DANCE MOVEMENT VISUALIZATION AND EDUCATION

IN VIRTUAL REALITY

An Undergraduate Research Scholars Thesis

by

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ABSTRACT

Dance Movement Visualization and Education
in Virtual Reality

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How can virtual reality be used to advance modern dance education methods? As a rapidly evolving technology, virtual reality has the potential to be developed for many different educational purposes. Previous research has shown that using motion tracking and virtual reality to learn dancing is plausible (Chan 2011), however the programs previously developed are lacking in user interaction and learning advancements. Our project builds upon these fundamentals. We captured dance movements from a couple of dancers and incorporated the capture data to a virtual dance avatar's movements. Students can learn about key dance movements by viewing and interacting with the avatar's dance movements in the virtual reality environment. The user will be able to observe the dance movement at any point in the routine, with the ability to slow down the dance in order to observe certain movements at a more comprehensible speed.

In the future, we would like this application will provide two views of the dance avatar; one as the physical character, the other as an anatomical model of the character's musculoskeletal system. Therefore students can learn detailed muscle movements when the

avatar dances. We will include three movements specifically the Arabesque, Second port de bras, and Retire from modern dance compositions, in the VR application. We chose these performances because of the common issues with misalignment of the body in these movements and the complex muscle/bone systems at play. Often students have difficulties performing or maintaining these positions correctly because of several reasons: muscular weakness, inability to identify and engage the correct muscle groups, and structural abnormalities.

This virtual reality program will allow the user to observe a 3D avatar performing a dance within the virtual world-space. The user will have different interactions they can perform in the program, such as visual feedback preferences for the avatar that will allow them to understand the dance in a more enhanced environment, as well as learn at their own pace. This will allow for greater user interactions, such as being able to rotate and view the performing avatar from different angles within a 3D world-space, along with the ability to playback the virtual performance and observe the dance at different rates of speed. Creating the ability to perform these interactions in virtual reality will allow us to add additional user interactions in the future, like virtual tutor feedback and visual correction feedback as previous projects have done. In addition to these interactions, our program will take user inputs from a virtual reality headset and trackers, such as those from HTC for their VIVE headset (HTC Vive and Vive Pro Helmets). The VIVE has the flexibility of having programmable user body trackers, which are much more affordable than a full-body motion capture suit. Furthermore, the ability to change the amount of body trackers used allows for the flexibility of adjusting tracking precision, based on usability and ease of evaluation. With this advancement of technology available for research purposes, as well as demonstration of previous successful techniques, the resources are available for the creation of a user-friendly, virtual reality-based modern dance education program.

ACKNOWLEDGMENTS

I would like to express my thanks to my amazing advisors, Dr. Hwaryoung Seo and Caleb Kicklighter, for inspiring me to do this project as well as for their guidance, support, and encouragement, not just throughout the production of this application, but during my years of study at Texas A&M University as well.

I would also like to extend my thanks to all of my wonderful undergraduate volunteers. Firstly, Caleb Duane, Christopher Kornosky, Erin Jarrett, and Jordin Gonzalez, for their amazing programming and concept work during the front-end of the research. In addition, Kamryn Massey, Julie Choi, and Vy Lam for their hard work in producing beautiful 3D models and animations for use in the final program.

Additionally, I would like to extend Professor Diane Bedford, as well as the entirety of Texas A&M Department of Dance and its students, for providing us with resources, guidance, and volunteers that helped us make our final product as accurate to the source material as possible.

Great thanks also goes to the Department of Visualization, including Tim McLaughlin, Sasha Kraguljac, and Bill Jenks, for providing us with the technology and space necessary to conduct our research, especially during the time of the Covid-19 pandemic.

Finally, thank you to my loving friends and family for supporting me through this project. Your constant encouragements through times of code breaking and software crashing made it all worth it, and I cannot express just how grateful I am for you all.

SECTION I

RESEARCH QUESTION/MOTIVATION/ARTIFACT

Problem

Learning to dance requires an artistic skill many wish to have, but few follow through to go learn it properly. In addition, even fewer stick with dance long enough to make it to a professional level. This is mostly due to the fact that learning dance properly requires three things: location, money, and time. For people wanting to learn how to dance professionally, they must first find an outlet where they can learn how to do so. These potential dancers often find this outlet in finding a traditional dance studio to learn from, complete with lessons from an instructor alongside other classmates. However, these studios are not available everywhere, and different instructors have varying levels of skill. Some instructors post video tutorials of different dances online to video sharing sites, a feasible and simple learning mechanism for those wanting to learn how to dance casually in their free time in the comfort of their own home (Patel, 2006). Those looking to step out in the professional world, however, usually need to seek out a professional dance studio. As convenient as online videos are nowadays, they do not provide the same real-time feedback training a traditional dance studio setting provides. Instructors can provide insight to the student regarding posture, muscle tension, and posing in face to face interactions during these learning sessions.

