Data for History 2020: Modelling Time, Space, Agents

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3D Digitization of the Bunker "Valentin": Methods, Challenges and Possibilities

We present the project "3D Mapping of U-Boot Bunker Valentin memorial with Air- Ground-, and Underwater-Robots" (Valentin3D), which is funded by the German Federal Ministry of Education and Research (BMBF) within the e-Heritage program and currently running at Jacobs University Bremen.

In spring 1943, due to a massive loss of submarines, the National Socialist government started the construction of a bunker in the north of Bremen. In this bunker, called "Valentin", a new type of submarine was to be assembled, protected from the increasing air raids on the Hanseatic town. Time was an issue as well as materials and workforce. The latter was solved by engaging prisoners of a labor education camp and concentration camps as well as POWs and forced laborers. Thousands of people thus worked under gruesome and life-threatening conditions, and around 1.600 died, until the construction site was shut down due to bombardment by Allied Forces in March 1945.

After World War II, Bunker Valentin was first used as a bombing test site by the American Air Force, and then from 1967 on, following much debate about what to do with the massive building (35.375m², length 419m, width 67-97m, height 20-33m), as a depot by the German Military (Bundeswehr). In the late 1970s, consciousness of the bunker and its history and a demand to remember the inhumane circumstances surrounding its construction began to grow amongst the public; this led to the erection of a memorial just outside the military area in 1983. In late 2015, after the Bundeswehr withdrew from the bunker, the entire site was inaugurated as the "Denkort Bunker Valentin" memorial, offering public access and an exhibition on the history of the site.[1]

Since then thousands have visited the site every year. One of the problems for the "Denkort" team, though, is the fact that a large part of the bunker cannot be accessed by visitors. The air raids during and after the war left parts of the (never completed) ceiling destroyed, causing a high risk of rockfall in this part of the bunker, as shown in Figure 1.

Fig 1. Ruins inside the Valentin Bunker, not accessible to the public.

Besides leading to mystification, the inaccessibility impedes research. As a counteracting measure and to supplement the Denkort's exhibition, Bunker Valentin is currently being mapped three dimensionally in order to facilitate research and to allow visitors to explore it in a digital form. The project "Valentin 3D" started in 2018 at the Jacobs University Bremen in cooperation with the Denkort. Funded by the Ministry for Education and Research (Bundesministerium für Bildung und Forschung, BMBF) within the e-Heritage program, the project's main goal is the digitization of the bunker. To achieve this, computer scientists from the university's Robotics Group teamed up with historians. Due to the bunker's size, poor accessibility and water-submerged zones, Bunker Valentin is mapped using a wide range of robotic tools – such as laser scanner (lidar), unmanned aerial vehicle (UAV) or drone and underwater remote operated vehicles (ROVs), see Figure 2 for reference.

Specifically, the indoor part of the bunker was mapped using the laser scanner which uses the reflection of rapid laser pulses on the surfaces to obtain scans in form of dense clouds of 3D points representing the environment. The scans are integrated into a 3D model using among others previous own work in form of registration with Fourier-Mellin-SOFT (FMS) [2]. For the outside part, photogrammetry using an UAV is used due to its simpler technical operability, surveying speed and the availability of GPS measurements. Then, to create a 3D model from the UAV 2D photos, a state-of-the-art implementation of Structure from Motion (SfM) is applied. One challenge is to merge the 3D representations from both data-sources, i.e., the metric lidar data and the scale-free SfM data, in an automated way, i.e., without manually determining the relative scale between both sources. To tackle this, we also use Fourier-Mellin-SOFT (FMS). It is very robust when registering noisy 3D data as well as data from different sensors with, e.g., different densities, under varying recording conditions, e.g., light and dark scenes, and changes in scale [3]. In this way, multiple sources of information can be aggregated for a more complete analysis and visualization, for both researchers and the general public. Finally, for the bunker zones that are underwater, such as a basement which was never explored before, an ROV is used. Due to the inaccessibility of this basement to humans and large equipment, only a video survey of this place was taken so far. The visual surveys have been useful in organizing and supplementing the constructions blueprints from the bunker which, in turn, creates a synergy between the standard available analogue information and the new digitization methods. The project is currently still ongoing and further progressing with the digitization of the bunker. This also includes challenges and future possibilities, for example, questions of additional value related to historical research and education. Questions about the visualization of the data related to scale, incompleteness, quality and how to best aggregate the already available data (pictures, blueprints, recordings, etc) and the detailed 3D models (see Fig. 4) are also an issue to be reflected on by both historians and computer scientists. For our current results, please visit http://robotics.jacobs-university.de/projects/Valentin3D-DE

