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Adorning VRML Worlds with Environmental Aspects

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The Virtual Reality Modeling Language (VRML) has made virtual reality (VR) on the Web accessible to all sorts of users. In addition, researchers have applied this technology to cost-effective information visualization and global virtual design studios.

We believe that visualization and graphics will be the dominant technologies used to show information to people or guide them to information. VRML technology provides a powerful solution for information visualization. VRML worlds let users search and discover information from a representational 3D virtual world. Users can view and navigate it on the Web at any time or any place. For example, new students can walk through a virtual campus delivered across the Internet. Such applications can help potential students choose their favorite universities efficiently. In addition, VR provides an excellent way to promote a university to a much wider audience. Similarly, tourists can familiarize themselves with a foreign city by taking a virtual tour of it on the Web. Meanwhile, to take advantage of the local tourism industry, the local government can construct VRML worlds of the history sites and the holiday resorts to attract more tourists.

VRML has been used to create virtual worlds such as a university campus, city, or factory for interactive student orientation, architectural reviews, and real-time walkthroughs from a distance.

After reviewing the current VRML worlds on the Web, we saw that most were VRML architectural models that ignored environmental aspects such as flowers, trees,

grasslands, public furniture, and so forth. As a result, VRML worlds look less realistic and their visual qualities aren't as attractive as a series of photographs of the same scene. They also never change with time or season.

In addition, we found that little work has been done to add environmental aspects into VRML architectural models. The virtual campus of the virtual campus of Essex University (<http://vase.essex.ac.uk/demos/campus/campus-model.wrl>) and of Nottingham University (<http://www.nott.ac.uk/~itzmts/nott3d.htm>) completely ignored this aspect. The creators of Virtual Soma, the first virtual city on the Web (<http://www.planet9.com/earth/sf/bugsinsoma/index.htm>), have spent little effort on the environmental aspects since they built it.

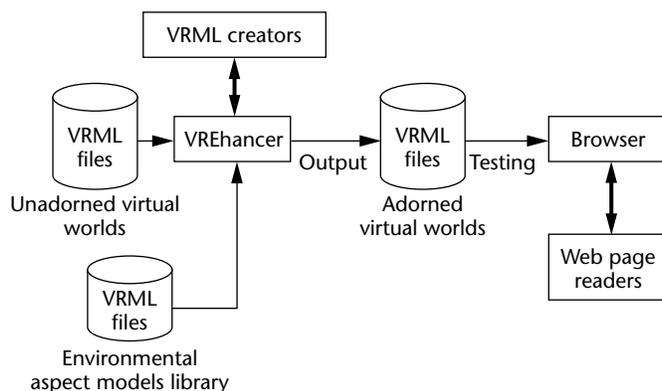
The 3D reconstruction of the history sites on British Broadcasting Corporation (BBC) online (<http://www.bbc.co.uk/history/3d.shtml>) has also neglected to consider this aspect. These observations led us to develop a software package named VREnhancer to address this problem.

With our project, we aimed to design an effective approach for adding environmental aspects to VRML architectural models. This approach tries to give VRML worlds greater realism and better visual quality while maintaining an acceptable navigation speed. VREnhancer has provided VRML world creators more flexibility and feasibility to adorn and change their design. This article looks at the development of the project, its design and implementation, and the related technology. It also evaluates VREnhancer through adorning the virtual campus of Hull University, UK, with environmental aspects.

A tool to adorn VRML worlds

We designed VREnhancer to add environmental aspects to a virtual world. Virtual world developers adorn their VRML creations by selecting and adding the appropriate environmental aspect models from a data library called Environmental Aspect Models Library (EAM Lib). Figure 1 shows this project's framework.

1 The project framework.



We made all environmental aspect model files into VRML 2.0 uniform and grouped them into the EAM Lib. VREnhancer lets users choose one model from the EAM Lib each time. In addition, we designed a procedure for viewing the snapshot of each model stored in the library to aid in selection.

VRML files exist in a parent-child hierarchical structure. Models are subparts of the world. Such a structure makes it easy to create large worlds or complicated objects, which reuse subparts or inherit attributes and behaviors from subparts. Therefore, adding the model into the VRML world is like merging the model file into the world file. However, it's not a good idea to insert the whole model file directly into the world file. This will usually result in a huge world file and further increase the download time. In our approach, we took advantage of the following mechanisms of VRML to incorporate the environmental aspect models:

- *Inline node*. Permits incorporating another VRML file distributed across the Web or anywhere on the local system. Therefore, each model file is linked into the unadorned VRML world file by using the Inline node rather than by adding the file itself.
- *Transform hierarchy*. Lets users manipulate 3D objects by controlling their translation, scale, and rotation. Thus, we apply the transform hierarchy to arrange the environmental aspect model in the scene by moving, scaling, and rotating.

