SculptUp: A Rapid, Immersive 3D Modeling Environment

Kevin Ponto*   Ross Tredinnick†   Aaron Bartholomew‡   Carrie Roy§   Dan Szafir¶

Daniel Greenheck‖   Joe Kohlmann**

University of Wisconsin–Madison

Figure 1: A snail scene created using the SculptUp system rendered in Maya. The snails took two minutes to create, the trees took approximately three minutes to create, mountain range took approximately three minutes to create, the rocks, clouds and grass took less than one minute to create.

1 INTRODUCTION

Modeling complex objects and effects in mainstream graphics applications is not an easy task. Typically it takes a user months or years to adapt to the comprehensive interfaces in order to make compelling computer graphics. Consequently, there is an imposing barrier to entry for novice users to fully utilize three-dimensional graphics as an artistic medium. We present SculptUp, an immersive modeling system that makes generating complex CGI easier and faster via an interaction paradigm that resembles real-world sculpting and painting.

SculptUp runs in a Cave Automatic Virtual Environment. Users interact with the virtual environment through a handheld wand and voice recognition. There are two unique states of manipulation that the user switches between: sculpt mode and world mode. In sculpt mode, the user can create and modify volumetric material, modeled as isosurfaces, using a minimalist control scheme. This control scheme allows the user to make highly detailed objects by arbitrarily adding, subtracting, and painting isosurfaces similarly to how a user would sculpt a clay model in reality. User's can also change paint and volumetric colors through a speech-based interface. In world mode, the user operates in an OGRE scene, where he or she can use their detailed volumetric models to design the salient features of a large-scale scene. All of this work can be exported from the SculptUp system into a rendering environment for the production of high quality images as in Figure 1. Ultimately, SculptUp's interface substantially expedites the creative process and catalyzes rapid scene prototyping.

2 METHOD

The SculptUp system consists of two unique states of manipulation that the user switches between: sculpt mode and world mode.

*e-mail: kbponto@wisc.edu

†e-mail: rdtredinnick@wisc.edu

‡e-mail: abartholome2@wisc.edu

§e-mail: croy@wisc.edu

¶e-mail: dszafir@wisc.edu

‖e-mail: dgreenheck@gmail.com

**e-mail: jkohlmann@wisc.edu

2.1 Sculpt Mode

The SculptUp system utilizes fast GPU centric volumetric manipulation and visualization to enable a simple user experience. The system utilizes 3D framebuffer objects which remove the need of transferring data between the CPU and GPU. This 3D texture holds an intensity value in its alpha channel used for determining geometry and color information in its RGB channels for each voxel. Changes are made to the VolumeBuffer by running a fragment shader program and rendering slices of the volume sequentially. Real-time meshing is accomplished using the marching-cubes algorithm using a geometry shader and normals and colors are generated using a fragment program [1]. This allows the volume to be fully rendered and manipulated in a highly interactive realtime fashion, something essential for immersive virtual systems. Users can manipulate the volume in several ways:

Addition : Users can add to the volume in two ways either as spheres or cubes. In the sphere mode, when the user presses a button, the volumetric data continually adds to the intensity volumetric data channel with an inverse distance squared radial falloff from the tip of the wand controller inside of the fragment program. This approach gives a similar feel to *Metaballs* as shapes can be easily merged together [2]. This method is useful for generating organic structures. The second method of volumetric manipulation is the cube mode, in which a user specified region is filled in completely. This is generally useful for inorganic structures. The color of the volume for all new additions will be the currently selected color, while adding new material near pre-existing material will cause the colors to be blended together correspondingly.

Removal : Users can remove volume using a tool that visually resembles a light beam jetting out from the tip of the wand controller. The beam is resizable (radius and length) using the joystick on the wand interface. The intensity volumetric data determined to be inside of the beam is removed using point-to-line distance calculation inside of the fragment program.

Paint : Users can virtually spray-paint onto the sculpted objects at any point during the sculpting process. This method is similar to the Addition tool mentioned above where the color of the volume is interpolated between the painting color and previous color using an inverse distance squared radial falloff from the tip of the wand controller. Users can change the size of the color manipulation using
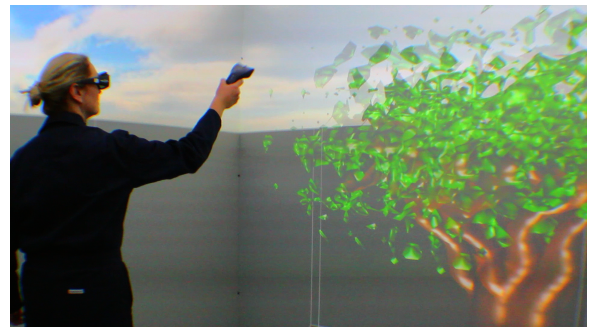

