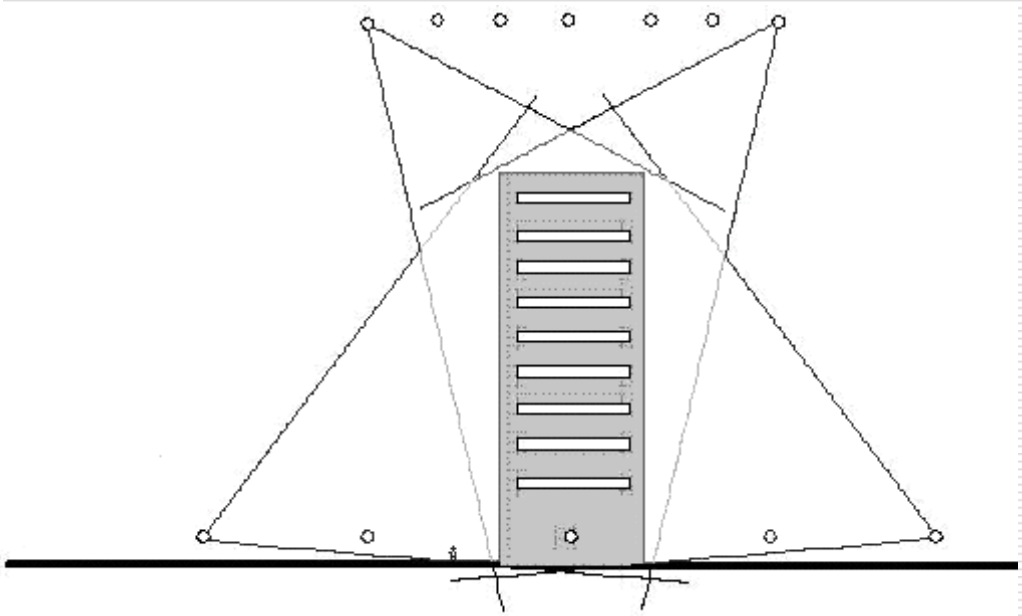
Software: **PhotoModeler©** of EOS Systems

Suitable image acquisition for the PhotoModeler s/w

For better accuracy and more reliable data determination, images should be taken rather with a convergence of 20°-90°, instead of the desired normal case of the conventional procedure of stereo-restitution



