EXPLORE BALLENBERG
COMBINING 3D LANDSCAPE MODELS WITH ADDITIONAL INFORMATION

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KEY WORDS: three-dimensional, information systems, content integration, interaction, prototype implementation

ABSTRACT:

The management of the open-air museum Ballenberg with about 100 original century-old buildings from all over Switzerland plans an attractive new overview map and a 3D information system of the museum area and exhibits. In this paper we investigate how highly detailed 3D terrain and building models can be utilised as base data for a flexible interactive 3D information system. The system shall be usable as source of information for museum visitors as well as an interface to more complex information for the Ballenberg management and architectural researchers. The integration of information in a 3D information system has to take into account that the user is able to freely navigate through the 3D model but nevertheless is limited by the fact that the 3D environment is projected onto a 2D screen. The presentation of additional information within a 3D environment might interfere with depth cues which allow perceiving the landscape model as close to reality and in 3D. The project employs a prototype to conceptualise and discuss the possibilities for inclusion of different types of information and media in a 3D environment. To create an effective interface to the different information contained we also explore how 2D and 3D presentations can be combined side by side or nested. The interaction with 2D and 3D objects on the screen with the help of commonly available input devices such as the keyboard and the mouse is discussed and methods for information linking and retrieval are suggested.

1. INTRODUCTION

The open-air museum Ballenberg in central Switzerland exhibits about 100 original century-old buildings from all over Switzerland. In 2008 the museum will celebrate its 30th anniversary and on this account plans to replace the current overview map of the museum area (Figure 1) by a new and attractive product consisting of a combination of a printed overview map for tourist orientation and navigation in the museum area and an interactive 3D information system allowing access to different information about the museum and its exhibits. The 3D information system uses a Virtual Environment of the area with additional information linked or integrated. It shall be useable in different settings like, for example, for tourists and school kids who wish to prepare or follow-up their visit in Ballenberg but also as an interface to additional information for scientists such as architectural researchers or historians.

Figure 1. Extract of current Ballenberg museum overview map (www.ballenberg.ch)

These circumstances give us the possibility to investigate how the same 3D base data can be applied to two different tasks, the preparation of a printed overview map and an interactive 3D information system. For economic reasons it is sensible to collect specific base data such as 3D building models once and then use them for different products. This paper describes how a prototype is employed to conceptualise and discuss the possibilities for inclusion and linking of different types of information and media in a 3D Virtual Environment showing Ballenberg and its surroundings.

A detailed analysis of the other part of the project, deriving a 2D overview map of the museums area from the same 3D base data can be found in (Bleisch and Nebiker, 2007).

1.1 3D information systems for museums

Open-air museums exist in many different countries. An evaluation of the Internet presence of different museums in Europe and Overseas has shown that most of them use a 2D map or some kind of (mostly sketched) 3D bird's eye view to show the visitors the museum area and objects (Figure 2 shows some examples). Very often this map or map-like representation is combined with additional information, such as links to text or images, panoramic images and in one case a 3D fly-through video of the museum. Popular are virtual tours which link information like text and photos or panoramic images from spatially successive places by the means of some kind of forward/backward navigation. We did not find a museum website that offers a 3D visualization of its area and buildings or objects with user-defined navigation.

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Figure 2. Extracts from overviews of diverse open-air museums ([1]www.skansen.se, [2]www.roscheiderhof.de, [3]www.freilichtmuseum.com, [4]www.shantytown.co.nz, [5]www.wealddown.co.uk, [6]www.upernivik.gl)

1.2 Related research

The question of how to best integrate additional information in Virtual Environments has not been researched extensively. Bowman et al. (2003) summarise the knowledge about 'information-rich virtual environments', virtual environments that are enhanced with abstract information such as text, numbers or graphs, and define a research agenda. Most research which is concerned with integrating additional content into Virtual Environments studies the integration of short texts or labels (e.g. Maas and Döllner, 2006; Polys and Bowman, 2004). Only a few studies have also discussed other types of data (e.g. Bolter et al., 1995).

