

# Virtual Monuments and Virtual Museums in a Game Engine – An Immersive Experience using the VR System HTC Vive

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## **EXTENDED ABSTRACT:**

Recent advances in contemporary Virtual Reality (VR) technologies are going to have a significant impact on everyday life. Through VR it is possible to virtually explore a computer-generated environment as a different reality, and to immerse oneself into the past or in a virtual museum without leaving the current real-life situation. For such an ultimate VR experience, the user should only see the virtual world. Currently, the user must wear a VR headset which fits around the head and over the eyes to visually separate himself from the physical world. Via the headset images are fed to the eyes through two small lenses.

Cultural heritage (CH) monuments are ideally suited both for thorough multi-dimensional geometric documentation and for realistic interactive visualisation in immersive VR applications. Furthermore, VR is increasingly in use for virtual museums to enhance a museum visitor's experience by providing access to additional materials for review and knowledge deepening either before or after the real visit. Using today's available 3D technologies a virtual museum is no longer just a presentation of collections on the Internet or a virtual tour of an exhibition using panoramic photography. Additionally, the game industry offers tools for interactive visualisation of objects to motivate users to virtually visit objects and places. In this paper the generation of virtual 3D models for different cultural heritage monuments (e.g. the wooden model of Solomon's Temple and the Selimiye mosque in Edirne, Turkey) and the development of a virtual museum (Old-Segeberg Town House), and its processing for data integration into the two game engines Unity and Unreal are presented. The projects have been carried out by the Photogrammetry & Laser Scanning Lab of the HafenCity University Hamburg, Germany to demonstrate an immersive and interactive visualisation using the VR system HTC Vive. The workflow from data acquisition to VR visualisation, including the necessary programming for navigation and interaction, is described. Furthermore, the use (including simultaneous multiple users environments) of such a VR visualisation for CH monuments and a virtual museum is discussed in this presentation. Photogrammetry and laser scanning offer the opportunity and challenge to model the world of the past and of today in a way that we can visit it in the virtuality.

## **Technical components**

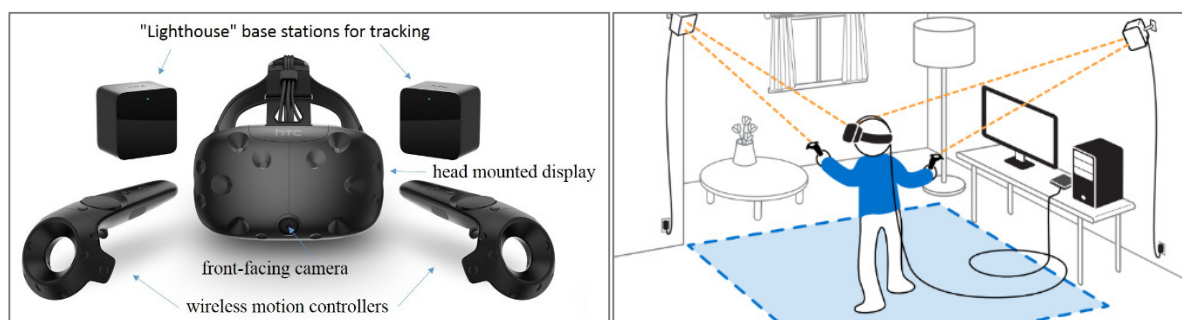
For virtual reality applications the two game engines Unity and Unreal were used at HafenCity University Hamburg. A game engine is a software framework designed for the creation and development of video games for consoles, mobile devices and personal computers. The core functionality typically provided by a game engine includes a rendering engine for 2D or 3D graphics to display textured 3D models (spatial data), a physics engine or collision detection (and collision response) for the interaction of objects, an audio system to emit sound. It includes tools for scripting, animation, artificial intelligence, networking, streaming, memory management, threading, localisation support, scene graph, and may include video support for cinematics. A game engine offers the ability to control the course of the game and is responsible for the visual appearance of the

game rules. For the development of a virtual reality application, game engines offer many necessary concepts with much functionality so that users can interact with the virtual object.

In the past, the development of game engines was mostly based on the development of a specific game with subsequent paid licensing to external game developers. In recent years, however, most of the large engine providers have focused more on the advancement of engines and additionally offer free access for developers with eventual profit-sharing royalties. Examples of game engines with potential free use are the engine Unity from Unity Technologies, the CryEngine of the German development studio Crytek, and the engine Unreal from Epic Games ([www.epicgames.com](http://www.epicgames.com)). The selection of the appropriate engine for a project is based on the provided components mentioned above, the adaptability in the existing work processes as well as special preferences of the (game) developer.

In the framework of these projects, beside Unity the game engine Unreal was selected due to the opportunity to develop application and interaction logics using a visual programming language, the so-called Blueprints. Visual programming with Blueprints does not require the writing of machine-compliant source code. Thus, it provides opportunities for non-computer scientists to program functions for a VR application using graphic elements. The saving in time associated with this method of software development allows for the generation of additional scenarios and for more intensive user testing.

The solid 3D models of the different objects were transferred to the game engines using FBX file format. 3D modelling of the temple was intended for interactive use. Therefore, a low polygon modelling scheme was applied. In this scheme each building and object structure was generalized and simplified as much as possible resulting in as little polygons as required for high-end visualisation when not viewed in direct close-up views. Most of the necessary visual details such as column capitals are not generated as a polygon model but displayed by different maps such as texture and normal maps. Together with the general low polygon modelling this supported a further reduction of complex geometry to insure sufficient computer performance during VR visualisation. At the end of processing in Unity and Unreal, two executable programs for the VR system HTC Vive were developed visualising two different scenarios of the temple: the first version using only the main building in Unity and the second version integrating the main building in surrounded courts implemented in Unreal.