Learning modern dance in any environment also requires as significant amount of time and energy. This fact can contribute greatly to a person's decision on whether to go find a studio to learn from, or take lessons from online instructors instead. Despite the limitations of a 2D video format, many people opt for this way of learning dance thanks to its convenience. Many of

these online classes are a “learn at your own pace” style of teaching, meaning people can go to learn different fundamentals of modern dance as their schedule allows, letting them be flexible with their learning time (Gross 2008). It is important to note, however, that many of these people are only hobbyists, not looking to pursue dance as a career path. For those wanting a career in modern dance, face to face studio time with an instructor is imperative for good learning growth. But this puts pressure on them, having to balance time in the studio with time for work, school, and other responsibilities that life throws at them. Sometimes at a certain point, the travel time alone necessary to reach the studio makes learning to dance professionally not a reasonable career path. Because as helpful as studio lessons are, many people do not have the available extra time to travel out or practice for them (Gross, 2008).

Despite the helpfulness of face to face dance studio lessons, they come with a major drawback: cost. While a dance studio may be in an area feasible for a potential student to access, lessons do not come for free. In addition, for those wanting to pursue a professional career, the cost of classes increases exorbitantly. The higher of a level of experience a student wishes to reach in modern dance, the more lessons they will have to pay for. In addition, as they go up in skill, the more specialized the field of modern dance becomes, and thus they will have to pay a premium to go to these more specialized classes in order to pursue a higher level of experience (Gross, 2008). Although some scholarships exist to help combat this issue, sometimes the cost is not feasible for everyone, limiting the number of people that could reach that high point of professional modern dance, but sadly cannot due to lack of funds (Gross, 2008).

Question

In our research, our team is seeking to develop the answer to how dance education can be improved upon and enhanced by using virtual reality as a learning tool. Our research seeks to

build upon tools and applications built by other teams in the past, but by using a more accessible technology in virtual reality. The goal is not just to build a functional dance education program, but to build one that could be easily be acquired and used by anyone anywhere. Essentially, a mobile dance studio that could be set up in an apartment, a home gym, a university lab space, and so on, provided the user has enough movement space. The application will have a virtual avatar as an instructor for the user, providing that necessary element of having a physical tutor for professionals wanting to use the program to increase their skills. Instead of being projected onto a screen, our dance program will exist entirely within virtual reality. This will allow for greater user interactions, such as being able to rotate and view the performing avatar from different angles within a 3D world-space, along with the ability to playback the virtual performance and observe the dance at different rates of speed. In addition to this, we have the unique opportunity to take advantage of more modern technology and development techniques by using virtual reality, which allows the project to be easily expanded upon in the future. By doing this we can help set the groundwork for how virtual reality can be used as an advantageous learning tool in dance education.

Unfortunately, there are not many programs out there to point to as good examples of how technology has been used in the past to improve dance education. In fact, many previous examples of using technology as a dance mechanism exist only in the realm of entertainment games, and less so as a purely educational application (Charbonneu, 2013). Some programs have used other technologies such as motion capture suits and cameras to achieve a feasible virtual dance education program (Chan 2011). However, setups requiring motion capture suits are very high end and very expensive. Creating a program utilizing a motion capture suit will definitely have its advantages in terms of user interaction, as well as posture and motion feedback.

However, it is not a feasible setup for someone wanting to learn the basics of modern dance in an affordable setting. We want our program to be simple to set up, as well as accessible to as many people as possible. As virtual reality headsets like the Oculus Rift and the HTC VIVE become more and more ubiquitous in the past decade, more people have a greater access to this technology in comparison to motion capture. Thus, it would be more reasonable for us to develop on a virtual reality platform, as it is feasible to use a virtual reality headset's standard setup as the basis for an educational tool such as the one we will be developing.

My artifact will be a prototype of a dance education application for the HTC VIVE called *Pirouette VR*. It will include three movements that commonly appear in modern ballet dances that the user will be able to mimic and learn from. However, since we will be building the program completely from scratch, our intended project scope will be very limited, in order to build a good foundational, functional program that will be able to be updated and improved upon in the future. Improvements would include more visualization tools for the user, like a view of an anatomical model performing the movements and showing which muscles should be flexed or relaxed for proper dance posture. We would also like the next version of the application to include a user's own personal avatar that would move with them in the virtual space, taking user inputs in order to provide visual feedback on posture and positioning of the body. For now, the program will be functional as an assistant program for practice and review of these movements. The user will be able to interact with a virtual avatar performing certain movements for the user to learn. By using interactive tools like playback speed, pause and play, as well as scrubbing and model rotation, the user will be able to observe a dance in the virtual space, in order to review complex movements without having to be restricted to a single view angle in a video, or to classroom environments where they can only learn by watching a physical teacher.

