More than rendering – printed tourist maps and an interactive 3D information system from highly detailed 3D landscape models

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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 printed 2D overview map of the Ballenberg area. Several aspects are found to influence the creation of effective 2D tourist maps of the area. The project uses Cinema 4D to vary and analyse visualisation parameters like viewing angle, textures, alignment, etc. of the view, the terrain, the buildings and the woods. Discussing the advantages and disadvantages of the different parameters two different types of maps of the museums area are proposed. The first is similar to the current overview map of Ballenberg and the second uses a map-like overview window and several zoomed views to show details.

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, right) 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. 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 the trials and findings of optimising the 3D base data and adding cartographic knowledge to the rendering process to create a printed overview map of the Ballenberg museum area. The final map will be created together with

professional designers. A detailed analysis of the other part of the project, implementing a prototype 3D information system of the museums area using the same 3D base data can be found in (Bleisch and Nebiker 2007).

Figure 1: Previous overview maps (left, middle) and current overview map (right) of Ballenberg (www.ballenberg.ch)

1.1 Existing overview map

The current overview map of Ballenberg (Figure 1, right) is the first to integrate a representation of the terrain which gives a spatial impression. However, the 'pancake' model with lighting from north-west is difficult to interpret for most museum visitors (statement Ballenberg management). The buildings in the current map are sketched to show their most impressive side and they are scaled up (using different scales for different buildings). The orientation of the buildings on the map which is not aligned with building orientation in reality confuses some visitors. Additionally, the scaled up buildings mislead many visitors to underestimate the dimensions of the museums area. The woods are represented by green coloured areas on the map.

With the examination of different visualisation and rendering parameters described below we try to overcome some of the above mentioned limitations and to create an effective 2D overview map from the 3D base data.

1.2 Characteristics 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. 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 those colours are adopted for the design of the new overview map.

2. DATA, METHODS AND TECHNOLOGY

2.1 3D base data

For the museum area the digital elevation model DTM-AV with 2m point spacing is available for the visualisation of the terrain. Additionally, a digital surface model with the same resolution and covering the same area is available. For texturing the museum's terrain Swissimage ortho imagery with 0.5m resolution can be used.

The buildings were either modelled as relatively simple block models based on ground plan information and on roof shapes collected from aerial photogrammetry (Figure 2a) or as more detailed models using close-range photogrammetry (Figure 2b). The detailed models were textured with photos. Additionally, we experimented with tinting the roof or the surrounding ground in the building group colour (Figure 1 & Figure 2a), c)-e)). Figure 2f shows how non-photorealistic rendering can be used to intensify the edges of the buildings and thus to make them better visible. This technique can also be applied when parts of the building are textured in detail.

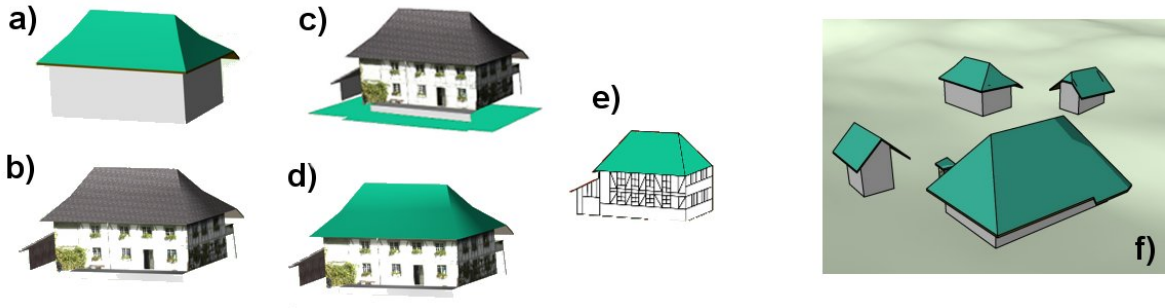

Figure 2: Different levels of detail for the buildings, a) block model with coloured roof, b) detailed & textured model, c) detailed & textured model with coloured ground, d) detailed & textured model with coloured roof, e) building sketch from current Ballenberg overview map, f) non-photorealistic rendering ('Sketch and Toon')

2.2 Visualisation parameters

The size (80x40cm including, legend, text and images) and the scale of the map are kept about the same as for the current overview map of the museum's area. The map is north

oriented. For the optimisation of the visualisation and rendering of the Ballenberg terrain, buildings and woods we examined the following parameters.

