Virtual Reality in the landscape design process

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Summary
The paper starts to introduce the landscape architectural design objects. From a digital perspective these interrelations of these objects can be modelled. Especially modelling changes in time by Virtual Reality could support the design process. After a introduction of Virtual Reality by the seven factors (immersion, interactivity, information intensity, intelligent objects, autonomous agents, augmented, selection) the promising opportunities for design are presented by results of the Salix-system. Finally some conclusions, based on the first experiences.

Introduction

In the mid 90's of the last century an article about Sculptor (Engeli, 1996) of CAAD, ETH Zurich was published. This system gave students the ability to have a kind of immersive environment to develop an to experience their design expression. Important architectural principles of geometry like size and shape as well as concepts like rhythm, proportions that are based on specific topological relations between design objects could be experienced. The Sculptor basics were simple but intriguing . Instead of scale based drawings and scale-models there existed an opportunity to find out the real world size effects of the designed ideas.
Nowadays, hardly ten years later, we are confronted with common available virtual reality (VR) tools like VR -construction sets and VR-viewers, which do have the opportunities to experiment with a wide arrangement of design proposals on a real-world representation. As such VR-scenes promise a three-dimensional laboratory to experiment with landscape architectural design proposals.

A short review of the contemporary publications about VR shows that at least seven factors could offer a digital design environment with even more challenging features for a current generation of landscape architects. In this paper the seven factors will be discussed in favour of their support to some landscape design steps.

Considering these factors a computer system has been developed [Lammeren, 2001] which is named Salix. Salix is an acronym of Simulation Agents in a digital Landscape archItectural desIgn eXtension.

This paper doesn't focus on the technical design of the Salix system itself. The system is only used to illustrate the opportunities that such types of computer applications could offer to the landscape architectural in the design of exterior spaces. For this reason the results of Salix are solely used to illustrate the perspective of the seven factors.

LA design objects

Simonds [1997] introduced three important conceptual architectural objects in landscape architecture: base planes, vertical planes and overhead planes. The size and shape of each object as such is an important feature in the design process but the topological relation between these objects is sometimes even more important considering architectural concepts like unity, rhythm, proportion and symmetry

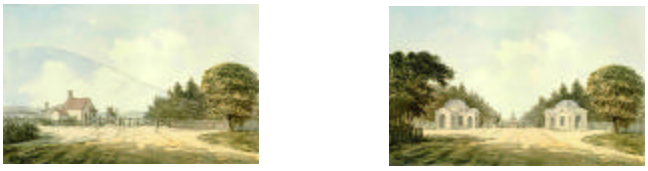


Figure 1: An before and after drawing of Repton

However the main challenge for each landscape architect is the realisation of an architectural vision, which conceptually is based on these architectural objects but created out of living materials like trees, shrubs, herbs and grasses (planting objects). Rather then architecture, in which the created interior spaces are static, landscape architecture deals with dynamic exterior spaces. The planting objects do change in time by their nature (growing process), by human inference (via. maintenance and use) and by physical factors (eg. influenced by climatic and hydrologic regimes etc.). The "before and after" pictures of Humphrey Repton [1994] showed already an interest in changes through time, but the design result itself was somehow time fixed because the "later" pictures showed only one certain moment in time.

The relation between architectural objects and planting objects are of particular interest if one considers that both object types are interrelated to each other: architectural objects have to be created by planting objects. Ruyten [2000] made an overview of these interrelations. The term interrelation is used because of the relation between architectural objects and planting object and the time depended relation between planting objects themselves. Figure 2 shows by the grey columns these interrelations. The planting objects (vertically) are divided into three main types: herbs (1.x), shrubs (2.x) and trees (3.x) as well as their height in comparison with the average view height of man. The latter effects dominantly the architectural effect. The architectural objects (horizontally) have been divided into four main types: solitaires (A), base plane (B.x), vertical plane (C.x) and overhead plane (D.x). The subdivision between of the plane types points at the range of landscape architectural use.

