Introduction to photogrammetry
(with an underwater flavor)

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Outline

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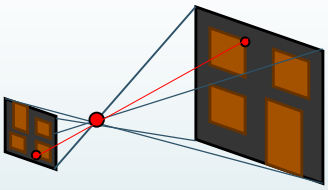
  - Brief history
  - Why
  - *Applications*
- HOW
  - Basic workflow
  - Notes about cameras
  - Notes about control points
  - S/W
  - Output & products
- How we do it on Mazotos
- HANDS ON EXPERIENCE

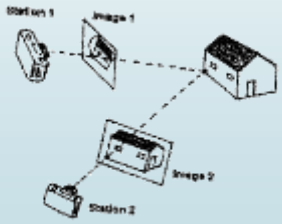
INTRO
What is photogrammetry?

- Definition: Photogrammetry is the science and technology of extracting reliable three-dimensional geometric and thematic information, often over time, of objects and scenes from image and range data.
- Resultant data can be used for the development of spatial databases and spatial information systems (SIS, GIS), in digital, graphical and image forms.
- The technology is employed for image-based, three-dimensional measurements in mapping, engineering, heritage recording, forensic analysis, robotics, driver assistance systems, medical applications, computer gaming, special effects in movies and other fields, where it provides geometric and semantic object information for populating spatial DB and for creating virtual reality scenes with real-life textured models.
- Basically its **reliable and accurate 3D models from photos**
- Increased popularity in recent years: Google Project Tango, Web services for 3d from photos, etc

INTRO
Basic principle

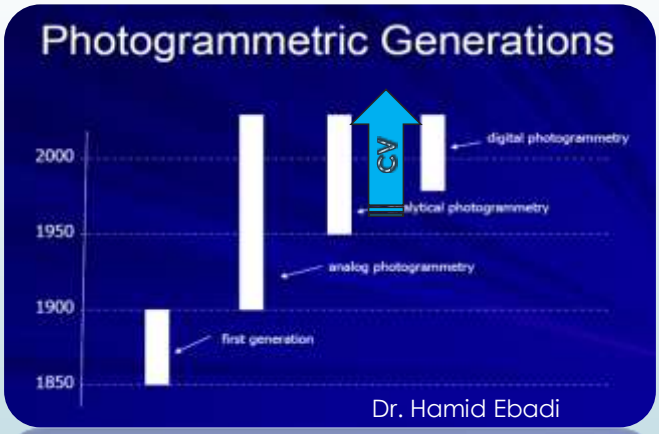
- Any given photo, is a 2D representation of the 3D reality, through central projection
  - There is a dimensional reduction
  - We can easily go from 3D to 2D
- Can we go from 2D to 3D ?
  - Yes, but we need at least 2 photos of the same scene, from different view angles
  - Assuming we know the positions and rotations of each camera station
  - We can measure the same point on the two (or more) photos
  - We can intersect the 3D lines in 3D space





INTRO
Brief History

- Photogrammetry is as old as film (Nadar used photos from balloon over Paris to make map)
- Milestones of development are connected with WWI & WWII
- Instruments: Stereoplotters
  - Analog,
  - Analytical,
  - Digital,
  - **Hybrid (!!)**
    - Digital Photogrammetry with computer vision (2009 onwards)



INTRO
Why photogrammetry

Disadvantages

- Simple, but not simplistic
- Need of trained personnel
- Dependent on external measurements, if absolute coordinates are necessary
- Sometimes need of expensive h/w & s/w

Advantages

- Any accuracy
- Instant recording
- Non contact
- Simultaneous recording of quantitative and qualitative information
- Full 3D recording
- Recording on a specific time, hence monitoring and/or archiving
- Highly versatile method
- Unique properties, allow for unique & numerous applications

INTRO
Why photogrammetry

So it can be used for:

- Very small objects
- Very large objects
- Moving objects
- Deformable objects
- Unapproachable or inaccessible objects