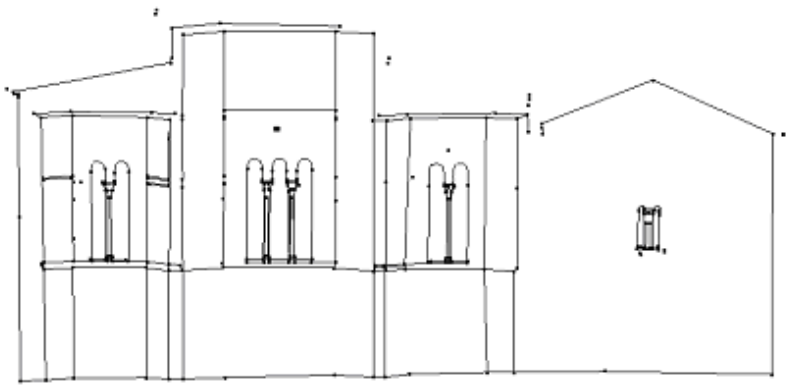
Horizontal plan

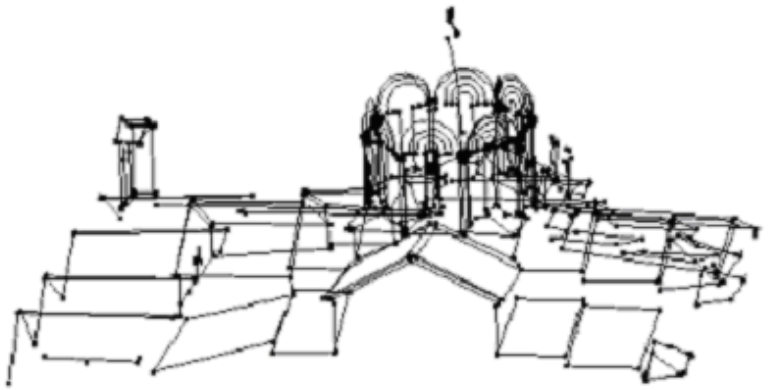


Vertical section

Creation of 3D model in PhotoModeler s/w

The creation of the model is achieved by selecting points that create planes or other mathematical surfaces (cylinders, cones or spheres) and by adding geometric constraints in space