In some disciplines such as medicine or chemistry 3D visualizations already have some tradition. Also for more exotic applications such as structuring and retrieving documents (Robertson et al., 1998) 3D visualizations have some value. Zhu and Chen (2005) have shown that interactive 3D visualizations are a promising approach for knowledge retrieval. However, the use of virtual environments and 3D map-like representations also has some limitations and problems that need to be addressed (Harrower and Sheesley, 2005).

This paper describes how an information-rich virtual environment of the Ballenberg museum is implemented and how it might be used for information retrieval at different levels depending on the audience. It also examines how 2D and 3D presentations can be combined side by side or nested.

1.3 Characteristics and specialities of Ballenberg

Typically, areas which are modelled with 3D building models are cities or urban areas and the models are, for example, used for planning or tourist purposes. Ballenberg is a little different as the buildings included in the landscape model are scattered over a large area (0.5km wide, 2km long) with woods in-between. There is basically ample space for the integration of additional content but as the information is mostly related to buildings which stand together in groups the space for displaying information is nevertheless limited.

Each building in Ballenberg was originally built and used in a different part of Switzerland. They are typical for specific regions and types of use and were carefully dismantled, transported to Ballenberg and rebuilt. In addition to the buildings also the surroundings are formed and cropped to resemble the original area where a building comes from.

In the current overview map and also in the signposting system of the museum the different groups of buildings which represent specific areas of Switzerland are tinted in different colours. To help user navigation and to be consistent with the signposting of the museum we tried to adopt those colours in the Virtual Environment.

2. DATA AND TECHNOLOGY

2.1 3D environment base data

The terrain in the Virtual Environment is based on existing data sets, the DHM25 elevation model with 25m resolution for the closer surroundings and the DTM-AV with 2m resolution for the museums area. These models are integrated in the model of Switzerland (SRTM data) and the overall model of the whole earth visualised as sphere. Integrating the 3D landscape model of Ballenberg into a Virtual Environment of the whole earth has the advantage that the landscape does not stop at the museum boundaries and no 'end of the world' photos need to be included (Cartwright et al., 2005). Additionally, the integration into a seamless 'virtual Globe' has the advantage of enabling virtual visits to the original building locations throughout the country.

The terrain in the museum area is textured with Swissimage, ortho imagery with 0.5m resolution. For the rest of Switzerland a satellite image with 25m resolution and for the world a data set with 8km resolution is used. Within Ballenberg ortho imagery with 0.05m resolution generated from a photo flight with a model helicopter is used in the area where buildings are also modelled in more detail.

The buildings were either modelled as relatively simple block models based on groundplan information and on roof shapes collected from aerial photogrammetry (Figure 3a) or as more detailed models using close-range photogrammetry (Figure 3b). The detailed models were textured with photos. Additionally, we experimented with tinting the roof or ground in the building group colour (Figure 1 & Figure 3, a), c)-e)).
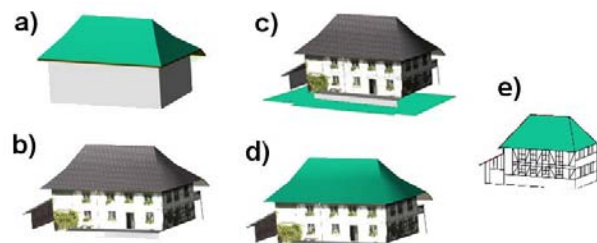

Figure 3. Different levels of detail for the buildings, a) block model with coloured roof, b) detailed & textured model, c) detailed & textured model with coloured ground, d) detailed & textured model with coloured roof, e) building sketch from current Ballenberg overview map

2.2 Additional information for integration

Existing information: The Ballenberg museum possesses an abundance of information related to the buildings and objects on the museum grounds. The information that is relevant to the visitors, such as texts and photos explaining the buildings and their surroundings is contained in the printed museums guide, the current overview map and on the Internet. Additionally, detailed building plans, historic information and some in parts extensive publications about different buildings and groups of buildings but also on biota, handicraft and tools of the trade exist.