Figure 2: A user generating a tree model in the SculptUp system inside of a CAVE environment.
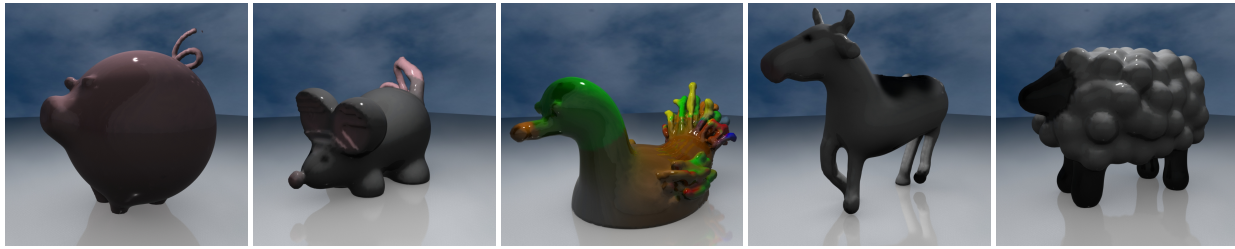
Figure 3: A series of models, each made in under five minutes in the SculptUp system. All images were rendered in Maya.

the joystick on the wand device.

ColorSelection : Users can change the color of the paint of the addition or paint tool using a voice based interface. The SculptUp system utilizes the Microsoft Kinect Speech SDK for the voice processing. The user speaks the trigger phrase "color change" and then asks for a given color from an inventory of 44 colors. The trigger phrase was used to prevent inadvertent change of color through casual conversation.

2.2 World Mode

When users have finished sculpting they can bring the objects into a standard object manipulation interface. We use the OGRE graphical environment for model rendering in this space. The volumetric data is read from the GPU and a CPU based marching cubes is used to tesselate the data. This tessellation is then used to create an OGRE mesh that can be transformed. The user can select an object by pointing a beam from the wand device at an object. From this, the user can translate the object, scale the object, and rotate the object. The user can also duplicate an object to create multiple instances of the same geometry, as shown in the fence for Figure 4.

2.3 Integration

In order expand the utility of the SculptUp system, we created a scene and model exporter. In order to a maintain the per-vertex-color generated by our sculpting process, we chose to use the ply model format. After a scene is created, positioned model files are saved to disk. These model files can be easily read into most modeling environments.

3 RESULTS

The SculptUp system has been shown to enable the rapid creation of 3D models. For instance, all of the models in Figure 3 were created in under five minutes. Scenes such as Figure 1 and 4 could be easily created in ways that would be extremely difficult in traditional modeling systems.

Figure 4: A farm scene constructed using the SculptUp system rendered in Maya. The fences were created from duplicating the posts in world mode.

The SculptUp system has been demonstrated to a few dozen individuals informally. User's comments were extremely positive about the experience and control over the modeling environment. We selected four individuals who lacked any experience with the SculptUp system for more specific feedback. Of these individuals, three were also novices to the CAVE environment. After receiving a small tutorial on the button mappings for the system, the users were given 15 minutes to create and use the system. Upon completion, each user was given a questionnaire about their experience consisting of 14 questions.

The questions consisted of three categories of the following overarching qualitative criteria:

User Interface : the ease in which a user is able to understand and adapt to SculptUp in order to be productive. Example questions: "The user interface made sense to me" and "I imagine most people would learn to use this application quickly".

Experience : the user satisfaction with the SculptUp experience compared to other computer modeling experiences. Example questions: "I would enjoy using this application frequently" and "I did things with the application that I have never done before with similar tools".

Capability : the degree to which users felt they could used SculptUp to design models and scenes. Example questions: "I thought it was easy to model the intended items" and "I thought it was easy to add colors to different parts of my models".

The score for each criteria was determined by averaging all of the individual responses across all of the questions in the category. The *User Interface* score was mostly positive, with a mean of 3.54 out of 5. Most of the negative responses came from unfamiliarity with the CAVE interface. Users who had never used a CAVE before felt less confident than users who had. Users unanimously felt that given more time they could use the interface competently.

The *Experience* criteria score was exceptionally positive, with a mean of 4.5. Users overwhelming enjoyed using SculptUp, with every user responding 5 when asked if they had a lot of fun using the application. Additionally, every user provided a 5 when asked if they felt they we're able to do things using SculptUp that they hadn't been able to do with similar modeling tools.

Finally, the *Capability* criteria score was mixed, with a mean of 3.5. Overall, users were not disappointed with the limitations of the SculptUp system, but they did not feel like they had the capability to competently model their intended object. Given more time and training and a specialized toolset, these shortcomings could potentially be overcome.

REFERENCES

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