SECTION II

HISTORY AND LITERATURE REVIEW

History

In the recent years, there has been a great deal of technical development in the use of virtual reality as a tool for training or education. Virtual reality allows the user to perfect a certain skill within a controlled environment. Previous studies have shown that using this technology as a learning mechanism is far more beneficial than a simple video, especially in terms of learning how to do various physical activities, such as dancing (Patel, 2006). This kind of motion technology has already been shown to be effective in teaching basic dance to those interested in the art, however the current techniques are mostly used in casual gaming scenarios, and not intended for use for those pursuing a career in modern dance (Charbonneau, 2013).

Traditionally, most people who want to learn modern dance can only learn how do to so from a dance instructor in a traditional studio environment. In standard dance education, the instructor will teach the student to perform certain moves and poses, which will eventually the student will learn to use to perform a certain dance. Usually, the student learns best by adopting certain physical mannerisms and techniques from their tutor, a common learning process called "mimesis." (Tsampounaris, 2016). This mimicking of the teacher, as well as the teacher's evaluations and corrections, are critical in a student successfully learning a specific move or series of movements in a dance. However, not everyone has access to these resources, thereby making it hard for them to pursue modern dance, either as a hobby or professional endeavor (Gross, 2008).

Another concern is time. Many studios have set schedules for when they are teaching, and for those in school or with full-time jobs, learning dance may not be feasible with their work schedule (Gross, 2008). By creating a virtual reality education program for dance education, all a user would need is a well-suited play area in order to learn the fundamentals. They can determine when to take a class and how advanced they want to become. This research project will create the groundwork for a virtual dance tutor program that will allow greater access to learning the fundamentals of modern dance for those that have limited time or resources.

Literature Review

Only a few previous research projects have made advances in the realm of using Virtual Reality as a medium for dance education. However, many of these projects were developed around the same timeframe that Virtual Reality was just becoming accessible as a new and innovative technology and viable tool for research. Therefore, the technology and knowledge for developing in the Virtual Reality workspace was very limited at the time. Many of these projects took advantage of other types of motion recording systems that were just becoming available at the time, such as motion capture suits in conjunction with cameras. A previous virtual dance education research endeavor by a team in Hong Kong made major strides in this particular educational application by doing just that. The team created a system where a user wearing a motion capture suit could learn different dance movements from an avatar projected in front of them on a wall. Cameras around the room would track the user's movements using the reflective indicators on the motion capture suit (Chan, 2011). As the user would perform, mimicking the avatar to the best of their ability, the avatar would give visual color cues to the user to show whether or not they were performing the movement correctly. At the end of the performance the user would be able to see their performance accuracy in a box on the screen, and would be able

to try again. The user also had the option to slow down a dance performance in order to evaluate a specific move at a more comprehensible speed (Chan, 2011). This project is the best example of what we wanted to build upon in our research. It had specific user interactions that would help the user actually learn and get better at a dance. However, there are severe limitations to this particular program setup that would become problematic in the long run. For one, the technology in the program did not allow the user to interact directly with the performing virtual avatar, as it is merely displayed on a projection screen. This makes it very hard for dancers, who typically learn in three-dimensions, to learn a dance by observing, as they are limited in their angle of view of the avatar (Chan, 2011). In addition, the team used a professional motion tracking suit in order to track the player's movements, which is a technology that is not easily accessible to those without the resources (Chan, 2011). Our project aims to build upon these known issues by using the significant advancements made in terms of game development as well as educational tools that virtual reality has developed since this last project.

SECTION III

EXPLANATION OF EXHIBIT/VENUE

Pirouette VR: Application Design Process

Pirouette VR was visualized to be the first step in creating a user-friendly education program for modern dance fundamentals, utilizing virtual reality to create a virtual studio learning experience, as well as create new learning tools for users to take advantage of in order to successfully learn a dance routine. That being said, our research had to be carried out by creating iterative prototypes. Our methodology in approaching this project is based on the idea of "Research through Art Practice". This means we approached our development and research in a scheduling and production process similar to that of many simulation development studios. By using these industry level methods, we were able to keep ourselves on track to produce a usable program within our set timeframe. We have been fortunate enough to have access to a Virtual Reality lab provided to us within the Department of Visualization, where we can program, test, and reiterate our software on virtual reality headsets like the HTC VIVE, as well as record the necessary motion capture data we needed to make the program's dances as accurate as possible.