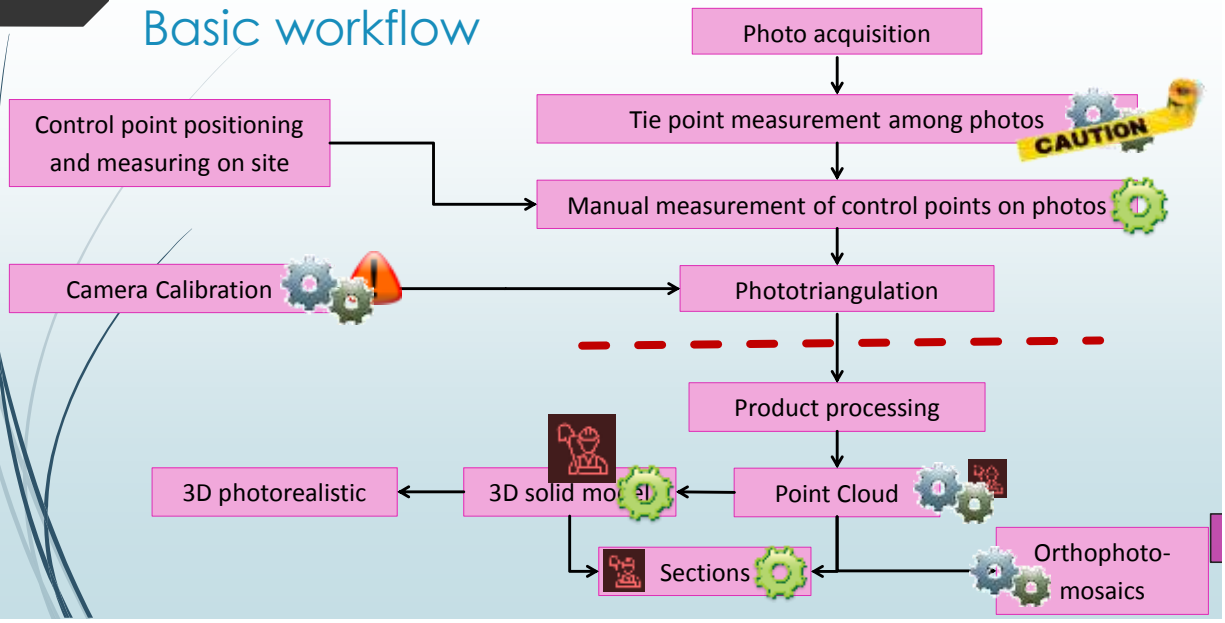
In applications where

- Many details
- Complex shapes
- Dynamic phenomena
- Very small objects
- It is sure that measurements will be needed
- At the acquisition time, we are not sure what to measure

INTRO
Why photogrammetry in underwater CH

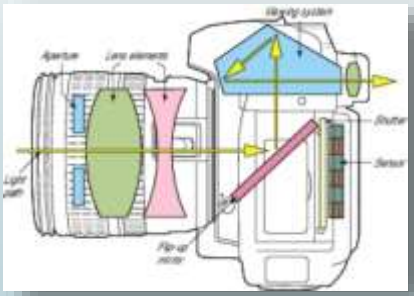
- Adaptable and versatile
  - Accommodate any size of objects
  - Record position of finds, as well as shape
  - Superior end-results to traditional tape measurements
  - More products
- Fast acquisition of measurements
- Rather cheap equipment (camera and s/w)
  - Excellent cost/results ratio
- Brings a 3D 'instance' of the trench to the office
  - Monitoring
- By product: excellent archive of images
  - For reference
  - For re-processing with better future s/w

HOW
Basic workflow



HOW
Some notes about cameras

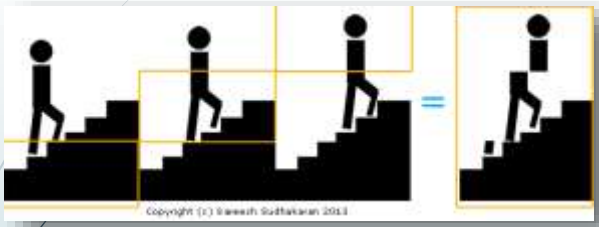
- Pin hole camera
- DSLR and mirrorless cameras



