CHAPTER 14

# Temple Complex 'Virtual Nako'

## 3D Visualization of Cultural Heritage in Google Earth

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## Abstract

The preservation of cultural heritage and the communication of its vital importance for modern society represent an increasing and demanding challenge for the scientific community. Due to the occurrence of cultural objects in geographic space and time, cartographers are questioned, amongst others, to deal with new forms of geo-visualization. These new visualizations improve communication between scientists and a broad audience by facilitating a more efficient information exchange. A national research network gave the setting for cartographers at the University of Vienna to develop and implement a Google Earth 3D visualization of a Buddhist temple complex built during the early second millennium.

## 1 History of Cartography and Relief Depiction

Cartography has a long history beginning with maps as cave paintings and rock carvings executed some ten-thousand years ago. Later examples are maps carved on clay tablets, maps painted on walls, and papyrus maps. These early maps were very naturalistic, mostly inaccurate and reflected the beliefs at the respective time. In the middle ages a variety of so called *mappae mundi* were produced. These maps depicted situation and relief in a strongly generalized manner. Towns and mountains were sketchily drawn in front view. FIGURE 14.1 shows the area of today's Italy in the Ebstorf world map (around 1300).

Later, when the first complete topographic surveys of European countries were conducted, mountains were depicted from above more characteristically with hachures that showed the terrain's steepness by varying

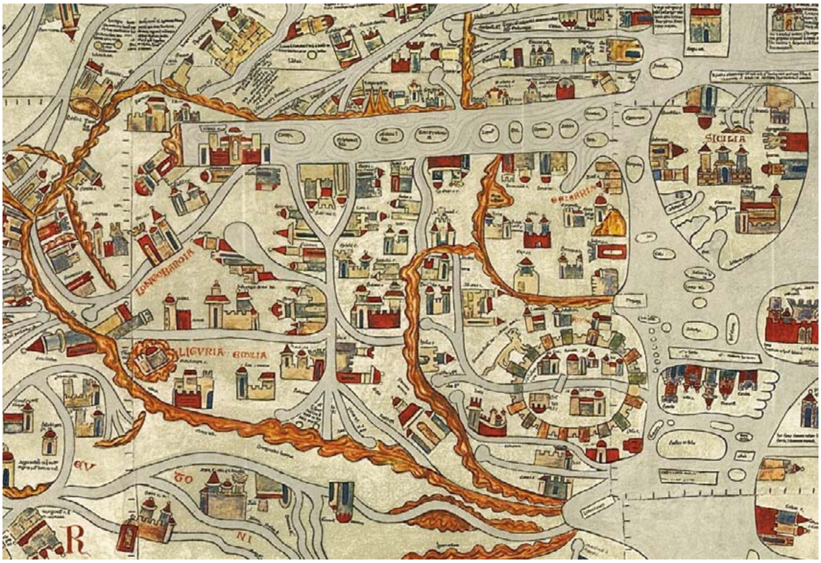


**Figure 14.1** Ebstorf world map, around AD 1300. Source: http://en.wikipedia.org/wiki/File:Ebstorfer-stich2.jpg

density and/or hachure weight. Other forms used hachures that mimicked natural illumination and thus tried to create pseudo-3D effects. Similar effects are still employed in mapping today. Shading techniques (shaded relief) are commonly applied to create a more naturalistic depiction of mountains and valleys.

## 2 Maps as Representations of Place and Space

Maps in orthogonal projection (view from above) are undoubtedly the most popular and widely applied medium for communicating place and space. With a certain degree of abstraction they represent real or fictitious objects and conditions which feature a spatial component, position or extent. Most often these maps provide a combination of topographic as well as thematic content. While topographic information describes the space itself — relief, morphology, land cover, natural and artificial situation — thematic information in maps can be of almost any kind comprising spatial and temporal reference. Information density and the selection of content are strongly dependent on map scale and the intended map purpose. These classical maps have been in use for ages and have rapidly gained complexity during the last century through the advances in technology — printing, data acquisition (remote sensing, GPS), and computer technology. For understanding more complex maps and gaining knowledge from such depictions, sound interpretational skills — described as graphicacy (Balchin 1976) — and context awareness are a prerequisite.

