

INTERACTIVE VISUALISATION FOR THE INTERNET IN LANDSCAPE PLANNING WITH VRML

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1. Abstract

Interactive visualisations, in particular for the internet, offer new perspectives and possibilities for visual communication in the designing process. Geometry- and attribute-data combined via hyperlinks open a wide area of potentials for landscape planning to create geographic knowledge- and information-bases on the internet.

VRML (Virtual reality modelling language) is one of the leading technologies to create navigable, hyperlinked interactive worlds on the internet since 1994, and it is the international standard file format (ISO/IEC 14772) for describing interactive 3D multimedia. This language can be seen as the 3D equivalent of HTML.

The advantage of VRML is that it is widely platform-independent, easy to create by exporting from standard 3D-Graphics Software, and it works well with the newer browser generations. The current version (VRML97) contains a wide range of interactive nodes to bring "life and motion" into these worlds. These offer a tool to visualise 3D content, make them experienceable and combine them with other data, graphic and/or multimedia components from the internet. In particular, in planning projects with public participation or projects of public interest, can be easily extended with these features.

On the other hand, bottlenecks like internet-bandwidth and computer performance (on the client-side), make it difficult to create landscapes that are detailed enough to serve "reality" with a picture quality and polygon size that can be handled by nearly all clients.

In particular, in landscape architecture it is difficult to create high-end VR-projects for average desktop-computers because of landscape structures like vegetation and complex terrains which need thousands of polygons to be displayed in a realistic way. This fact can drastically reduce the usability of VRML for landscape visualisations. As a consequence, it is necessary to find and to use optimisation techniques to reduce the scene to a meaningful size, but to retain an acceptable quality.

There are two main possibilities to reduce a scene - pixel-optimising and polygon-reduction.

Optimising pixelgraphics means, that one tries to reduce the file size of used graphics by adjusting resolution, optimising color depth and -palette and image compression. The goal is to create small sized graphic files with an acceptable quality.

Polygon-optimising is a way to reduce the vector count and size of a scene by combining similar polygons, deleting invisibles or by using alternative techniques (e.g. TIN vs. Elevation Grid,...).

This process of reduction is necessary to guarantee usable scenes, but means also, that the designer needs to work on two different models, one detailed model for the construction and building process as well as for high-end renderings, and one file-size-optimised model for the internet. This fact makes it essential to use a well-structured project-management for data-handling, from the beginning of the planning process. This paper tries to show the potentials, but also the problems of interactive worlds for landscape planning. Beside the VRML-language, alternative technologies (e.g. Quicktime VR) will be explained and compared.

2. Keywords

VRML, Interactive Visualisation, Scene Optimisation, Vegetation visualisation, Terrain Modelling

3. Introduction

Humans, and the world they live in, are three-dimensional. That makes it obvious that landscape planners use 3D environments - in particular digital environments - to plan and to present their work. In the past, problems with computer performance made it difficult to create such scenes. But today, decreasing costs of computer hardware, rapidly increasing computer performance and a wide spectrum of available software make it easy and affordable to work with virtual 3D-worlds.

But the real world is not only three-dimensional, it is also dynamic and interactive. Dynamics in a landscape can be separated into three major types [Ervin 1999]:

- movement *through* the landscape
- movement *of* the landscape
- interaction *with* the landscape

One language for creating interactive worlds is VRML (Virtual Reality Modelling Language), which is the standard format for transporting interactive three-dimensional content over the internet. VRML has many interactive features and can be linked easily with other multimedia content on the internet.

This makes it possible to create geographical knowledge- and information-bases for the internet to reach a large number of interested people.

4. VRML – A Short Introduction

4.1 Overview

VRML (Virtual Reality Modelling Language) is one of the leading technologies to create navigable, hyperlinked interactive worlds on the internet. Since 1994 it is the international standard file format (ISO/IEC 14772) for describing interactive 3D multimedia. This language can be seen as the 3D equivalent of HTML.

A VRML-scene is a hierarchial structure of shapes, transformations, cameras, and lights. Every object-property is a part of this structure and is named „node“. The hierarchy can have any given number of levels, where each level controls the ones underneath.