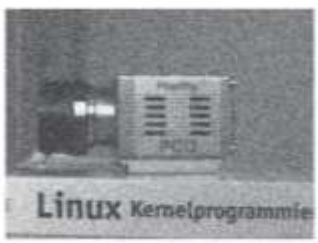
HOW
Some notes about cameras

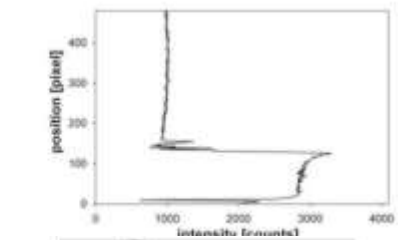
- Good sensor & good optics makes a good camera
- Sensor size (and pixel size) does matter!
  - Get a full frame camera if you can afford it !
- Rigid body does matter
- # MP doesn't matter
- JPEG or RAW does matter
- Lens, very important
  - Geometry
  - Radiometry
- Video is not just frames!
  - CMOS vs CCD

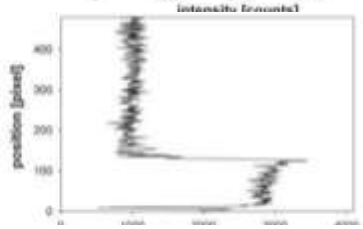
CCD vs CMOS

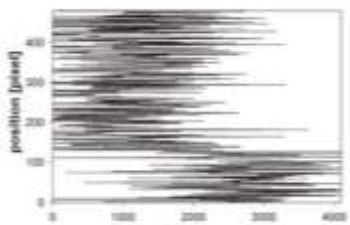


Pixel size and noise





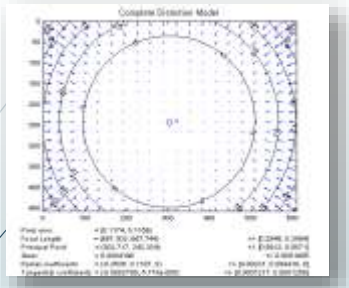
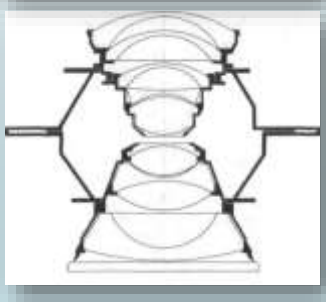
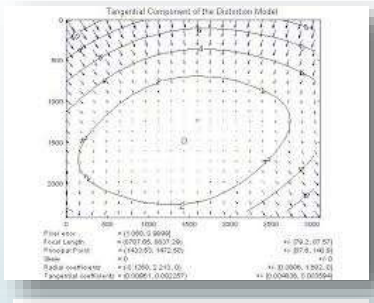
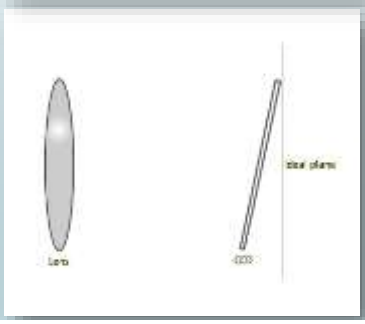