Topic	Parameter	Values
View	Projection	Parallel, perspective
	Viewing angle	0° (front view) - 90° (top view)
Terrain	Contour lines	with/without, div. equidistances
	Vertical exaggeration	0x – 2x
	Shading	Phong, Oren-Nayar (Oren and Nayar 1994)
	Texture	Shades of colour, ortho imagery
Buildings	Size	to scale, 1.5x, 2x
	Tilting angle	0° - 40°
	Alignment	Realistic – 'optimal'
	Degree of abstraction (Figure 2)	Realistic (detailed and textured models) – abstract (colours, non-photorealistic rendering)
Woods	Single trees	Abstract / realistic
	Digital surface model	
	Block model	Opaque - transparent

The following sections provide more information about the experiments done by varying the above mentioned visualisation parameters. The most appropriate representations are then selected and result in two map proposals for the overview map of the Ballenberg museum's area. The representations are not tested in user surveys but rather selected after informal discussion with colleagues and family.

2.3 Software

The software Cinema4D (http://www.maxon.net) is used for the 3D visualisation of the Ballenberg museum area and objects and the renderings for the 2D overview map.

3. EXPERIMENTATION

3.1 View

The 3D model is rendered into a 2D image according to a chosen projection. Parallel projections have the advantage of showing an area without distorting the proportions of size. Traditional 2D top view maps use such projections. The perspective projection distorts all objects but we are used to it from looking at our environment and experience it as more natural.

The viewing angle can be varied from 0° (front view) to 90° (top view). Häberling (2003) proposes to use a viewing angle of 45° as it looks natural, shows the terrain differences and gives a good overview of the terrain. A viewing angle of 30° displays perspective distortions and objects such as buildings might occlude each other. A viewing angle of 60°

approximates a parallel projection and gives a good overview. However, the impression of terrain differences is lost to some degree.

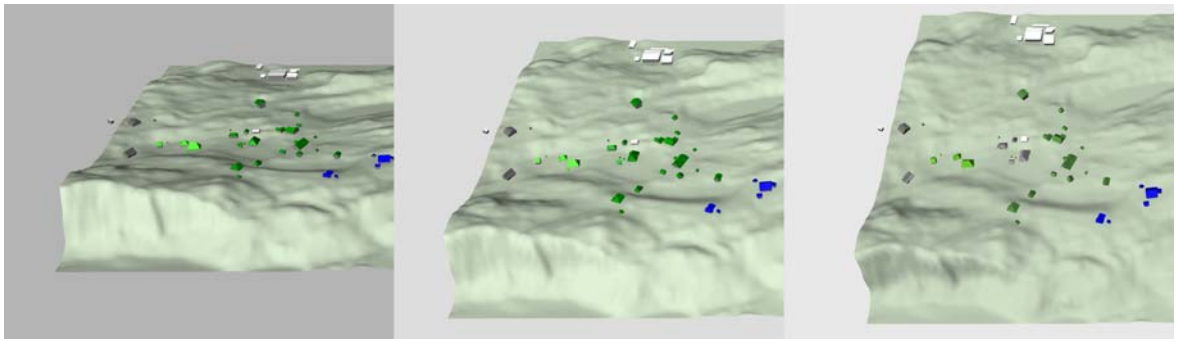

Figure 3: Different viewing angles: 30°, 45°, 60° (left to right)

3.2 Terrain

Adding contour lines to the representation of the terrain improves the interpretation of the terrain for trained map readers. Visitors with difficulties reading contour lines might be confused. We overlay contrasting (dark lines on light background and vice versa) contour lines with equidistance of 5m and 10m.