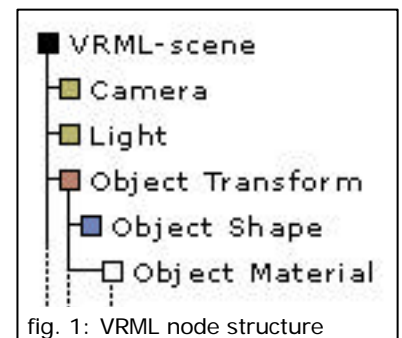


fig. 1: VRML node structure

The advantage of VRML is that it is widely platform-independent and easy to create by exporting from standard 3D-Graphics Software. It also works well with the newer browser generations. To view VRML-files, the client computer needs a VRML-viewer, or a java-supporting webbrowser. The current version (VRML97) contains a wide range of interactive nodes to bring "life and motion" into these worlds. The intergation of VRML worlds into HTML-documents offer the possibility to visualise spatial information for the internet and to create public panels for planning content.

4.2 Interactive Visualisation

Interactive Visualisation means, that the user can interact with the model depending on the complexity level of the scene. In the simplest case, the user can “walk through” the model, or can explore the model by moving or rotating it. More interactive complexity means that users can trigger different actions or move objects in the scene.

There are three different levels of virtual reality. Every level is based on the preceding one and includes additional features which increase the complexity.

passive level	active level	interactive level
<ul style="list-style-type: none"> No control from outside Defined movement is possible 	<ul style="list-style-type: none"> Movement from outside is possible without limitations → experience 	<ul style="list-style-type: none"> The user can not only experience, but also modify the scene (e.g. Objects can be moved and/or created)
Examples:		
<ul style="list-style-type: none"> Rendered pictures Movies 	<ul style="list-style-type: none"> VRML 1.0 	<ul style="list-style-type: none"> VRML97 Network Games

Table 1: Virtual Reality Levels [Aukstakalnis, Steve & Blatner, David, 1992]

The complexity of interactive models is increasing rapidly, the more interaction and content is integrated.

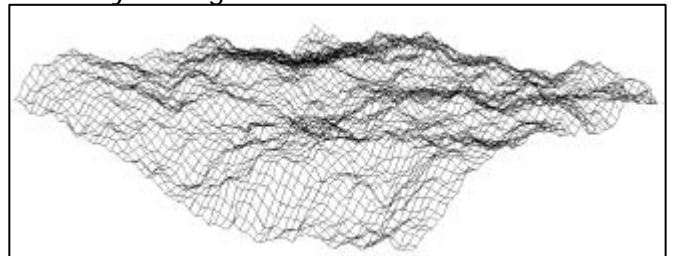
5. Specific Needs in Landscape Planning

Landscapes mainly consists of terrains, vegetation, water, infrastucture, animals/humans and an atmosphere [Ervin 1999].

Particularly in landscape architecture structures like terrains and vegetation are very essential for the visualisation. But these structures are mostly very complex and thus difficult to visualise - especially for interactive scenes, because of the high computer performance needed to handle the complex structures in real-time.

5.1 Terrain Modelling

Digital elevation models describe the height data of a terrain as Triangular Irregular Network (TIN) or as an elevation grid with a fixed gridsize, where one cell defines one unique elevation value. In VRML the elevation model can always be described over a polygon-mesh, but the disadvantage of this technique is that high-detailed models need a large number of polygons to define a terrain. A lower download rate caused by a large filesize is the result. For this reason, VRML can handle terrain models with the “ElevationGrid”-node. The advantage of an elevation grid is, that the grid dimension and cell size can be defined in the beginning of the node. Then only the height-data for each cell (from lower left to upper right) must be entered.



	Polygon mesh	Elevation grid
Filesize [kB]	654	25
Vertices	4096	4096
Faces	7938	7938

fig 2: Polygon Meshes and Elevation Grids

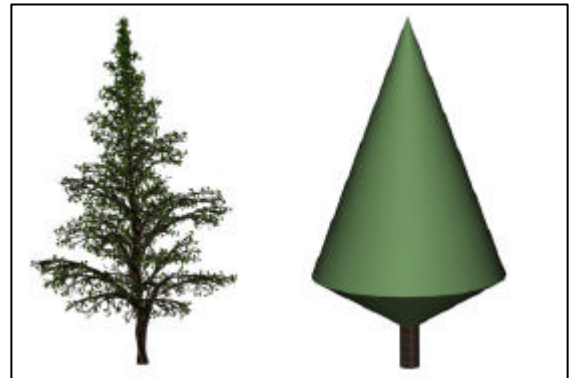
5.2 Vegetation

The high-detailed visualisation of vegetation is very important to create realistic scenes. On the other hand the complex structures of these objects make it difficult to keep the virtual landscape navigable.

