

# CLOSE-RANGE SCANNING OF THE CUVILLIES-THEATRE IN MUNICH

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## ABSTRACT

This project was an European proposal in January 2006. The aim of the project was indicated to scan the Cuvillies Theatre in Munich with an accuracy of 0.4 mm leading to a 3D-visualisation of the whole theatre. According to the dimensions of this project the estimated time to capture only the 3D data by scanning will take about 1 year and about 3 years of postprocessing in office.

It is the biggest 3D-close-range scan project in the European market and is integrated in the complete renovation of this 1755 built theatre. A scaffold constructed into the auditorium offered the unique chance to place the 3D-scanner – triTOS system of Breuckmann - in a way it was needed.

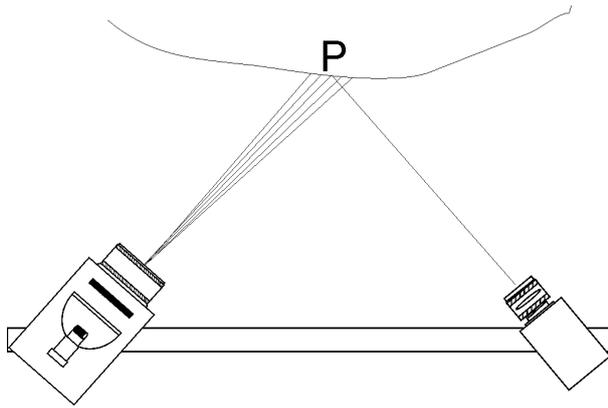
## 1. INTRODUCTION

The company Linsinger from Austria/Salzburg, highly specialized in surveying, scanning and photogrammetrical issues since 1972, offers documentation of cultural heritages with highest precision. We have done more than 400 projects throughout Europe, China and Bolivia. The name “Linsinger Kulturgutvermessung” (translation: “Linsinger culture documentation”) is well-known in whole Europe and we have won several prizes for our techniques. The following projects are examples:

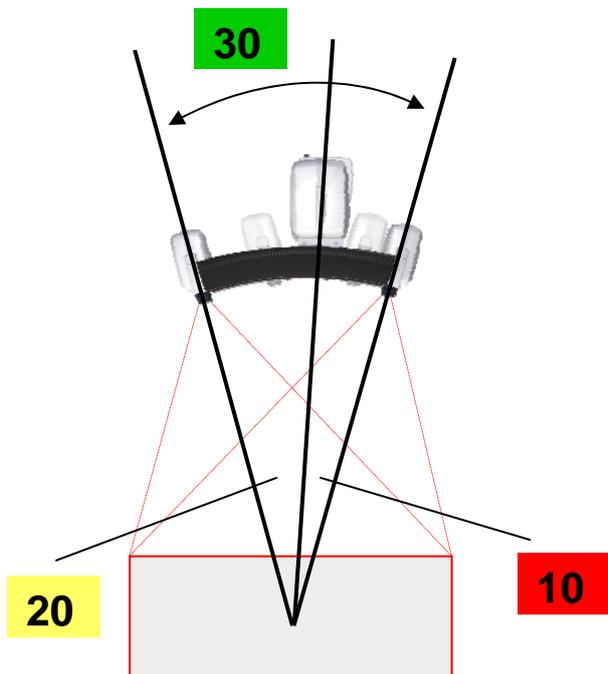
- Cuvillies-Theatre in Munich/Germany 2006-2008
- Dinosaursteps in Sucre/Bolivia 2006
- 250 Figurines in Xian/China 2005-2006
- Herkules and Antäus / Vienna 2006

## 2. TOPOMETRICAL 3D-METROLOGY

Topometrical 3D-metrologies are based on the principle of *full-field triangulation by means of structured illumination*. Thus, these techniques allow the acquisition of a large amount of 3D-data *at a glance* (up to several million points within a second). The typical and commonly used set-up for topometrical 3D-sensors consists of a projection device and a camera unit (see figure 1). The detector is positioned at a certain distance and angle relative to the direction of projection.



**Fig. 1 :** Topometrical set-up



**Fig. 2:** Set-up of the stereoSCAN-3D



**Fig. 3:** The new triTOS-3D scanner of Breuckmann

Light patterns or sequences of patterns (e.g. fringes) are projected onto the surface of the measuring object and recorded by the camera. For each camera pixel, one can calculate the corresponding 3D-coordinate according to the geometric laws of triangulation by using the related pixel coordinates of the camera and the phase information of the projected pattern. To get highly accurate 3D surface information it is also necessary to consider aberrations of all involved optical components.