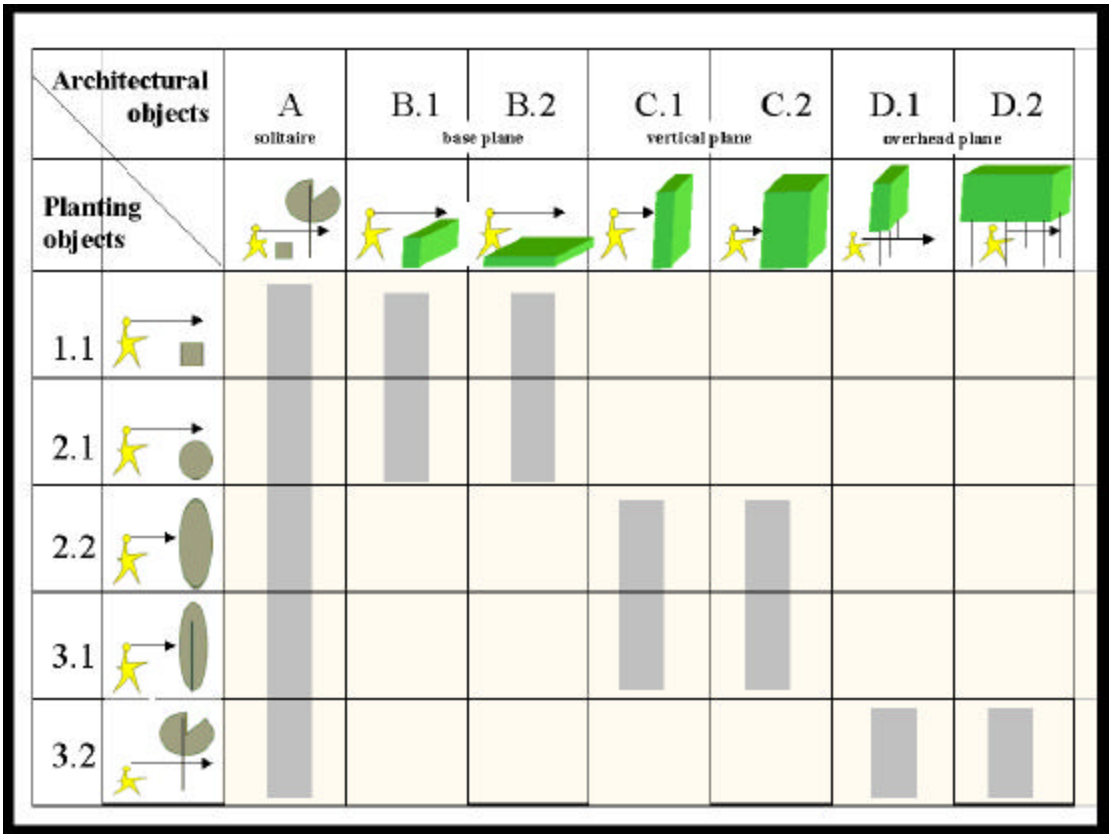


Figure 2: Design objects: Interrelations between planting and architectural objects (after Ruyten,2001)

Virtual Reality could provide a mean to understand the interrelation of design objects and their temporal change as result of growing processes. Landscape architectural training and practice to support the design of exterior spaces and monitor them, can make use of it.

Virtual Reality factors

Despite the rapid growth of virtual reality as a research field, there are still relatively few criteria for assessing the effectiveness and usability of virtual reality environments, and of geo-visualisation techniques in general (Chen 1999). Recently the work of Heim (1998) and MacEachren et al. (1999) has provided four "I" factors important in creating virtual environments. These are immersion, interactivity, information intensity, and intelligence of objects.

Immersion has been defined as "a psychological state characterised by perceiving oneself to be enveloped by, included in, and interacting with an environment…" (Witmer and Singer 1998, p. 227). In fact the 3D-representation, by VR, of the real world offers a first immersive level but it can be experienced in a weak sense mode (sitting behind a monitor) or strong sense mode (eg. CAVE).

Interactivity refers to enabling a user in a virtual environment to change their view point on the environment (e.g. through body and head movements corresponding head-tracking). The overall term interactivity is rather diverse. Reacting on Heim and

MacEachren we found out that interactivity is mostly called navigation (eg way finding and orientation.). Another type of interactivity is called scene manipulation. Elements of scene manipulation are object position change of the relative position of objects (e.g. making it possible to interact with a virtual object by picking it up and rotating it in the hand (Heim 1998)); full object change by which object in the scene can be deleted or added; object attribute change mentioned MacEachren *et al.* (1999) to change colour, bitmaps, thematic attributes and object querying to derive quantitative or qualitative information related to objects.

Information intensity deals with the level of detail in the GeoVR. The term GeoVR is in our opinion crucial, because landscape architects deal with the design of exterior spaces which are based on real world based information (geo information !). Thus conventional rules for automated map generalisation may be useful in deciding about the appropriate level of detail. The rules have, however, never been tested in GeoVRs and the research has been oriented toward abstract symbolisation for two-dimensional maps. Support for changes in details as users zoom between scales is just being tackled now (See http://www.digitalearth.gov).