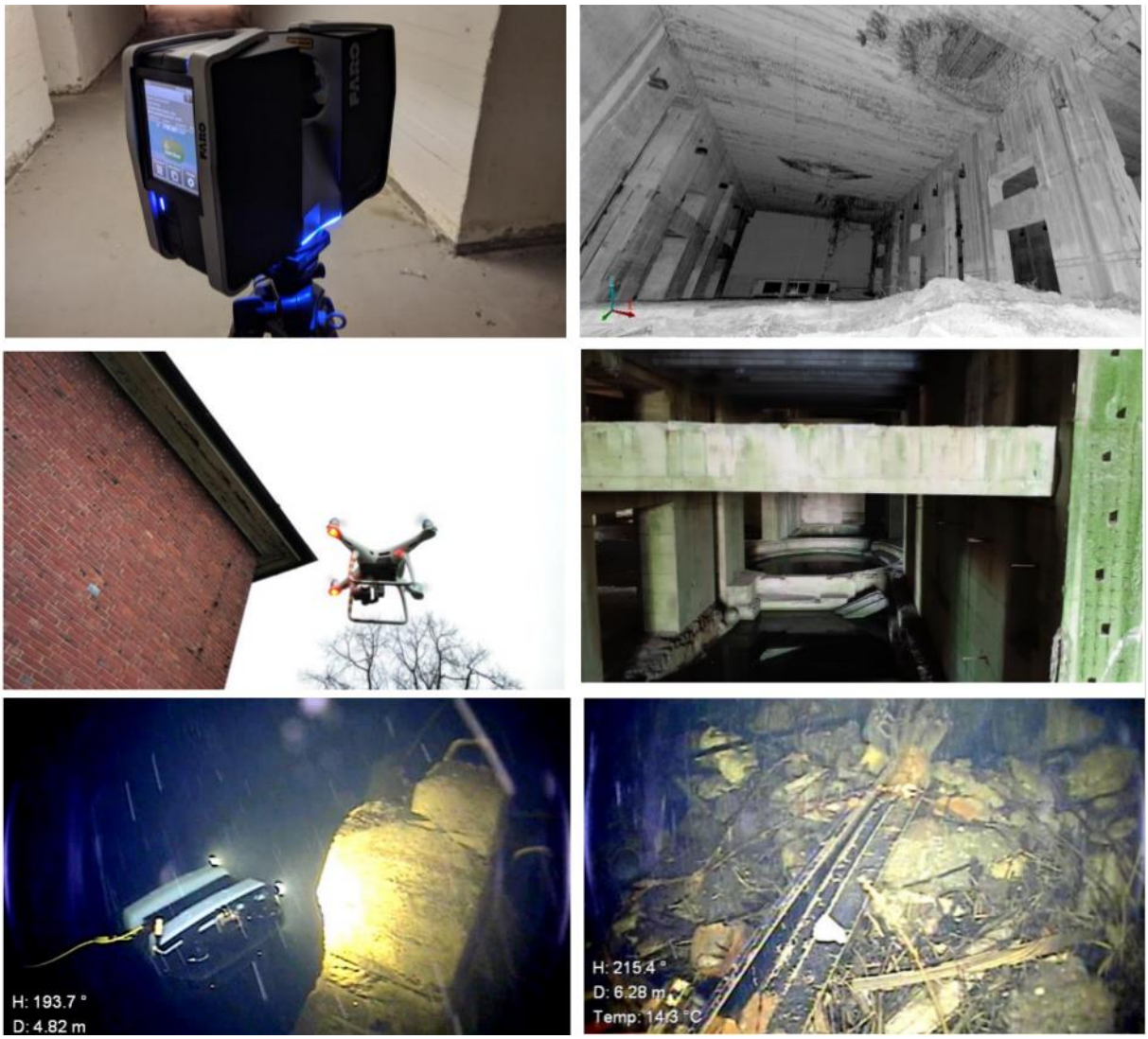

Fig 2. Sensors/robots used (left column) to explore different parts of the Bunker (right column): inside ruin part, ceiling and water basin -- from top to bottom.

