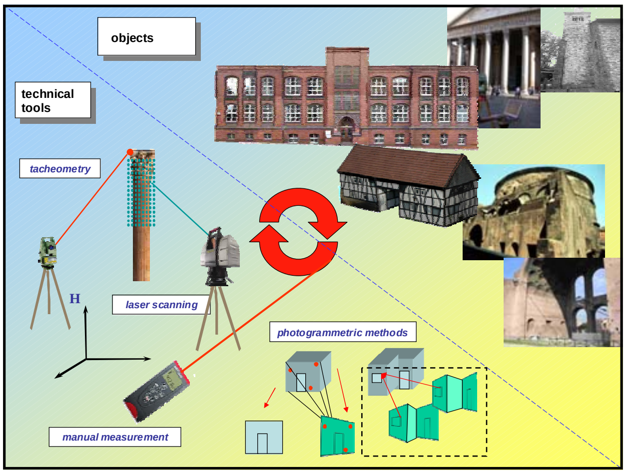
Architectural Surveying and Visualization using “Photo-Tacheometry”

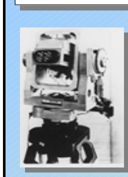
1. From conventional measuring methods to photo-tacheometry
2. Intelligent tacheometry for low-cost-recording of geometry
3. Photo-tacheometry, based on intelligent tacheometry

Ruhr-Universität Bochum Geodäsie im Bauwesen
Prof. Dr.-Ing. habil. M. Scherer

Cairo, Egypt, 16–21 April 2005



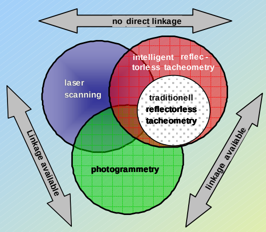
From traditional tacheometry to photo-tacheometry



≈1970	electronic tacheometer measuring to a reflector = total-station
≈1990	first total station without reflector = here called traditional or conventional tacheometer or total-station
1994	prototype of intelligent total station; constructed by Ruhr-University Bochum
1997	photo-tacheometry with external camera
1999 2001	first commercial intelligent total station: Leica TCR first equivalent instrument by Zeiss/Trimble prototype of first photo-total station (developed at RUB)
2001	first “video-total station” (RUB)
2003	total station with diaphragm for high-resolution-scan (RUB)
2004	first commercial reflectorless measuring video-total station with integrated cameras: Topcon



Intelligent tacheometry in relation to the other measuring methods



Intelligent Tacheometry →

- Intelligent Scanning
- Intelligent Instrument control

a) Exact motorized pointing of the totalstation (horizontal and vertical direction) to precalculated points of the object. This enables surveying technologies based on iteration and control circuit mechanisms.

b) This ability to give feedbacks distinguishes the active, object-oriented totalstation fundamentally from the passive, not object-oriented laser scanner.

The circuit-steps are: measurement – calculation – automatic pointing - measurement ...

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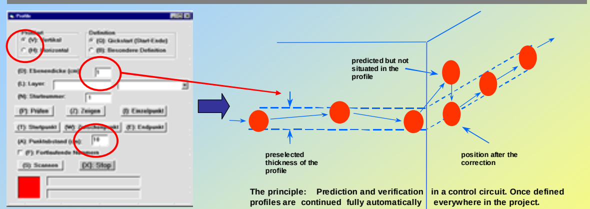
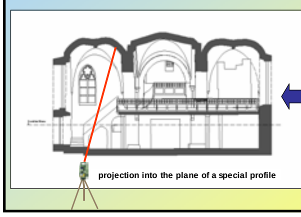
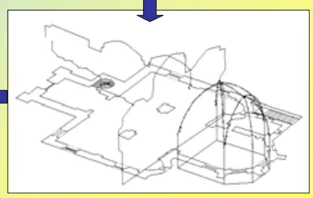
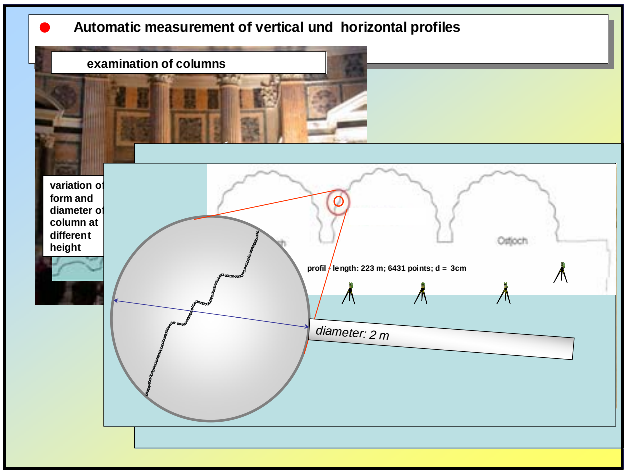
Automatic measurement of vertical und horizontal profiles