Intelligent objects can assist users in interpreting GeoVR environments. Some examples are intelligent objects assisting users in navigation through and understanding virtual geographic landscapes or in retrieving geo-spatial information (Cartwright 1999).

We [Wachowicz et al.., 2002] extend this list, as mentioned before to interactivity, and grouped into two main categories named as: GeoVR Construction and GeoVR Use. In the GeoVR Construction category, the criteria are related to the creation of a GeoVR environment. They are selection, immersion, information intensity, and autonomous agents. In the GeoVR Use category, the criteria are related to the exploration of a virtual environment. They are interactivity, augmented reality, object behaviour, and autonomous agents. Table 1 summarises these seven factors.

Table 1: The GeoVR factors

GeoVR Construction	GeoVR Use
Selection	Interactivity
Immersion	Augmented Reality
Information Intensity	Object Behaviour
Autonomous Agents	Autonomous Agents

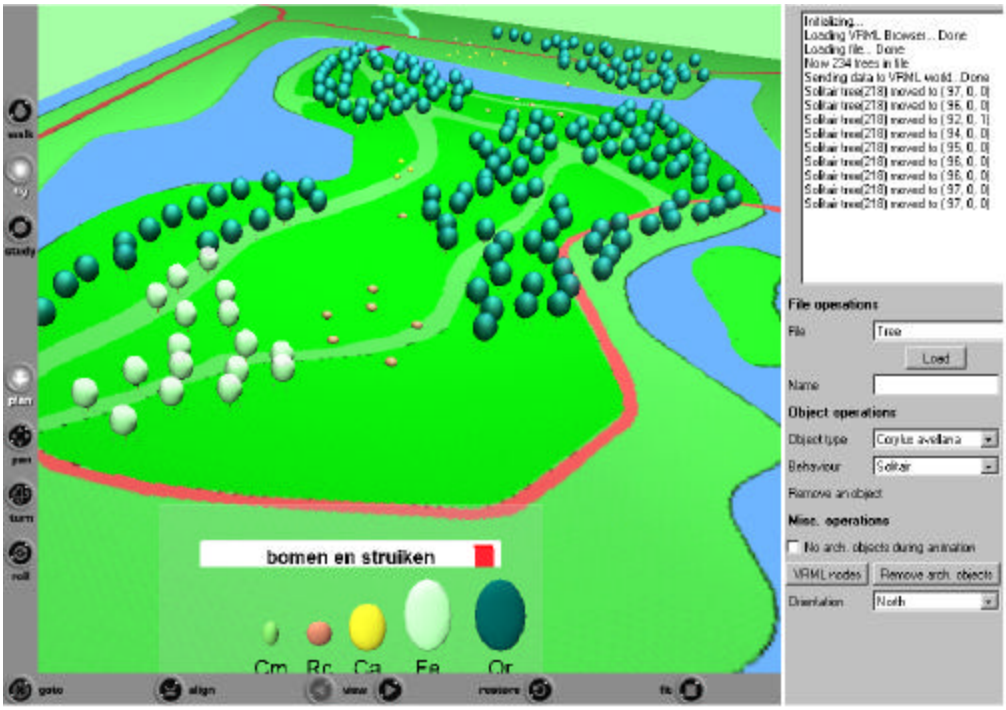
Landscape design: GeoVR Use

Each of these GeoVR use factors will be explained and discussed from a design-supporting context.

As already mentioned before the factor ***Interactivity*** can be divided in navigation and manipulation. Navigation must be understood as user movement through a GeoVR scene. Instead of video or animations the user doesn't have to follow pre-described flight paths, walk troughs and view points but could freely move through and around

the 3D-scene. In fact a number of projections (eg. top view, bird's eye perspective, profiles) could be obtained to have a close watch to the design solutions. Most of the VR-viewers do have these abilities to navigate. SALIX makes use of a VRML viewer (figure 3). Experiences with GeoVR show that like the real world a user can become lost in the 3D-scene. For this reason a number of navigation supporting tools (an example of augmented reality items), like view direction windows, should be offered to the users

Figure 3: Salix user interface



The interactivity component manipulation has been subdivided into four sub-components: full object change, object position change, object attributes change and object query. Each of these manipulative components is of interest in the landscape design process. Full object change means that on the fly a designer could make or delete design objects. In the SALIX system these design objects are in the first place planting objects which can be deleted or created.