There are three main techniques to embed vegetation into a VRML-model:

Vegetation as Polygon Models

Using vegetation visualised with polygons makes it possible to create high detailed objects which are really three-dimensional. Such objects can be created with common 3D-Graphics Software or special 3D vegetation modeler (e.g. AMAP, XFrog, TreePro, etc.), or can be taken from free and/or commercial 3D-libraries. Unfortunately these objects are nearly unusable for interactive worlds on conventional client-computers because of the high polygon amount needed. In many cases it would be impossible to display even one single tree, and a whole forest would multiply the number of polygons, of course. The following images show the comparison of a high-detail tree (using L-Grammar [Prusinkiewicz & Lindenmayer 1990]) and the same tree abstracted using a cone. The table below shows the polygon statistics.



	high-detail	abstracted cone
Filesize [kB]	7150	24
Vertices	58.549	282
Faces	86.698	48

fig 3: Vegetation as Polygon Models

This example shows that one single high-detail tree needs an amount of polygons which is hard to handle for a client computer. In most cases, a landscape scene needs more than one tree. On the other side, the abstracted cone-tree does not look very realistic.

Bitmaps Used as Billboards

VRML offer the possibility to use bitmap pictures as billboards. A billboard is an object that is always at right angles to the line of sight. This technique is very useful for visualising vegetation in a realistic way without the need of thousands of polygons, but can also be used to simulate other simple objects such as street lights etc.

The disadvantage of billboards is that they appear as a line in birdview.

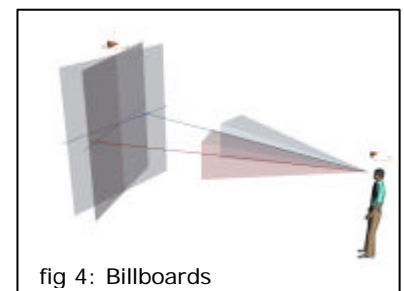


fig 4: Billboards

The example tree shows the same L-grammar tree as above, but as a ray-traced GIF-image with a transparent background.

	Bitmap billboard
Filesize [kB]	3
Vertices	4
Faces	2

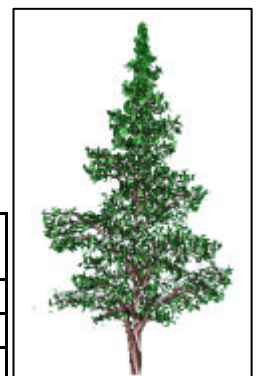


fig 5: Vegetation as Billboards

Textures

The third technique to integrate vegetation is to use textures which are mapped over the digital elevation model. This is necessary for the visualisation of bigger areas.

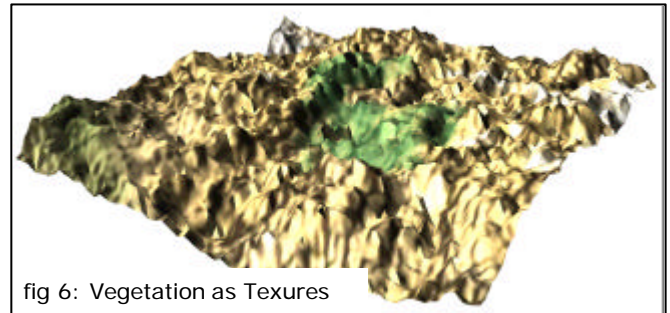
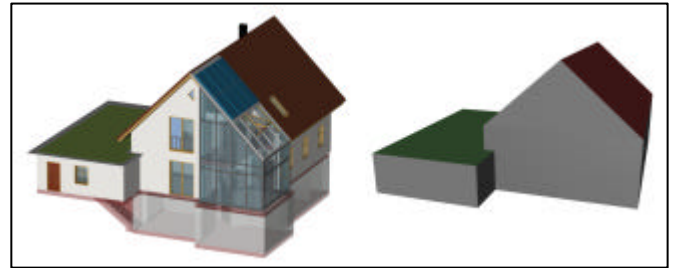


fig 6: Vegetation as Textures

5.3 Buildings and Infrastructure

In particular in urban planning, it is important to integrate buildings and other infrastructural content. Again it is important to find a good balance between abstraction and reality. To enhance abstracted buildings it is possible to map images of house fronts onto it – this technique is often used to visualise existing buildings. For other urban content like street lights, traffic signs, etc. it is useful to apply the billboard node as described above.



	Full 3D-modeled	generalized
Filesize [kB]	488	4
Vertices	3435	24
Faces	6603	30

fig 7: Buildings in VRML-models

5.4 Geographic data

Landscape planners often work with geographic data from various GIS-applications. Converting the data into the VRML-format often used to cause problems. Therefore an extension set named GeoVRML was developed.

The following list shows the capabilities of GeoVRML 1.0.