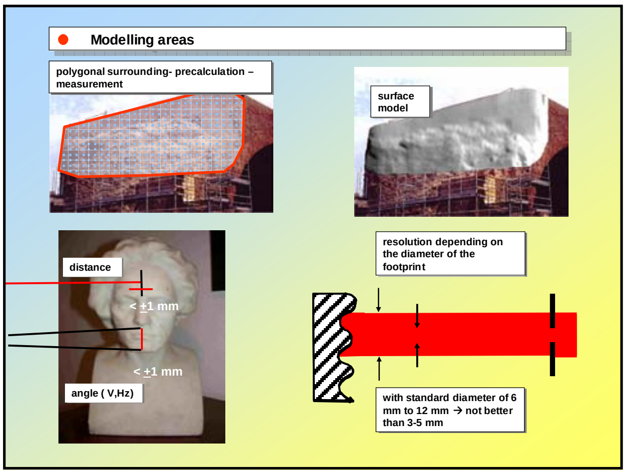


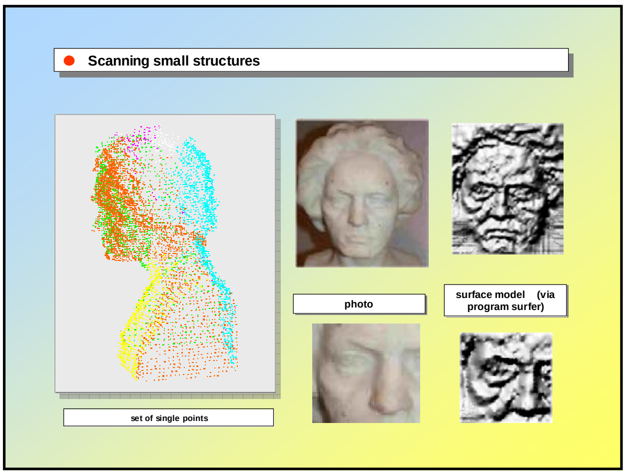
The principle: Prediction and verification in a control circuit. Once defined profiles are continued fully automatically everywhere in the project.