Application Overview

When the user first loads the application, they find themselves in a three-dimensional environment built to look like an average modern dance studio. In front of them, there is a life-sized virtual avatar, standing in a rest position in preparation for the dance to be performed. Behind the avatar is a large floor-to-ceiling mirror, not unlike the mirrors one would find in a dance studio, so that the user can see the virtual avatar performing from all angles. On the mirror to the left is an options button that, upon selecting, displays a list of dance moves that the user

can select from to have the avatar perform. With the help and advisements we received from our collaboration with the Texas A&M Department of Dance, we chose three different dance movement lesson plans for the user to study within the program. These were specifically the Arabesque, Second port de bras, and Retire, common motions found in many modern dance compositions. These performances were chosen because of the common issues students learning them had with misalignment of the body in these movements, as well as the complex muscle and bone systems at play. Often students have difficulties performing or maintaining these positions correctly because of several reasons, such as muscular weakness, inability to identify and engage the correct muscle groups, and structural abnormalities. Upon selecting a dance movement from the menu, the avatar will perform the selected movement, return to a rest position, then repeat the motion again. Using the playback toolbar on the right of the model, the user can adjust the speed of the avatar's performance, pause and play the movement, as well as interact with the model using other tools within the user interface to create a flexible and personalized learning experience (Figure I).

Driven by our desire to meet industry standards in our final application product, we used industry standard software and development tools. From the very beginning, we wanted to create a learning experience that felt very natural and would not alienate the user in terms of the virtual reality hardware we chose to use. Learning in virtual reality is a very different experience compared to learning in real life. In addition to this, it can take a while for a new user to get used to the "rules" of the virtual world space and fully adjust to interacting with the virtual environment. We kept this in mind through every artistic choice made for the design process, such as whether to have a standard dance studio environment or a more abstract, avant-garde one for the sake of aesthetics. This also determined the design of our virtual avatar as well, whether

we would make it realistic or more stylized like many industry game characters are, and what the color pallet for the final model texturing would be. We came to the conclusion that we wanted the user to focus on the movements of the avatar, free from as many distractions as we could eliminate. Thus, we concluded that a clean, modern design for the dance studio environment was a required element for the project, in order to allow the user to feel more grounded in reality and be able to focus more on learning rather than exploring a novel, fantastical environment. Since this application is also meant to be a beginners' training program, we wanted the aesthetics of the avatar character to match the clean aesthetic of the environment. In doing so we made sure to keep his proportions realistic so as to mimic proper body physics, but with a more stylized approach to keep the user from focusing too much on the details of his body and more on the overall silhouette of his dance movements (Figure I).

