1 Introduction

Using 3D visualization software is already common practice in the process of landscape visualization (BISHOP, 2005). The ability to walk around or fly through virtual landscape makes it easy to evaluate the design itself and the way the design fits with the existing parts of the landscape. The whole design or parts of it can be adjusted to see how alternative landscape designs look like.

Plantings, trees and shrubs, are the main materials to shape space in the landscape design process. These are challenging materials because of their living nature. Materials that show temporal changes during their lifetime (like changes of length, width and shape) and during annual seasons (like blossoming and fruitening periods and seasonal characteristics of deciduous trees). However like GAZVODA (2002) stated “All of the above facts about planting maps are so common to the landscape architect, that we usually do not consider them as any special products”. This is an interesting remark because in contrary to landscape ecology (BOLLINGER ET AL., 2006), designing forest management (BASKENT, 1996) and green maintenance (PINCETL, 2010) the temporal dimension of the design process seems of little interest according the results of literature research.

The actual view of the landscape architectural concept depends largely on the phase of the designed landscape and specifically on the growing stage of the vegetation related to that phase. When depicted in an early growing stage with the vegetation shown as young trees and shrubs, the 3D visualization might not reflect the architectural concept as intended. When depicted in a full grown stage the design may envisage the architectural concept but neglects the initial phases that could differ a lot.

In landscape design we struggle with, what we like to call, the architectural concept constraint. It means that during the design the architectural arrangement of components and materials are spatially well defined, guided and tested by a leading concept aiming at a certain landscape scene. But that leading concept forwards also a “narrow-minded” approach when the impact of the life stages of planting is taken into consideration. FILOIR (1994) does illustrate this constraint when he stated “Returning 25 years later to reappraise the project, Jellicoe was satisfied that the concept had generally survived the passage of time”.

Nowadays some software like Landsim3D (BIONATICS, 2009) provide the option to generate views of different moments in time, including successive stages of plant growing. These successive stages and their visual representations of trees and shrubs (MUHAR, 2001) are generated automatically based on growth parameters associated with tree or shrub species, for example the Landsim3d native tree models or generated from specific three-dimensional (3D) plant object models that represent the appearance of the tree at a specific
age (BARCZI ET AL., 2008). Unfortunately for every time step a new 3D view has to be generated by using generic growth parameters. A smooth and real time transition of the 3D view between time steps is not provided.

In this paper we present the SALIX approach to favour all four dimension (space and time) in the landscape design process with a particular interest in the role of plant growing stages. First we describe the main idea of this approach and present the SALIX software. In the software we include growth parameters for most species depending on the actual plant location and its surrounding environment. Then we present two real world cases in which the software played an interesting role. Finally we discuss the options to include this approach in practice, including education.

2 SALIX: A Temporal Approach

The development of the SALIX software started in 2001 (LAMMEREN ET AL., 2002). SALIX is an acronym of Simulation Agents in a digital Landscape architectural design eXtension. The basic idea was to provide an interactive tool to students in landscape architecture that can be used to create a landscape design and to evaluate the development of the design over time.

This original approach started with the concept that the design process is based on a transformation of a private mental construct into a graphical construct (ROWE, 1992). The latter may be used for discussion, analysis and refinement on a personal, group or societal base (STYLIADIS ET AL., 2008). Finally it may be used as guideline and model for realization.

This transformation will start with creating a sketchy lay-out. In the SALIX approach this may start with adding and modifying architectural objects, as defined by SIMONDS (1997). These architectural objects are known by terms like a ‘screen’, a ‘roof’ or a ‘block’.

A next step is to disaggregate these architectural objects into planting objects by a planting pattern. The planting objects may be based on simple geometries because the refinement of the architectural arrangement has to be discovered. Making use of architectural objects and the derived planting objects are only the first steps in creating a landscape architectural composition (GAZDOVA, 2002) and its metrics. Detailing the shape of space, fine-tuning the order, hierarchy and rhythm of spaces, and adjusting (a)symmetry of the composition need editing of planting objects.