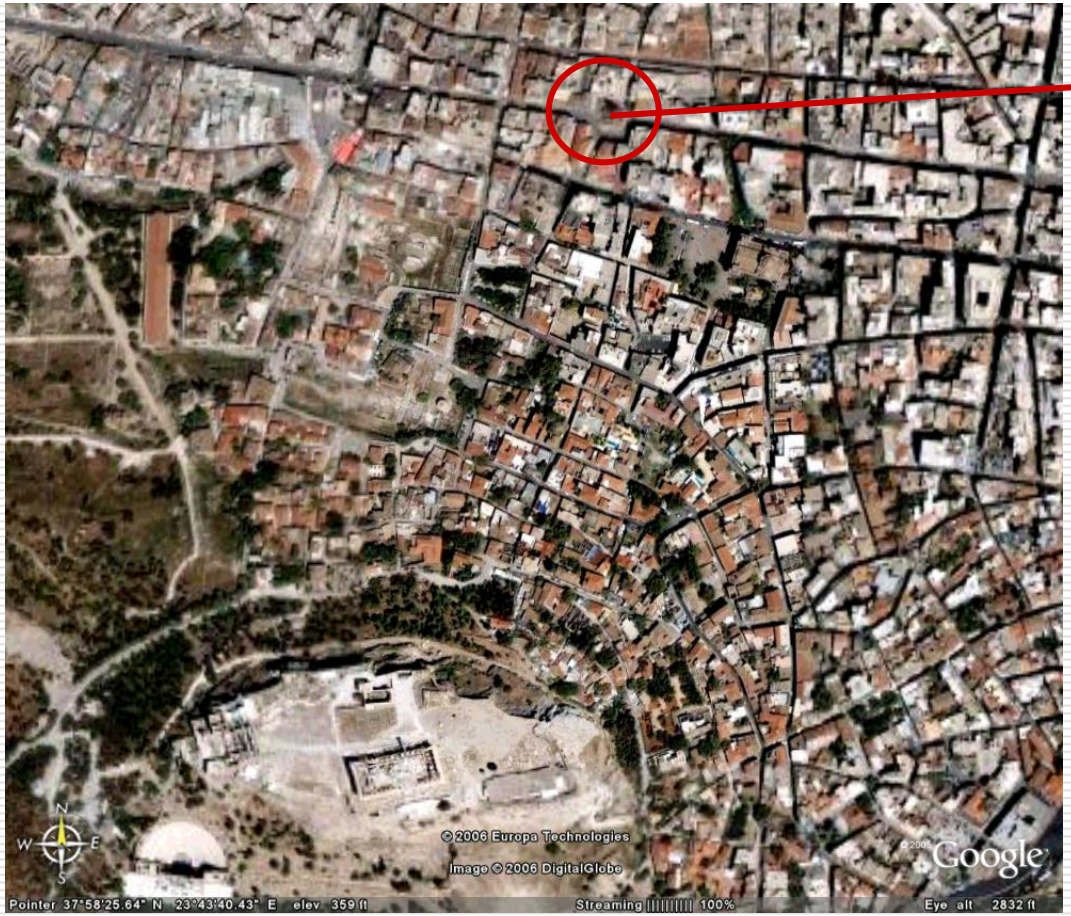


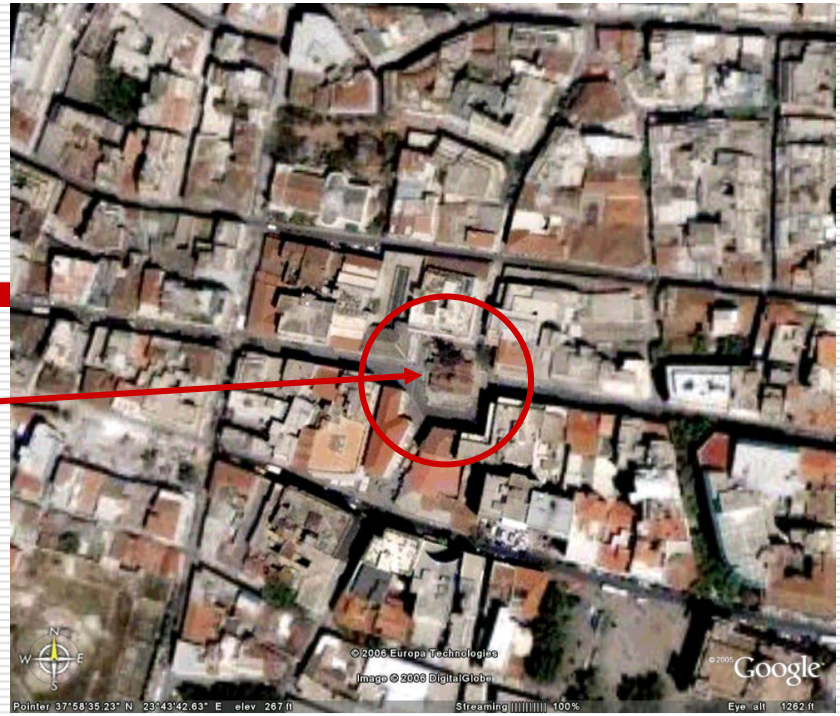
Main characteristics of PhotoModeler

PhotoModeler software has the ability of:

- Self-calibration
- Use of lines between points
- Imposing constraints
- Determining epipolar lines
- Producing models without control points
- Adding mathematical surfaces to the model
- Producing orthoimages
- Creating TIN & wireframe models
- Applying texture from images

