Gesture and Form

Shane Cote
Dalhousie Computer Science
GEM Lab
Halifax, CA
shane.cote@dal.ca

Rowland Goddy-Worlu
Dalhousie Computer Science
GEM Lab
Halifax, CA
rowland.goddy-worlu@dal.ca

Jordan Finner
Dalhousie Computer Science
GEM Lab
Halifax, CA
jordan.finner@dal.ca

Peter Halter
Dalhousie Computer Science
GEM Lab
Halifax, CA
peter.halter@dal.ca

Abrar Bazara
Dalhousie Architecture
MBE Lab
Halifax, CA
ab796445@dal.ca

Alexander Crosby
Dalhousie Architecture
MBE Lab
Halifax, CA
alexander.crosby@dal.ca

Derek Reilly
Dalhousie Computer Science
GEM Lab
Halifax, CA
reilly.cs.dal.ca

James Forren
Dalhousie Architecture
MBE Lab
Halifax, CA
james.forren@dal.ca

Claire Nicholas
Oklahoma, USA
cbnicholas@ou.edu

Katherine Perry
Oklahoma, USA
katherine.c.perry-1@ou.edu

Abstract

Within our Gesture and Form research, we aim to contribute to the development of an augmented reality (AR) tool that aids in architecture and design. Prior to being added onto the Gesture and Form team, a prototype was developed to bridge the gap between Rhinoceros 3D/Grasshopper (a three-dimensional modeling software and its visual scripting environment) and Unity 3D. With this prototype, a wearer of the Microsoft HoloLens 2 mixed reality headset can view and interact with 3D objects using hand gesturing and positioning [1]. Now, we aim to continue this work by adding the ability to support the architectural process of designing textile-based sculptures, with the goal being to present the added features within various youth workshops. Through these workshops, we can demonstrate architectural techniques through our AR application, using interactable components in order to enhance the learning experience of the youth.

Keywords—augmented reality, Rhino3D, HoloLens 2, architecture, design, learning, Fologram, modelling

I. Introduction

The process of learning by doing allows one to engage more strongly with a given task, and in doing so, retain a larger amount of new information. Augmented reality is increasingly becoming a popular tool for learning, as its use gives its users the ability to digest concepts in an environment that encourages interactivity and collaboration [2]. Furthermore, the excitement surrounding emerging technology can be used to an educational advantage – bringing enthusiasm to new ideas, as well as the accessibility to explore hard-to-grasp concepts within the limitless space of AR.

Dalhousie's GEM Lab teamed up with the Dalhousie Department of Architecture and Oklahoma University's Department of Psychology in order to learn more on how the newly developed HoloLens 2 is able to utilize AR technologies to help in the process of learning, as well as to measure how much the learning experience can be improved when using it within an architectural problem-space. The goal was to put together a workshop for high school students that would be able to demonstrate the capabilities of learning through AR, as well as an opportunity to learn AR strengths and improve their weaknesses. Within our project, there is a strong influence of cultural bead weaving throughout our research explorations, and it was through these explorations that we chose to follow these styles of knit stitching in our structure design (Figure 1.). In addition, much research was done on sustainable structures across the world. As technology advances further, it is important to be aware of the negative environmental effects that its production has on the planet. Instead of disregarding this, the architecture department chose sustainable materials, including recycled water bottles, as the basis for our structural build. This draws additional awareness to the importance of environmentally friendly art being created in unison with modern technology.

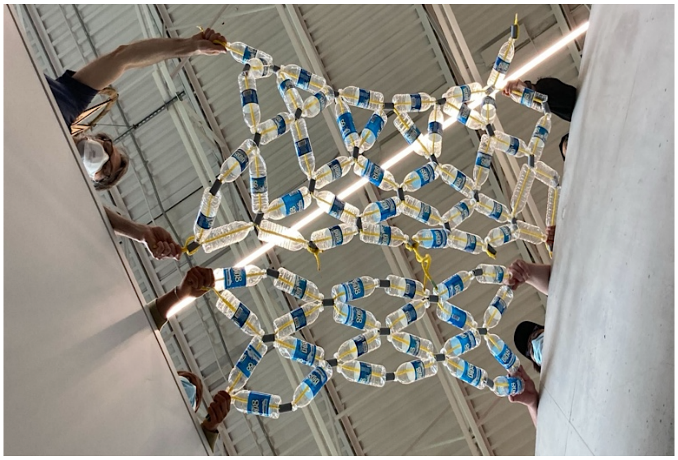

Figure 1. Testing out structural integrity of reusable materials.

