Integrating Motion Capture Technology into Theatrical Performance

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Abstract

Motion capture technology is becoming more and more accessible to artists, and there is potential for wide integration into the performing arts. In particular, any feature of computer animation can be implemented into a theatrical production via live video projections or virtual reality sets. I set out to evaluate a commercially-available motion capture system and explore its artistic potential for the average user. I paired the Rokoko system, the first affordable motion capture suit on the market, with Maya, a 3D computer animation software.

A breadth of acting techniques can be applied to motion capture performance, so I worked alongside the MFA Actors at the UVA Department of Drama to explore the capabilities of the suit. During a week-long motion capture workshop, I captured data of the graduate actors' performances in a virtual costume and environment. Unlike current practices utilized on film sets, the actors were given live feedback of their virtual performance by watching a monitor displaying their avatar – responding in real-time to their movements. This setup allowed the actors to make adjustments to their performance on the spot and let them interact with objects in the virtual world. This user interaction led to more authentic performances, more creative, risk-taking acting choices, and more confidence in the final rendered animation's look.

After the workshop, the captured data of the actors' performances was fully rendered into 3D computer-animated videos. The actors and I discovered many use cases for motion capture performance, and I explored ways to further research and enhance the usability of these tools for artists and educators.

Introduction and Research

"The object of art is to crystallize emotion into thought, and then fix it in form."

– Francois Delsarte (1811-1871)

My Background

My journey as an animator and filmmaker started during my Second Year at the University of Virginia. As a double major in Drama and Computer Science, I've always been encouraged to push the limits of the technology in the medium of performance: from creating a 360-degree short film to utilizing cameras for actor-tracking projections. As I conducted research over the summer, my interest was drawn to motion capture's use in film and theater.

Over the summer, I attended SIGGRAPH 2021 virtually. SIGGRAPH is a conference where researchers, developers, and artists in computer graphics share their work with the public. I saw many presentations by major companies in animation, including the latest rendering and simulation techniques by the engineers at Disney/Pixar. In particular, I was inspired by presenters detailing their latest research utilizing motion capture technology. I eventually set my goal to evaluate the current state of this art, its shortcomings, and how it could be improved.

Application of Motion Capture in Film

In filmmaking, motion capture refers to capturing an actor's motion and physical performance, so that it may be translated into a CGI character (DeGuzman, 2021). The history of motion capture in film is almost as old as film itself. Early on, animators utilized rotoscoping to capture motion into drawn characters. Rotoscope is the process of drawing frame-by-frame over reference footage of motion (DeGuzman, 2021). Rotoscoping was slow and tedious, but it resulted in very realistic and convincing movement. Over the years,

various systems have been developed to capture motion directly from a person. Early motion capture systems were used in diverse applications – from robotics to military simulations to hospital operating rooms. After the advent of computers towards the end of the 20th century, the data of a person's movements could be fully digitized.

Currently, there are two main systems for capturing motion: optically or inertially. Optical systems usually utilize a camera and reflective markers to track joint angles. Inertial systems have mechanical sensors embedded within the suit, calculating joint position and orientation via magnetic receivers. Today, motion capture is an extensive field, with multiple methods chosen for any given project. Animators are trying to advance computer-generated imagery of humans to progress past the uncanny valley and into hyper-realism – to the point that we can now "resurrect" actors back from the dead with CGI (Allen, 2017). Some famous films to use fully motion-captured characters include the franchises of *Star Wars, Harry Potter,* and *Lord of the Rings*.

Fig. 1. *Peter Cushing in Star Wars: IV A New Hope (1977) (left) and his CGI counterpart in Rogue One (2016) (right)*

Application of Motion Capture in Theater

Compared to film, motion capture technology is not as widely implemented in other performing arts. Especially in theater, motion capture is still very expensive and requires current technical knowledge, which many smaller theater companies lack. For instance, in 2016, the Royal Shakespeare Company put on a production of *The Tempest* that had one of its fantastical characters, Ariel, portrayed by an avatar — projected live onto the set behind an actor in a motion capture suit. The show was a major achievement in theater, but it was only possible because the Royal Shakespeare Company is already very large and established. The RSC have the money and resources to experiment, especially as their production of *The Tempest* was a collaboration with Intel.