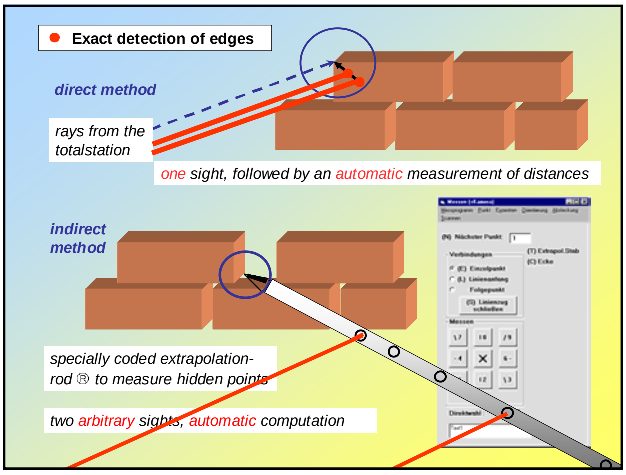


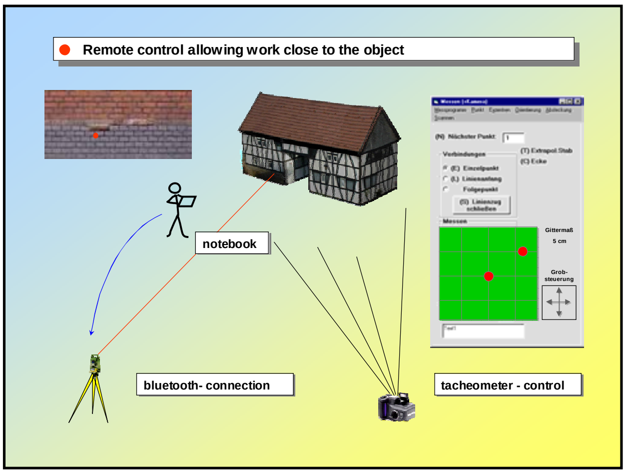


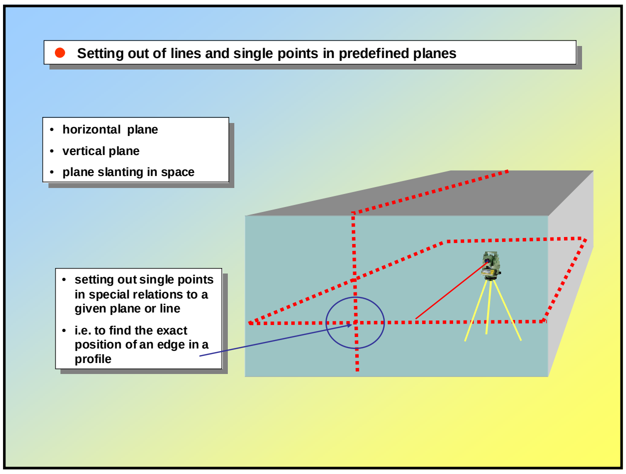

Automatic measurement of vertical und horizontal profiles
examination of columns
variation of form and diameter of column at different height
profil - length: 223 m; 6431 points; d = 3cm
Ostjoch
diameter: 2 m

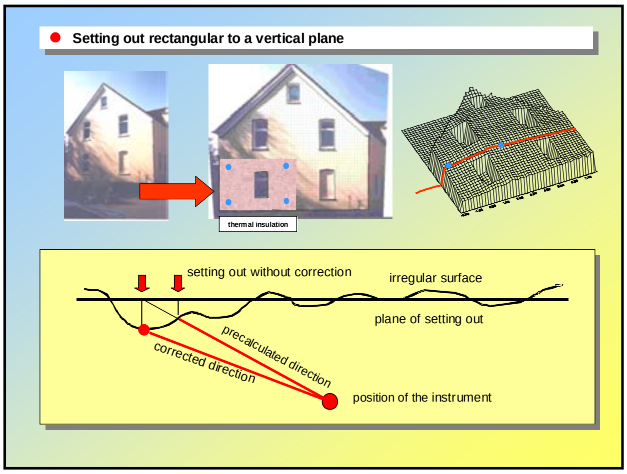

Modelling areas
polygonal surrounding- precalculation – measurement
surface model
distance
< ±1 mm
< ±1 mm
angle (V,Hz)
resolution depending on the diameter of the footprint
with standard diameter of 6 mm to 12 mm → not better than 3-5 mm

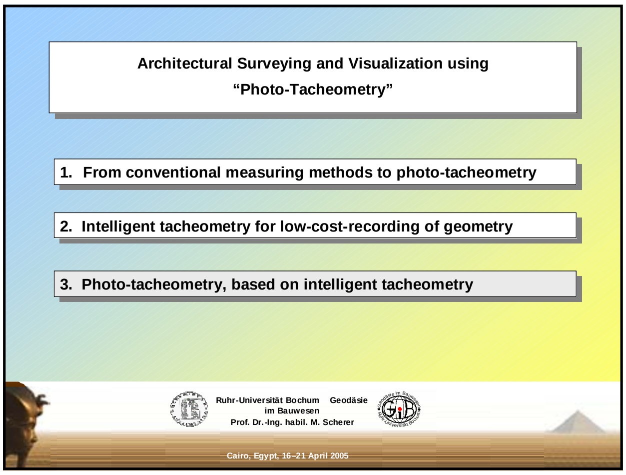

Scanning small structures
photo
surface model (via program surfer)
set of single points