For optimization's sake, usability researchers believe that if a 3D model can be viewed through a 360-degree rotation, it's more beneficial for users. Thus, we incorporated a multimedia player to view the 3D animation of the selected model in VREnhancer. We designed the 3D animation to rotate the model 360 degrees around the y-axis for two seconds, which generates the animation in the audio video interleaved (AVI) format.

VREnhancer implementation

Since VRML doesn't define an application programming interface (API), most users usually write VRML files via text editors like NotePad or WordPad. However, these editors lack a visual interface to provide interactive capabilities. This limits VRML application developers in creating a larger and more complex VR application efficiently. These weaknesses also restrict less technical users such as Web-based artists in creating a VRML world. Therefore, VREnhancer must provide the graphical user interface (GUI). In this project, we designed the GUI in Windows NT 4.0 and matched the functions of VREnhancer. We developed the VREnhancer GUI, shown in Figure 2, with Borland C++ Builder.¹

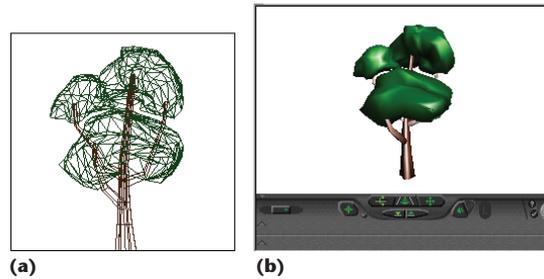
Modeling environmental aspects

Generally, popular environmental aspects concern trees, flowers, grasslands, and some public facilities. In this project, we represented them as 3D models and imported them into the EAM Lib.

VRML geometric modeling is mainly based on geometric primitives such as cubes, spheres, cylinders, cones, and so on. It's difficult to create environmental-



2 The VREnhancer GUI. If users choose the flowerpot model from EAM Lib and then click the 3D view button on the interface, the pot.avi small screen will pop up.



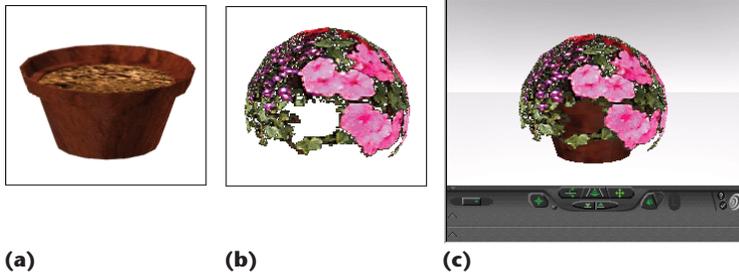
3 Modeling a tree as the polygonal representation. (a) The polygonal representation. (b) A view of the model through Cosmo Player.

aspect models like trees and flowers with only these primitives because their shapes are natural and irregular. Even if organic objects like trees can be modeled by a professional geometric modeling package such as Kinetix' 3D Studio Max, the size of the 3D models can be very large because of the number of polygons required. Figure 3a shows a tree generated as the boundary representation using most commercial modeling packages such as 3D Studio Max. The mesh of polygonal facets is a classic representational form for 3D objects. Figure 3 shows that it takes a lot of polygons to approximate the tree's shape. After exporting the file to VRML 2.0, the model's size increases because each polygon is converted into an IndexedFaceSet node description. We can view such a tree through a Web browser like Cosmo Player as Figure 3b shows.

Since VRML worlds are delivered across the Web, we must consider the network bandwidth and navigation speed. Thus, it's impractical to add such complex 3D models into a VRML world. The overload of polygon rendering may result in reducing the sense of presence and the capability of interaction.

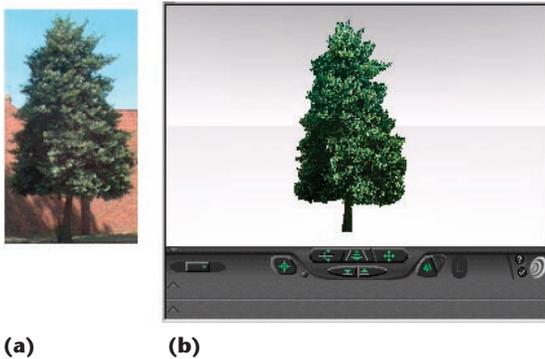
As a result, we designed models in the EAM Lib by combining VRML features² with some advantages of commercial modeling packages. In this hybrid method, VRML's features concerning shape, color, appearance, texture, and prototyping mechanism are integrated with geometric primitives to model some complex organic objects. In addition, some models must be designed individually according to their respective requirements. For example, we can model the pot of flowers shown in Figure 4 (next page) with the hybrid method. We divide the process of modeling the whole object into the following stages:

4 A photo of a pot of flowers.



5 Modeling a pot of flowers with the hybrid model. (a) Generate the model in 3D Studio Max. (b) Use the Sphere node in VRML to create the flowers. (c) Group the pot and the flowers in a hierarchical scene graph.

