AUTOMATION OF TOPOMETRIC 3D-ACQUISITION OF COMPLEX SURFACES USING OPTIMIZED REFERENCE CUBES

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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 for which then various types of diagnostic tools may be employed for numerical evaluation and comparison.
Complex object surfaces, however, are still a challenging problem for this technique, thus an approach to automize the measuring process will be discussed.

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.
The complete recording of a complex surface needs several measurements from different positions. These measurements have to be transformed into one global coordinate system. Usually this is done by the use of reference points, which are fixed on the object. These reference points are identified manually and therefore the method is very slow.
Thus, a concept for a reference system has been developed consisting of calibrated cubes with special reference plates on its sides which allow automatic processing. Each reference plate consists of three circular marks, which are needed for the transformation into the global coordinate system. A digital bar code on the reference plate allows the automatic identification of the number

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of each plate. In this way measurements from different viewpoints may be adjusted automatically if only at least one side of the cube is viewable. The cubes can be attached to the objects with special clamps. In order to be able to measure e.g. the front and the back side of an object, it is possible to mount both the object and the reference cube onto a glass plate which allows access from both sides.

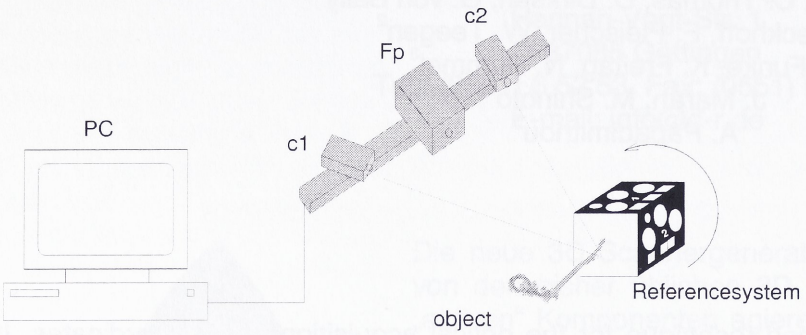

Fig.1. Experimental setup for 360 degree 3D data acquisition
Fp: fringe projector, C1, C2: CCD-cameras, Ob: Object, PC: personal computer

Using the obtained coordinate points (*point cloud*) the object surface is reconstructed by triangulation, i.e. by covering it with a grid of triangles.

Examples for archaeological applications

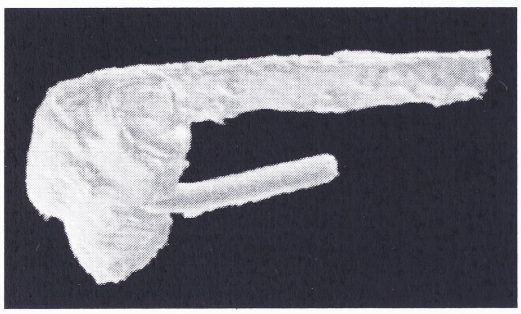

Fig.2 Reconstructed object surface of a fibula

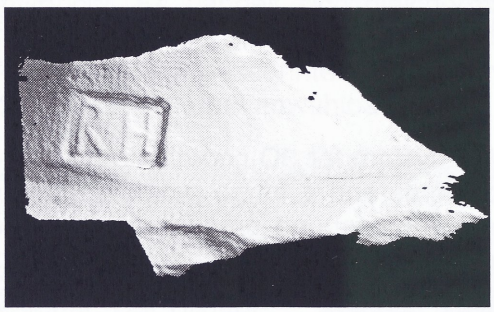

Fig.3. Reconstructed object surface of a stamp

Fig.4. Reconstructed object surface from stairs at the citadel of Tiryns (Greece)[6]

Object size: 8x4x2 m

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