# OPTICAL ACQUISITION AND EVALUATION OF RANGE DATA FOR ANALYSIS AND DOCUMENTATION OF ARCHAEOLOGICAL SAMPLES


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## Introduction

Photogrammetry is a well established technique for the optical acquisition of 3D coordinates. In conjunction with digital image processing and active projecting techniques like phase measuring profilometry, its possible field of application greatly increases, since topometric sensors are now able to digitize far more coordinate points automatically and thus allow a digital reconstruction of the object surface. This method therefore has an interesting potential for the digital documentation and analysis of archaeological samples. Various types of diagnostic tools may then be employed for numerical evaluation and comparison of samples.

## Methods

The basis of the system for 3D coordinate measurements is a topometric sensor head consisting of two CCD cameras and a fringe projector fixed on an adjustable-height rail via a tilting device (Fig.1). During the measuring process a sequence of four phase shifted quasi-sinusoidal fringe patterns is projected onto the object and registered as stereo images by the CCD cameras. After calculating the phase distribution, the stereoscopic images are evaluated by photogrammetric techniques and a 3D coordinate is caculated for each valid pixel. The achievable measurement accuracy depends on the triangulation angle (angle between the cameras), the image field size, as well as on the number of camera pixels. With a triangulation angle of 40 degrees and an image diagonal of approximately 20 cm, for example, the height resolution is situated at < 50 µm, the lateral at approx. 200 µm. With this computer controlled setup, data from different viewpoints can be acquired, integrated and processed automatically.

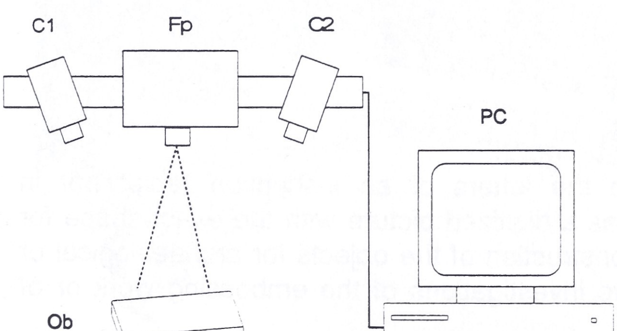


**Fig.1.** Experimental setup for 360 degree 3D data acquisition
Fp: fringe projector, C1, C2: CCD-cameras, Ob: Object, PC: personal computer

Using the obtained coordinate points (*point cloud*) the object surface is reconstructed by triangulation, i.e. by covering it with a grid of triangles. As the investigated objects are quite complex, an approach is used which does not make special assumptions about the surface structure and iteratively connects neighbouring points, only controlled by preset angular and distance constraints. It allows automatic processing - including the computation of range images - of large numbers of samples.

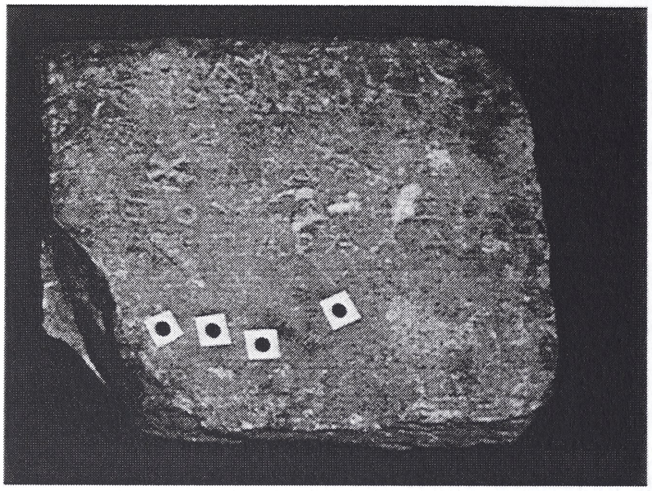

**Fig.2a.** Photo of the inscription tablet

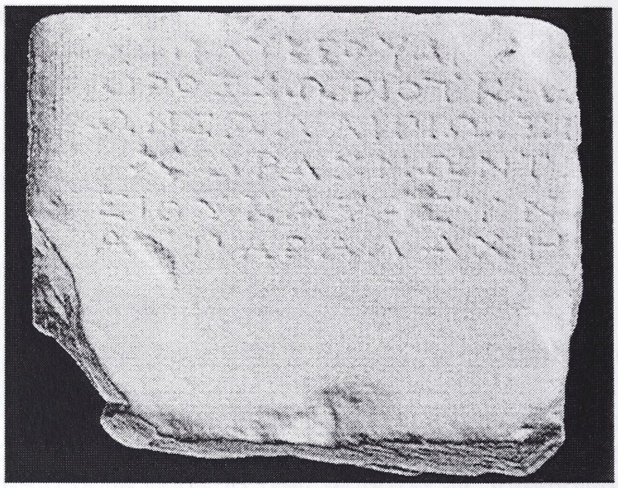

**Fig.2b.** Reconstructed object surface of the inscription tablet

## Archaeological applications

The presented system has been applied successfully for the investigation of inscription tablets (Fig.2a,b) for example. Besides being a digital documentation, the achieved data allow a further quantitative evaluation.
After computing a height or range image, usually visualized in false colors, image processing routines may be applied to enhance e.g. shallow inscriptions and thereby support their deciphering (Fig.3).

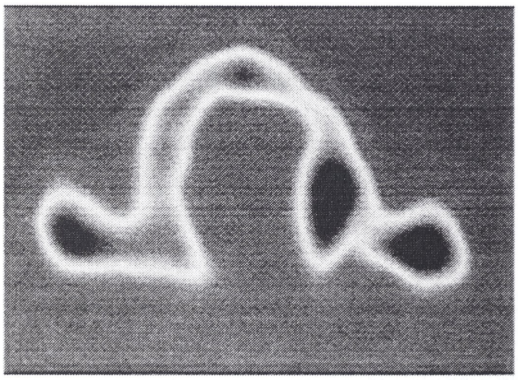

**Fig.3.** False color range image (reproduced in gray-level form) of one letter of the inscription tablet

Another advantage is the possibility to distribute the letters of an inscription tablet not in standardized form as it is used in books today but as a digitized picture with the exact shape for example via Internet. Due to the distortion-free reconstruction of the objects for archaeological or historical samples, this technique allows quantitative investigations of the embossing work or of numismatics .

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