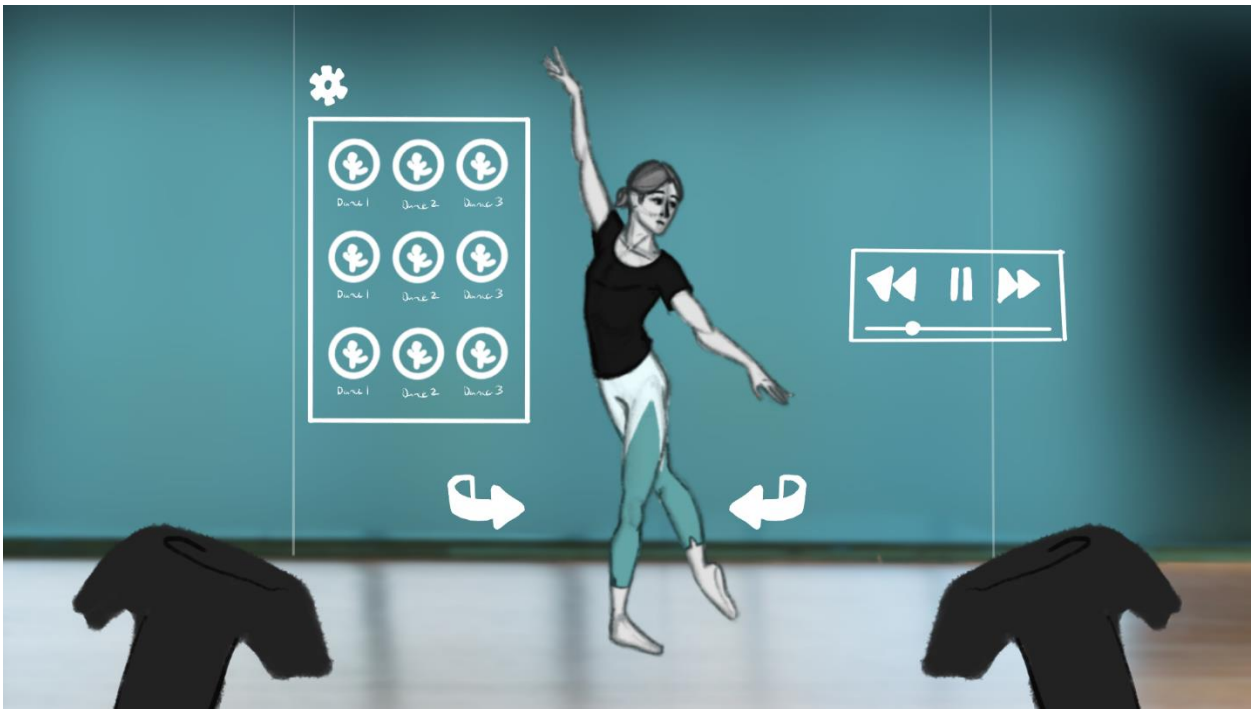


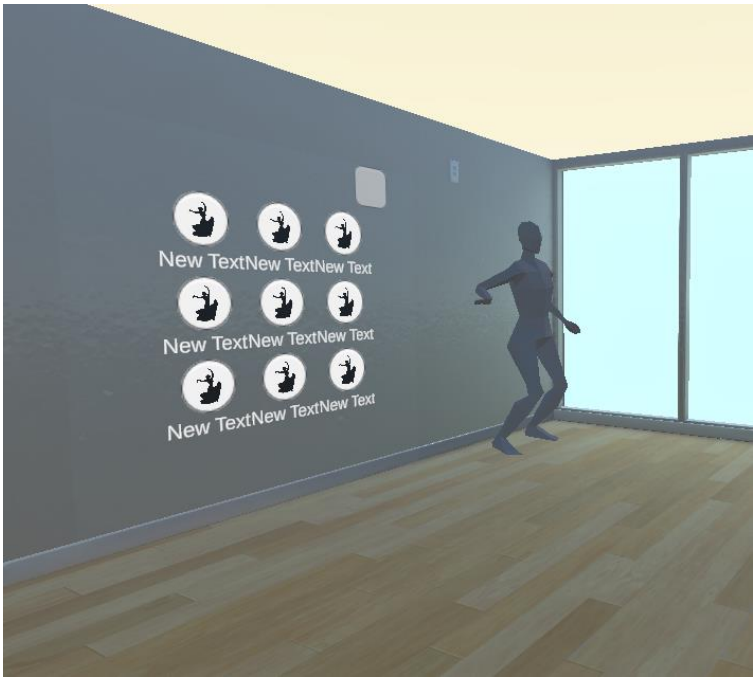
Figure I. Early concept art of the dancer within the virtual studio environment, along with initial ideas for a menu system.

3D Modeling, Rigging, and Texturing

As stated previously, we used industry standard 3D production tools for our production process, in order to ensure file compatibility between all of our software, as well as a high quality final product. Initial 3D modeling for the virtual avatar was done in Zbrush (ver. 2020.1.1; Pixologic, 2020), which is a program that essentially lets the user sculpt out a model as one would do with clay. We used this for our model as well as many anatomical models as reference during the process. Although we were going for a slightly more stylized aesthetic in the program, we still wanted the physics and proportions of the character to be realistic and believable. This would play into later aspects like animation, in order to ensure the model looked and moved like a human, and demonstrated proper posture at all times in the program. Had we not been sure to use realistic human proportions, this level of accuracy would not be possible.

For the finalization of the virtual avatar model, as well as the modeling of additional 3D assets, we used a program called Maya (ver. 2020.1; Autodesk, 2020). Maya is a very powerful 3D production software, and is useful for a variety of 3D processes, such as modeling, rigging, visual effects, and so on. It is used by many companies for animated films and game productions, as well as a variety of other professional projects, which is why we chose it as our main asset production software. The assets for the dance studio environment were completely modeled within Maya (Figure II). In addition to this, we used Maya to rig our dance model for animation. Rigging is the process of adding virtual joints to a 3D model as deformation points, allowing us to control the model as one would control a puppet (Figure III). Along with Maya's packaged rigging tools, we also used a plugin called Advanced Skeleton 5. This plugin allowed us to create complex rigging structures very quickly. Different rigging techniques allow for different ways for an animator to edit and work with a model in a more artistic and flexible manner. However,

implementing these features by hand without the use of scripts is very time consuming, and thus was not feasible without the use of a plug-in. Advanced Skeleton also allowed us to build a standardized rig for our model, so that it can be applied to other 3D humanoid models in the future. We did this with the thought in mind of keeping a flexible character creation pipeline, so that we could add more character visualizations in the future, such as a female instructor or an anatomical model. While we only have the one male instructor for now, we have plans to add these additional character visualizations in the near future. The Advanced Skeleton 5 plugin also allowed us the unique opportunity to us motion capture data in our animations, as it had scripts to allow us to easily transfer motion capture data to our rigged model.