## 3 From 2D to 3D Mapping

Nowadays cartography is a very diverse science encompassing a wide range of media and techniques from classical maps to oblique views, from paper maps to interactive Web-mapping and multimedia applications, from desktop screens to mobile consumer electronics. Cartographic artifacts like panoramas or oblique views have long been used to convey information of rugged or mountainous terrain in a pseudo-3D fashion. These depictions are well-suited for overview purposes, since they mimic what people are used to see when looking from mountain tops or plane windows and thus convey terrain characteristics in an easily comprehensible way (cf. Schobesberger 2007, Häberling 2003). 3D maps allow the user to more easily understand the geography and relations of places without having to be expertly trained in map interpretation.

This knowledge and the advancement of computer technology, together with the availability of broadband internet connections, have led to the development of so-called earth browsers (also virtual globes, geobrowsers) that allow free navigation in three-dimensional space and the tilting of viewing angles in all directions. By seamlessly zooming and panning, the users can look at all parts of the world in varying scales and get a better understanding of the interrelation of places. Earth browsers generally offer satellite images or orthophotos (rectified images from airborne photogrammetry) that are stored on the servers of the software providers and downloaded on demand. Additional information can be added by third parties or end-users via the Web. Prominent examples of earth browsers are Google Earth, NASA WorldWind, and Microsoft‘s Virtual Earth[1].

Google Earth — a Google Maps spin-off — is an earth browser by Google that is available for free on various computer platforms. It features satellite and aerial photogrammetric images and can easily visualize user

[1] See, respectively, http://earth.google.com, http://worldwind.arc.nasa.gov/, and http://www.microsoft.com/maps/.

generated overlays (stored in KML or KMZ files). The software uses a digital elevation model to allow pseudo-3D views of areas all over the world. 3D navigation and tilting of viewing angles allows observing places from virtually any viewing point. Additionally, temporal navigation facilitates the communication of historic circumstances and the viewing of objects as they change over time.

Over the last years true 3D display technology has found its way into consumer devices and thus allows immersive experiences for users when exploring space or georeferenced data. Virtual reality and augmented reality technologies are advancing rapidly, and cartographers are researching the vast opportunities of these methods for geographic knowledge transfer. Powerful and affordable mobile consumer electronic devices with constant access to the Web have changed and will further change the ways of mapping and using maps.

Against this background the cartography group at the University of Vienna has decided to research the potential of communicating geographic and cultural-history information by means of a 3D application for Google Earth within an interdisciplinary research network.

## 4 Cultural History of the Western Himalaya

The national research network *The Cultural History of the Western Himalaya from the 8th Century* (CHWH),[2] financed by the Austrian Science Fund (FWF), was founded in 2007 at the University of Vienna. As part of this research network, the Department of Geography and Regional Research has developed a map-based online information system for visualizing cultural history in the area of the western Himalayas. Within this Cultural History Information System[3] (CHIS) special views form a complementary component of the comprehensive information architecture.

Special views represent interactive applications that depict certain research objects relevant to the national research network in large-scale detailed visualizations using integrated-media techniques. The specific use of new media techniques is primarily intended to improve and simplify geo-communication processes in an interdisciplinary setup. The implementations vary according to the requirements and objectives of the special view, and form a substantial part of scientific research. Thus special

[2] See http://www.univie.ac.at/chwh.

[3] See http://www.univie.ac.at/chis.

views within the CHIS provide the possibility of a deeper examination and better understanding of selected research objects (cf. Kriz et al. 2009, and Chapter 1 in this volume).

In the following, the design and modeling processes of the multimedia application *Virtual Nako* will be described in detail. The focus is on outlining methods for the virtual reconstruction of the Buddhist temple complex and on potential future developments for 3D visualizations of cultural heritage.

## 5 The Nako Research and Preservation Project

Nako is a small village in the district Kinnaur in Himachal Pradesh, northern India, situated at about 3,600 meters above sea level and surrounded by the impressive Himalayan mountain range. The Buddhist temples of Nako give evidence of a particular cultural heritage and a former centre of Buddhism in the Western Himalaya. The complex is among the oldest foundations in this area and can be dated back to the early second millennium ($11^{th}$ to $12^{th}$ century; cf. Luczanits 2003).