The object position change offers the user the ability to reposition the design object. In the case of SALIX it means the reposition of the planting objects.

The object attribute change has been implemented in the prototype very limited. The user can change the relation between the planting object and the architectural object by a simple change of the object interrelation type from solitaires into planes or vice versa. Changes of graphic attribute values or thematic values are not implemented.

Finally the object query to find out what kind of object offers the plant species, the age and the interrelation type.

A virtual reality replaces the real world, but ***Augmented Reality*** supplements the VR-model of the real world with additional information (Feiner *et al.* 1997). In the case of SALIX some extra windows pop-up to assist the designer. A special object is a human scale reference. The human scale reference shows vertically and horizontally size steps of 2 meters. This object is linked to the user's path and viewpoints in the 3D-scene (figure 4).

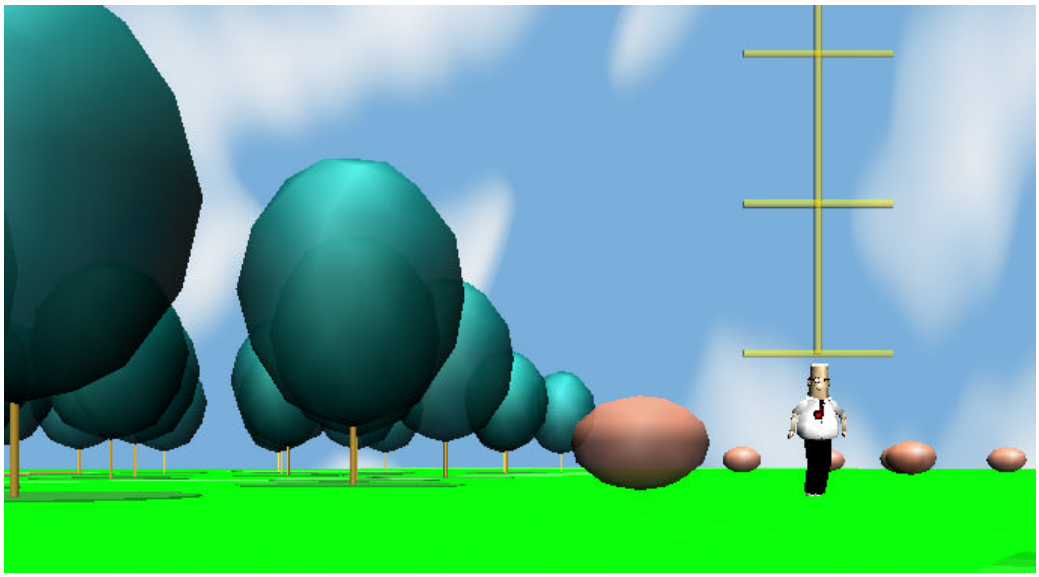
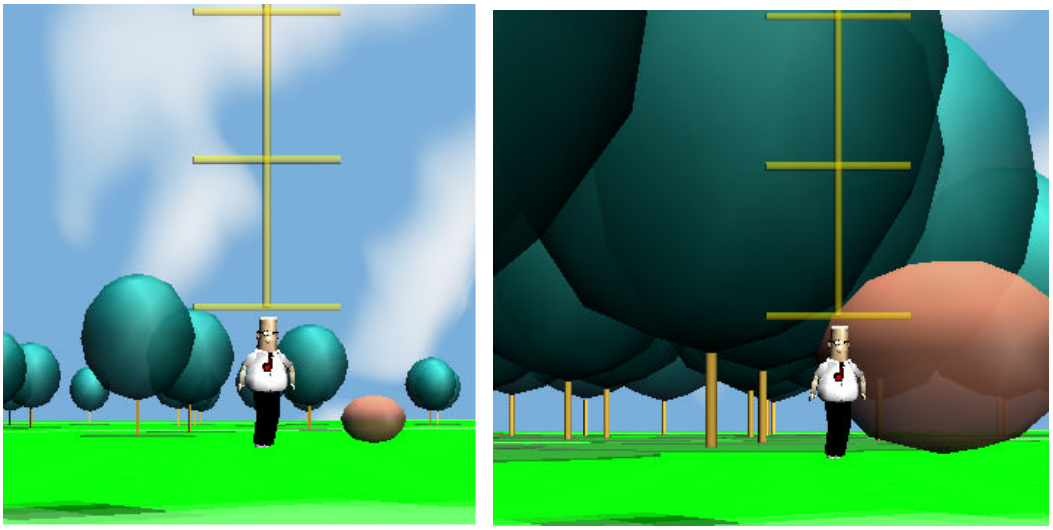


Figure 4: Reference to human scale

Object Behaviour refers to how objects change continuously, either with or without user control. In Salix the object behaviour is realised by a connection between planting objects and specie specific growth simulation. The growth simulation, a simple polynomial function calibrated via empirical data, initiates a resizing of the geometrical model of the planting object - in fact by a simple morphing algorithm- (figure 5) .