The most important information for the casual museum visitor is the original location (town and canton) and the year of construction of each building.

Collected information: In order to be able to test the integration of different media panoramic images were constructed from photographs taken at selected locations (within and outside buildings). The panoramic images are linked together by hot-spots that can be clicked on and thus navigated through a series of panoramic photos.

We could think of much more information that could be integrated in the 3D environment. Nebiker et al. (2007) describe what types of data are basically possible to integrate in 3D environments.

2.3 Audience

The 3D information system shall be useable by a diverse audience. The 'standard' user will be the museum visitor who wishes to prepare or follow-up his or her visit to Ballenberg. They are interested in information related to the museum as a whole (opening times, events, etc.) but also in specific information regarding buildings or building groups. Their interest in specific buildings might not be satisfied by a short text and an image but might go further, for example, including the history of the building or its construction plans.

Another important audience are kids, especially school kids who have to prepare or follow-up their trip to the museum. For them basic information about the buildings and the building groups might be sufficient. Additionally, the museum could think about integrating games or quizzes which can be solved using the 3D information system but that is not included in this study.

Another group of users are researchers from diverse disciplines who are interested in different aspects like, for example, the history of the objects, the construction or the behaviour and interests of museums visitors. For this group of users the 3D information system could serve as a spatially enhanced access to diverse materials and information as most of it is related to a specific location or object.

We looked at the possibilities to integrate information that satisfies the first group of users. However, we also keep in mind that the system might be extended in the future.

2.4 Structure of information

As described above, there is much information available that could be integrated into the Virtual Environment. To decide what to integrate and where, we followed the visual information seeking mantra "Overview first, zoom and filter, then details-on-demand" (Shneiderman, 1996). That serves nicely as a structure for information integration. On the top level, the overview level, only general information about the museum should be integrated. This serves also the casual user who does not want to know more. Additionally, on the overview level several possibilities for retrieval of further information are included (details-on-demand). In a Virtual Environment the zoom and filter aspect of the visual information seeking mantra is achieved by navigating the visualization. This does not exactly filter the information but allows zooming in, thus blending out information in areas further away and to focus, for example, on a building or building group. This action is reversible. From a specific focus the user can also navigate back to the overview and maybe focus on a different location or object.

2.5 Prototype

The Prototype was implemented using an early version of the virtual globe technology i3D. The i3D viewer is a 3rd generation 3D geovisualisation engine developed at the University of Applied Sciences Northwestern Switzerland (FHNW). The viewer uses spherical rendering based on the WGS-84 Ellipsoid. The engine is highly optimized for current generation GPUs (Graphics Processing Units). It uses the OpenGL Graphics API and is cross platform (Windows, MacOS X and Linux).

The virtual 3D terrain can hold several terabytes of aerial imagery and elevation data. This data can be streamed over a network or can be loaded from a local hard drive. There are also channels for 3D objects, including city models, POI, and 2D vectors. The i3D technology is currently being extended towards real-time content, namely geo sensory input, and geospatial collaboration capability (Nebiker et al., 2007).

The i3D viewer can either be run as an application or alternatively as a browser plugin which can be embedded into a webpage (Figure 8). With its built-in web browser, the i3D viewer is capable of rendering HTML pages, including typical multimedia content such as video or sound. The internal browser window can either be positioned dynamically, based on the position of the corresponding POI or 3D object, or in predefined screen positions.

Using the 'in-house' technology i3D gives us the possibility to implement and evaluate new content types as well as new navigation and interaction features, which would not be available in commercial virtual globe technologies such as Google Earth or Microsoft Virtual Earth.

3. USER INTERACTION

Most of the users described before do not have special 3D viewing and interaction hardware available. They view the 3D Virtual Environment on their 2D screens and interact with it using the keyboard and some pointing-device such as a mouse. To ensure a satisfying experience for the user we have to take this into consideration.