Using a vertical exaggeration (factors 0.5 – 2) improves the interpretation of the terrain differences. However, it seems unnatural in some places, makes the terrain rougher than what it is and may result in occlusion of objects.

The use of different shading algorithms (Phong and Oren-Nayar (Oren and Nayar 1994)) results in different impressions of the terrain. When no vertical exaggeration is applied Phong shading seems to show more detail of the terrain, give a more natural impression and help the interpretation of the terrain.

We examined different colours and the use of ortho imagery as terrain textures. The ortho imagery gives a quite realistic impression of the area but is too disturbing to be used as terrain texture for an overview map which shows also quite detailed building models. A generalisation using different shades of colour to represent the diverse ground covers (e.g. paths, woods and lakes) seems most suitable for the purpose of an overview map.

3.3 Buildings

The buildings of Ballenberg are modelled in differing degrees of realism (Figure 2) to examine the possibilities for building integration. The current overview map shows quite detailed building sketches (Figure 2e) which are scaled up compared to the rest of the map. Even though scaling up the buildings confuses some users it may be necessary to show enough building details. We experimented with scaling factors 0x - 2x (Figure 4).

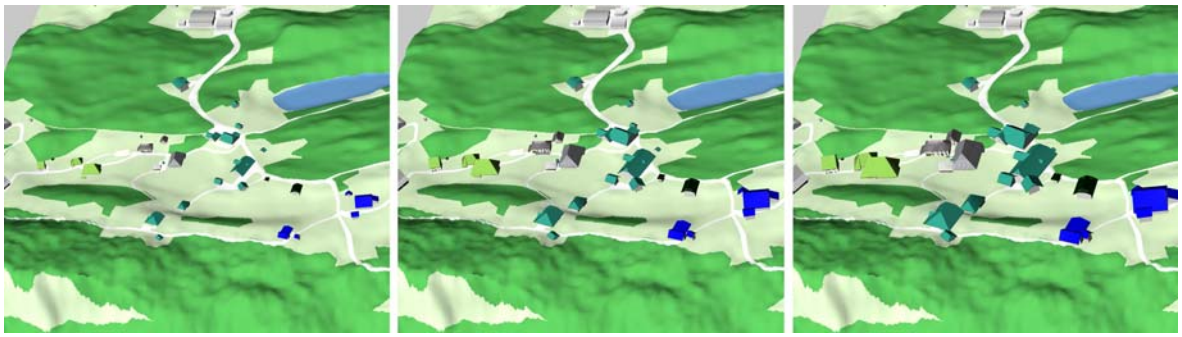

Figure 4: Comparison of different building sizes: original (left), 1.5x (middle) and 2x (right)

Another difficulty is posed by the viewing angle of 45°. Looking at the map from this position shows only roof shapes for most buildings in Ballenberg. To be able to see details of the façade we tilt the buildings upwards. A larger tilting angle (Figure 5) results in buildings with more of the façade visible but also visually disconnects the buildings from the terrain.

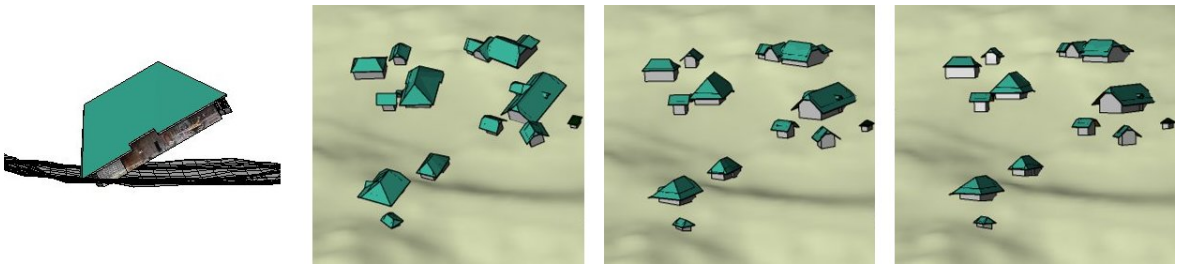

Figure 5: Tilted building (left); different tilting angles for the buildings (original – no tilting, 30° and 40°)

The current overview map has arranged the buildings to show them from their 'best side' and to avoid overlaps. This is confusing for some museum visitors. For the new map the buildings shall be placed as close to the real location as possible. Some rearrangements are needed when they are scaled up to avoid overlaps.