6 Comparing a tree model to its photo. (a) A photo of a tree. (b) A view of the model in a VRML world.



1. *Model the pot in 3D Studio Max.* We generated the pot in 3D Studio Max because its shape wasn't a standard cylinder or any other geometric primitive. See Figure 5a.
2. *Create the ball of flowers with VRML features.* Because the outline of the ball of flowers resembles a sphere, we constructed it using a Sphere node with a transparent GIF image of the flower as the texture. See Figure 5b.
3. *Export the pot model into VRML 2.0.* We converted the pot's polygonal representation into the description of IndexedFaceSet nodes in VRML 2.0.
4. *Group the pot with the ball of flowers into an entity.* We grouped two parts of the pot of flowers into an entity in the hierarchical scene graph. See Figure 5c.

Optimization attempts to make models more realistic while keeping file size as small as possible. It enables a realistic VRML world and an acceptable navigation

speed for different performance machines. We can optimize models through two efficient methods:

- Use level of detail (LOD) to optimize performance by drawing fewer or simpler polygons for objects far away from the viewer. The object in the virtual world can be modeled at several LODs so the virtual world retains adequate real-time operation and interaction.
- Use textures to make 3D models look more realistic. Texture maps often account for the largest percentage of the VRML model's size. You can reduce download time by reducing texture map size. One key factor is the resolution of texture maps; the other is to use gray-scale textures whenever possible.

EAM Lib implementation

To implement EAM Lib, we first took digital photos of environmental-aspect objects like trees, flowers, and so on. Then we processed the color, contrast, and brightness of these photos in a commercial image-processing package such as Adobe Photoshop. Next, we chose a suitable resolution for the texture. Finally, we saved the images as JPEG files or exported them in the transparent GIF format.

In the project, we constructed some models (or their subparts) in EAM Lib by using VRML geometric primitives. We represented irregularly shaped objects (or their subparts) as a mesh of polygonal facets in 3D Studio Max. We converted the mesh into VRML 2.0 through the VRML plug-in, then built environmental-aspect models with the hybrid modeling method. Finally, we unified the model files and put into the EAM Lib.

Trees

Trees play a primary role in environmental aspects. VRML worlds usually need many trees to simulate the real world. In this project, we implemented trees by using the VRML Billboard node. The Billboard node defines a tree with the IndexedFaceSet node and applies the texture in transparent GIF format. This is one of the most typical uses of Billboard. Figure 6 shows the result.

Flowerbeds

Flowerbeds are also a popular type of environmental-aspect model. In this project, we modeled a flowerbed shown in Figure 7 from the Hull University campus. We used Box nodes and Cylinder nodes in VRML 2.0 to implement the three layers of flowers, and implemented the pine trees with the Billboard node.

Flowerpots

In this project, we created a flowerpot using the hybrid modeling method (see the section "Modeling environmental aspects" and Figure 5).

An adorned virtual campus

In the final stage of this project, we asked VRML world creators and Web users to test VREnhancer and the EAM Lib. As a typical test, subjects used these tools to adorn the Hull University's virtual campus of (<http://www2.dcs.hull.ac.uk/msc/08931/demos/vrmlcampus/HullCampus.wrl>) with environmental aspects. VREnhancer



(a)



(b)

7 Comparing a flowerbed model to its photo. (a) A photo of the flowerbed. (b) A view of the model in a VRML world.

selected and added environmental-aspect models into the university VRML architectural models. This process let us test all the parts of VREnhancer and EAM Lib.

Figures 8 and 9 show the contrast between the previous virtual campus—which consisted of only VRML architectural models—to the virtual campus adorned with environmental aspects. Moreover, the unadorned campus without optimization had a slower navigational speed than the adorned campus.

Future work

We've described an effective approach to adding environmental aspects into VRML architectural models. We successfully applied it to adorn the virtual campus of Hull University along with other general virtual worlds such as a virtual castle. These worlds are currently available on the Web at <http://www.wlv.ac.uk/~in6716/current/Hulluniversity.wrl>.

We plan to extend our work by enriching the EAM Lib with more models for adorning virtual worlds with the change of seasons and time. We also plan to work on the art design to enhance the realism of scenes. ■

Acknowledgments

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References

1. K. Reisdorph, *Borland C++ Builder 3 in 21 Days*, Sams Publishing, Indianapolis, Ind., 1998.
2. R. Carey and G. Bell, *The Annotated VRML 2.0 Reference Manual*, Addison-Wesley, Reading, Mass., 1997.

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Readers may contact department editors by email at rosenblum@ait.nrl.navy.mil or Michael_Macedonia@stricom.army.mil.



8 The view of Hull University's main campus. (a) The unadorned architectural models. (b) The adorned virtual campus.



9 The view of Hull University's library. (a) The unadorned architectural models. (b) The adorned virtual campus.