< Figure II. Early model of the dance studio environment within Unity, pictured with a menu prototype and a proxy motion capture human model

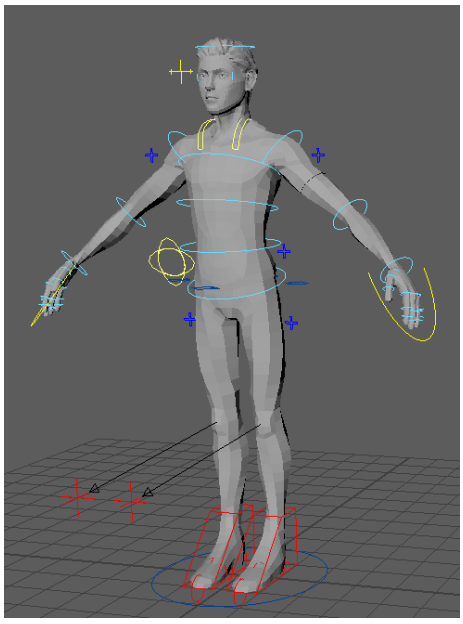


Figure III. Final model of the virtual dance tutor, along with rig skeleton controls attached and ready for animation within Maya >

For the final aspect of our visual asset production, texturing, we used two programs in conjunction with each other, Substance Designer (ver. 2019.3.1; Adobe, 2020) and Substance Painter (ver. 2019.3.3; Adobe, 2020). Substance Designer is a node-based software that allows users to use different images nodes to create procedural texture assets. Procedural textures are unique in the fact that they are purely math-based. These types of textures use math expressions to combine images together to create a final texture. We used this to create the wooden floor pattern for our studio, as well as the metal for the studio light housings, and the studio walls. It was a far easier and faster process than painting all of the textures out by hand. However, we still needed an artistic touch for some of the assets, like the layering of cloth textures over our final model to create the appearance of clothes. This is where we used Substance Painter in our process. Substance Painter works a lot like the photo editing software called Photoshop, in that you use a layer-based system to stack different photo effects, colors, and textures on top of one another to make a whole new image. This software allowed us to paint textures directly onto the virtual avatar, as well as mask out different areas of the 3D mesh and assign them different colors and materials to be exported out in one easy texture mapping system. We were even able to take our procedural textures from Substance Designer and import them into Substance Painter, so that we could paint out masks for our procedural textures as well.

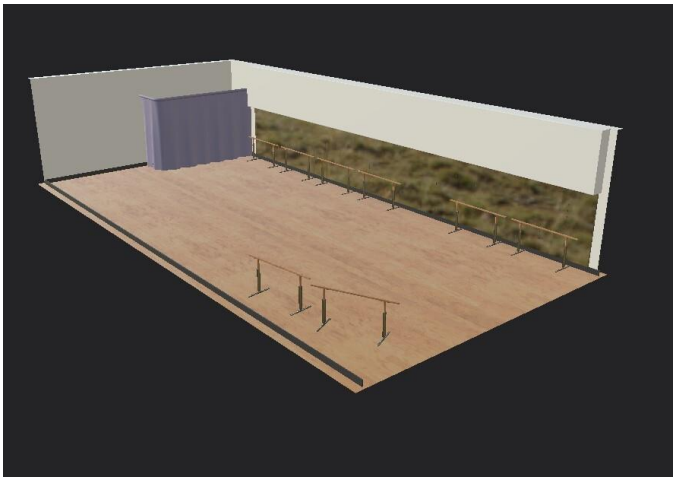


Figure IIV (Left). Final environment with textures in Substance Painter

Figure V (Right). The final textures for the rigged model in Substance Painter

Motion Capture

When we started this project, we knew from the beginning we wanted our dance animations to be as accurate as possible to real life, so that we could correctly translate proper posture and performance in our virtual model. To do this, we decided we would use motion capture data taken from high-level dancers and incorporate their movements into the virtual avatar's final animation. Unfortunately, our team did not have access to a motion capture suit within our department. We explored many options, including perhaps hiring and renting out the motion capture studio in the Department of Engineering, but all of our ideas ended up being far too expensive or far too time consuming for them to be effective. However, thanks to some ingenious research done by the volunteer programmers on our team, we rigged up a motion capture system that made use of the HTC VIVE body trackers in conjunction with our programming software, Unity (ver. 2018.3.10, & ver 2019.3.7, 2020), and figured out how to convert the inputs into usable data for our animation software.

With a usable system in hand, we now needed volunteer dancers to record. My advisor was able to reach out to a professor within the Department of Dance at Texas A&M, to ask if she would help advise us on our program development and if she had any high-level dance students that would be willing to help participate in our research by recording dance movements. After working out a deal that their time recording with us would count towards the total number of research hours the dance students were required to complete at the end of the semester, we received several willing participants on the day of recording. We recorded the dances in three ways. One was with the motion capture system in Unity. Another was a straightforward video recording of the dancer from front, side, and three-quarters angles. These videos would be used as reference when we went back to clean up the motion capture data. Finally, we recorded the

dancers using a Microsoft Kinect camera, which essentially records not only motion data, but also depth of field data, or "z-depth" data. While we did not end up using the z-depth data in our final product, it was still a great experience learning how to use the hardware, which could have potential applications for our program in the future.

Unfortunately, we did not get to use the motion capture data as we would have liked. While the data we had was somewhat useable, despite our less than optimal setup, the plugin software that we were using in Maya to transfer the data from the motion capture model to our virtual avatar model was not working. We tried several different methods to troubleshoot it, but ultimately we chalked it up to Advanced Skeleton 5 not liking our homebrew motion capture setup. So we used the three-point video system from the recording day as a backup plan and ended up doing the animations by hand. We were careful to be as accurate as possible in our animation work, so that we could still achieve the same level of realism our motion capture data would have provided.