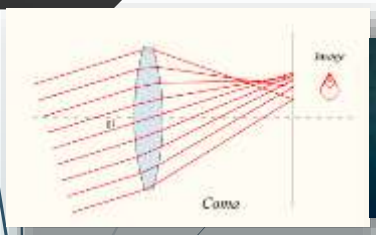
TIFF & JPG

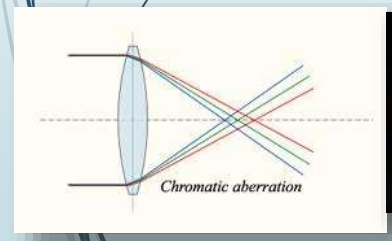


Lens problems - Geometric

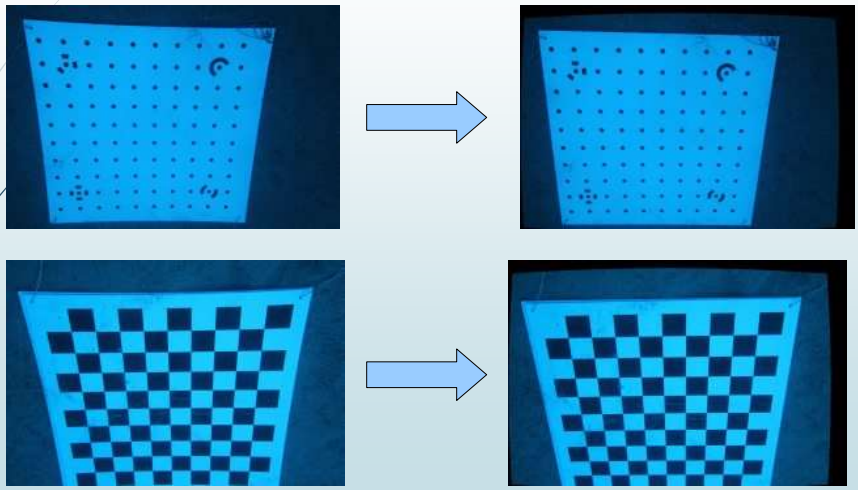
Lens problems - Radiometric





Vignetting

Camera calibration correction using analytical models



- Where
  - Around the AOI/object
- How to measure
  - With a more accurate method
  - At the coordinate system, that you wish to use and have your final results
- How many
  - >>3 using a calibrated camera
  - Limitation is your time and cost
- Targets or natural points
- Scale as an alternative
  - When only shape needs to be recovered

HOW
Some notes about control points

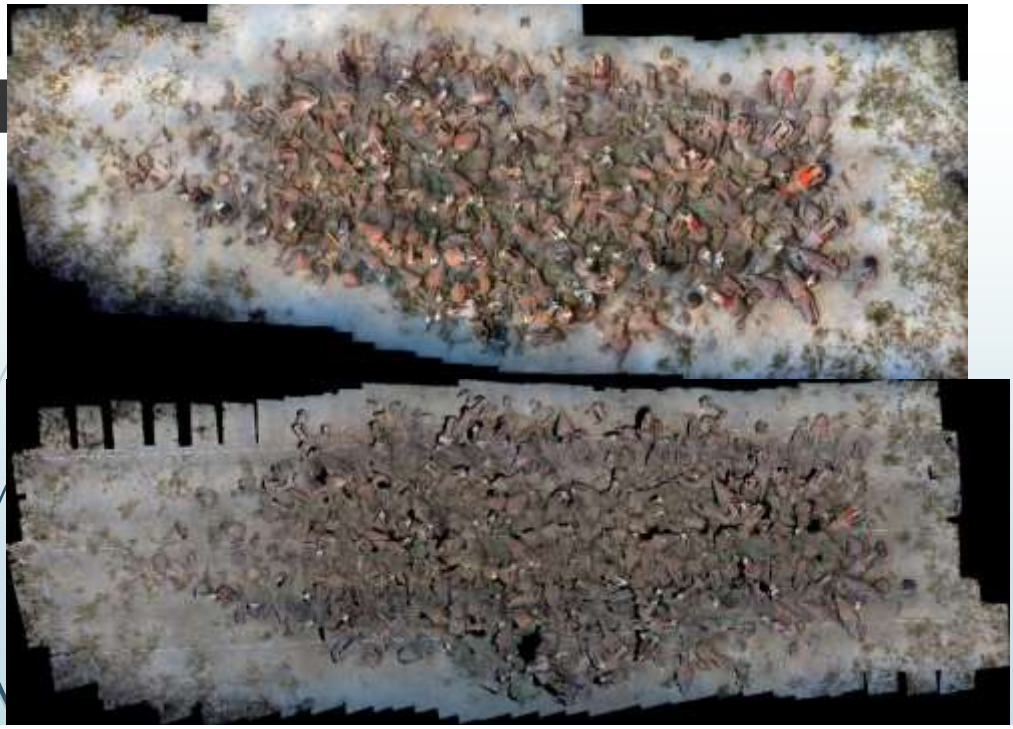
HOW - S/W

- Web services
  - 123dCatch
  - Photosynth
  - Arc3D
- Free
  - Visual SFM
  - Python Photogrammetric Toolbox
  - MicMac
- Commercial
  - Agisoft's Photoscan
  - Capturing Reality
  - Acute 3D
  - Photomodeler Scanner
  - iWitness

Free Point cloud manipulation s/w: Meshlab, CloudCompare

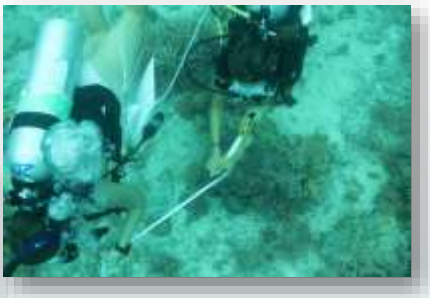
Lot's of open source s/w in http://photogrammetric-vision.weebly.com/software.html

HOW
Output & products



Detail comparison

INTRO
'How we do it in Mazotos'



Tedious tape measurements:

- Error prone
  - Currents
  - nitrogen narcosis
  - straight line
- Time consuming
- Small distances
- Limited information
  - Cannot extract shape
  - Each point in 3D requires >3 measurements)

Divers work together to map a part of the site. Photo courtesy of Stephen Smith.