As provoked by the Integral Planting Method (RUYTE, 2006), the local growing parameters of trees and shrubs should be included in the design process. By using the SALIX approach it is possible to determine distances between the planting objects while taking into consideration both initial and final crown dimensions and vegetation heights in relation to the conceptual design (With conceptual design we mean the layout of the architectural objects). This more dynamic approach has led to the integral planting method by which the space required for maximum growth in a plant’s mature phase is combined with the realization of architectural functions. The desired effect is defined by the initial size of the trees and shrubs. The growth movement towards the dimensions of the maturity phase is part of a composition in time and space. The developed SALIX software is capable
to handle five different types of planting objects. Each planting object type is represented by an abstract 3D object consisting of cylinder and sphere (in case of a tree) or only a sphere (in case of a shrub). For each planting object type, the colour and the growth parameters are unique and fully adjustable. The total amount of objects is only limited by computer memory and capabilities of the graphics card.

Salix makes use of a VRML viewer (Honjo et al., 2001) for the 3D visualization and the VRML 2.0 External Authoring Interface (EAI, a Java Applet) for interaction between the user and the virtual environment (VRML97 specification). EAI handles all user actions like adding, moving or removing planting objects. All planting objects are stored in an Access database.

The object growth is implemented as a simple polynomial function calibrated via empirical data. Usually, the specific growth function for a planting object type is derived from measurement of existing trees or shrubs in the field. This makes it possible to implement a growth function that is specific for the geographical location for which the landscape design is made. But also generic growth parameters for a given type can be used. The growth simulation is activated by the user by dragging a slider that manipulates the time (in years) The SALIX interface is shown in figure 1.

In SALIX the area for which the 3D visualization is made is treated as a plane without implementing the earth curvature. It is possible to use a height model for the area by importing an existing digital elevation model (DEM) as a VRML object. This is a workable setup for the local or large scale design process.

![SALIX interface diagram](image)

**Fig. 1:** SALIX interface
Being able to use both space and time in a 3D virtual environment provides the landscape architect with full access to the virtual landscape design. The design result can be viewed from every desired position and angle, e.g. as a birds eye view or as a human eye view. At every desired view position the growth can be set to the desired year in the future and each planting object can be moved or removed or new planting objects can be added. Newly added planting objects automatically inherit the selected year and are visualized at the correct size based on the growth function of its planting object type.

The abstract representation of the planting objects with a cylinder and sphere is useful when focusing on the layout of the landscape design but it does give a limited impression of the green elements. It is a suitable representation for architects in several stages of the design process but is not convincing in communication with the general public. A more realistic view of the landscape design can be created by using realistic 3D representations of the planting object types. Since the 3D representations are VRML objects, any desired 3D representation can be used. These can be simple bitmaps to high detailed 3D objects (MUHAR, 2001). For performance reasons, we don’t use high detailed 3D objects because it slows down interactions via the 3D viewer, especially when using too many objects. Using 3D objects that consist of crossed billboards, two bitmaps placed in a cross representing the tree crown (actual pictures of the tree crown), and a bitmap draped on the cylinder for the tree stem generally provides an acceptable view of the planting objects and provides a good performance in the 3D viewer.

3 Case Study Observations

However we originally intended to support landscape architecture design education by Salix it turn out that case studies, commissioned by municipalities and other administrative boards were more interested in using such a tool. As an illustration of the way that Salix favours four dimensions we present our observations of two different case studies in the Netherlands: Eindhoven and Arnhem. For both case studies we do describe the purpose, the procedure including the participants, the activities performed by the application, the outcome and conclusions regarding the four dimensions.

The Eindhoven case objective opted to review a road design through an industrial area that includes an area with dwelling houses. It is also an important connection for traffic between the centre and the orbital roads outside the city area and an important road that opens up the industrial area. The road lengths about two kilometres. Its profile and lay out meant to be a full reconstruction of the original road lay out and have to be inviting. The review took place in one session of three hours in which the landscape architect and the representatives of Eindhoven municipality administration were involved. In total 7 people were joining this session.