Figure 5: Simulation of growth



This simulation of planting objects growing can run continuously but also by incremental steps. In combination with the interactivity factor it offers the opportunity to have a temporal based design process and a temporal based tracking of the design impact.

Finally, ***Autonomous Agents*** are usually capable of having their own actions and internal states (autonomy), reacting to environmental changes or other agents actions (responsiveness) until they complete their tasks (social ability) (Weiss 1999). Agents raise some appealing possibilities to assist users while interpreting GeoVRs. One could even think of avatars showing human like responses The Salix prototype offers two type of agents. The first type monitors the overlap or collision of planting objects. During the temporal based design process these agent watches, which object will collide and when a case of collision is determined it will graphically show it to the user (figure 6). This agent provides the designer with information about the temporal development.

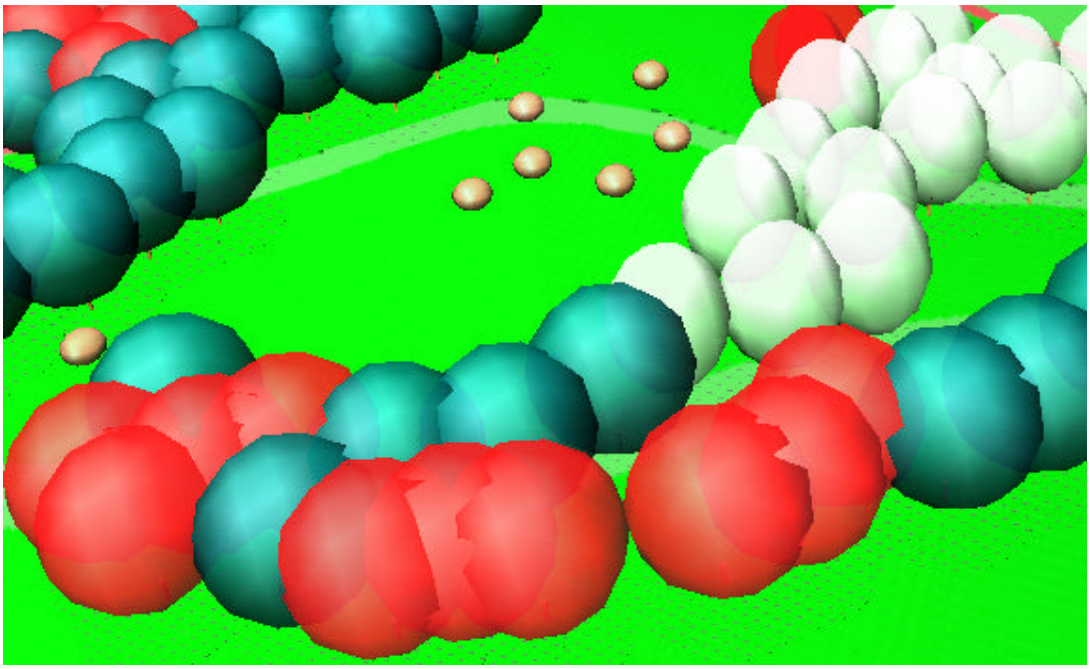


Figure 6: Collision between planting object viewed from a bird's eye perspective

A second agent in the prototype translates, on a time step base, the planting objects into architectural objects - ground plane, head plane and vertical planes -. The origin, depending on the planting object type, of the architectural object is graphically shown (figure 7). This agent provides information about the interrelation between planting objects and architectural object and when a certain architectural object will be obtained.

Landscape design: VR on demand

The previously discussed factors and the way landscape architects deal with them is strongly dependent from the GeoVR itself. In the SALIX prototype little interest is given in this subject. According the "VR on demand"-factors the following ideas about a flexible way of creating design supporting GeoVR's can be thought of.