3D model of a Byzantine Church





'Kapnicarea' church

Size: 12 x 10 m^2

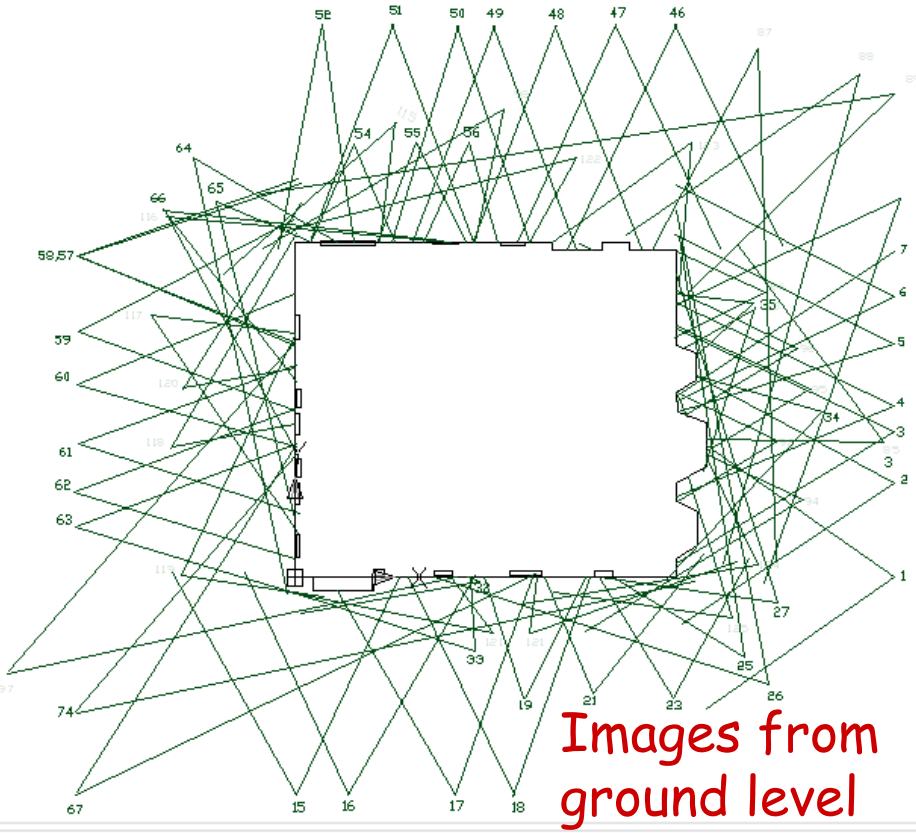
~ 9 m height

2 domes / multilevel roof

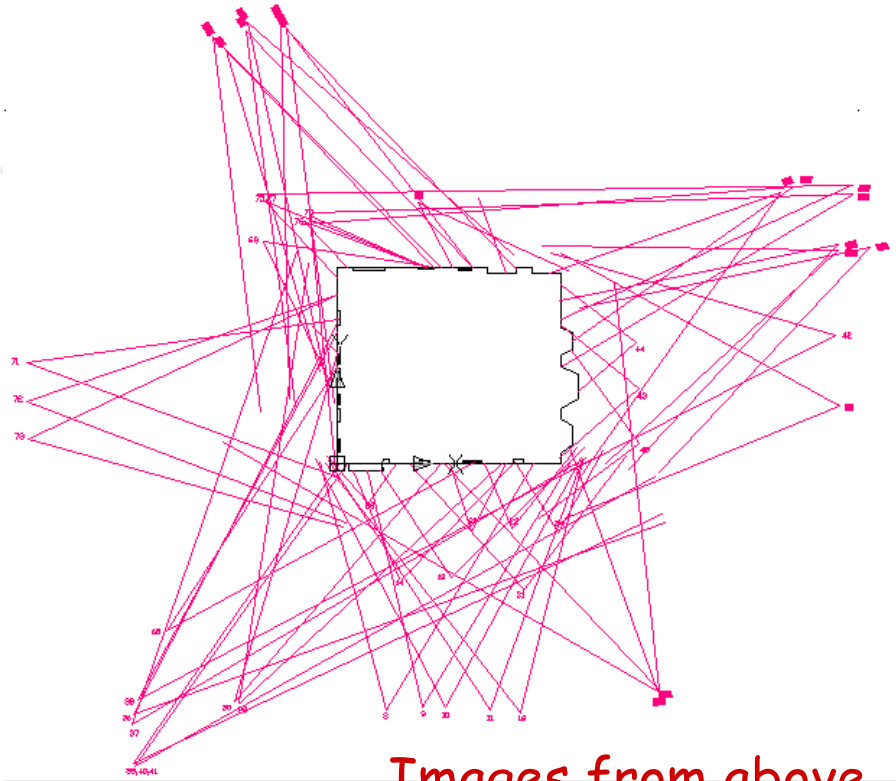
Image acquisition

Digital camera: SONY DSC-F707 5 Mpixels

Number of images: 126



Images from ground level

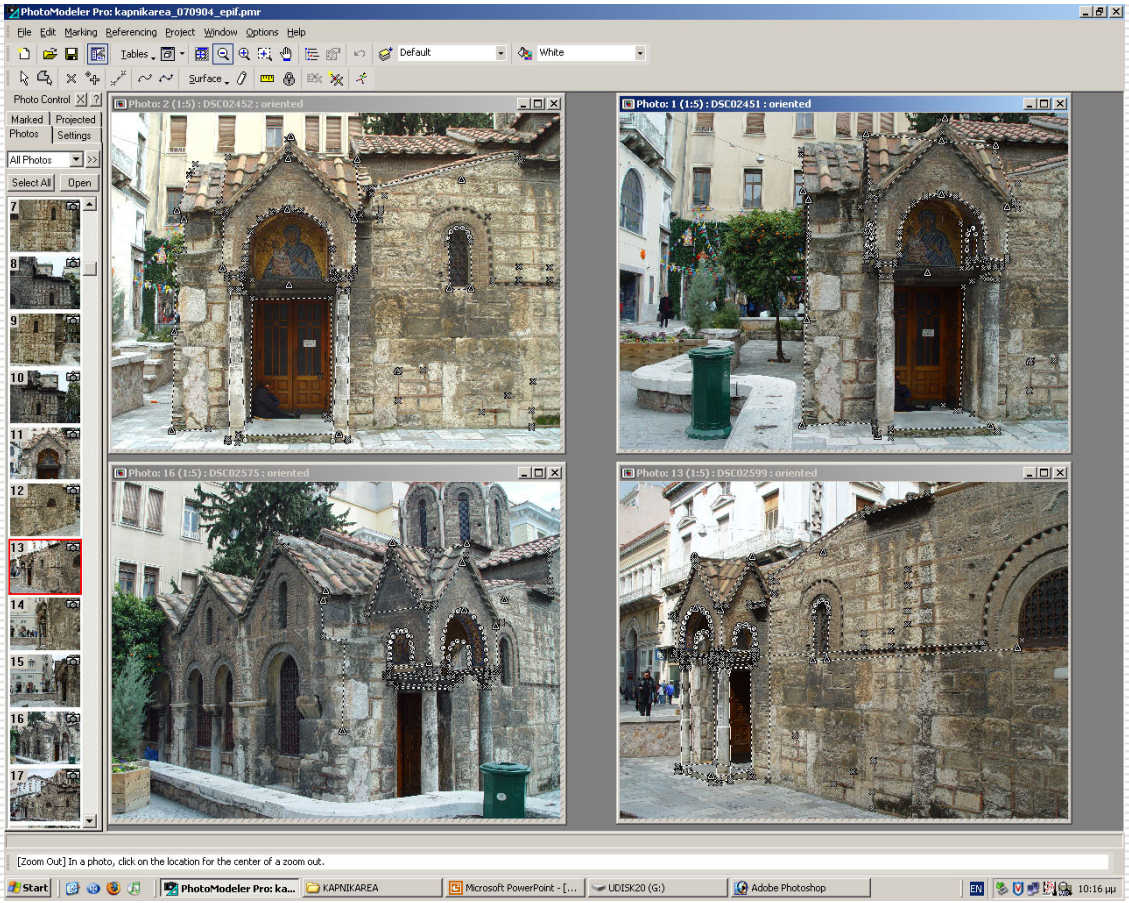


Images from above

Photogrammetric processing using PhotoModeler s/w

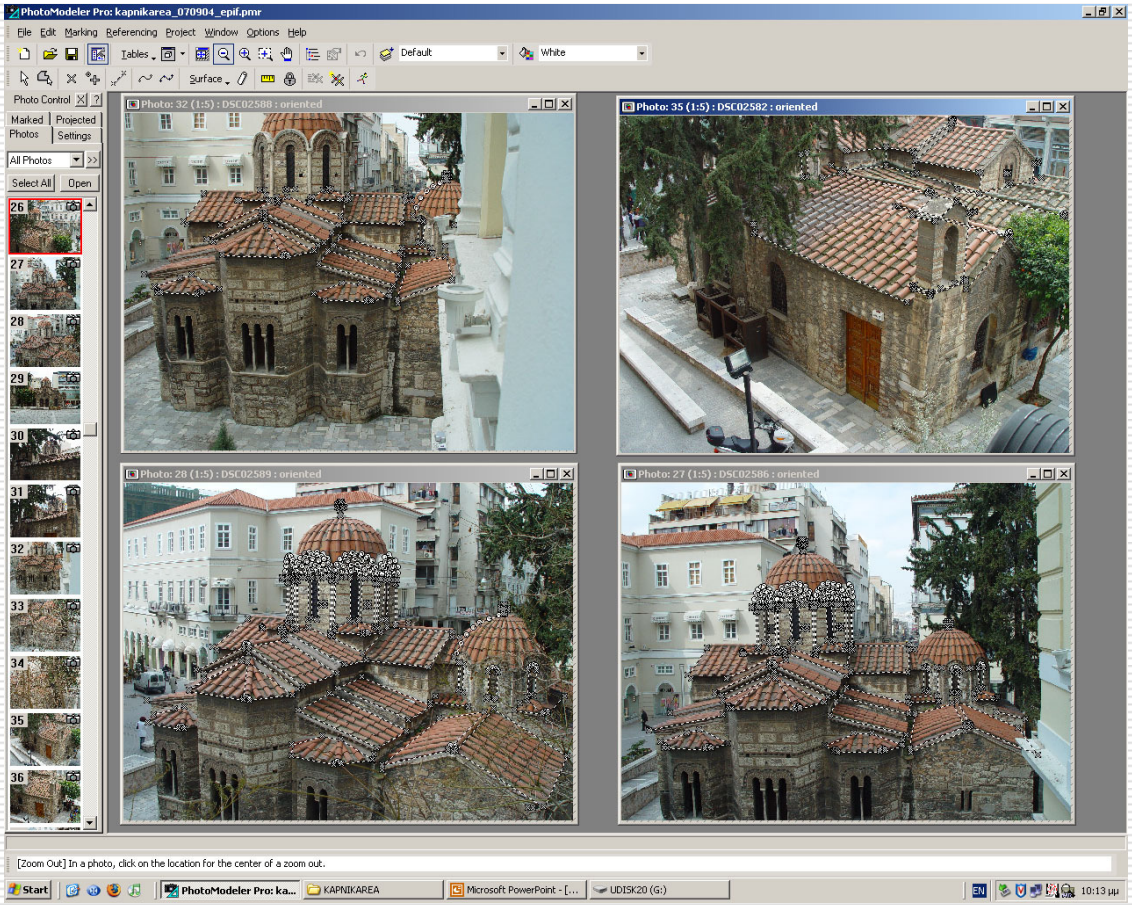
- All available overlapping images were used
- Camera calibration parameters were calculated during the adjustment
- Homologue points and objects were marked manually and matched on the images
- Constrains referring to the parallel and vertical lines on object surfaces were entered
- Distances were used for scale determination
- Object surfaces were defined & 3D textured model was created

