Software Specification Design Document

Group 61: iCreate - Generative Design in Virtual Reality

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Abstract

The iCreate Generative Design in Virtual Reality is a software program that allows the user to create complex architectural structures using a series of spawned objects. As precision in movements and gestures are important, the UI has been designed in such a way that the user is unhindered and experiences a limited learning curve when using the software for the first time.

PARTICIPANTS

The ICreate - Generative Design in Virtual Reality senior software engineering project consists of the following team members:

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CONTRIBUTIONS

The members of the design team have contributed to the following sections as listed:

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- Base formatting of LaTeXdocument
- Section 1: Introduction (Includes all subsections)
- Section 2.0 / 2.1.2 / 2.1.4 / 3.1
- Section 2.1.1 / 3.2 (Co-authored with Nabeel)
- Figures 1 and 2

Nabeel Shariff:

- Section 2.1.1 / 3.2 (Co-authored with Hannah)
- Section 3.3/ 3.4

Rhea Mae Edwards:

- Participants Section
- Section 3.5: Curves (Includes all subsections)

1 INTRODUCTION

1.1 Scope

The software application described in this design document is to be utilized as a tool for the generative design of architectural structures. The goal of this software is not only to be used as a resource for the building of said structures, but also to be a tool for learning more about the limits of a standing structure.

1.2 Purpose

The purpose of this Software Specification Document (SSD) is to provide a detailed description of the interface for the iCreate software. Included is the layout and functionality of the user interface.

1.3 Intended Audience

This document is intended for the stakeholders and architectural designers who intend to use this software. In addition, this SSD will be used as a reference for the stakeholders and Capstone professors in the case of a differing opinion in regards to the requirements of the design and performance.

1.4 Definitions and Acronyms

- **VR** - An abbreviation of Virtual Reality which is described as, "the computer-generated simulation of a three-dimensional image or environment that can be interacted with in a seemingly real or physical way by a person using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors." [1]
- **Virtual Space** - A 3D area in VR in which the user can maneuver around in and interact with objects.
- **Generative Design** - A form finding process that can mimic nature's evolutionary approach to design. [2]
- **GUI** - The graphical user interface allows the user to interact with the program via buttons or other types of graphical icons.
- **Primitive** - General 3D shape.
- **Diegetic** - Interface that is included in the game world – i.e., it can be seen and heard by the game characters.[3]

2 SYSTEM ARCHITECTURE OVERVIEW

The iCreate software program is a developmental tool that can create architectural structure designs using the generative design process. As the user will be working with delicate structures, the GUI of the iCreate software must be laid out in a way that is intuitive, efficient, and neat.

2.1 Design Viewpoints

2.1.1 Concerns of Design Stakeholders

In regards to the developers, this software program should be simple and easily maintainable. The goal is to implement libraries and APIs that provide the functionality in this program to reduce the complexity of the overall codebase.

Users will be concerned about the overall look and feel of the software. The program's interface must be polished, neat, and intuitive, allowing for a seamless and comfortable experience. The goal is for the user to be able to comfortably and successfully design projects with minimal interruptions.

2.1.2 Context

While developing the components of the iCreate software, the main consideration the developers had was the ease of use. As this program is meant for people with different types of technological backgrounds, the GUI must be easy to navigate.

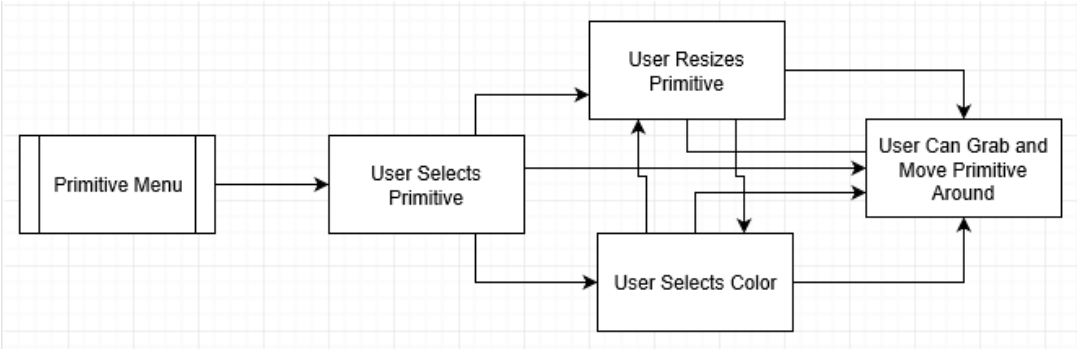

Figure 1. The flow of using the UI menu to spawn a shape.

2.1.3 Interface

Since iCreate's user interface is meant for an intuitive experience, the developers have chosen to implement a design for the menu that is neat and robust at the same time, as well as comfortable for the user in terms of hand and eye strain.

2.1.4 Structure

Each of the components are separate objects which means that each primitive is able to have its own physics and settings. This makes manipulation of several primitives easier, and the learning curve smaller.