3.1 Displaying 3D environments on 2D screens

When a Virtual Environment is displayed on the desktop we do not really see 3D space but rather perceive different depth cues, such as perspective cues, occlusion or structure from motion, that create the illusion of 3D space (Ware, 2004). Integrating additional information into the Virtual Environment might support some depth cues (e.g. occlusion as there are more objects in the environment) but it might also interfere with others. For example, adding upon request a non-perspective 2D window with further information to the Virtual Environment might disrupt the perception of space from perspective cues. As our prototype implementation supports user-defined navigation, the 3D space perception from motion, kinetic depth effect and motion parallax, is probably most important.

An advantage of the display on 2D monitors is that they have a very high spatial resolution but on the other hand, they are not very immersive (Bowman et al., 2005). However, immersion is not only dependent on the type of display used but also on user engagement. Even though 'being in' is persuasive, in some situations 'looking at' is more effective (Shneiderman, 1998).

3.2 Interaction

Having the screen as output device and keyboard and mouse as input devices we need to know what interaction in the Virtual Environment is possible with those tools. Additionally, we need to incorporate the fact that the navigation of the 3D

visualization already occupies some functionality of the keyboard and mouse. Bowman et al. (2005) define the basic 3D manipulation tasks as selection, positioning and rotation. For our application only selection is important as it is not meaningful to replace or rotate museum objects. We need to be able to identify and select the object for which we want more information. This is done by touching the object with the pointing device using the ray-casting technique. A ray is attached to the mouse cursor which intersects with the virtual viewpoint, the cursor and the object when an object can be selected. The selection can take place by mouse over, click or double-clicks with the left mouse button. Other buttons could be included but that might be more difficult to learn.

Additionally, we need to think about consistent ways of marking or highlighting the buildings and objects which can be touched or clicked on for more information. From the WWW we are used to specially marked hyperlinks (e.g. coloured differently and/or underlined). In the Virtual Environment we need more subtle but nevertheless recognisable hints to links. The simplest and most consistent case in Ballenberg is the links to basic building information. This information is available for every building and thus every building itself should become clickable and a link to further information. This is quite intuitive and needs only short learning time. For other information it is more difficult to decide what should directly be integrated into the Virtual Environment like, for example, labels showing infrastructure such as toilets or food stands, or to integrate labels or images that link to further information. We need to think about how intuitive it is if some labels can be clicked on and link to further information while others are itself the additional information. An option could be to change the label slightly when the mouse moves over it and if it is a link. But then, the user has to search the Virtual Environment for links by try-and-error moving the mouse over all labels.

The keyboard does not offer very intuitive ways of selecting objects in the Virtual Environment.

3.3 'Museum visit' metaphor

Ideas of how to interact with the 3D environment and linking to additional information are gathered on the basis of the 'museum visit' metaphor. We think about using the Virtual Environment quite similarly as visiting the museum in the real world. We enter the museum, maybe not through the entrance but rather from an overview perspective and then navigate to the places we like to visit. If I want to know more about a specific location or object I stop my navigation and click on the available links. Similar actions are well-known from the WWW where links most often lead to more information.

Additionally, the information panels of the real world could be integrated into the Virtual Environment. They could display information themselves or also link to further sources. This might make the metaphor of a 'museum visit' even more realistic.

3.4 Combination of 2D and 3D windows

Simple information such as 'here are toilets' is easily integrated into the 3D environment using a label. Basic information about buildings, like a short history, the original location and the year of construction, could popup as a 2D window in the 3D environment when one clicks on a building. As this information is mostly text and images this might feel like reading a sheet of paper or an information panel about the building. Such a 2D window within the Virtual Environment to some degree destroys the perception of the 3D space. But the metaphor of

reading a sheet of paper will help in switching back to the 3D world after closing the 2D window.

We can also have a 2D window beside the 3D view which allows displaying additional information. We couple information querying and retrieval in the 2D window with navigation in the 3D view. After a query there should be the possibility to click on a link like 'show me the object/related objects' in the 3D environment. Then the Virtual Environment navigates to show the building or area about which more information was requested in the 2D window. The 2D window could update the same way with additional information when objects in the Virtual Environment are touched.