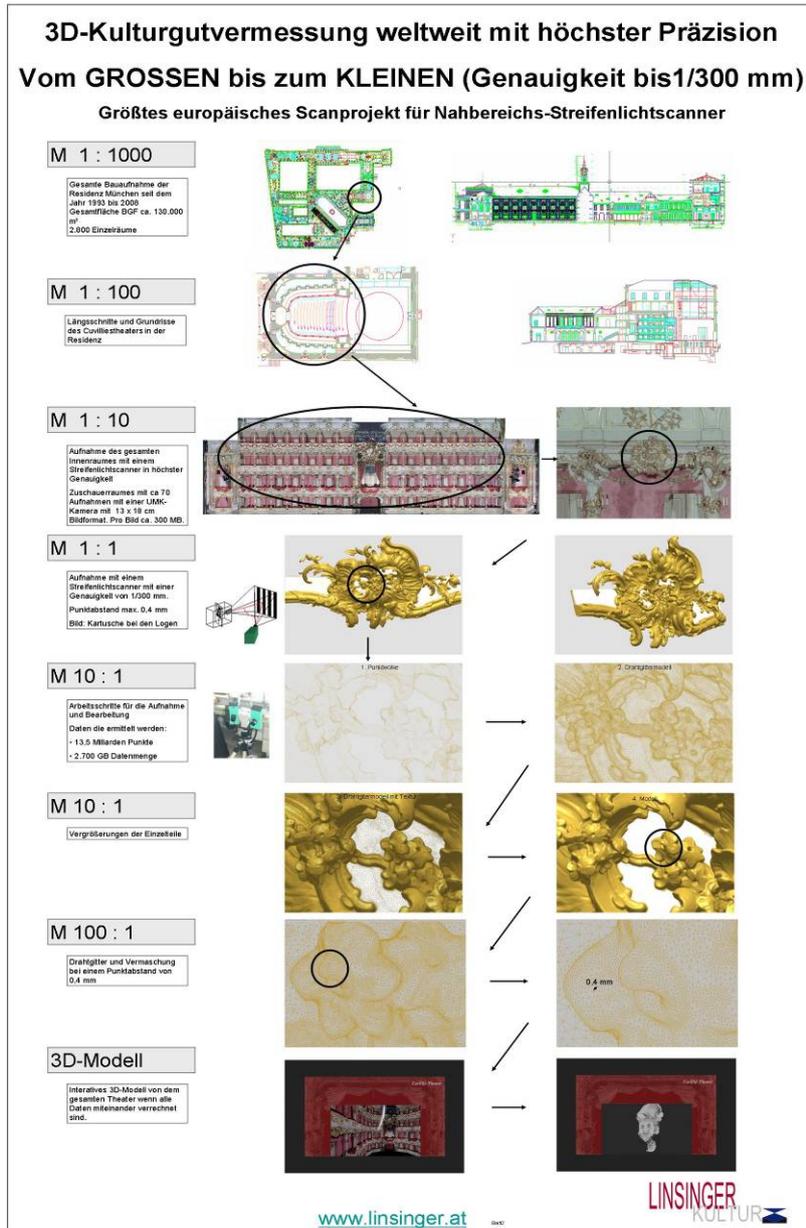
A different configuration is based on a stereometrical approach combining a two camera set-up with a projection unit. In this case, the calculation of the 3D-coordinates is based on the pixel information of the cameras only without using the geometrical and optical parameters of the projection unit. The information of the projected light structures, e.g. the phase information of fringe patterns, is only used for the determination of homologous points. The stereoSCAN-3D and the new triTOS-3D systems of Breuckmann GmbH combine these two approaches by using a two camera set-up with an asymmetrical projection unit (see figure 2 and 3). This allows the stereo-metrical calculation of highly accurate 3D-coordinates with the large triangulation angle of the two cameras. Moreover, each camera can be combined with the projection unit as a standard topometrical set-up. Due to the asymmetrical position of the projection unit one gets two additional sensor configurations with reduced triangulation angle. This allows a more complete data acquisition even for complex object structures.

For this project a 1-camera triTOS scanner with the following specifications was used:

Digitization:	1.4 MPixel per shot
Field of View ( FOV ):	600 x 400 mm
Spatial Resolution:	0.4 mm
Accuracy:	< 100 $\mu$ m

## 3. CLOSE-RANGE SCANNING OF THE CUVILLIES THEATRE

### 3.1 The Scan process



This was the biggest scan project in the European Union and was hardly to make because of the requirement of the customer. We expect to generate an amount of data of approximately 2.700 GB and have to handle more than 17 billions of points on our systems. So we had to grade up a lot in Hard- and Software to fulfil our aim.

The time schedule for the scan in the theatre was very hard because of the limitations given by the scaffold. It was only possible that one person could work on it because of problems of the wiggles. So we have worked nearly 10 months 24 hours a day.