Processing (1/2)



- Homologue points marking
- Determination of lines & curves
- Creation of surfaces

Processing (2/2)



- Homologue points marking
- Determination of lines & curves
- Creation of surfaces

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3D model
Orthophoto-mosaics

Views of the 3D model

South-eastern view

South-western view

Orthophotos of the facades

Eastern façade

Southern façade

Advantages of PhotoModeler s/w

- ☺ Affordable, user-friendly & multipurpose software, which creates 2D and 3D products in an accurate and quick manner
- ☺ No special photogrammetic knowledge is needed
- ☺ Compatible with CAD and photorealistic software
- ☺ Determination of scale can be achieved using only measured distances (or few control points)
- ☺ Ortho-rectified images can be produced
- ☺ All main photogrammetric algorithms are provided, except the automatic matching of homologue points

Disadvantages of PhotoModeler s/w

- ☹ Lack of automated procedures
- ☹ Insufficient ways for the assessment of the accuracy
- ☹ Multiple image coverage of all the characteristic object points is necessary
- ☹ Manual marking of homologue points is difficult to be applied on complex monuments

Concluding remarks

- Geometric documentation of cultural monuments is necessary
- Detailed and accurate products can be derived from conventional but time and cost consuming photogrammetric and laser scanning techniques
- The use of simple photogrammetric methods and user-friendly software for close-range applications can provide complete and good quality results
- Especially useful for architectural applications in historical city centers and buildings, to produce 3D models and animations