Four temples and a number of associated structures occupy an area of about one thousand square meters, which gradually slopes from the eastern to the northern edge. Due to the imminent corrosion of the temples' fabric and the precious wall paintings within, the villagers asked for help to restore and preserve the sacred temple complex (cf. Klimburg-Salter 2003).

Figure 14.2, a village plan of Nako which was created in a joint effort by scholars from the Vienna University of Applied Arts and cartographers at the University of Vienna, shows the general layout of the village and the position of the temple complex.

Since 1998 the University of Vienna and other institutions took charge of this problem and supported the local community via different channels. With the foundation of the Nako Preservation Project[4] (later Nako Research and Preservation Project — NRPP), involving architects, conservation experts, art and religious historians and cultural anthropologists, the main rebuilding and conservation activities were realized between 2002–2007. In 2007 His Holiness, the Dalai Lama, held a consecration ritual and gave Buddhist teachings in the restored temples of Nako (cf. NRPP)

[4] http:/www.univie.ac.at/nako

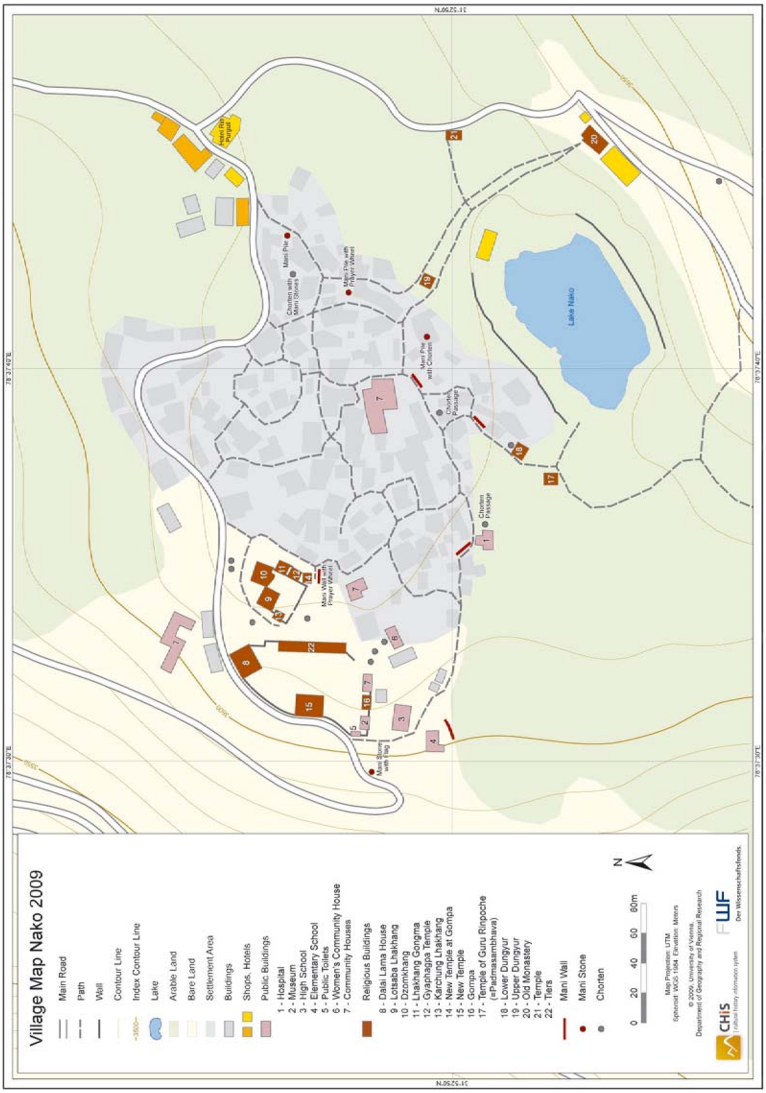


**Figure 14.2** Village Map of Nako, 2009

The NRPP is associated with the national research network CHWH, and therefore the conception of a 3D visualization relating to this research object was an obvious choice. The mission statement of the NRPP, *"Preserving the past in order to serve the future"*, underlined the potential for a scientific examination for the geo-visualization of cultural heritage.