- Coordinate Systems
Allows to embed latitude/longitude or UTM coordinates directly into a VRML file.
- Scalability
For managing large models over the web
- Metadata
For creating a generic subset of metadata describing geographic objects, including the ability to link to a metadata description.
- Introspection
Functionality is provided to be able to query a GeoVRML scene and discover the geographic coordinate of any georeferenced point.
- Navigation
Basic support for navigation schemes that are specific to geographic applications.

6. Alternatives

6.1 Quicktime VR®

Quicktime VR® uses the principle of branch outable movies. That means, that movie-sequences are combined at specific nodes according to their spatial navigation path. The users orientate themselves within a 360 degree panorama and can navigate within the defined nodes. The advantage is that such panorama movies are easy to create and use. The disadvantage is the limited possibilities of navigation and interaction. To view such panoramas, the Apple Quicktime Player is required. Other panorama techniques works with Java-applets, this means, that no plugin, but a java-supporting browser is needed.

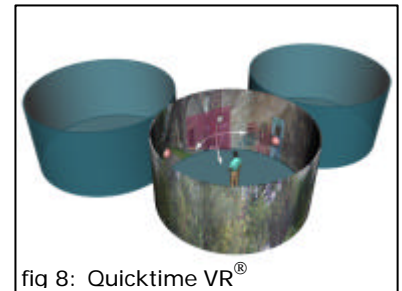


fig 8: Quicktime VR®

6.2 Java 3D

Java 3D is an API (Application Programming Interface) which extends the Java platform with capabilities for three-dimensional graphics.

The difference between Java3D and VRML is, that Java3D is a low-level programming API for 3D graphics rendering. The code must be compiled to move it into an executable form. VRML is a text based modelling language that is interpreted dynamically from the source code. A working group is developing a 3D-browser to combine VRML and Java3D. To run Java3D models a Java-supporting Browser is required.

6.3 Networkgames

A very new alternative to VRML are gaming engines used to visualise landscapes.

„Shoot-em-up“ games like Quake are highly optimised to run smoothly on a standard PC, even with a cheap 3D-graphic card. These games can also be played over the internet.

There are two ways to create scenes for these games:

- a. Level builders, which are mostly easy to use. The problem here is, that these products often don't have specific landscape construction tools.
- b. Export-Plugins for 3D-Graphics Software

There are some minor compromises on graphics quality, but they are highly compensated by the emphasis on extreme interactivity.

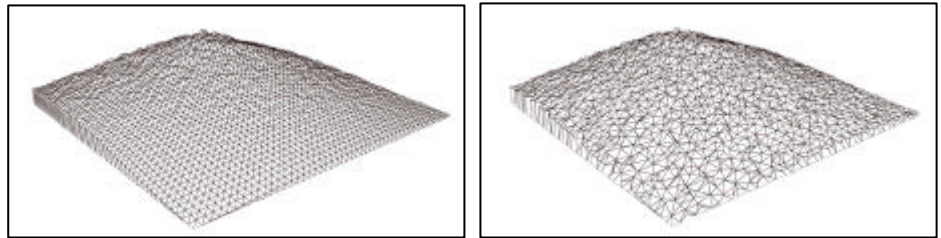
7. Optimising VRML Scenes

7.1 Polygon Reduction

To reduce the size of polygons it is necessary to build the model with major attention on the complexity of the scene. This means, that the planer often needs to work on two different models, which makes a well-structured project management and model essential. Once the manually optimised model is finished, it is possible to use reduction filters. These are included in some software-products or outsourced to special optimising software. In particular for VRML, a program named *Chisel* (Trapezium Software) is able to validate the VRML script and optimise the code by using different reduction algorithms where the parameters can be set manually. With skillful reduction settings you can obtain major polygon reductions with little loss in quality. The following table shows the reduction potential of *Chisel* using the default settings: Step 1, „Formatted and Cleaned“, means that the file was restructured by removing comments and wrapping lines, and cleaned by removing unused and repeated values. During this process no polygons where removed. In the second reduction step, „Reduced“ an abstraction of the

model by clearing polygons takes place. Reduction algorithms are used for smallest edges, smallest triangles, parallel edges and coplanar triangles.

Example model:
Terrain as Polygon Mesh
Dimension: 1000x1000
meters
Gridsize: 20x20 meters



	Original file	STEP 1: Formated and Cleaned	STEP 2: Reduced
Filesize [Kb]	690	447	284
Filesize g-zipped [kB]	135	122	85
Vertices	5202	5202	3423
Faces	10400	10400	5828
Polygon Reduction [%]	0	0	37
Filesize Reduction [%]	0	27	27

fig 9: Formating, Cleaning and Reducing VRML-worlds

7.2 Pixel Optimising

Pixel Optimising is a technique to get the smallest images for textures, billboards, etc. at an acceptable quality level. The internet and VRML can handle primary three different image-formats – GIF, JPEG and PNG.