Another possibility would be to make all buildings and objects for which additional information is available to links. Clicking on a link would open a 2D window where one can select what additional information, like for example historical information, construction plans, anecdotes or events, which should be shown. A selection from this links then brings up the information in the current 2D window within the Virtual Environment, in the 2D window beside the 3D view or in a new 2D window. Such a structure is probably more complicated for the user as he has to click at least twice to get basic information but on the other hand allows integrating much more information. The amount of links shown could also be dependent on user preferences or default settings for different audiences.

4. IMPLEMENTATION

In a prototype implementation we tried to implement some of the ideas described before with the i3D technology. Because of limitations of the technology not everything was possible but such limitations will be reduced in the future and more possibilities available.

Most information is integrated in the Virtual Environment using POI (points of interest) which inform through their labels (Figure 4) or link to additional information (Figure 5).

Figure 4. Labelled POI for information about infrastructure (no links)

Figure 5. POI linking to additional information (left: image and text, right: icon)

Different colours are used to show that the POI belong to different categories of information (e.g. yellow are museum entrances, white is general infrastructure). The POI which are

links are symbolised using small pictures or symbols (with an optional label) which can be clicked on. Figure 5 (left) shows how information about interesting areas in the museum, like for example the herb garden, is linked by using POI with a small image of the garden and a descriptive label. The links to the panoramic images (Figure 5, right) use symbol POI placed on the very location where the panoramic image was taken. Clicking on those POI opens a 2D window within the Virtual Environment (Figure 6).

As i3D does not yet allow clickable or touch-sensitive 3D objects we needed to overlay each building with a transparent POI (Figure 7, left). Those POI can be clicked on and basic information about the building is shown in a 2D window within the Virtual Environment.
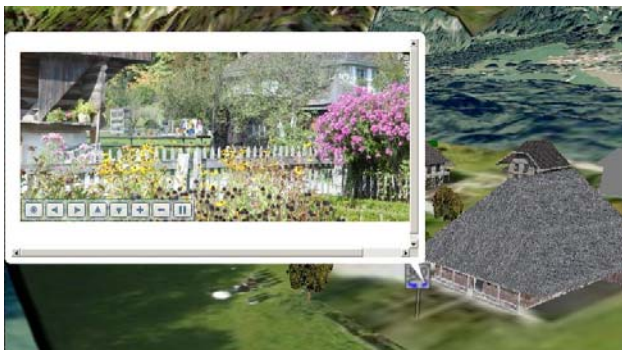

Figure 6. 2D window within 3D environment displaying a panoramic image

Figure 7. Transparent POI used to add links to buildings. The red frames show the area where the POI are clickable.

Those POI also showed us another problem. Virtual Environments which are based on the globe allow very large changes in scale by zooming in and out (if not restricted). It is possible to define different visibility thresholds based on distance to the viewer for categories of integrated objects and thus make objects invisible when a certain distance from the object is reached.

The size of the Ballenberg (0.5km wide and 2km long) does need zooming out for getting an overview of the whole area. This scale then does it make impractical to still show all the POI. We decided to show the building POI even though a single building in a group of buildings is quite difficult to click on at the overview scale. On the other hand, leaving the POI unscaled (Figure 7, right) makes them overlap and selection is even more difficult in some areas.

For Ballenberg we used a 3D view in combination with a 2D window beside it (Figure 8). In addition to the query possibilities in the 3D view described above a selection of a building or building group in the 2D window brings up additional information below in the same window. The user also has the possibility to click on a button which causes the 3D view to navigate to the selected objects. The 2D window also contains some options for user defined settings like navigation speed in the 3D view or help menus. Due to technical