The Arnhem case reviews also a road design of an existing road in an urban renewal area. The lay out of the road design is of interest because it will form the link or boundary between the residential quarter and the central green, a park, of this urban housing region. The conceptual design includes a redesign of five lanes of existing trees along a dual carriage road. Like the Eindhoven case the design challenge is given by the reconstruction of an existing lay out.
The review assignment in a first session of one hour by a project group of ten people focused on the preferred lay out. The project group consisted of people from different public services like urban landscape design, green maintenance, road design and maintenance, recreation and public safety who had to agree on the final design. The goal of the visualization of the different design alternatives was to demystify the discussion and have a clear vision what the effect of the different alternatives would be. A second Arnhem session aimed to get approval of the preferred design as a result of the first session. This session was chaired by the local planning authority of the municipality and took also one hour. 15 persons did address this decision making session.

In both projects, Eindhoven and Arnhem, the participants of the session were sitting in a room and watching a screen that showed the design results rendered via the Salix application. In the Eindhoven session the procedure was rather informal and the chair operated as an moderator who instructed the Salix specialist to act. However the Salix expert could realize a more pro-active role. This informal setting was also the case in the first Arnhem session. In the second Arnhem session, that followed a formal procedure, the chairman collected ideas, remarks, requests of the participants and instructed the Salix expert.

The original design discussed during the Eindhoven session was only known by top view maps. The 3D visualization offered, as mentioned by the participants, for the first time a real insight in the spatial consequences. During this session the participants used the application to “walk through” the design idea and discussed by this mode of movement the design details. For the purpose of this explanation we consider the planting of the road sides and the road itself as being the conceptual design. The conceptual design included a number of already existing older trees of interest, contrasting clusters of new planted trees and line of views. The designer intended a specific role of these trees in the conceptual design. During the walk through the participants checked by changing the age of the planted trees what will long of the specific roles from different points of view. During this check up the location of the new planted trees were moved too. During the walk through on both the car track and the bike track another interesting thing happened. The surroundings of the conceptual design, surrounding buildings, plantings on a far distance, and vistas have been discovered by having perpendicular views which started to become gradually of more importance for the conceptual design. The changes of the design, by moving or deleting trees, were continuously verified by the temporal change of tree sizes.

During the session the participants mainly used the walk through mode (app. 80% of the time) and the bird’s eye view less (20%). The full freedom of movement through the model and the ability to look into the future by applying tree-growth at every requested location during the tour lead to lively discussions about the design between the principals and the designer. The designer also made the remark that the model sometimes portrait a different view than he anticipated but had to admit that the model did show a more transparent view. This had also to do with the inclusion of the surrounding areas and buildings. This gave a better understanding of the conceptual design than just imagining the design when looking at a 2D map on which the design was drawn.

In the Arnhem session the first session discussed a new conceptual design in which a lane structure formed the generic principle of the renewal. The conceptual design of the existing situation, labelled block structure, offered a set of mature sycamore trees (50 years and
older). The discussion in the first session originated from this lane structure concept and focused on cutting trees on the road and planting new trees. The participants found alternatives of cutting and planting ways and experiences the time range needed to reach tree sizes which support the lane concept including trees that were not cut. Finally a conceptual design was agreed upon.

Figure 2a/2b shows the existing situation. The five lanes consist of only sycamores and were all planted about 40 years ago. The trees are grouped in blocks and the blocks are positioned to mirror the blocked structure of the neighbouring apartment buildings and in the meanwhile to create a visual connection with the public green space. The size of the trees differs per lane due to different conditions of the neighbouring environment. The trees on the outside lanes are placed in a broad lawn and experience not much influence from the nearby roads. These are the largest trees. The trees on the inside lanes are placed in a small lawn and are influenced by the nearby roads. These trees are smaller than the trees in the outside lanes. The trees in the middle lane are the smallest. They are planted in a very narrow path (50 cm’s wide) and experience the influence of the roads from both sides.