Fig 3. Final 3D model from the outside part of the Bunker, ready for visualization.

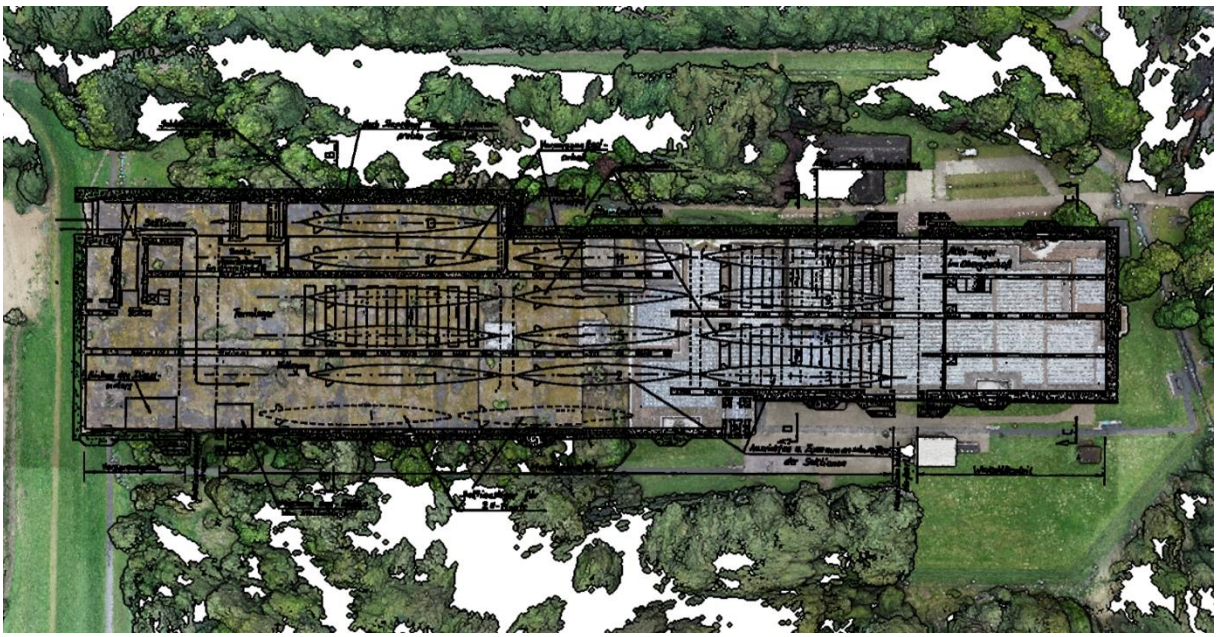

Fig 4. Overlay of bunker blueprints with 3D model, aggregation of analogue and digital data.

[1] Cf. Marc Buggeln: Der U-Boot-Bunker Valentin in Bremen: Baustelle, Lager, Nachkriegsnutzung, in: Inge Marszolek, Marc Buggeln (Ed.): Bunker: Kriegsort, Zuflucht, Erinnerungsraum, Frankfurt a. Main 2008, p. 103-119; for a more detailed account of the Bunkers history cf. Marc Buggeln: Der U-Boot-Bunker “Valentin”. Marinerüstung,

Zwangsarbeit und Erinnerung, Bremen 2017, and the website of the Denkort: https://www.denkort-bunker-valentin.de/startseite.html.

[2] Cf. Heiko Bülow and Andreas Birk: Scale-free registrations in 3d: 7 degrees of freedom with fourier-mellin-soft transforms, in International Journal of Computer Vision (IJCV), 2018, vol. 126, no. 7, p. 731–750.

[3] H. Bülow, C. A. Mueller, F. Buda, A. G. Chavez, and A. Birk: A Divide and Conquer Method for 3D Registration of Inhomogeneous, Partially Overlapping Scans with Fourier Mellin SOFT (FMS), IEEE International Conference on Robotics and Automation (ICRA), 2020.