limitations it is not yet possible to update the 2D window when objects in the 3D view are selected.
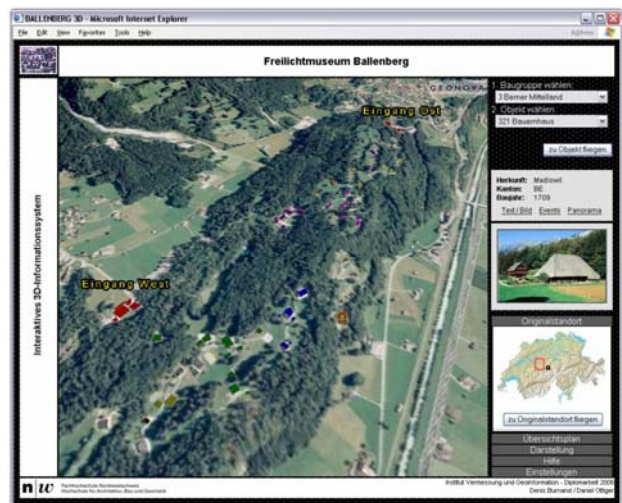

Figure 8. 3D information system Ballenberg, 3D view and 2D information window on the right hand side

As a speciality we integrated the construction plan for one selected building as terrain overlay in the Virtual Environment. The 2D window gives the possibility to change between two views for this specific building: normally show the 3D building or make the building invisible but show the 'laid-out' construction plan at that location instead (Figure 9). The problem with this kind of representation is the resolution. The laid-out construction plan serves as an overview rather than as source for detailed information.

Figure 9. Normal view of the 3D building (left) and integration of construction plan as terrain texture (right)

The construction plan view gives us also the possibility to include POI to panoramic images taken in two rooms inside the building in the 3D view (Figure 9, right). Such links located within a building are difficult to integrate if the building is shown as 3D object. It might not be intuitive to understand to what they link if they are, for example, placed on the roof of the building. But the 2D window on the side makes it possible to retrieve such information that is not easily referenced in the 3D view.

5. DISCUSSION AND OUTLOOK

The implementation described above is specific to Ballenberg and the technology used. However, some of the ideas and experiences with this project might be adaptable to other projects in rural or even urban areas and different implementation technologies.

The technical integration of information in the 3D view as labels or as POI which link to additional information is possible in various software. More difficult is to decide where to place

the labels and link so that they are understood intuitively and seem related to the object or location they are really related to. This is especially difficult for points that regard locations within buildings but also if a POI (being a point object which marks a specific location) is related to an area such as the herb garden or even a larger area. Additionally, much attention needs to be given to making the integration of information as consistent as possible. If we decide that every building in Ballenberg is also a link to further information about that building then we need to ensure that such information is available for each building. That might sound trivial but gets trickier when also, for example, small sheds are integrated where the information is not readily available.

Colours and different types of images or symbols for the POI seem a good way to distinguish between different categories of labels and links. However, this has not been tested with users yet and using too much colour might interfere unpleasantly with the coloured background of the ortho imagery.

For the buildings and other assets in Ballenberg there is much more information available than what is integrated in the prototype. Adding more information in more diverse data formats might result in further challenges. For the future we think about integrating 3D models of the buildings that are not only more or less detailed and textured building hulls but are also modelled and textured on the inside. Such models could be integrated directly in the Virtual Environment posing some challenges to the navigation or added as extra 3D views (linked from the 3D view of Ballenberg) allowing detailed exploration of the building's interior.

From the experiences we made in this project we highly recommend to combine 2D and 3D views either nested (the 2D window pops up within the 3D view) and/or side by side. The two different views complement one another and are understood quite intuitively (showing it informally to colleagues and family). We think that the possibility of updating each of the two views when something is selected in the other view (e.g. navigating to a building in the 3D view when it is queried in the 2D view) should be offered but the action only be conducted if the user triggers it (e.g. by clicking on a corresponding button). This separates information retrieval from navigation and is likely to be less confusing.

For the future we would like to test the integration of information in 3D Virtual Environments with a more diverse set of users and see what is really useful and what not. It might also be useful to try and integrate the woods as in the overview map (Bleisch and Nebiker, 2007) or in general more of the flora in Ballenberg. Additionally, we could think of extending the system and combine it with a museum navigation system which the visitor could take on his walk around the museum (as for example in Webpark (Burghardt et al., 2003)).

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