Graphics Interchange Format (GIF)

The GIF-format consists of a 256-color (8-bit) lookup table (CLUT). That means, that the RGB-values can be managed from one central table, and decreases by this way the file size. These CLUT's can also be color-optimised according to the image. A primary advantage is, that a GIF-Image can contain transparent areas, which is very useful for vegetation mapped on billboards. The GIF-compression is loss-free (Lempel-Ziv-Welch-compression) and works line by line and with pattern recognition.

Joint Photographics Expert Group (JPEG)

Unlike GIF, JPEG-compression is a lossy process. The image will not look the same as the original after compression. JPEG supports truecolor and grayscale-images and is therefore better for photographic images. On the other hand JPEG does not support transparency, why the use as billboards is limited.

Portable Network Graphics (PNG)

The Portable Network Graphics (PNG) format was designed to replace the older and simpler GIF format, combines the advantages of JPEG and GIF (truecolor, transparency with an „real“ alpha-channel), and has extra features like gamma correction (cross-platform control of image brightness), and two-dimensional interlacing (a method of progressive display).

7.3 Level of Detail

For the „level of detail“-node, the planer needs to create several differently detailed objects which are displayed according to the distance between object and viewpoint. This enables a faster navigation through the model, especially through bigger ones.

7.4 Filesize Reduction

File zipping

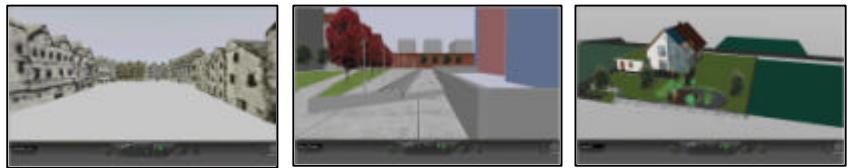
VRML browsers also can handle g-zipped VRML-worlds, as long as they have the same file-type extension (.wrl). GZIP is a UNIX compression utility that is the standard compression algorithm for VRML files. This step can often reduce the filesize by 70% (see Table 6.). The short compressed file gets downloaded from the server and is automatically unpacked by the VRML browser or plugin.

File splitting

One of the capabilities of VRML is to reference other VRML files into the main file – called “un-inlining”. This allows the planer to manage large models in a much more convenient way. However, at runtime, the browser is forced to make more fetches from the Web server. Un-inlining these files often results in significantly faster loading of the VRML world. This technique is not really a filesize reduction, but the splitting into several files results in faster loading.

8. Performance Comparison

To demonstrate speed differences when using VRML on different computer hardware configurations, three different virtual worlds were used to compare the attainable framerate of these systems. To guarantee a smooth motion, a minimum framerate between 12 and 15 frames per second (fps) is needed. With a framerate less than 1 fps, a serious navigation is nearly impossible.



		Judenplatz Vienna, Austria	Rennwegkaserne Vienna, Austria	Garden (draft) Gafrenz, Austria
Vertices		1273	4167	11458
Faces		1063	5438	21528
PC Configuration	Framerate [fps]			
PC233, 128MB RAM 8MB Graphic card	min	4	3,5	1,2
	max	15	7	3
PC333, 256MB RAM 4MB Graphic card	min	6	5	1,5
	max	15	10	4
PC450, 128MB RAM 8 MB Graphiccard	min	7	5	2
	max	20	11	5
PC700 256 MB RAM 32 MB Graphic card	min	10	9	3,5
	max	25	20	8
PC800 256 MB RAM 32 MB Graphic card	min	17	10	5
	max	25	22	11
PC1000 512 MB RAM 64 MB Graphic card	min	19	14	5
	max	50	33	12

fig 10: Comparison of different VRML-worlds on different computer systems

This table shows, that in this test, the computer-processor is the main speed-factor for the tested VRML-worlds.

9. Problems Using VRML in Landscape Planning

Interactive Visualisation is very useful to transport planning content, in particular in disciplines which are working in and with spatial dimensions. For landscape planning it is possible to build three-dimensional projects with VRML to involve the public into the planning process.

On the other hand, there are many problems and limitations, caused by the complexity of landscape structures and vegetations, but also by the interactive content. Therefore it is necessary to optimise the content and the structures to create efficient worlds.

Beside VRML there are alternative techniques, with other advantages and disadvantages, depending on their emphasis.

The main advantage of VRML is, that it is the standard-format for interactive worlds on the internet. But this causes, that it is more static in the development than other technologies.

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