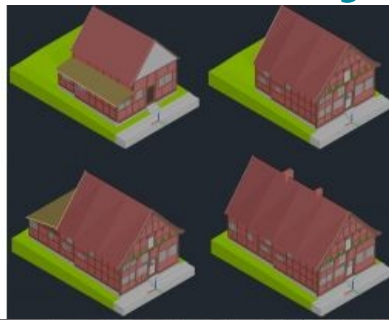## *AN INTERACTIVE 4D RECONSTRUCTION OF A HISTORIC BUILDING IN VIRTUAL REALITY*

The Development of a Virtual Museum in Germany

A 'virtual museum' (VM) has the potential to greatly improve the experience of a traditional museum visit, adding the possibility to provide information in a new, entertaining and convenient way. Interactive digital visualisations in particular can increase the comprehensibility of a complex topic. Such an application has now been developed as part of a master's thesis for the Museum Alt-Segeberger Bürgerhaus in Bad Segeberg, Schleswig-Holstein, Germany. The whole building, the museum exhibition and six historic stages of construction have been reconstructed based on the capture of 3D data. Visitors can explore the historic building in a real-time 3D environment, both in a desktop application and in virtual reality (VR).

The Alt-Segeberger Bürgerhaus is the oldest building in Bad Segeberg. Constructed in 1541, the building has changed its form and function several times during its 475-year history. In collaboration with Nils Hinrichsen, historian and head of the museum, it was possible to identify the appearance of the building during six major periods of construction. It started as a small three-room house after a fire destroyed most of the town, including the previous building, in 1534. Several rooms were subsequently added to the building over the centuries. The facades and the interior design changed in line with the needs and possibilities of the corresponding eras. The last major renovation took place in 1963-64, when a museum was established in the building for the first time. Since 2012 it has been accommodating exhibitions about both the history of the city and the building as well as German culture (Figure 1).

Since 2011, there has been a cooperation between the museum and the HafenCity University Hamburg (HCU), whereby the museum building has been used in the practical education of students from the HCU's bachelor programme in geomatics. Students have recorded both the exterior and interior of the building and created 3D models for the purpose of learning photogrammetric 3D recording and visualisation techniques. This data forms the basis for the VM project.

3D modelling

The first step was to construct the building in its current state based on the data mentioned above. In order to optimise performance, the model was not calculated from the point cloud by meshing but constructed manually in AutoCAD instead. Thus a stable frame rate for visualisation could be achieved, even on standard computers, while still having a decent amount of significant object details included in the scenes.

The historic models were created using the model of the current state as a starting point and retracing the steps of every known reconstruction change (Figure 2) using historic sources. Furthermore, the buildings in the museum's surroundings were modelled with non-textured, simple geometric shapes to provide an environmental context for visitors standing outside the museum. Additionally, the most

important parts of the exhibition were modelled for later integration into the building interior. The total triangle count of all objects amounts to approximately 100,000 triangles, which is a good basis for a low-cost, real-time visualisation application.

Game engine and programming

The interactive part was developed using the Unreal Engine 4 game engine. Game engines provide very high performance for real-time rendering and ever-increasing support for virtual-reality systems. For the desktop version, several fixed positions were placed both inside and outside the building. Users can look around freely from any position and can switch between positions with a short animated transition or can use direct teleportation by clicking on the desired position on a miniature overview map. The interaction with the environment is provided by a total of 52 clickable information signs. Each sign opens a menu with further information about the object of interest. The menu usually includes a text and a sizable photo (Figure 3). It is also possible to implement other media such as videos and separate small 3D models within the menu.

The main feature of the VM is the visualisation of the construction history. Designed as a 'model within the model', the historic states of the building can be explored by walking around them and activating animations which provide an exploded view of every state of construction (Figure 4). Alternatively, individual changes in the appearance of the building can be displayed slowly, from one state to the next, accompanied by comments about the main changes during the construction period.

Virtual reality

The VR version of the VM was created using HTC Vive, which has been available on the market since April 2016. The fixed positions were replaced by a free navigation, either via teleportation or direct walking. Two motion controllers were also used to interact with the environment; one controller fulfils the teleportation function and contains a laser beam to activate and interact with the menus, while the other contains the menu screens and the miniature overview map. The freedom of perspective and the improved sense of scale makes the VR museum an immersive 3D environment. This allows an even deeper analysis of the 4D model of the building's evolution by giving visitors the possibility to actually stand inside the building while it changes around them (Figure 5).

Results and conclusions

The final desktop version of the program is 500MB in size and is executable on Windows-OS without software installation. This extends the field of application from the museum itself to most personal computers (PCs), enabling visitors to purchase the program and further deepen their knowledge about the exhibition topics they have seen.

The VR version of the program has been demonstrated on several occasions, including at Intergeo 2016 in Hamburg. The very positive feedback showed the promising potential of such applications, which is particularly high in – but not limited to – the museum context. In theory, any application which benefits from a realistic representation of the environment and is improved by an immersive experience can benefit from the use of interactive VR. This can increase the entertainment aspect, a person's understanding and their motivation to deal with an unknown topic, and the approach can help to convey information in presentations, promotional and/or educational settings.

Further Reading

- Kersten, Th., Tschirschwitz, F., Deggim, S., 2017. Development of a Virtual Museum including a 4D Presentation of Building History in Virtual Reality. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XLII-2/W3, 3D Virtual Reconstruction and Visualization of Complex Architectures, 1-3 March 2017, Nafplio, Greece, Editor(s): D. Aguilera, A. Georgopoulos, T. Kersten, F. Remondino, and E. Stathopoulou,
- 361-367. Kersten, T., Hinrichsen, N., Lindstaedt, M., Weber, C., Schreyer, K., Tschirschwitz, F., 2014. Architectural Historical 4D Documentation of the Old-Segeberg Town House by Photogrammetry, Terrestrial Laser Scanning and Historical Analysis. In: *Progress in Cultural Heritage. Documentation, Preservation, and Protection, Lecture Notes in Computer Science (LNCS),* Volume 8740, Springer International Publishing Switzerland 2014, 35-47
- Tschirschwitz, F., Kersten, Th., Zobel, K., 2014. Interactive 3D Visualisation of Architectural Models and Point Clouds Using Low-Cost-Systems. In: *Progress in Cultural Heritage. Documentation, Preservation, and Protection, Lecture Notes in Computer Science (LNCS)*, Volume 8740, Springer International Publishing Switzerland 2014, 268-278.

About the Authors

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