Fig. 2. *From the Royal Shakespeare Company's production of The Tempest (2016): Ariel (center) is wearing a motion capture suit, and his avatar (projected above him) is draped in a computer-generated fabric material.*

Recently, the Royal Shakespeare Company ventured back into the world of motion capture to try out a more ambitious and technically advanced production. During the pandemic, they created an entirely virtual reality, motion capture performance of an

adaptation of *A Midsummer Night's Dream*. Their computer-generated avatars weren't projected live on a screen, but instead, the show remained on a fully online medium. Audience members could log onto the performance as little lightning bugs to observe the tree-like characters move within the space. In actuality, the actors were wearing motion capture suits in a studio space where cameras could detect their movement via reflective "ping pong ball" sensors attached to their clothing. Everyone could remain fully masked and socially distant, so the show was a huge success during a time of need.

Fig. 3. *From the Royal Shakespeare Company's production of Dream (2021): Actors wearing motion capture suits interact with the audience inside a virtual forest.*

Motion capture is also experimented with in dance performance, especially as the character's virtual depiction doesn't need to be justified with a story. One motion capture development company, Noitom, created a dance showcase in 2019, called *Hidden Movement*. It was a virtual reality experience using their Perception Neuron motion capture system that tracked the movement of the dancer's limbs to create painterly overlays of lines. Unlike the Royal Shakespeare Company's productions, their dance videos aren't in real-time or live. The "light painting" effect is added in post-production, using the key points of motion tracking data on the body to draw lines that have a linear rate of decay. Thus, creating the "painting" effect we see sweeping across the screen (Perception Neuron, 2019).

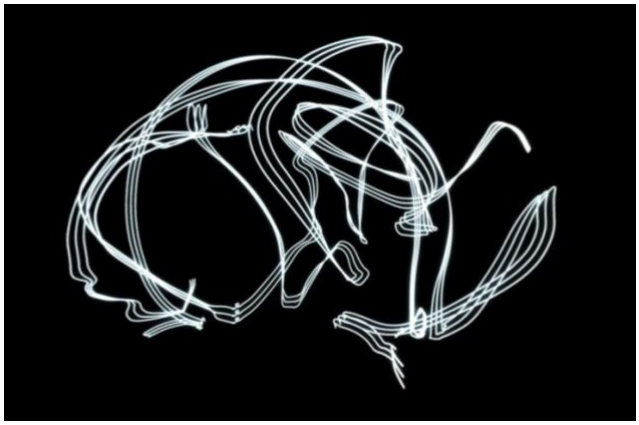

Fig. 4. *Still image from Hidden Movement, a multi-media art installation by Stefan Yazzie Herbert and Jolly Schwarz. After capturing the movement of the dancers, they use the data to create light trails in a 3D environment.*

Potential Implementations

Motion capture technology is the future of theater, film, gaming, and even social interactions. The Facebook "Metaverse" is a 3D virtual reality world where you can interact with anyone via an avatar you create. Even if a user is not a performance artist, the globe's interactions are migrating more and more onto an online format (on Zoom, social media, gaming, etc.). Anyone's public persona is now a performance, with every online platform operating as a "stage" that we all act upon (*The Theatre Times*, 2021). Motion capture is becoming more and more accessible and easy to use, and it will soon be a common tool in every household to embody your online persona. Therefore, now it is more important than ever to research and develop this technology. So I set out to evaluate a commercially-available motion capture system and explore its artistic potential for the average user.

Setup of the Rokoko System

After researching other people's artistic and technological achievements in motion capture, I knew I wanted to create something in this vein. For this project, I used a Rokoko motion capture suit that my advisor, Professor Kasra, acquired for the Digital Media Lab in the Drama Department. Rokoko's Smartsuit is the world's first consumer-oriented motion

capture suit on the market – and there is nothing else like it at this price point. The motion capture systems on Hollywood film sets cost millions of dollars and require an entire room of cameras and technicians to operate. Conversely, the Rokoko Smartsuit utilizes only fifteen motion sensors embedded at key points all over the body, such as the hips, joints, and head. The sensors work by detecting relative inertial motion from an original calibration and sending the collected data over WiFi to a computer. Thus, Rokoko doesn't require any cameras or external equipment, as older motion capture systems do. I knew right away I wanted to create a live demonstration employing this Smartsuit with the UVA Drama Department and study the potential of this interactive hardware system up-close.