"Underwater measurements in Mazotos shipwreck" in http://photogrammetric-vision.weebly.com/presentations.html

Data acquisition

Several aspects to consider

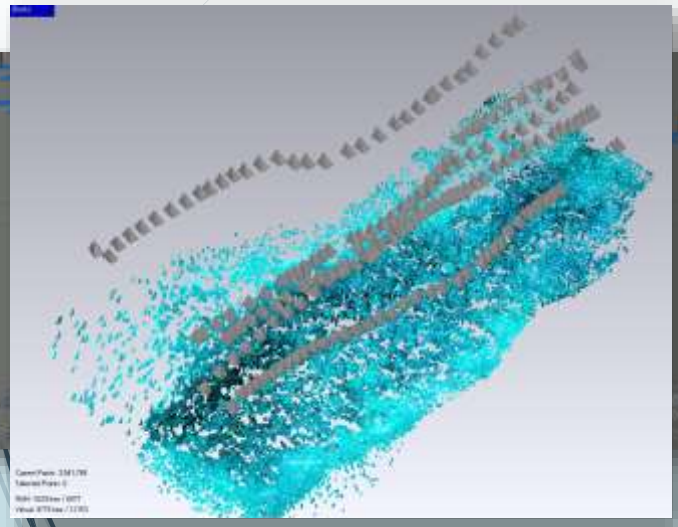
- Underwater photography
  - Color, flashes, etc
  - Light absorption (far objects invisible)
- Photogrammetry aspects
  - Control points
  - Block geometry
  - Accuracy and pixel size
  - Coverage (the whole AOI & adequate overlap)
- S/W aspects
  - Automated on nor processes
  - Computer power/speed & memory limitations

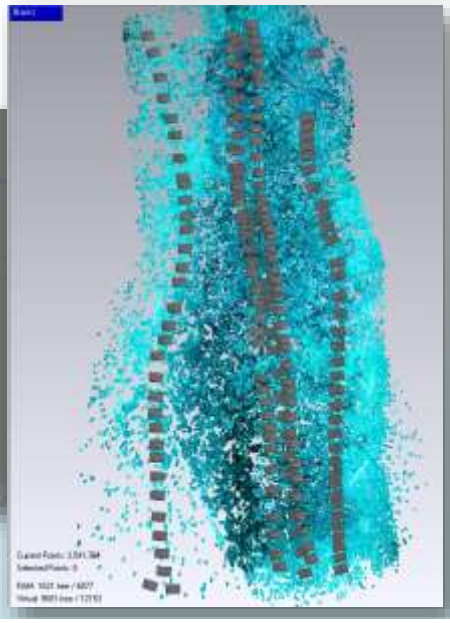
Skills necessary (diving, uw photography, photogrammetry)

Data acquisition in strips

Data acquisition in strips

Alignment wt camera self calibration
(Relative orientation)