Exact detection of edges
direct method
rays from the totalstation
one sight, followed by an automatic measurement of distances
indirect method
specially coded extrapolation-rod ® to measure hidden points
two arbitrary sights, automatic computation


Remote control allowing work close to the object
notebook
bluetooth- connection
tacheometer - control


Setting out of lines and single points in predefined planes
• horizontal plane
• vertical plane
• plane slanting in space
• setting out single points in special relations to a given plane or line
• i.e. to find the exact position of an edge in a profile


Setting out rectangular to a vertical plane
thermal insulation
setting out without correction
irregular surface
plane of setting out
precalculated direction
corrected direction
position of the instrument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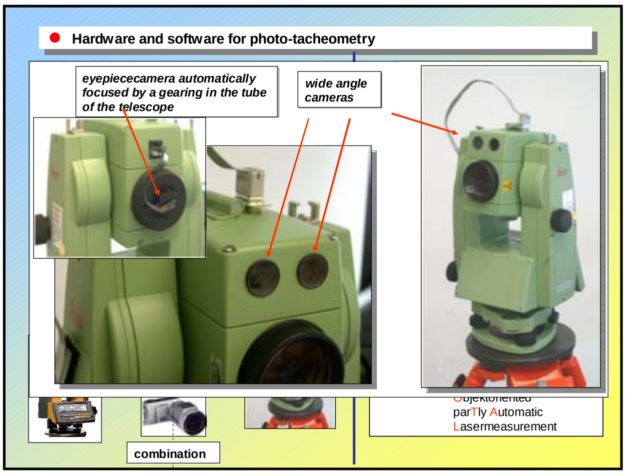
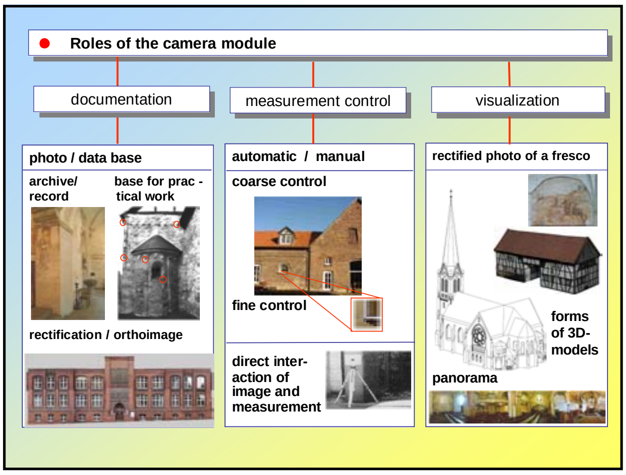
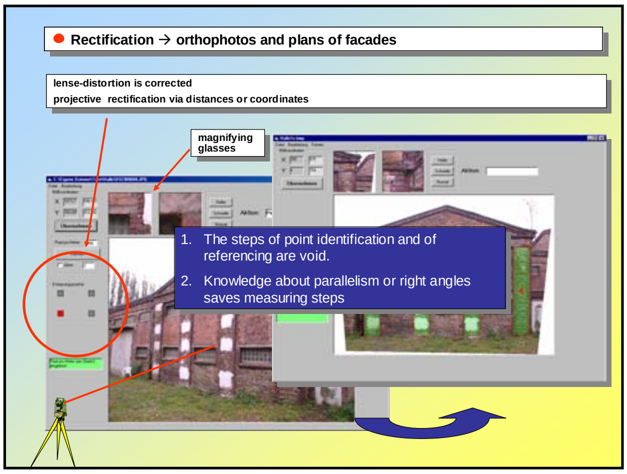
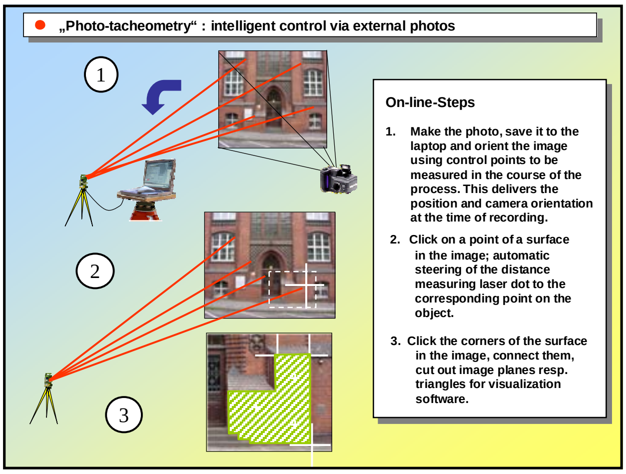
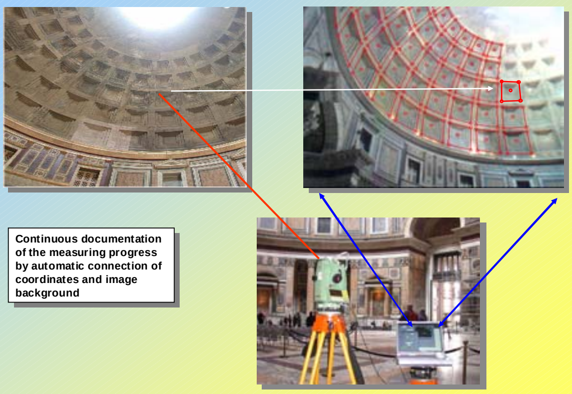