II. Rhino3D, Grasshopper, & Fologram

When beginning to understand our goal outcomes for the workshop, we first had to decide which software platforms we wanted to use. Though we had recent work done within Unity, our current problem surrounded a heavier emphasize on 3D architectural modeling within Rhino3D. Rhino3D is a common 3D modeling software used within many architecture projects. Grasshopper, a Rhino3D plugin, allows designers who use Rhino3D to use visual programming, enabling the 3D models to be much more adaptable to changes. As 3D models are being designed, there are typically a large number of parameters that can be changed, and manually updating a completed model can be time consuming and inefficient when there are so many components holding a model together. Grasshopper takes away the redundancy of changing a model's parameters, as it allows us to design the model using variables that can be updated given the users preferences, and the 3D model will recalculate to appropriate fix within the newfound constraints. However, instead of simply viewing the 3D model on a screen, the Fologram plugin for Rhino3D allows the 3D model to sync with HoloLens 2, allowing users to render a real-world space with the HoloLens 2 into a virtual environment, design the model within Grasshopper on a computer, and then project the holographic image virtually through the HoloLens 2 onto the real-world location.

Ultimately, we decided to isolate the workshop to solely use Rhino3D and its plugins. Through testing out the two software's together with multiple AR connections, we found the latency that occurred between the Unity and Rhino3D's communication was too large and impacted the AR experience immensely. In addition, since we need many instances of each Rhino3D model, Unity struggled with enabling all users to be able to see a 3D model from their unique point of view, while maintaining that if one person altered the model, only a select few should be able to see the change (given that there will be different groups working at one time). Finally, the Fologram plugin for Rhino3D eliminated many of the pain points we were experiencing with Unity, as Fologram is designed to aid in similar HoloLens 2 based AR projects involving modeling and manipulation.

III. Youth WorkShop

The goal of our workshop is for the students to learn about architectural design through augmented reality explorations. For two days, they will be working collaboratively to design and build a large-scale mesh using recycled water bottles, rope, and PVC piping. Once built, we will hang and display the finished product in the main floor of Dalhousie's Medical Tupper building on their Carleton Campus.

During the workshop, there will be approximately 20 students separated into equal groups of either 4 or 5. When the students arrive on July 12th, they will be given a short introduction to the workshop where we will welcome them and give them a synopsis of the task they will be taking on within the following days. In addition, we will lightly explain the tools we will be using, and how they will help us to achieve our desired outcome. After this, the students will move to the final location of their structure in the Tupper building. Once there, they will be able to use the HoloLens (as well as other devices such as iPhones or tablets that allow the Fologram app from their app store and can scan the required QR code) to view the 3D rendered model of a structured mesh hanging from the staircase in the main hallway. Using the visualization of the starting model, the teams will be able to manipulate their model, changing parameters such as length and height to see how their choices will change the outcome of their design. As these parameters are changed, the real-time image of the 3D model will adapt to these changes, therefore the students can discuss amongst themselves regarding which design they believe to be the best (structurally and visually) and why.

Once the design decision has been discussed and chosen, the students will be able to build the real structure that they have just envisioned. We will carry out the next portion of the workshop within a classroom on the second floor of the Tupper building, where the students will be split up into their smaller groups and can each have the space to build their section of the structure. Using the HoloLens 2 once again, the students will be able to see a holographic image of the first step of their desired result overlayed onto the floor in front of them. With this, the students can use the materials provided (this will be the PVC piping, reused water bottles, and rope materials) to see from the AR outline what they will need in their first step in order to build their structure. Once their real build matches the outline of the first step shown with the HoloLens, they will be able to tap on a virtual AR button in order to move on to their next step. This process will repeat for each step, for each group, demonstrating the different steps that each group must take in order to complete their portion. Once each group is done, the HoloLens does a similar step-by-step process to show how the groups can merge each of their sections together.

We anticipate that the above agenda will take up the first day of the workshop on July 14th, and then the students will have a day in between before they return for the second day of the workshop on the afternoon of July 14th. On the second day, the students will get the see/aid in the process of placing the completed structure above the Tupper building staircase, as well as present their piece to their family at the end of the day. In addition, there is some time in the end for the students to fill out an in-depth questionnaire.