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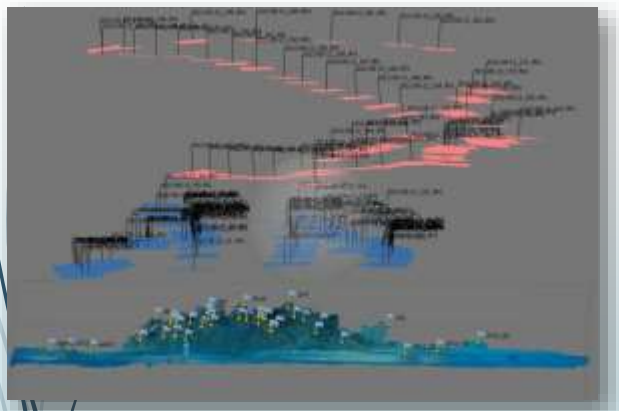
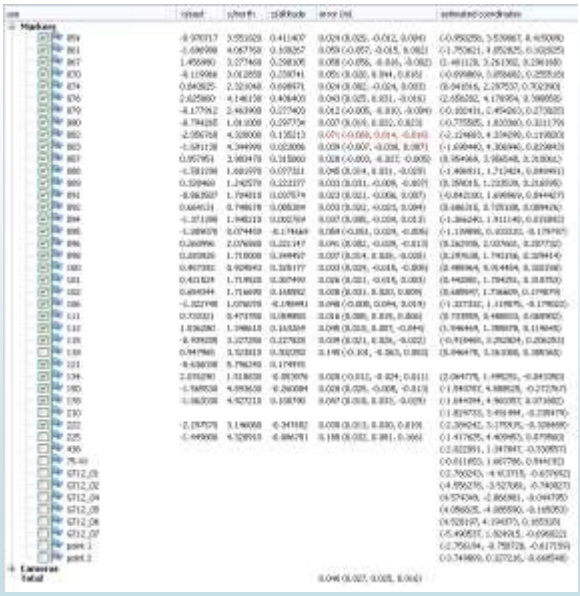


Photo measuring the control points

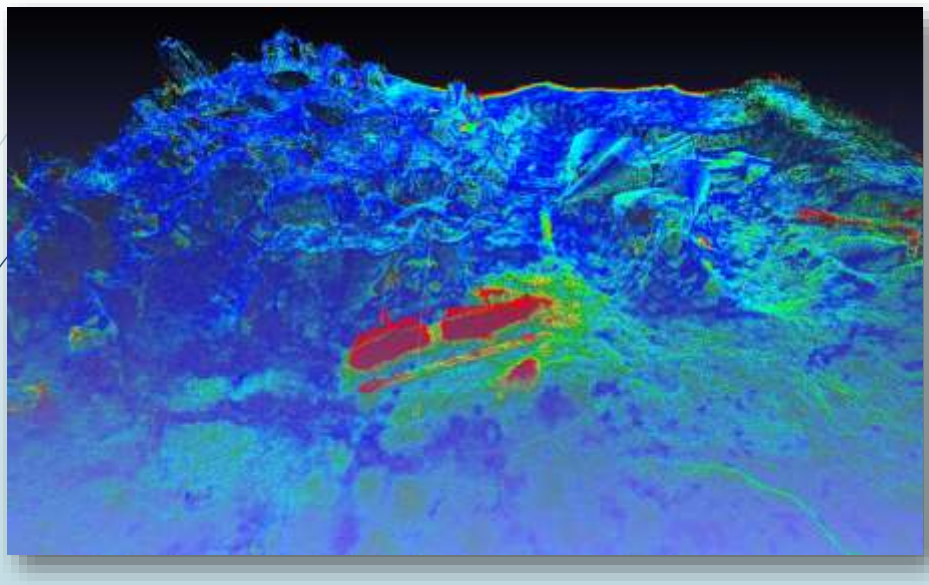
- Insert list of coordinates
- Locate and measure at least three points on photos
  - The rest are back-projected to photos automatically
  - Manually refine suggested locations
- Add scale bars (if existing)
- Perform ‘optimization’
  - Final calibration of camera

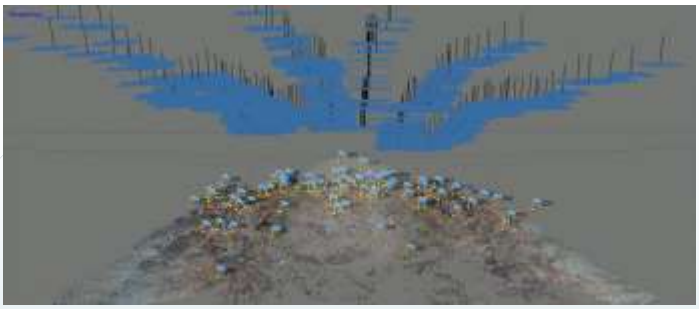


PC generation

Solids (mesh, TIN of PC)

PC comparisons





Finds 3D modelling (2010)

Amphora 3D model

Measurements based on 3D models

- Basic dimensions
- Sections
- Alignment checking
- Volumetric checks

HANDS ON EXPERIENCE

- Photo set of 2015-10-17
- 52 photos (Strip)
- GoPro photos
- Control points
  - 'Sketch' of control points
  - Coordinates of control points