The next step of the project, the processing of the recorded data, will begin in March 2007 and last till December 2008. Finally a 3D-model of the whole theatre will be available.

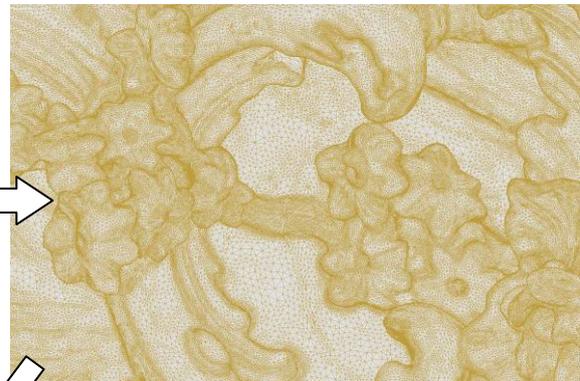
**Fig. 4:** Scanning the Cuvillies Theatre in Munich

The scan-program OPTOCAT of the triTOS system allows the recording of the 3D-data, the alignment / registration of point clouds, recorded from different viewing positions, as well as the polygonisation and merging of all recorded data. The alignment can either be done by means of the object geometry, which requires a manually pre-orientation of the recorded point clouds, or automatically by using index marks. Up to several hundred single shots can be handled within one project ( see figures 5 - 8 ).

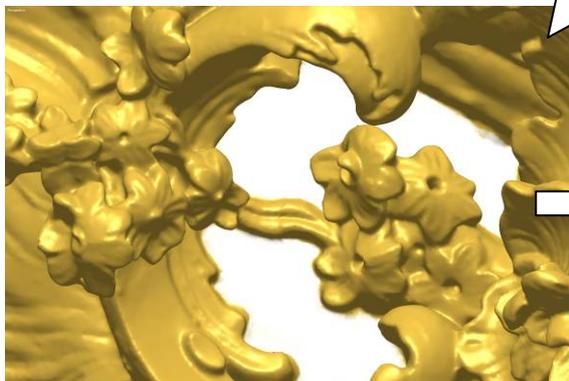
Finally the entire model is textured with pictures taken by an analogue Mamiya-camera extended with a high-resolution digital attachment of about 22 million pixel to improve the impression of virtual reality ( see figures 9 and 10 ).



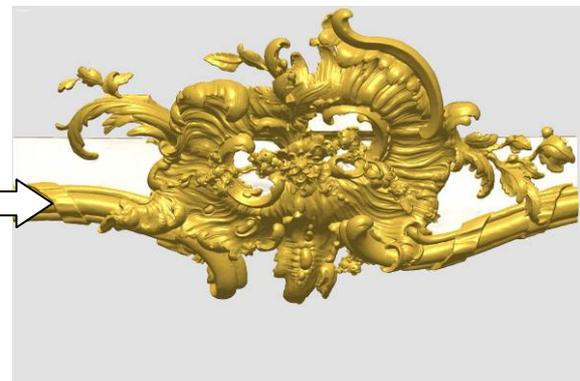
**Fig.5:** Pointcloud created by system



**Fig. 6:** 3D-mesh



**Fig.7:** Closed model



**Fig. 8:** Entire object



**Fig. 9:** Closed Model



**Fig. 10:** Texturized Model

During work in the theatre several difficulties had to be handled. A few test-scans had to be made to find the optimize settings for the data acquisition and to minimize distortions due to difficult object and environmental conditions.

Another problem was caused by the scaffold that was meant to be build back step by step, which led to immense time pressure. 2 shifts a day 7 days a week helped to solve that matter.

Furthermore for some scanning jobs only one person could work on the scaffold because of problems with the wiggle. The dayshift besides had to arrange its work according to the restorers that were working on the scaffold at the same time.

### **3.2. Post-processing - Leading to the final result**

The next step of the project will begin in March 2007. The post-processing of nearly 250 objects needs to be handled. To calculate each object in its highest resolution, cleaning the datasets from erroneous areas and filling holes in areas that could not be reached while scanning are an overview of the work that finally is leading to the result of an interactive 3D-model that represents the whole auditorium of the Cuvillies-Theatre.

Using the laser tracker HDS 3000 from Leica ( see figure 11 ) the whole construction successively was scanned with an accuracy of about 8 mm and transformed into the superior coordinate system. Each of the objects scanned with the triTOS system of Breuckmann finally is aligned to that system and can be shown in high-resolution.



**Fig. 11:** Leica HDS 3000

## **4. FINAL CONCLUSION**

Today, after one year of scanning in the theatre we finished our work on site and we improved a lot because of the development of the instruments and the software.

But also the post processing which is calculated one hour Scanning in the theatre is 15 hours after working in office has improved a lot because of the development of our Software Rapidform.

We are looking positive forward to finish this project in Summer 2008.