## 6 Defining the Concept of *Virtual Nako*

Based on the collected data and outcomes of the NRPP, requirements for an interactive special view had to be formulated and outlined.

This task led to the idea of *Virtual Nako*— a 3D digital reconstruction of the Nako temple complex embedded in the virtual surroundings of Google Earth. Following this, the geospatial location and placement of the model in its exact position in the Himalayan mountain range and the integration of additional multimedia content (text, images, virtual-reality panoramas, map-overlays) were assured.

The added value given by a 3D perspective in combination with an interactive and intuitive navigation concept allows the user to explore and learn about cultural objects more effectively and intensely.

Further emphasis was put on visualizing the structural changes of the temple complex before and after the restoration in a comprehensible way and thus offering the user a direct comparison between different periods.

## 7 The 3D Modeling Workflow

The composition of the special view *Virtual Nako* followed a standardized workflow from data acquisition, over the 3D modeling process, to the integration of supplemental multimedia content. In the following the different implementation stages of the concept will be discussed in more detail.

**7.1 Base Data** The level of detail and quality of a 3D model strongly depends on the available base data. Fortunately, the data collected by the NRPP offered a large variety of pictures, architectural plans and drawings. Furthermore, the expertise and knowledge of scholars from the national research network assured the visualization quality and correctness.


**Figure 14.3** Architectural floor plans of the temple complex in Nako (NRPP 2003)

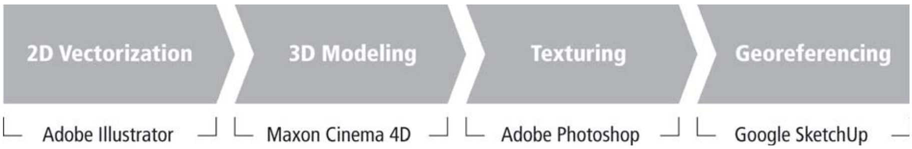


**Figure 14.4** 3D-modeling workflow

**7.2 From Scratch to a 3D-Model** In order to expound the characteristic architectural elements of the temple complex and its geo-localization, a consistent visualization workflow and the required tools (cf. Figure 14.4) had to be defined.

By starting with the vectorization of the overview floor plan, it was assured that the sometimes slightly curved and asymmetric temple walls were captured. The depiction of structural alterations during the restoration period was facilitated by two different basement drawings, which show the complex before (ca. 2003) and after (ca. 2007) the preservation work.

In a next step the digitized line data was imported into a 3D modeling software, extruded and transformed into appropriate objects. During this phase of the workflow, special focus was put on the temples' correct scaling and their relative proportions. The modeling of characteristic stabilizing stone piles that surround the temples represented a significant task.

In order to meet the requirements of an easily perceptible and differentiated 3D model, textures were produced from the available pictorial information. Adhering to the technical and visual limitations of Google Earth,

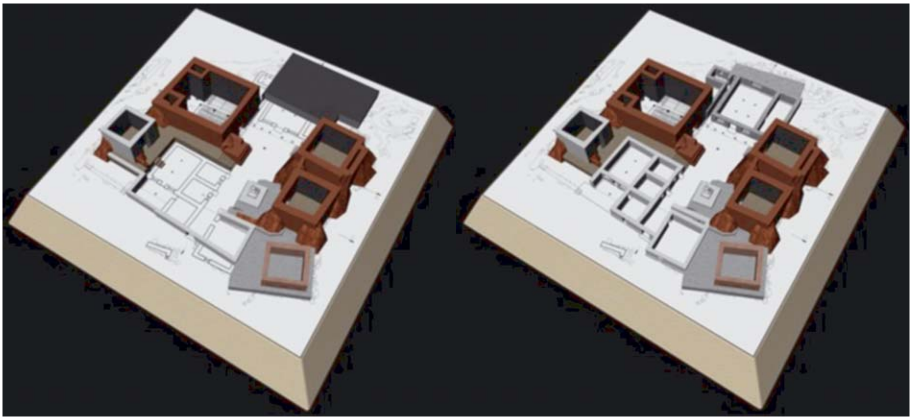

**Figure 14.5** Views of the textured 3D models

the level of detail and complexity of the buildings and their textures were adjusted in such a way that a pleasing output could be obtained. Following this, a detailed but not photorealistic model, displaying the main features of the temple complex like its shapes, colors and textures, was produced.