3 COMPONENT DESIGN

3.1 VR Environment

The default scene for this software is an empty grey area. It was decided that an empty area would be best as it would reduce obstruction and distractions. Other scenes can have simple skyboxes with different floors to simulate a different scene.

Locomotion will allow users to move around within the virtual environment, so the team will implement the keypad of one of the controllers to provide the user with a method of locomotion.

3D objects can be instantiated in the virtual environment by the users themselves. The user can spawn 3D objects by selecting from a menu of available primitives, and can also create multiple instances of that 3D object.

3.2 User Interface

The interface will need to functionally allow the user to spawn a 3D object, then modify it via either a controller or gesture input. Additionally, the user will be able to save to a library for later use or load their creations to create complex structures. Finally, the application will display a way to transform the 3D objects by allowing the user to scale or resize the object.

The interface for iCreate will mostly be based on Diegetic and spatial UI. Diegetic UI will be used for accessing tools and options from a menu attached to the recessive hand's controller. For all other menus and uses, spatial UI will be used to relay relevant navigation information to the user. The dominant hand will either be used to select options from the menus presented to them, or draw within the virtual Environment.

Figure 2. The UI menu that features the primitive and color options as well as the size slider. This menu will hover over the controller as a diegetic UI component

There are three sections to the menu which can be seen in Figure 2. The first section has four primitives available to use: a square, circle, pyramid, and hexagon. The second part is a slider which can be used to adjust the size of the primitive spawned. Lastly, there are four color options for the primitives. As each primitive are separate objects, it is possible to have different combinations of sizes, colors, and shapes.

3.3 Load and Save

The save and load feature for iCreate can be realized through data serialization. To save the data of the scene, we will be using the FileStream and BinaryFormatter classes in Unity.

The FileStream class will be used to first create a save data file. Next, BinaryFormatter will be used to serialize the scene's data into the save file. Once the data is serialized, FileStream can be used to close the file we were writing into..

Finally, to load the save file, BinaryFormatter can be used once again to deserialize the data from the save file and load the scene. The save and load features can be implemented via two buttons on the in game menu, one for saving and one for loading.

3.4 Object Library

The Object library will also utilize Unity's serialization to save and load objects to and from a library of 3D objects created by the user. To save the object, BinaryFormatter can be used to save the attributes of the object, like position and rotation (x, y, z), material, etc, into a file or another GameObject. This file or GameObject will be the library.

Finally, to load the saved object from the library into the game world, we can deserialize from the file or GameObject. The user can access and utilize the Object Library from within their in game menu.

3.5 Curves

3.5.1 Drawing a Curve

The generation of a 3D within the program's virtual environment, will be created with the user drawing a 3D curve in their space given. The program offer the user a variety of curves to choose from in order to start the generation of their curve, being a list containing the selections of a bezier curve, b-spline curve, ellipse curve, circle curve, hyperbola curve, and parabola curve. Each of these selections are characterized in the code as an equation with the possibility of an additional process in order to such curves depending on its type.

After the user's selection of a type of curve, the system will offer a base curve once the user selects a starting position within their given environment. Once the user selects the start of the curve, the program will adjust the size and trajectory of the curve itself based off the user's physical movement of moving a controller around the environment from the starting position, generating the curve and sizing accordingly. The user's movements of the controller will provide a variety of inputs for the system given the equation selected by the user earlier. After a button indication from the user, the generated curve will be set in place by the system, giving the finality of that curve within the environment.

3.5.2 Circle Curves, Ellipse Curves, Hyperbola Curves, Parabola Curves

Circle curves, ellipse curves, hyperbola curves, and parabola curves have set alegbraic equations that can be written in code that represent these four types of code. The program will apply these equations along with the user's curve drawing process explained above.

3.5.3 Bezier Curves

For generating bezier curves within the program, the Handles.DrawBezier will be able to take in inputs such as the start position, end position, start tangent, and the end tangent of a bezier curve, which we are characteristics and inputs we are interested in creating in regards to the generation of such a curve. These inputs will be given by the user, from their selection of this curve type and then draw given these specifications within the environment. [4]

3.5.4 B-Spline Curves

B-Spline Curves will inherit the same process when it comes to generating bezier curve within the program, but in addition with its slight difference of consisting multiple bezier curves generating a single b-spline curve. Due to a b-spline curve's notable characteristic of smoothness with multiple peaks and lows, such a curve can be generated with multiple bezier curves in order to be physically represented.

3.6 Transformation and Translation

The transformation feature will be primarily used while the shape is being instantiated. During the creation, the user can choose to alter the size of the shape via sliders on the diegetic menu attached to the user's controller.

The translation feature allows the shapes to be maneuvered about the environment. The shapes are not influenced by gravity, so they will float in place. The user is then able to grab the shapes and move them around the environment at will. It was decided to not have the shapes under the effects of gravity to aide in the design process to prevent the shapes from rolling around.

List of Figures

REFERENCES

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