Programming And User Interactions

Pirouette VR was developed on the HTC VIVE using Unity. Unity is a game development software and engine that has been known for its constant advancements in different software development fields, such as virtual reality, augmented reality, and much more. Using Unity was also advantageous to our project, because it had several plugin options to assist us with the virtual reality interaction aspect of the project. We used Unity's standard user interface building tools to make our menus and buttons, as well as custom scripts to control different user interactions within the virtual studio. These interactions included controls for model animation playback speed, playback scrubbing, animation pause and play, as well as model rotation (Figure VI). Due to our limited timespan and lack of volunteers at the time, we were not able to get an

aesthetic design applied to our user interface before the final version of the application was finished. However, this is something our team plans to implement within the weeks prior to the end of the semester, as a personal goal to polish out the final program.

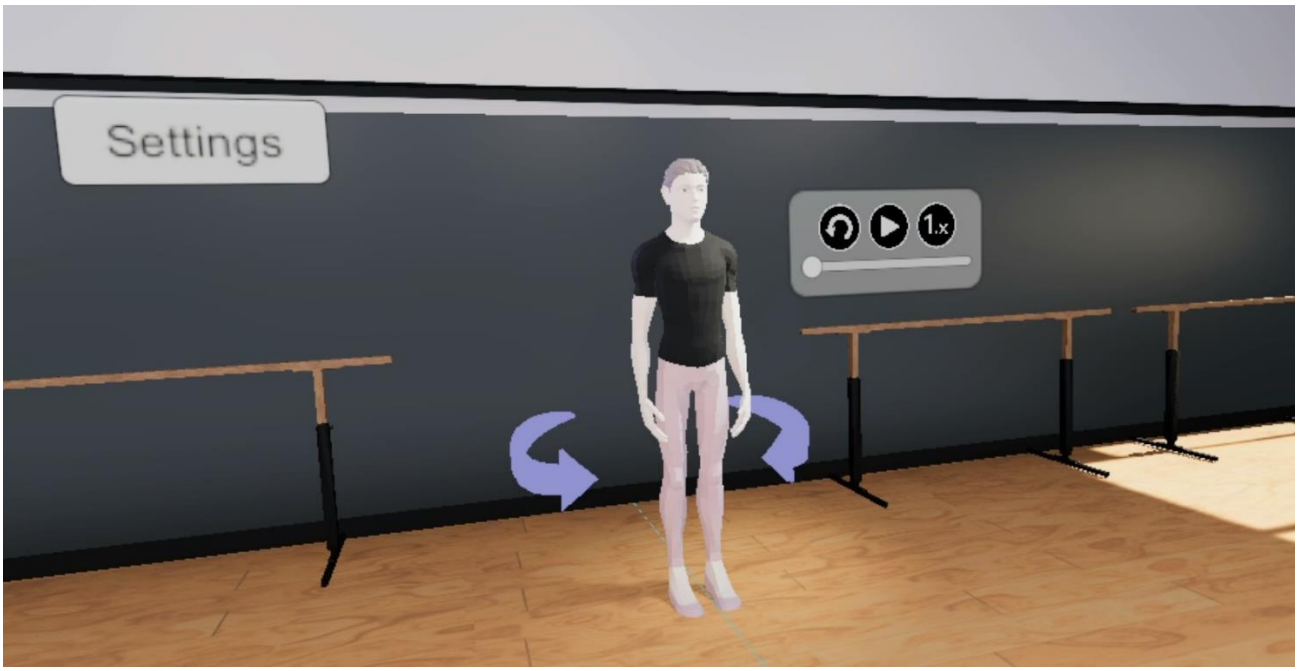


Figure VI. Final Model and Proxy UI System as they appear in the final build of Pirouette VR

Public Presentation

For the presentation portion of our project, we decided to present at the Texas A&M Undergraduate Research Scholars Symposium, which took place Wednesday, February 26th, 2020. This event was held at the Memorial Student Center at the College Station, TX campus. At the event I presented a poster that listed our progress in the production of the application thus far, and provided visuals that illustrated our concept work and what the application currently looked like. Presenting at the Symposium helped me to objectively explain our project to others in the long run. Developing games and simulations in a virtual workspace comes with a whole slew of

industry-related terms that people outside of the industry are unfamiliar with. Learning how to explain my project in more relatable terms helped more people to gain an interest in our research project. Since the medium of virtual reality requires a lot of visuals and sometimes even interaction with the program itself in order to help people understand just how the virtual reality aspect of the project works, as well as what we are trying to achieve with it, practicing explanations with the limited visuals I had on hand was a great learning experience. It will enable me to go and present our findings elsewhere, even at places where I may not be able to set up a physical demo space so that people can try out the application.