Adding detailed textures to the facades of the buildings is sensible if the facades are big enough so the textures can be seen. It seems that colouring the building roof is most sensible to show the affiliation to a building group. Detailed roof textures are similar for most buildings and colouring the surrounding ground of a building might interfere with the perception of the landscape and ground cover. However, mixing realistic facades with coloured roofs might not be readily accepted by some users.

3.4 Woods

The woods are an important feature of Ballenberg which is dominant in the real world and should be given some importance in the visualisation. The representation of vegetation is

not simple and poses many challenges but also significantly enhances the visual impression of a 3D landscape visualisation (Ervin and Hasbrouck 2001). The current overview map integrates the woods by means of green coloured areas on the map. Visualising in 3D gives us many options to integrate the woods and to display them as an important feature. The goal is to find a wood representation that does not distract from or overlap with other map contents but nevertheless helps the visitor's orientation and navigation within Ballenberg.

Displaying the woods by means of single trees of differing degrees of abstraction results in either artificial looking 'tree nurseries' for abstract tree representation (Figure 6, left) or a distracting representation for detailed tree models (Figure 6, right). Another problem with single tree displays is that they suggest that each tree represents a tree in reality which is not true.

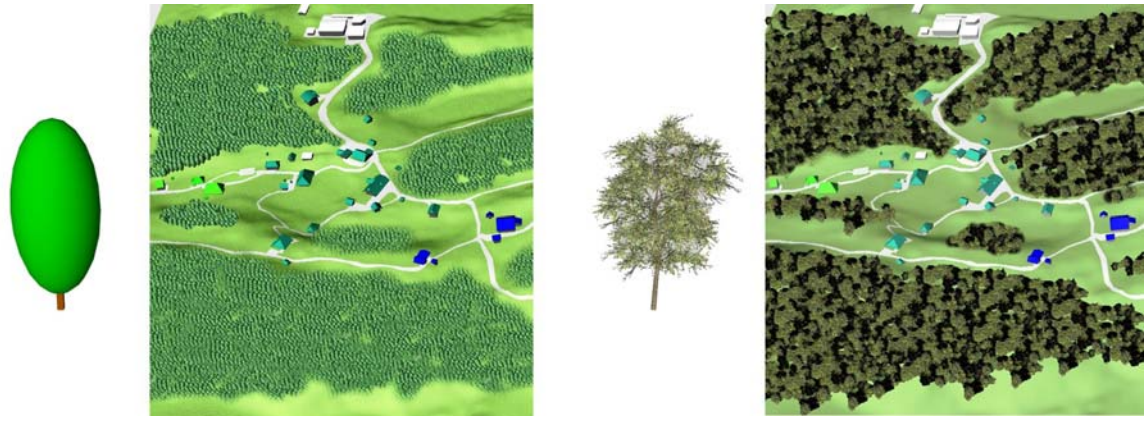

Figure 6: Woods represented by single trees: abstract (left), detailed (right)

Another possibility to represent the woods is to use the treetop points of the digital surface model (Figure 7, left). The result is a 'bumpy' wood which distracts from the other contents.

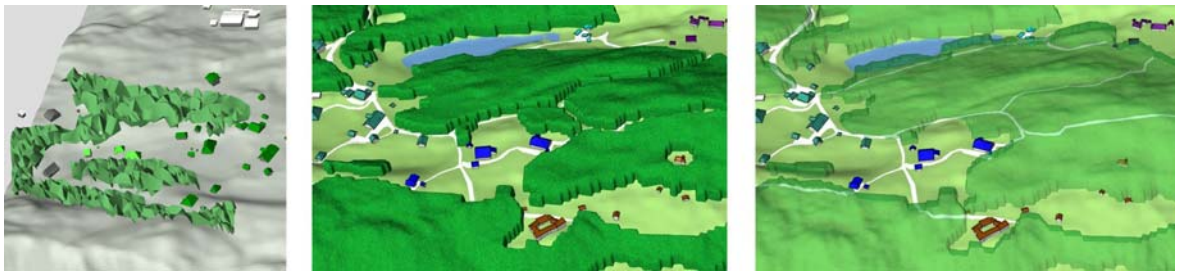

Figure 7: Woods: trees from digital surface model (left), block model (middle), transparent block model (right)

