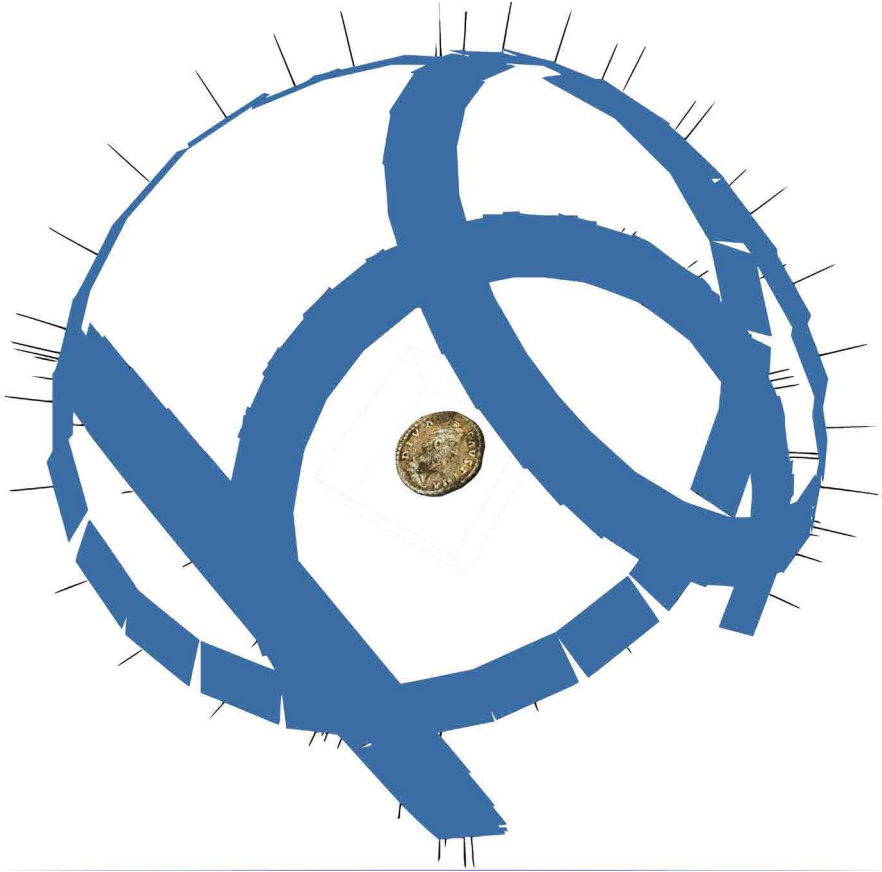

Collection Development, Cultural Heritage, and Digital Humanities

DIGITAL TECHNIQUES FOR DOCUMENTING AND PRESERVING CULTURAL HERITAGE

Edited by **ANNA BENTKOWSKA-KAFEL** and **LINDSAY MacDONALD**

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DIGITAL TECHNIQUES FOR DOCUMENTING AND PRESERVING CULTURAL HERITAGE

COLLECTION DEVELOPMENT, CULTURAL HERITAGE, AND DIGITAL HUMANITIES

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TOTAL STATION SURVEYING

MASSIMILIANO DITTA and AMANDINE COLSON

COSCH Case Study that has employed this technology: Bremen Cog

Definition

A total station is a surveying instrument using laser light. The distance between the instrument and the target is measured and recorded digitally. It is considered a direct surveying technique because the operator chooses the acquired points manually and defines them in advance. The degree of accuracy of each point remains high, but the global accuracy of the acquisition varies depending on the operator's methodology applied in a given context. A multitude of points, called a point cloud, will be produced providing geometrical data. This technique is very often used on building sites, as well as on archaeological excavations to measure large distances and establish maps.

Description

The total station is a composite technology, which allows selective recording of 3D coordinate points without direct contact between the instrument and the subject. The device integrates the functions of a theodolite (transit) for measuring angles, with an electronic distance meter (EDM) and a digital recorder. Angles and distances are measured from the total station to points under survey, and the spatial coordinates (X, Y, Z) are calculated using trigonometry and triangulation. The final output is a sequence of points with three-dimensional coordinates in relation to a local or geographical reference system.

The user has no visual feedback or control of the ongoing acquisition, until the process is completed and the data stored on the internal memory. However, there is a different way of using this instrument, as demonstrated in the COSCH case study of the Bremen Cog (chapter 7). The setup introduces a new element in the workflow, consisting of data acquisition, in real time, through software which

enables a direct communication between the total station and the host computer. The innovation lies in the use of 3D CAD software (Rhinoceros 3D) which can communicate directly with the total station through a plug-in, Termite, developed by Frederick Hyttel, a former student of the Maritime Archaeology Programme in Esbjerg, University of Southern Denmark. The most useful feature of Termite is the ability to resect the total station data on the fly. "Resection involves the computation of instrument position via observation of two or more reference marks or stations of known position. . . . Once the instrument has been moved to a new position, these marks can be re-observed to determine the new station coordinates" (Andrews et al. 2009, 9). The most troublesome aspect of total station recording is the necessity to record from several positions, whereas Termite allows all the data to be recorded in a single file, and then to keep that file updated with the total station's location and orientation (Hyttel 2011). For setting up the system, two sets of data are needed: (1) reference points; (2) target points. The network of reference points is necessary for establishing the positions of the total station and the subsequent resections, as well as to continue the monitoring over time. Suitable stations for the positioning of the total station must fit with two main requirements: a clear sight of at least four reference points, and a visual contact between the target or reference points and the total station aiming cross between a 90° and 45° angle. Ideally, if the referencing network remains in place, the same file may be used for subsequent acquisitions, and no errors will be added to the existing network.

The recording of both reference and target points was carried out with the Leica TS06 in reflector-less mode set on "fine," thus with a linear accuracy of ±2 mm + 2 ppm at 200 m (Leica ScanStation P20 2013). The angular error for the Leica TS06 is five. The maximum operative distance between the total station and points is less than 25 m. The maximum difference between the coordinates of two points was ±0.03 mm, far beyond the total station's own certified accuracy. Therefore, it can be stated that, taking into account both the resection and the angular errors, the measurement noise is expected to fall well below 1 mm.

Significant Applications

Since 1999, the Vasa Museum in Stockholm, Sweden, has been using a total station to monitor the deformation of their sixteenth-century, 69 m-long wooden ship, known as the Bremen Cog. The survey methodology was designed by Milan Horemuž from the Royal Institute of Technology in Stockholm, in cooperation with the team of the Vasa Museum, and the archaeologist Jacob Jacobson. Two campaigns per year enable the change in shape (Jacobson 2003, 186 and 188) to be measured. The 3D data are processed and visualized in a programmed platform in

MATLAB, including environmental information such as temperature and relative humidity collected by other sensors in the exhibition room (Horemuž 2003, 5). The acquisition includes 301 targets on the hull taken from sixty-six positions (van Dijk et al. 2016, 106).

In the field of cultural heritage, the total station is used daily all over the world in archaeological excavation (Howard 2007, 3) and for historic buildings (Lane 2016, 15) as a standard measurement tool. The recording of the Khaplu Palace located in northern Pakistan gives a concrete example of the use of a total station to document architecture. The information acquired constituted the basis of a large conservation and restoration programme (Muhammad 2011, 74) funded by the Aga Khan Trust for Culture that started in 2005. Combined with the local building traditions, the survey was both more accurate and less time consuming than manual sketches (Muhammad 2011, 76). The palace was fully restored in 2011 and has since become a luxurious hotel.

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