

iCreate - Generative Design in Virtual Reality Winter 2018 Midterm Progress Report

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Abstract

The purpose of this document is to explain an overall progression of what the Generative Design in Virtual Reality (Group 61) has done and experienced throughout the first half of the Winter 2018 academic term at Oregon State University through writing. To accompany this written document is a slide presentation visually and audibly explaining similar content that is also explained in this document. There will be struggles, achievements, and human interactions that will be described. Along with a general chronological format that will represent what and when a task has been done or have been experienced.

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1 PURPOSE AND GOALS

The virtual reality (VR) application will utilize a virtual reality headset with input from the user via a controller or gesture recognition software. The VR headset will be used to look around in virtual space while the controllers or gesture recognition software will be used by the user to draw sketches. The application will also need to utilize the GPU in a computer to both run the VR application and render 3D objects in the virtual space. Additionally, the 3D modeling will be based on generative design techniques, and the assembly of the complex 3D designs will utilize mathematical equations and algorithms to derive the appropriate structure of the design.

The outcome of this Oregon State University Computer Science senior capstone project is a virtual reality program that allows the user to utilize generative design to develop complex architectural structure.

2 HANNAH SOLORZANO

2.1 Current Status of Project

The three sections that I was assigned in the Technology Review Document were the graphics card, the development environment (Unity vs. Unreal Engine), and the User Input Controls (Hand motion sensors vs. HTC Vive Controllers). As a group, we decided that the best technology for the graphics card was the Nvidia 1060 and that Unity was to be the development environment as it is the easiest to learn and has a large amount of documentation and tutorials available online.

Initially, we intended on using the Leap Motion's hand sensors which use the user's hands as the controller to interact with the environment. As we researched more about the capabilities and limitations of the hardware, we ultimately decided that it may be easiest to utilize the HTC Vive controllers instead. This resulted in the program's UI to be redesigned to be more simplistic, with limited menu options and more gesture actions. In order to prevent UI collision, we had to carefully plan out how each feature would be related to each other, so that we could create a organized flow where completing one gesture would lead to another becoming available.

In regards other components of this project, we currently have a few of the features working as intended such as the ability to create a 3D shape, and then transpose that shape in the virtual reality environment. Also finished is the main menu which has the ability to load up a previously saved environment, or to enter into a new one. Other components such as the movement of the user and the ability to resize shapes are also in the late stages of development.

As for the documentation, our Technology Review document was recently approved by our client. Our biggest concern at the moment is Design Document which has yet to be approved, though the client says that if we were to add a class event diagram, he would be willing to approve it.

2.2 Remaining Features for Development

The next features that I plan to implement are those that allow the user to move around the environment, as well as the ability to take a game object and resize it to the desired dimensions. The allowance of movement is important because it enables the user to get up close to the architectural structure or to stand back and look at proportions and layout.

Other remaining features include the algorithms for the curves that the game objects spawn along, the UI menu's, and the load/save functions. The curves, such as Bezier, Ellipses, and Parabolas, would aid in the generative design process and is the main feature of this project. We plan to have diegetic menus that are attached to the controller for ease of use and the different UI menus enable the user to switch between different shapes and the different types of curves. Lastly, when a user likes a completed project, or wants to work on a different project, the load and save functionality allows them to save projects for the future.

2.3 Problems Impeding Progress and Solutions

The main problem that I currently have is trying to figure out how each feature should interact with another. While some UI features are mapped to the controllers' buttons, others may be designed to function only when the user is doing a specific task. For example, if the user is trying to resize the object, the program should know that whenever

the user has grabbed the game object with both controllers, that they are attempting to modify the size. The client has suggested using a class diagram that lists out how all the UI elements interact with each other. Not only would it show each element's relation, it also helps us by having us think through each step more thoroughly.

Another issue that I am encountering is the learning curve for developing a virtual reality program. As I have never used Unity or built a virtual reality program, I have to spend time looking through lots of documentation and tutorials.