Beside the possibility to colour the wood areas on the terrain we constructed a block model of the woods by raising the wood areas 20m above ground and rounding the sharp edges of the model (Figure 7, middle and right). The results are artificial looking woods which do not distract much from other map contents but provide nevertheless good orientation for

the Ballenberg visitor. The opaque block model (Figure 7, middle) makes it difficult to see the paths leading through the woods even though they are cut out of the block model. Additionally, the woods might occlude whole buildings or parts of them. A solution to those problems is to make the block model partly transparent (Figure 7, right) and thus enable the map user to see the paths and buildings through the woods. A fine bump texture can be applied to the surface of the block model to make it look more wood-like and less artificial.

4. RESULTS AND DISCUSSION

Experimenting with the above described visualisation parameters leads to two different proposals for an overview map of the Ballenberg area (colouring of the map objects is not optimised yet). The first displays all information on a single map (Figure 8). The buildings are scaled up to show enough details and all building facades are textured in detail (Figure 8 does not show all textures yet). Additional information such as building labels are integrated into the representation. As the buildings are scaled up and rearranged to avoid overlaps the visual impression of the building groups and the connection of the buildings with paths and neighbouring objects is lost to some degree. Additionally, the scaled up buildings make the woods look toy-like and might lead the visitors to underestimate the dimension of the museums area. This proposal is basically a new version of the current overview map. Improvements compared to the current map are the less disturbing representation of the terrain and the block model woods for better orientation. The problem with this type of map is that it looses clarity with every change of the objects (scaling, rearrangement, etc.) away from the original representation and comparisons of, for example, objects or distances are more difficult to make.

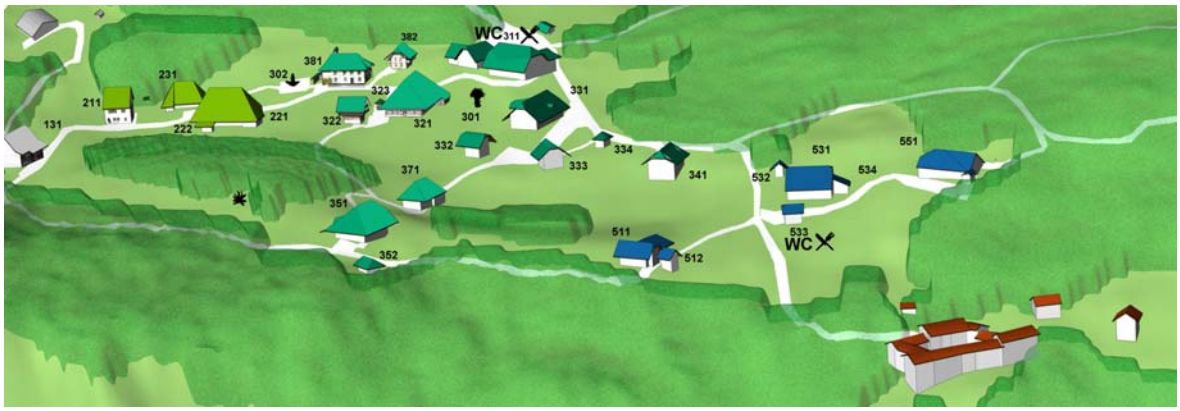

Figure 8: Ballenberg overview map showing all content in one window

The second map proposal includes an overview map in the centre with all objects in the same scale and at original locations (Figure 9). To provide more information, each building group is displayed in a separate window which is connected to the overview map by means of coloured frames. The zoomed in views of each building group contains textured buildings and additional information such as building labels. General information such as locations of toilets or picnic places is shown in the overview map. This type of map has the advantage to show much detail in the zoomed windows and nevertheless to allow comparisons of distances and objects in the overview map. There is a danger that museum visitors have difficulties to integrate the different views. Especially, as the detailed windows show the building groups from an optimal viewpoint and are not necessarily aligned to the display in the overview map. At the moment the detail windows do not show the woods.