Before I ran a motion capture workshop with actors, I first needed to set up many tools in Rokoko and Maya, including rigging various characters' skeletons ahead of time. While I tried out other Rokoko-compatible software, such as Isadora and Unity, I found that Maya worked best for my experience as an animator and my intention to render out high-quality footage of the workshop after it was over. Thought, the other software options have notable uses. For instance, Isadora is a 2D projection software that doesn't map motion to 3D models, but it works well for that "light painting" dance effect that *Hidden Movement* used (as mentioned in the previous section). As seen below, Isadora software can interpret the Rokoko suit's motion capture data into visually-immersive live dance performances.

Fig. 5. *A video tutorial by Isadora's creator, Mark Coniglio, showing how to integrate the Rokoko Smartsuit Pro with Isadora for real-time painterly motion effects.*

Components

This is how I implemented my Rokoko Smartsuit with Maya, but setups with other 3D software will vary from mine. The following components are needed:

- PC Gaming Laptop (with a powerful graphics card)
- Router or Hotspot (Settings → mobile hotspot on, power-saving off)
    - There will be difficulties if the suit connects to a school/institution's network that has firewalls and password-protected access.
- Rokoko Smartsuit and Gloves
- Portable chargers (external batteries for suit)
- Rokoko Studio program, Maya program, and the Rokoko/Maya plugin
- Rigged IK skeletons on various Maya characters

Time to Set Up

About 15-30 min (not including rigging the character models in Maya)

Pipeline

As the Rokoko Smartsuit and Maya are continuously updating and multiple versions of the software are available, please refer to the latest tutorials and manuals available. This was my pipeline at the time of research for integrating Rokoko Studio (v1.20) and Maya (2022) on Windows:

1. Create the skeleton of some characters in Maya. Parent the model to the skeleton.
    a. *Note that the key joints do not need to be perfectly one-to-one from the character to the motion capture suit's tracked points. Your character can have exaggerated, unrealistic proportions, and it'll still work in parenting to the motion capture suit.*

2. Set up the Rokoko suit to a router WiFi or mobile hotspot.
    a. *If using a router, make sure it has priority over the computer's default WiFi.*
3. In Rokoko Studio, pair the input to the DemoProfile.
4. Set "Livestream On" in Rokoko Studio.
    a. *This feature requires purchasing a Premium subscription to Rokoko Studio.*
5. In Maya, open a project, and start the plugin (automatically).
6. MEL code to open the Rokoko window: *showRSLM*
    a. *Or click on the Custom tab → the Rokoko symbol*
7. Click "Start Receiver."
8. Right-click on the DemoProfile, then click "Map to Active Character."
9. Wear the suit, calibrate, hit record, & start acting!

Performing a Motion Capture Workshop

Principles of Acting for Motion Capture

I eventually mastered my pipeline setup after conducting multiple tests in the lab with Professor Kasra and Camilla Galavis —a Media Design undergraduate who kindly assisted me, as getting suited up is not a one-person job. For our next step, we wanted to collaborate with a professional group of actors so we could focus more on the technicalities. Professor Colleen Kelly in the Drama Department heard of our project and invited us to conduct a workshop in her MFA Acting class. She teaches a studio course called "Acting: Period Styles," and motion capture would be the most modern acting style to ever be included.

The graduate acting students were excited by the opportunity to try out this motion capture suit. Motion capture acting is a promising area of study in their industry as the world moves more into digital production. 3D animation is also a great continuation of the Delsarte "mask work" they were already learning in class. Delsarte created a procedural system to

map a person's emotional state down to certain poses and expressions of the body and head. He believed that "emotions and feelings could be symbolically expressed through visual means" (Wallwork, 2015). Of course, this style of communicating emotions has largely fallen out of fashion in favor of more naturalistic portrayals. Modern acting principles, such as the 19th-century realism pioneered by Stanislavski's techniques, go far beyond simply "slouch when your character feels sad." However, it was Delsarte who systematically categorized these natural associations of body positions that are psychologically ingrained in human perceptions of emotion.

A similar principle of the body is taught in animation schools. The artists who draw characters highly exaggerate their poses to convey an emotion. From a character's exaggerated proportions (*Is a character top-heavy or bottom-heavy?*) to a character's posture *(Is their stance concave or convex?*), every design choice subtly conveys information to the audience about their personality and emotional state. As the animators are actors through their drawings, so are the MFA Acting students — similarly studying how to use their bodies as vehicles to convey the emotion of a persona.