Hardware and software for photo-tacheometry
eyepiececamera automatically focused by a gearing in the tube of the telescope
wide angle cameras
parTly Automatic
Lasermeasurement
combination


Roles of the camera module
documentation
measurement control
visualization
photo / data base
archive/ record
base for prac - tical work
rectification / orthoimage
automatic / manual
coarse control
fine control
direct inter- action of image and measurement
rectified photo of a fresco
forms of 3D- models
panorama

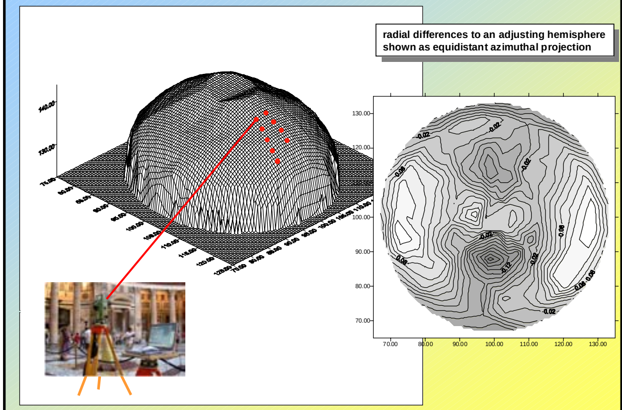

Rectification → orthophotos and plans of facades
lense-distortion is corrected
projective rectification via distances or coordinates
magnifying glasses
1. The steps of point identification and of referencing are void.
2. Knowledge about parallelism or right angles saves measuring steps


„Photo-tacheometry“ : intelligent control via external photos
1
2
3
On-line-Steps
1. Make the photo, save it to the laptop and orient the image using control points to be measured in the course of the process. This delivers the position and camera orientation at the time of recording.
2. Click on a point of a surface in the image; automatic steering of the distance measuring laser dot to the corresponding point on the object.
3. Click the corners of the surface in the image, connect them, cut out image planes resp. triangles for visualization software.