**Fig. 1.** The components of the VR System HTC Vive (left) and the setup of the Virtual Reality System HTC Vive (HTC Corporation 2017b)

HTC Vive ([www.vive.com](http://www.vive.com)) is a virtual reality headset (Fig. 1 left) for room-scale virtual reality. It was developed by HTC and Valve Corporation, released on April 5, 2016, and is currently available on the market for EUR 899 (June 2017). Basic components are the headset for the immersive experience, two controllers for user interactions and two "Lighthouse" base stations for tracking the user's movement (Fig. 1 right). The visit offers the possibility of experiencing the temple in different scales from a real person's point of view and interaction scheme as well as shrinking the temple to the scale of the wooden model and therefore recreating the real object. For this purpose, the controlling positions have been defined by the possibility of free movement by the user. To bridge long distances in the virtual object, teleportation or fly-through functions can be developed for navigation of the user.

The technical specifications of the HTC Vive are summarized in the following: a) two screens with a field of view of approximately 110 degrees, one per eye, each having a display resolution of 1080×1200 pixel with a refresh rate of 90 Hz, b) more than 70 sensors including a MEMS (Microelectro-mechanical systems) gyroscope, accelerometer and laser position sensors, c) 4.6 by 4.6 m tracking space for user operation using two "Lighthouse" base stations for tracking the user's movement with sub-millimetre precision by emitting pulsed IR lasers, d) SteamVR running on Microsoft Windows as the platform/operating system, e) controller input by SteamVR tracked wireless motion controllers, f) a system for overlaying the real room's bounds for static objects in the real world called Chaperone and (g) a front-facing camera for looking around in the real world to identify any moving objects in a room as part of a safety system.

The device uses a gyroscope, accelerometer, and laser position sensor to track the head's movements as precisely as one-tenth of a degree. Wireless controllers in each hand, with precise SteamVR-tracking, enable the user to freely explore virtual objects, people and environments, and to interact with them. The VIVE-controller is specifically designed for VR with intuitive control and realistic haptic feedback. The Lighthouse system uses simple photo sensors on any object that needs to be captured. By sweeping a line laser over an object, the time difference of arrival is calculated over various photo sensors to estimate a 6-DoF pose. To avoid occlusion problems by non-penetrative laser light and to increase tracking accuracy, this is carried out with two diagonally positioned Lighthouse stations that light the space.

### VR Projects at HafenCity University Hamburg

The following virtual reality projects were already developed at HafenCity University Hamburg:

- The wooden model of Solomon's Temple from 1680 in the game engine Unity (Fig. 2) and in Unreal (Fig. 3). The detailed project description is published in Kersten et al. (2017c).



**Fig. 2.** Perspective views of the inner sanctuary of Solomon's Temple illustrated in the software Lumion 3D as the basis for the game engine Unity.



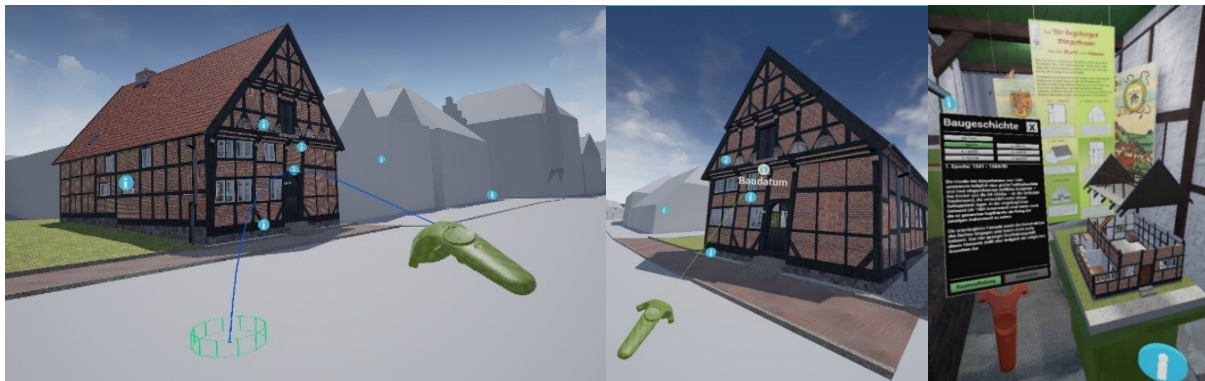
**Fig. 3.** Different views of the inner sanctuary of Solomon's Temple illustrated in the game engine Unreal 4 – the exterior environment (top) and the interior (bottom).

- The Selimiye mosque in the city of Edirne, Turkey in the game Unreal (Fig. 4). The detailed project description is published in Kersten et al. (2017a).



**Fig. 4.** The Selimiye mosque of Edirne (left), the VR System HTC Vive in action using the controllers for interacting in the environment (centre left), navigation controller for the motion in the environment (centre right) and the multi-user feature of the HTC Vive presenting two avatars with controllers (right).

- The virtual museum of Old-Segeberg Town House in the game Unreal (Fig. 5). The detailed project description is published in Kersten et al. (2017b).



**Fig. 5.** Navigation in the virtual museum Old-Segeberg Town House using the developed teleportation function (left), menu navigation with green motion controller by "laser beam" (centre) and second red controller for the information menu (right) for the Virtual Reality System HTC Vive.

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