2.4 Interesting Code Snippets

One section of code I found to be particularly interesting was the C# script that enables the user to manipulate objects in the virtual reality environment. I thought that it was interesting in how it used the bounding box on the controller to find the object, then assigns the object to be a literal part of the controller.

More specifically, to allow the user to grab objects, the controller needs to communicate the x,y,z position of the controller and relay that information to the `ControllerGrabObject.cs` script. This is done by attaching a bounding box to the controller object that keeps track of all the gameobjects that come within a certain distance from the head of the controller. Afterwards, the script checks a few details about the current controllers status, as well as the components of the object. First, the code checks if the controller is currently holding another object in its grasp. If so, the code does not allow the object to not be assigned as a member of the Collider class, which is what enables the object to become interactive. The second check that is performed is to see if the object has the RigidBody component. This component puts the object under the effects of physics, i.e. the object falls under gravity, or can be knocked around by a shifting environment and its contents. If the object has the RigidBody component and the current controller is empty, then the object is assigned as a member of the Collider class, thus enabling it to be a potential grab target.

Next, the object is removed from the collider variable it was previously stored in, and is added as a joint to the controllers hand. The script adds the object as a joint through the method:

```
joint.connectedBody = objectInHand.GetComponent<Rigidbody> ();
```

Afterwards, when the controller releases it's grasp on the object, the script has to check to see if there is a joint present that is attached to the hand. If so, then it removes the objects status as a joint and nulls the connection. As the object is under the influence of physics, the velocity and angular velocity of the controller are stored as it is releasing the object. This is to create a realistic arch as the object flies through the air.

A second interesting script is the one that enables the user to spawn different blocks. This script, called `PrimitiveCreator.cs`, uses the keypad to cycle through a list of 3D objects called primitives, which are spawned at the exact location of the controller when the trigger button is pressed. This script, alongside `ControllerGrabObject.cs`, are dependent upon each other as it is important that the blocks are initialized with the correct components, otherwise the controller won't be able to grab the object. More precisely, when `PrimitiveCreator` initializes a block, that block gets assigned the RigidBody component which is required for the `ControllerGrabObject` to work properly.

3 NABEEL SHARRIF

3.1 Description of the Current Status

To start, I am working on the user interfaces, which are currently the main menu and the in-game menu. Additionally, I am also working on the save and load features of this project. Moreover, along with Hannah and Rhea Mae, I am also working on the Curves feature of the program.

To elaborate, the main menu is a scene that the player loads into and is free to walk around in, and is presented with options on a translucent wall. The wall has four components: a welcome message, a "new project" button, a "load project" button, and a "quit program" button. Currently, the quit and new project buttons have been implemented, with the load button still pending. Selecting the new project button will take the user to a new blank scene. On the other hand, selecting the quit program button will exit the program.

The new blank scene loads the user into an empty room with a white floor. For now, the only feature implemented is that the user can push the trigger on the right controller to draw a line. This line however, is drawn in such a way that it remains static within the virtual environment, unlike Unity's default drawing system that draws a line that continually faces the user (is not a proper line).

3.2 Remaining Features for Development

Still pending is the implementation of the menus, save and load features, and the curves aspect of the project. The main menu needs to be polished, and the load project button needs to be given the load feature. Additionally, the in-game menu needs to be finished and implemented.

Currently, I am working on a basic menu interface, and a new kind of menu that offers the intuitiveness this project has promised. Furthermore, the save and load features need to be tied into the project so that the 3D objects and the scenes themselves can be saved and loaded as the user pleases. The save and load feature also needs to be tied to the in-game menu to make it possible to save and load without having to go to the main menu first. Finally, the main feature of this project, Curves, needs to be finished and implemented so that the user can draw and transform curves, and then turn them into complex 3D structures.