Public Showcase and Q&A Session

Previously, we had planned to have a public showcase of our software in the Department of Visualization's VIRL Lab space. We would have invited faculty and staff from both the Visualization Department as well as the Department of Dance to come see a demo of our application, and then allow them to try it for themselves. Afterwards, we would provide a question and answers session so that we could receive feedback from our peers regarding what we could do to improve the project. This would have occurred during the latter half of March 2020. Unfortunately, we were unable to host this public showcase, as during that time, the Covid-19 virus, otherwise known as Coronavirus, was declared a global pandemic. As a result, group events became restricted in an attempt to preserve the overall health of the community, which sadly resulted in the cancellation of our application demo as well.

SECTION IV

REFLECTION

Working on *Pirouette VR* helped me learn what makes an education program helpful to others, as well as the advantages and disadvantages creating such a program in virtual reality provides. Everyone in our target audience that we brought this concept to was excited to see its potential and final demonstration. Though we were unable to do a final Public Showcase and Q&A session with faculty and students of our finished program, and get solid user feedback, my team and I have already identified some areas of the program that could be heavily improved upon in the future to make it a more helpful educational tool, rather than just an optional additional training program.

One aspect of the project that we had wanted to incorporate from the beginning of the fall semester was the specialized anatomy viewing portion of the dance routines. We had wanted some way to display to the user which muscles were being activated in the model, so they could pay more attention to what their body was doing as they performed different movements. Within a traditional dance studio class, the instructor will often help the student by showing them what muscles to flex or relax, and we wanted to incorporate that vital aspect of dance education in Pirouette VR. However, due to time constraints of the total thesis project, we quickly realized we would not be able to meet this goal, and decided to set it aside for the time being.

Additionally, we wanted to incorporate a basic navigational tutorial system that would play upon the user first opening the program. Based on personal experience from demoing virtual reality experiences, new users need a minute to adjust to the environment and it's "rules" of interaction. Many of these interaction techniques, such as using the controller as a sort of laser

pointer to select menu items, are standardized across many virtual reality interactions. This is much like how keyboard commands and mouse clicks are used to interact with a computer, and that such commands typically produce a similar result when using them in different computer programs. Currently, virtual reality headsets are not as widespread as computers, so a new user will need some sort of tutorial guide to teach them how to interact with the virtual space properly.

Finally, one more major aspect of the program we would like to implement in the future are planned out lesson modules. Similar to the dance practice modules we have developed for the program currently, we would like to take these modules one step further and have on screen text and perhaps a voiceover for the student to follow and learn from as they learn to perfect a certain dance move. This is to further immerse the user within the virtual dance studio space, allowing them to learn from a virtual tutor as well as they would from a live dance teacher in a physical studio. Thanks to our current partnership with the Texas A&M Department of Dance, we can work with current dance educators to create accurate lesson plans for these modules. In addition, we would like to have visual feedback in these modules for the user to let them know if they are performing correctly or not. For example, we would like to have the arms and legs glow in a spectrum from red for incorrect, to yellow for almost there, to green for perfect posture. This would help the user be more aware of their body and thus have a more helpful learning experience using the program (Figure VII).

Figure VII. Concept of a transparency-based muscle visualization system we could develop in future iterations of Pirouette VR

Conclusions

We believe *Pirouette VR* will be a great stride in the direction of advancing modern dance education through technology. In its current state, the application can be used as a review software for beginners in modern dance. Using the interactions provided for the virtual avatar, they will be able to review dances they learned in class within a studio environment. Students will be able to observe the dance from multiple angles in the world space, scrub through and pause the dances to observe a certain motion, as well as slow down the model's animation in order to practice the movements taught in class. This will help them to reinforce the spatial differences in their movements as they pursue a higher level of advancement in their respective careers.

Even though we have tried to make this application as accessible as possible, virtual reality as a platform still has its drawbacks. For one, the hardware required is still rather expensive, and thus may not be a cost-effective lab tool for dance educators. Also, although virtual reality headsets offer some mobility in comparison to a traditional dance studio, they still require a minimum amount of free space to be an effective learning tool for dance. We as a team would like to expand upon our user interactions further, but that would also require us to take into account the cost of extra hardware, such as body trackers or a motion capture suit, in order to create a deeper level of user interaction and immersion within the virtual studio. However, thanks to the feedback of dance educators and students alike, we believe we will be able to move forward with Pirouette VR with confidence. *Pirouette VR*'s advancements will provide new insights and ideas regarding how we approach modern dance education, as well as education as a whole, within the realm of virtual reality.

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CREATIVE ARTIFACT

Video

Description

A video demoing *Pirouette VR* within the virtual studio environment, as well as the ways the user can interact with the model.

File Name

PirouetteVR_PlaythroughDemo.mp4