The starting point for the discussion are two different designs. In both designs, the trees from the middle lane are removed. The available space for the trees considered to be too narrow to let the trees become full grown healthy trees. Also the trees from the outside lanes will remain in both designs; these are a part of the lane concept. In the new design A,

Fig. 2a:  Arnhem: Arial photo with project area within red box. Grey arrow indicates view direction for right picture.
the trees from the middle lane are removed and replaced by new trees. The original blocked structure is replaced by a lane structure. For alternative design B, all trees in the inside lane will be remain and new trees are added to fill the open spaces in the blocked structure and to create a lane structure. With the aid of soil improvement measures, the new trees will be able to grow into full grown size. All new trees will be sycamore trees.

Within the project group, the discussion mainly focused on the question if it seemed necessary to remove the inner lane trees to create a homogeneous lane structure. During the virtual tour this aspect was evaluated on many locations. Comparing design A and B in figure 3 shows the differences but also shows that within 20 years the differences between the existing and new trees are acceptable from the design point of view. One benefit for design B is that the trees in the inner lanes won’t have to be cut down. Design B was finally submitted to the local planning authority and also pictured three-dimensionally during the follow up session.

**Fig. 2b:** Arnhem: 3D model showing only the existing trees for the project area

**Fig. 3a:** Topview showing the design
Fig. 3b: Perspective view, showing the designs at the year of planting

Fig. 3c: Perspective view, showing the designs after 20 years

Fig. 3d: Viewpoint on the bicycle lane, showing the designs at the year of planting

Fig. 3e: Viewpoint on the bicycle lane, showing the designs after 20 years
In the second session a change of view came along. The building local planning authority favoured the block structure in contrast with the project group. During this session the lane and block structured were compared by moving over the car tracks, varying the size of trees by gradually growing of the plantings and stepping ‘outside’ the conceptual design and view lane and block conceptual designs from a distance by locations in the adjacent public greens. A virtual trip on the bicycle path showed the differences in lightning conditions on the bicycle path (compare fig. 3d and 3e with fig. 4c and 4d). The original design gave a slight impression of bicycling through a dark tunnel. Also the viewpoint from the road into the adjacent park is hampered by the lane structure design. The discussion during the meeting was continuously supported by interactive editing. The edited design results could be viewed immediately to validate the raised arguments. Finally the decision makers showed a preference for the block structure as an important design feature to maintain due to cultural-historic arguments and safety regarding reasons. That the meeting came finally to an approval would not have been the case if the suggested alterations had not been envisaged by a continuous and immediate feedback loop that presented the spatial impact in time and place. The final design is shown in figure 4 and 5.

During the first session the bird’s eye view has been used far more longer (app. 80% of the time) than the human eye’s view (walk through mode). During the second session the bird’s eye view and the human eye’s view have been used equally.

Fig. 4a: Perspective view of final design at the year of planting  
Fig. 4b: Perspective view of final design after 20 years  
Fig. 4c: Viewpoint on the bicycle lane, showing the final design at the year of planting  
Fig 4d: Viewpoint on the bicycle lane, showing the final design after 20 years.
We observed during the Arnhem session that the graphical quality of the 3D visualisation was not a topic under discussion. Although the plantings were simplified, the depicted views showed to be accurate enough to resemble the real world situation in the eyes of non-3D specialist. As Salix uses simplified 3D models, for performance reasons, it also let the participants understand that the presented design is still in a planning stage. This was obvious to all persons involved in the case studies because discussions were open and lively.

From these observations of daily practices we derived the following preliminary conclusions in line with the usability criteria mentioned by PAAR (2006). The use of this 3D visualization software seemed to be most suitable in these practices. It really did support and improve discussion between different stakeholders and professional designers. It also influence the efficiency of a decision making procedure. The application itself turned out to be sufficient for the stakeholders involved. All stakeholders appreciated this format to create a better “transparency” of the design options. It must be stressed upon that the participants themselves didn’t use the application. An operator of the Salix application presented, modified and asked for specification guided by the session moderators.

4 Discussion and Outlook

In the previous section we described the Eindhoven and Arnhem case studies and concluded modestly on some usability items. In this final section we will ruminate on the role of the fourth dimension as introduced in the application by simulating the growing of plantings.