To further elaborate, firstly for save and load, I will be using File Stream and Binary Formatting to save elements within the environment, or the whole scene itself, to a file, and then use the same tools to make loading the scene or elements into the game world possible. Secondly, for the menus, I want to implement a fluid system that allows the user quick access to tools with ease of use. To accomplish this, I wanted to create multiple in game menu layers that can be accessed from one controller itself by simply moving the controller to the layers after holding down a button. Selecting a layer will reveal a deeper set of options, and finally moving to a selectable tool will select it. I found this important because our client mentioned that it would be interesting if the user could use just one hand for selecting everything, while the other hand is focused on something entirely different, like drawing.

Moreover, concerning the design document, we are still pending client approval. However, we've been asked to create class and event diagrams, and upon doing so will receive approval.

3.3 Problems Impeding Progress and Solutions

The main thing to note about the program is this program is different from a painting app in that the user isn't painting, but rather designing via sketches and gestures. However, virtual reality blurs the lines between the two, and this presents us with an opportunity to develop a fun and intuitive way to design. However, blurred lines also spell difficulty, as now the main issue for us to tackle as a team is to find a way to draw and/or spawn curves, and turn them into complex 3D structures by either spawning objects along the curves, or to let the user spawn objects as they please along a path. The critical difference between the two is drawing the curve first then spawning the objects vs. drawing the curve at the same time as spawning the objects.

Additionally, there are other kinds of problems that also serve to impede progress. Firstly, our team has found it difficult this term to properly meet for long periods of time. Due to this, we're going to meet more often for shorter periods of time. Meeting physically with the group certainly eases stress and bolsters team progress, so solving this issue will give us a boost to finish up the rest of our features.

Finally, the biggest and most exciting issue I've faced is understanding how to develop in VR. In some ways, it is very straightforward and simple, like spawning and grabbing objects, moving around, etc. In other ways, it offers powerful tools at the cost of a steep learning curve. Virtual reality in general is something that is phenomenal and breathtaking, so sometimes simply trying to understand how to apply logic, math and code to a virtual setting can be an interesting hurdle to cross. But one that I am grateful for.

4 RHEA MAE EDWARDS

4.1 Description of Individual Current Status

As for my individual stance in regards to the implementation of our group's project, I have not contributed any code to the program yet. I am currently in the finishing stages of going through Unity tutorials and gaining the basic understanding for coding our virtual reality program. Currently, I do later have more short-term goals that will describe in the following subsection of this section, along with describing remaining features for further development of the project. These goals will allow and motivate me to finally contribute working code to the project's program.

Besides my lack of working code contribution, I have been working on other aspects and documentation in relation to the project in regards to the group's client and to the course. I have been taking a part within the creation of beginning

the recent assignment of the group's Engineering Expo poster draft. In addition, this first half of the term, the team has been revising our projects Preliminary Design Document, and individually had to improve and update the team's Technology Review and Implementation Plan document in order to both submit for the team's client's approval.

As a result, the team's client, Raffaele De Amicis, has only been able to approve the team's Technology Review and Implementation Plan document, whereas the Preliminary Design Document currently still needs additional work done in order to meet Raffaele De Amicis' document approval.

Along with the work that has been and is being done previously started above as a group and individually, I have also been in charge with taking meeting notes in the group's bi-weekly client meetings and weekly teacher assistant meetings with Behnam Saeedi on Mondays during these past weeks. In addition to documenting these meeting notes, I have been rewriting and constructing e-mails to send out to the appropriate recipients within the project group and course every week.

Furthermore, I have recently set my own individual goal in creating, learning, and applying how to create circle curves, ellipse curves, and parabola curves for and within the implementation of the project. I am currently in the process of researching these curves and learning how to implement these in code written in C#.

4.2 Remaining Features for Development

In the near future, finishing up the spawning of all of the types of 3D shapes and being able to manipulate these shapes in a handful of ways and form within our current created gaming environment for our project implementation is a task the group plans to complete soon. In addition, figuring out how to draw multiple types of curves and then being able to apply 3D shapes to a curve is another task that has to be done. Along with combining such user created structures, and then being able to save and read these files, which can be also known as creations, to the program.