A supplemental 3D-base block was created on which the 3D model was placed in order to compensate the hanging slope from the complex's east to north edge. By using the architectural floor plan of the temples (before the restoration work in 2003) as a textural overlay the visual perception of this base block could be improved.

In a last phase the model was imported into the geo-spatial environment of Google Earth. Its placement was done according to the available satellite imagery by Google Earth and using GPS data recorded during a field trip. A prerequisite for this step was the capability of the modeling software to export into a 3D studio scene file format.

Finally the imported 3D objects were optimized concerning their textures' file size and the amount of polygons to improve overall performance.

**7.3 Integration of Additional Multimedia Content** A central intention of the special view *Virtual Nako* was the additional integration of descriptive multimedia content. By enriching the visual information, the application enables the user to gain a deeper examination and understanding of the displayed objects. According to the concept of Google Earth, a consistent storyline of interchangeable overlays from small-scale overview maps (globe view) towards large-scale detailed object information (panoramic view) was designed. It consists of the following key elements:

- Map overlays: Various maps covering the area of this part of northern India offer a general overview of the research region for detailed geographic orientation. Large-scale level detailed site plans and architectural floor plans enrich the information content.
- Textural and pictorial information: Specified, interactive hotspots contain additional textural and pictorial information about the temples, certain sculptures and wall paintings.
- Virtual-reality panoramas: The integration of hotspots with navigable virtual-reality panoramas offers a photo-realistic view and therefore enables direct comparison of the existing temple complex with the 3D model.

**7.4 Final Composition and Summary** The final composition represented the last step in the workflow. It included the addition of an imprint, styling of the navigational tree as well as further refinements in the 3D visualization and addition of multimedia content. The integration into the CHIS as a special view finally provided a wider audience with the possibility to study the cultural heritage of Nako.

# 8 Outlook and Future Development

Positive responses from the research network partners and the obvious benefits which digital 3D visualizations have for the communication of object characteristics and changes in time to a broader audience verified the existing concepts. The further development and refinement of special views like *Virtual Nako* were strongly encouraged. The improvement in the 3D models' level of detail, as well as the possibilities to add multimedia content and the visualization of time periods, offers a great potential for communicating and preserving information about objects of cultural heritage.

A step towards a more immersive 3D visualization could even improve the depth and quality of the visualized information. Following this concept, tests with a virtual reality wall (single-channel, rear projection) have been conducted at the University of Vienna. Allowing the user to navigate

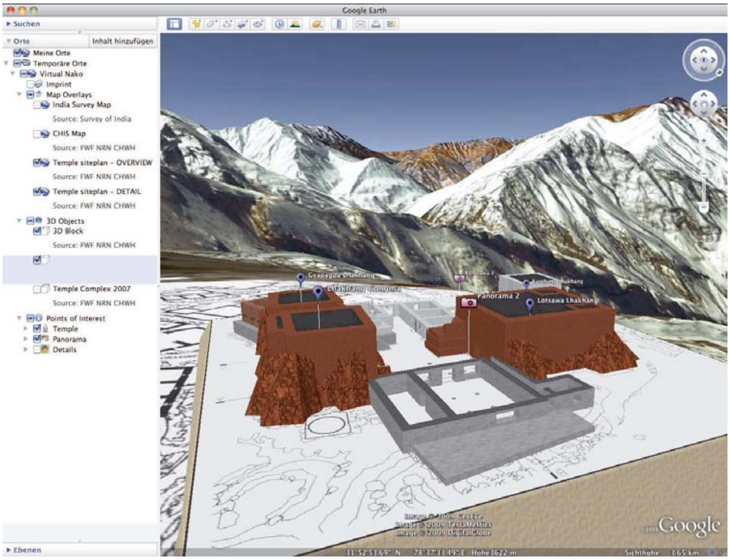


**Figure 14.6** Screenshot in Google Earth

through the sacred temple complex with a traceable joystick and looking glasses offers a new dimension of interaction and immersion. But still the availability, poor usability, and high complexity of such virtual-reality systems represent a significant obstacle.

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