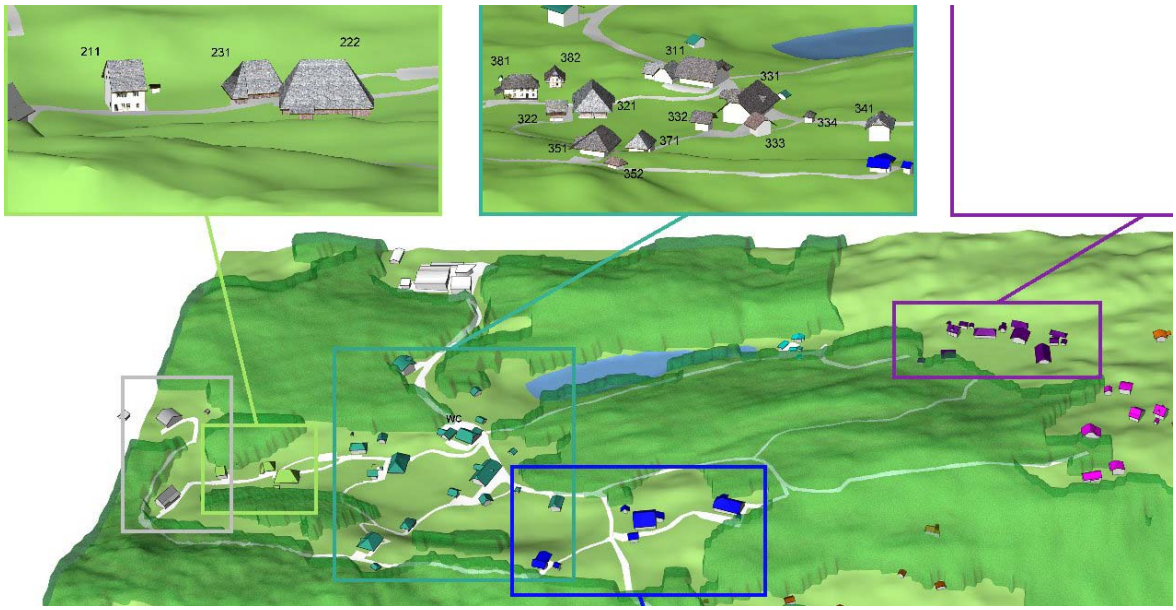

Figure 9: Ballenberg overview map with windows showing details

The two map proposals have not yet been tested with museum visitors. Depending on visitor reactions parts of them might need changing. The project has shown that creating a 2D overview map from 3D base data such as terrain models and detailed building models needs careful consideration of the different visualisation parameters. The characteristics of Ballenberg with its scattered buildings and woods pose further challenges. To have an overview of the area we need to zoom out what makes the buildings very small. Tiny building facades are not suitable for providing much detail such as photo textures but the buildings need to be shown in some detail as they are the important objects of Ballenberg. On the other hand scaling up and rearranging the buildings destroys the connectivity

between the buildings and other display elements and makes it more difficult to estimate distances from the map. The second Ballenberg overview map proposal (Figure 9) looks more map-like and the buildings are located at their original position and look 'correct'. It might be disturbing for some users that in the zoom windows photo-realistic buildings are placed in a generalised landscape. The coloured frames that link to the detail view can interfere with the interpretation of the overview map. Nevertheless, we think that the second map proposal (Figure 9) is a good trade-off between having a useful overview map and displaying some detail about the buildings in Ballenberg. From a technical point of view the second map proposal can be better automated as no manual input such as rotating or replacing buildings is needed. In both proposals the representation of the woods may help greatly with the orientation and navigation in the museums area.

5. ACKNOWLEDGEMENTS

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