From a landscape design perspective there seems always a illuminating path considering the outcome of the design procedure: the conceptual design. The conceptual design as an visualization of a mental construction pictures the landscape area under design by a fixed period after planting of trees and shrubs. In other words we may state that the life cycle of the conceptual landscape design is rather limited, because all plantings are mainly imagined at a fixed optimum for example forty years after cultivating and creating the intended design. The inclusion of the temporal dimension in the design process brings forward options to focus on conceptual design with a longer life cycle, and design programmes that offers alternating conceptual designs for an ample amount of decennia.

The driving force of such development is given by the temporal variability of main materials of the landscape design, trees and shrubs. Their life cycles give options of interest to experiment the longer life cycle of a conceptual design and alternating conceptual designs. From the two cases we experienced that the growing simulation of the combined young and older plantings raise options for a change of the conceptual design in the direction of a longer life cycle (the Arnhem case) and alternating concepts (the Eindhoven case). The impact of the growth of trees and shrubs on the design decision showed to be really impressive. In the Eindhoven case the participants and designers accepted modification of the conceptual design (eg. trees as landmarks could become after many years part of a tree cluster; trees have been removed from the design because they hinder after a while the view on the surroundings). In Arnhem the building quality commission
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did convince the other participants by showing that the growth of new plantings will revive and prolong the original conceptual design.

Maybe the growth simulation of trees did work well because the application used growth simulations that incorporates the local growth variations and were calibrated for the specific local conditions. The data to handle local variations were the result of measuring comparable tree and shrub species in an area within or adjacent to the design area (RUYTEN, 2006). We did assume that these local growth variations will not really alter in the future. This of course might not be the case. Monitoring the implemented design will give the necessary information to improve this local approach and adjust the applied methodology for the growth models. This local growth information could lead to construction and cultivation specifications that include temporal stages of the conceptual design. Linked to Salix the first experiments into this direction have been started in the Netherlands (RAATS, 2009).

This impact of the life cycle of planting materials (especially the morph-dynamics) on the life cycle of the conceptual design will of course influence the design process. The use of the temporal dimension within a 3D design oriented process should have to be supported. Depending on the initiating criteria, prospects and characteristics of the design area given the design process could evolve in many directions. However due to the use of 3D design applications it is possible to keep track of the concepts that have been explored. Like in Salix all intermediate design results could be stored, time stamped and may be discussed. The ability to simulating growing made it possible to depict the landscape design with the full intention of the designer at different stages of its development. The projective attitude of a designer has to be supported by trace back and feedback mechanisms. These mechanisms make the final stage of a conceptual design a starting point to gradually reason back in time to search for other design options.

As we stated at the beginning of this paper the Salix approach was originally intended to support education of landscape design. Based on our case study observations and to envisage options of the fourth dimension we like to propose some ideas for an educational setting. For that we recall some ideas of DANAHY (1989) as included in the TUMMS concepts. Danahy stated that geometric (built) form is only one of at least three major categories of space and form that a landscape architect must be concerned with, because terrain and vegetation have to be supported too. Nowadays students could be offered these three categories by latest 3D visualization tools. When the temporal dimension via the life cycle of plantings is included then the meaning of vegetation in this perspective could fulfill a major role during the design process. Such 3D applications for landscape design that offer real-time rendering of the subsequent design steps and designed results could improve the quality of feedback sessions and the assessments of the design results. Moreover it could also modify the dominant focus on the (!?) conceptual design. We believe, based on our observations, that this type of tools will help students “understanding the importance of perceived details, dimension, and time correlated to design concepts”. It helps to test their ideas because they could toggle between different projection types and representations of plantings and they could gain immediately feedback because of the 3D visualisation. Such educational perspective will indeed direct students’ intellectual attention to the specific principle or theory behind the exercise, and offer ways to debate the life cycle of the conceptual design.
It may be concluded that the aspect of time is an important feature in the landscape design process and a valuable dimension for exploration. Let’s favour the four dimensions of landscape design by promoting more experimental research on usability issues in practical cases and education.

References


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