IV. Questionnaire

The post-workshop questionnaire prompts the students to expand upon their opinions on different aspects and tools we used throughout the workshop. Since such a large portion of the workshop involves providing a new tool for learning, we want to understand how each student came away from the experience, and how it may have changed their perspective on AR, architecture, design, collaboration, and the process of learning as a whole. Ideally, we want the students to enter into a flow state, meaning a state where there is powerfully balanced mixed of comfort and challenge and you are completely engulfed in the process, so much so that time seems to pass by quickly. During these states, the learning process becomes easy and natural, as you are so engaged within the topic that you see exciting opportunities instead of daunting challenges. It is our hope that demonstrating the complexity of an architecture problem alongside the use of AR will break the barrier of complexity and encourage curiosity and experimentation.

Since the workshop takes place as part of a science camp, we anticipate that most/all students will have a strong enthusiasm for learning and technology. However, we do not know this for sure, and we will not know until the questionnaire is completely how much experience the students will have previously had with AR or any other potential architecture/3D modeling software. Any level of familiarity (from no familiarity to complete) with these tools with be valuable to us, as we hope for this tool to be equally as helpful for learners of all strengths.

In the questionnaire, we include a mix of yes/no questions, open-ended questions, and 5-point scale questions where a one represents "Strongly Disagree" and this is increased until five, representing "Strongly Agree". The yes/no questions will involve the experience-based questions, including whether they have been exposed to AR, VR, drafting, etc. The open-ended questions involve asking the student what other applications they may envision AR being helpful with, what their favorite part of the workshop was, etc. And finally, the 5-points scale questions help us to understand where we may be able to improve in further work, as we ask questions such as how strongly they felt the AR application helped them to learn, how much they enjoyed collaboration, how interested they are in computer science/architecture after taking the workshop, and how meaningful the workshop was to them.

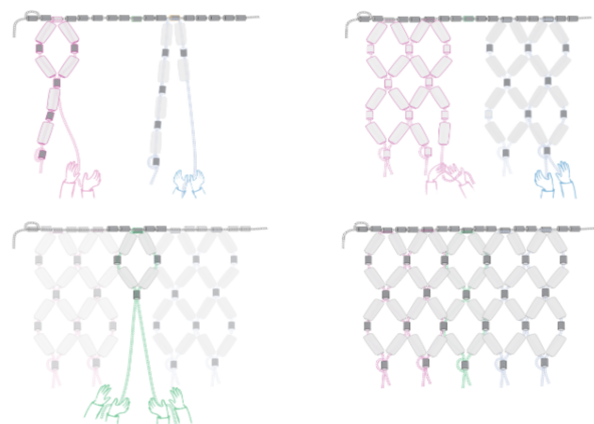

Figure 2. A demonstration of collaboration when building the structure. [4]

V. Conclusion & Future Work

Though we had initially set out to complete one workshop, we now plan on utilizing our iterative approach to Gesture and Form to participate in a handful of workshops. This will allow us to improve various aspects of our work, including how we structure the workshop, the performance of the HoloLens (latency issues, etc.), the clarity of design steps, the amount of engagement, etc., all based on previous workshop feedback. Though we have done many dry runs to date, we have yet to experience the full real workshop, and we know there could always be issues that arise on the day of the workshop that we may have not accounted for. Doing more workshops allows us to isolate these unexpected errors (should there be some), learn from them, change our current approach, and create an even better experience for the next iteration until we reach an optimal point.

In addition to this, we have a short-term goal of merging the current Gesture & Form application with another project members machine learning Unity based project. This tool is currently learning the appropriate techniques/steps to building a structure similar to the one the students will be building in the workshop, and its purpose is to be able to identify human error when the structure is being built. With this added technology, the HoloLens 2 will be able to read in the live video input it is viewing as a student goes to add two materials together, recognize if what they are doing is correct, and adjust their learning path if what they are doing is wrong. This feature will add an immense feature to the overall learning process of the student, as each unique student will be able to correct themselves in real time regardless of the error made. Currently, our application can only enable the student to proceed to the next step if they view their structure to match the visualized example shown through the HoloLens 2. Though the two structures may seem to match to the student, it is extremely possible for a mistake to be made, especially as the entire process will be so new for most students. The addition of a machine learning based model will seek to avoid these inevitable human errors, therefore increasing the odds of maintaining the structural integrity of the previously designed model once it has been physically built.

References

[1] Halter, Peter. (2021). A Comparative Evaluation of Augmented Reality Learning Techniques and Traditioal Learning Materials for Bead Weaving.

[2] Abuzandah, Sameer. (2020). Learning By Doing.

[3] Jahn, Gwyllim & Newnham, Cameron & Berg, Nick. (2022). Augmented Reality For Construction From Steam Bent Timber.

[4] Bazara, Abrar. (2022). Gesture and Form