Selection is the ability of users to dynamically select the geographical data, design objects, simulation models, and agents in order to construct a GeoVR environment ("Virtual on demand"). Users currently work with pre-built GeoVRs. Even the Salix application is pre-built. Some projects are already dealing with on-line construction of GeoVR out of geographical databases [Bulens et al., 2000].

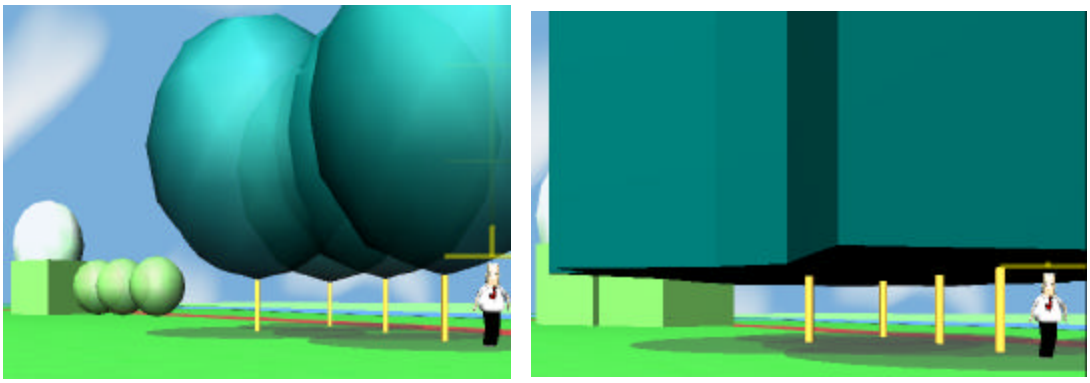


Figure 7: Architectural objects: right picture shows 14 years later

Immersion is perhaps the most important factor in the construction of a GeoVR, but we are just beginning to tap the full potential of being immersed. The prototype described in this paper is an example of a weak sense of immersion (available by monitor and head mounted device).

Information Intensity deals with how the levels of details (i.e. information about objects) can be represented in a GeoVR. For example, increasing proximity to an object should allow a user to see increasing detail, the use of sound to realise proximity to an object, or the use of a zooming to scale beyond those of normal vision to continue to provide additional detail. In the prototype the level of detail principle is only found via the popping-up of the human reference object. The level of detail is in fact the scale ratio in the traditional maps and scale dependent pictures approach in landscape design: the closer the object, the more detail. Extension of the prototype in this way means more geometrical details by geometrical model replacement or the use of detail-class bounded bitmaps. Which of the two approaches benefits most, asks for dedicated user oriented research.

A diversity and variety of ***Autonomous Agents*** could be developed and used during the design process. One can think of agent classes which controls the relation between the financial budget and number of planting objects, variety of species via the amount and diversity of planting objects, control sites that are exempted of design actions, and so on. In other words autonomous agents could offer a lot of analytical information on-line. Some of these agents' classes could be GIS-based tools like buffering, Boolean overlay and viewshed analysis.

Feedback

This research showed a first step in linking landscape architectural design objects with a mimic of reality using VR techniques. We showed that by connecting a

growth-simulation with a VR world we are able to generate a representation of these design objects that can be easily explored, adapted en comprehended by humans beyond traditional representations used in landscape architecture. For example the term "scale" could be defined from different perspectives: selection (which precision and accuracy will the scene finally offer); information intensity (how precise and accurate have the user to experience the different objects of a scene); navigate (which precision and accuracy of objects have to be in favour of a certain projection in relation to the distance between the viewpoint of the user and the scene itself).

So far we mainly focussed upon selection, interactivity, and object behaviour. We did not tackle many of the problems related to immersion, information intensity and "virtual on demand" . The result till know are however promising. Computer power is still increasing and efforts are being made in the standardisation protocols for creating VR-scenes. We showed that VR have clearly an added value to represent the often complex spatial concepts handled in landscape architecture on the level of the creation of exterior spaces. The details of the planting objects were no subject of the Salix research.

There are several reasons to explore the opportunities of Salix-like applications in design studios to find how the seven factors will influence learning attitudes and results of design classes and studios. For example what effect will have the "1:1 scale" navigation, the simulated growing process, the alternating shift between planting and architectural objects and the quick transition between different views and projections have on the spatial thinking and reasoning of landscape architectural students.
A promising set of interesting research subjects seems to pop up out of this the mutual related field of landscape architecture and geo-virtual reality. Possibly the results of these subjects, in relation to pedagogical and applied interests, lead to a new landscape architectural design approach.

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