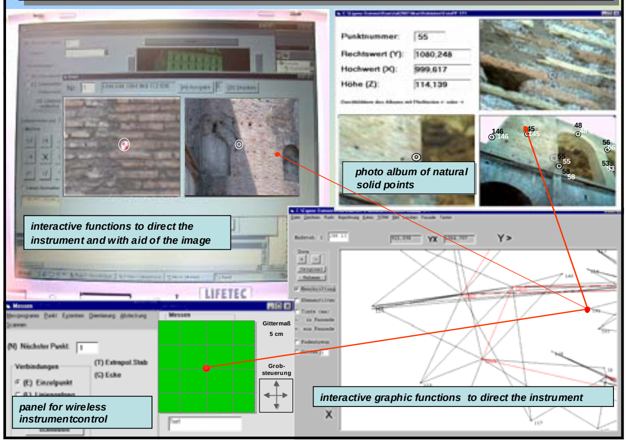
Dynamic visual measuring protocol



Pantheon – deformation of the dome



Practical work



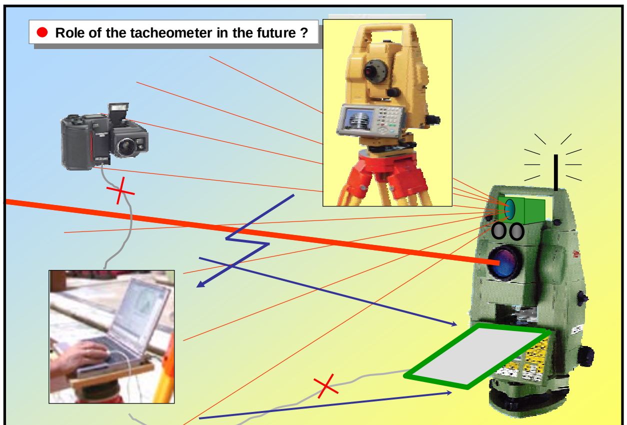
Increase in value of intelligent tacheometry

(i.g. all results on site)

			intelli-gent tache-ometry	traditional tacheometry	laserscanning
geometry	recording	- corners, edges	√	relative high expenditure	relative high expenditure
		- intersection-profiles (horizontal, vertikal, arbitrary)	√	impossible i.g.	extraction later
		- modeling of non mathematical surfaces	high ex-penditur	very high expenditure	√√
		- 3D-objects	√		√
		- monitoring – automatically repeated algorithms	ideal	very high expenditure	not possible precisely
		- smaller 3D-objects	precise	-	√ low accuracy
		- hidden points	√	√	i.g. not possible
	setting out	- intersection of lines (i.e. plane and object)	√	very high expenditure	not possible
		- engeneering surveying } 2D- Profiles 3D- Profiles	√		
		- setting out i.g.	√		
visuali-zation (external photo)	- rectification - orthophoto - 3D- model with photo-realistic texture	- plane / cylindric surface	√ point iden-tification	high expenditure for referencing of object- and imagecoordinates	partly √
		- projective or parametric projection	√ not neces-sary, partly		√ automatically
		- parametric rectification	√ automatic		
		- no targets for monitoring,	√	-	not possible
		- connection between different instrument setups via natural points	√		not possible
work with remote control (bluetooth)		- identification face to the object simple and safe	√ portraying	-	-
		- steering of the instrument via grafic/image/touchpad	way to work √		

One can use the advantages of intelligent tacheometry and photo-tacheometry only if one knows well the differences to traditional tacheometry and to laserscanning.

Role of the tacheometer in the future ?



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Conclusion

1. Intelligent tacheometry today is state of the art. All work may take place locally; the results are present on site.
2. It is a low cost alternative, using the intelligent totalstation, many governmental and private surveying companies own the hardware.
3. Intelligent tacheometry is predestined for monitoring and for setting out.
4. The capacity with visualization is very high and so far not exhausted.
5. It is a great advantage to work with exactly definable natural points.
6. In future developments should integrate photogrammetry, laserscanning and intelligent scanning.
7. The users of the results of architectural surveying and those having the technical know-how should work closer together.

http://cipa.icomos.org/

CIPA HERITAGE DOCUMENTATION
International Committee for Architectural Photogrammetry