All of these tasks are to be split among the group either to one specific person, a pair of people, or to the group working on it as a whole, depending on the task and situation at hand. Some of the tasks stated above have to be assigned in the progress for completion in some form or another already.

4.3 Problems Impeding Progress and Solutions

Personally I believe the first half of this term for the group has taken the saying that the little things do add up in the end.

The team as a whole has struggled a bit with the project in regards to the project's implementation and having to go through multiple submissions of trying to gain Raffaele De Amicis' approval on the group's Preliminary Design Document. Being that the Preliminary Design Document for some reason or another has felt to be the greatest obstacle the group has had to deal with so far this term, and honestly in a sense, still is. In hopes of having this dilemma figured out real soon though, after we have completed our Winter 2018 Midterm Progress Report. The team just has to now include a class diagram and sequence diagram within the document, requested by the client, in order to gain his final approval. A recently given direct request to finally satisfy for such an approval, whereas such a request was just simply suggested to the team weeks before.

Along the same lines as the previous situation just recently explained, being able to understand and interpret exactly what the client is truly looking for from the team in regards to the project has been confusing the group as a whole a bit, which we all plan on figuring out and working on soon in order to ease up the tensions a bit. There also has been some miscommunications and misunderstandings between the client and team on certain aspects of the group's organization as a whole also.

For example, recently there has been requests from the client that the group has been completing, such as e-mailing out pre-meeting agendas and inviting him to our GitHub repository, which have been done, but unaware to Raffaele De Amicis himself, causing some confrontations during a recent bi-weekly meeting, and leading to some confused and unsettled students towards the end. If there is one thing this senior capstone project experience has been teaching the group, it is patience by far, or least through my eyes, that is what I think.

Now in regards to just group obstacles between the three of us, not including the client, we did and do still have to face some of those currently, which I feel has been setting the group as a whole back a bit as time continues to go on.

First off, our team struggled during this first half of the term trying to figure out a set weekly time for just us three to meet up on campus during the week. Due to busy and conflicting schedules, and some lack of communication here and there done remotely, finding a time to meet up was very difficult. Some extra pushing and much realizations have take place to resolve this issue, but has been slowly working out so far. Currently meeting for multiple short times during the week has been concluded the only way we can go through with at the moment. I have been realizing as a group physically together has been very productive so far, and some tensions seem to ease, making these meeting times highly beneficial in the long run.

Secondly, along with meeting as a group physically, having a station to commonly meet up and test our pieces of code and program overall has also been one of our issues in order to work on the project's implementation effectively. We are trying to figure if we can have a common space in order to do so on campus, whereas the ones in the group who have a setup, let alone a properly working setup at home, is impractical for our group personally. Currently I am the only one in the group who does not have an available HTC Vive headset to test with or proper equipment to set it up. As a group, we are hoping to figure out this limitation in our favor soon.

In the end, all of these struggles and obstacles combined have been impeding our progress and solutions that the team as a whole and individually has yet to meet at the moment. The energy and time to work productively and efficiently on our project's implementation at the end of every day truly does take a toll on us. Along with other classes, commitments, and additional personal life struggles and situations, we have been feeling the weight on our shoulders one way or another at this point in the term honestly.

4.4 Interesting and Relevant Information

Personally, due to my current status with the project's implementation and other focused on documents, e-mails, and situation I am trying to work through, I do not have much interesting or relevant information to share about the project at the moment. Our team has been given and offered help throughout the weeks, which I have been greatly appreciated for, but there are still struggles having to faced, and tasks to be completed, where my mind has been blinded for anything otherwise, but at the end I am hoping to realized something better.

5 CONCLUSION

In conclusion, the team has made progress and has implemented methods for loading into an environment, spawning 3D objects, drawing lines, and offering the user some navigation through the program. Additionally, the team plans to polish the current features and update the program with features like saving and loading game objects and scenes, and also drawing and transforming curves. Along with the progress, the team has also experienced a number of challenges that we hope to conquer both individually and together as a team, in order to make this program into what we imagined it to be.