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Combined 3D Acquisition of Inscriptions and Terrain of the Worms Medieval Jewish Cemetery 'Heiliger Sand'

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Project Approach

Terrestrial laser scanning is increasingly attracting the geoarchological interest due to its fast, non-destructive and highly accurate documentation capabilities. Inscriptions on medieval tombstones made from sandstone become extremely weathered leading to characters hardly visible and partly lost.
Digitally capturing the geometric information is to preserve the today's state and to analyze it with tailored algorithms.


Fig. 1: View over the northern part of the cemetery 'Heiliger Sand'.


Fig. 2: Tombstone affected by weathering.

Study Area

The cemetery 'Heiliger Sand' in Worms (Fig. 1) is the oldest preserved Jewish graveyard in Europe, dating back to at least the 11th century AD.
Several famous rabbis of the so-called SchUM-community (Speyer, Worms and Mainz) were buried there. A total of almost 1400 tombstones clearly illustrate the outstanding size of the site. Due to their sensitivity and their low resistivity, the gravestones, which mainly consist of red sandstone, are heavily affected by physical and chemical weathering (Fig. 2). Hence, a fast and comprehensive documentation of the whole inventory and the inscriptions is required in order to preserve this cultural heritage from irretrievable loss and destruction.


Fig. 3: Installation the of mid-range laserscanning equipment combined with a digital camera for color acquisition. Data aquisition is provided online with RiScanPro running on a Toughbook.

Materials and Methods

Due to the high degree of surface weathering, inscriptions can barely be identified. Therefore, a 3D-scanner adopting the principle of structured light (Breuckmann smartSCAN 3D-HE color) was used for close-range 3D-acquisition, which allows for a highly precise capture of geometric details in the 10-100 μm range, like epitaphs.
Unusual for this kind of cemeteries is that – for unknown reasons – the graves neither show the customary orientation towards Jerusalem nor do they share the same orientation. The topography of the cemetery also provides insights to an old landscape in the heavily affected city area.
Consequently, a multimethod approach was implemented, applying supplementary mid-range Time-of-Flight laser scanner (Riegl VZ 400) with online full-waveform processing to precisely capture the position and orientation of the tombstones.


Fig. 4: Close-range 3D-acquisition of the inscription of tombstone Brocke No. 1061 using structured light (also known as coded light).

Results and Outlook

Simple light models can be used to simulate a neutral material without shadowing. Virtual light sources can be moved by the user making him independent from the once fixed setting up of a photographer. Additionally, curvature based analysis using Multi-Scale Integral Invariants (MSII) allows for enhancement of script and elimination of noise due to weathered surfaces. For documenting the inscriptions and extracting the characters the number of readable characters could be increased by 20%. Close-range acquisition time is approx. 1-2 hours per tombstone. As using this technique has the best ratio of effort to result for barely readable inscriptions, we are currently documenting the 30 most endangered inscriptions at the „Heiliger Sand".
A first-time documentation of nearly all tombstones and the entire topographical setting was possible. Data acquisition on the landscape scale is still in progress because shading effects of tombstones and trees require completion.
Future investigations and data processing will focus on the combination of mid-range Terrestrial Laser Scanning and close range object acquisition in order to provide a web compatible 3D-model of the cemetery. The inscriptions on the historically important tombstones are to be integrated in an information system and will then be accessible to the public.


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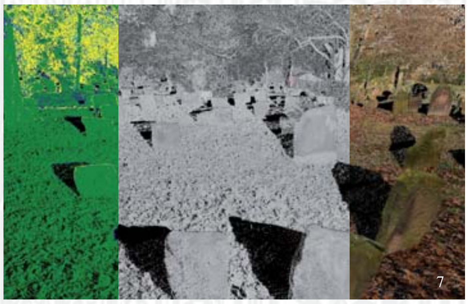
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Fig. 5 shows the 3D-model with virtual illumination without color information (texturemap) of the surface, which enables an easier descrption.
Fig. 6 illustrates the inscription using MSII analysis to locally highlight specific features in surface curvature. Epitaphs are marked in black. As MSII filtering is a local operation, additional characters written around the (left) corner become visible.
Fig. 7 shows a pointcloud of at all four registered scanpositions. The left part shows the different digitized echos. Green indicates single targets, and yellow first targets. Last and other targest are shown in blue and cyan. The middle represents reflectance-values for each point. On the right side the RGB-values taken from the mounted digital cameara are mapped on first and single target points.
Fig. 8 is a transcription by Michael Brocke, S.-L. Steinheim Institute
Fig. 9 shows a heightmap in respect to a plane fitted to the inscription (blue: <12 mm, green <21 mm, yellow <70 mm, red <77 mm and white <86 mm).

http://www.iwr.uni-heidelberg.de/groups/ngg/Worms/

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