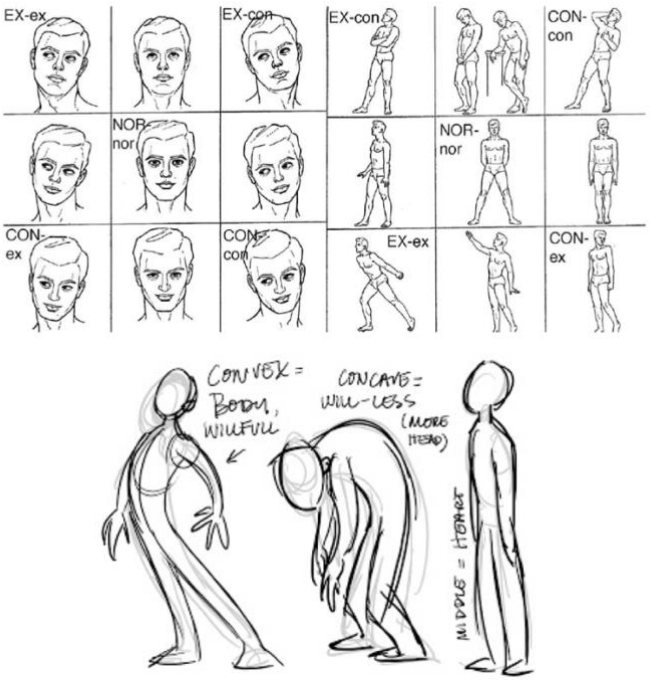

Fig. 6. *TOP: Delsarte's nine poses for the head and nine poses for the legs (Nixon, 2010). BOTTOM: Power is conveyed by a convex or concave body posture. (Wallwork, 2015).*

As seen in the figures above, Delsarte's principles of the body easily tie into how animators draw and exaggerate body positions to convey emotions. Therefore, this motion capture workshop seemed like a natural progression and inclusion into the MFA actors' curriculum.

From a computer science perspective, the success of an actor's portrayal using motion capture relies on the effectiveness of the software and sensor technology. Their motion capture data needs to be mapped accurately onto similar points of a three-dimensional character model and have a simple enough user interface for theater practitioners not engrossed in the practice to learn how to use it. A successful motion capture experience should also provide real-time feedback to the actors about the "virtual costume" they've put on. Only then can actors accurately evaluate their own performance and make adjustments as needed to their virtual character. I sought to achieve this through my own series of workshops with the MFA actors over the course of a week.

Goals for the Workshop

Before we met with the graduate actors, Professor Kelly and I set up some goals for the workshop to:

1. Familiarize the actors with the motion capture suit and let them become accustomed to this new medium of performance.
2. Test the technological potentials of our Rokoko suit, combining the suit and gloves with a live integration to Maya character models.
3. Allow each actor to perform a variety of scenes with characters of their choosing.
4. Receive feedback from the actors about their overall experience.
5. Capture the motion capture data from these performances and fully realize them in post-production.

The Workshop Itself

Over the course of a week, I came into the MFA actors' class on three separate days, working in 2-hour sessions at a time. The actors and I quickly learned a lot about the Rokoko suit's capabilities and limitations. Sometimes a foot sensor wouldn't work or a character's fingers weren't rigged, but that didn't stop the graduate actors from fully committing to the characters I brought in. The Rokoko suits are finicky and very sensitive to electromagnetic interference, which could cause a sensor not to work. The only solution was to restart the suit or record in another room.

Fig. 7. *Some of the models used during our motion capture workshop. They were downloaded from free websites such as Mixamo, Turbosquid, and Sketchfab.*

To prepare for our week together, the actors and I had a preliminary conversation about what types of characters they were interested in portraying. I brought in multiple rigged creatures of varying proportions: aliens, fairies, robots, monsters, and even inanimate objects. They ranged in limb length, weight, and age, so the actors could embody very distinct roles, some of which differed greatly from the human form. I also rigged a knight with a sword prop already attached in its right hand, which let us try out some motion capture fight

choreography. In the end, we created a series of short, animated sketches with all the hand-rigged models. The final renderings can be watched here: https://youtu.be/XXPJF4E0wOo

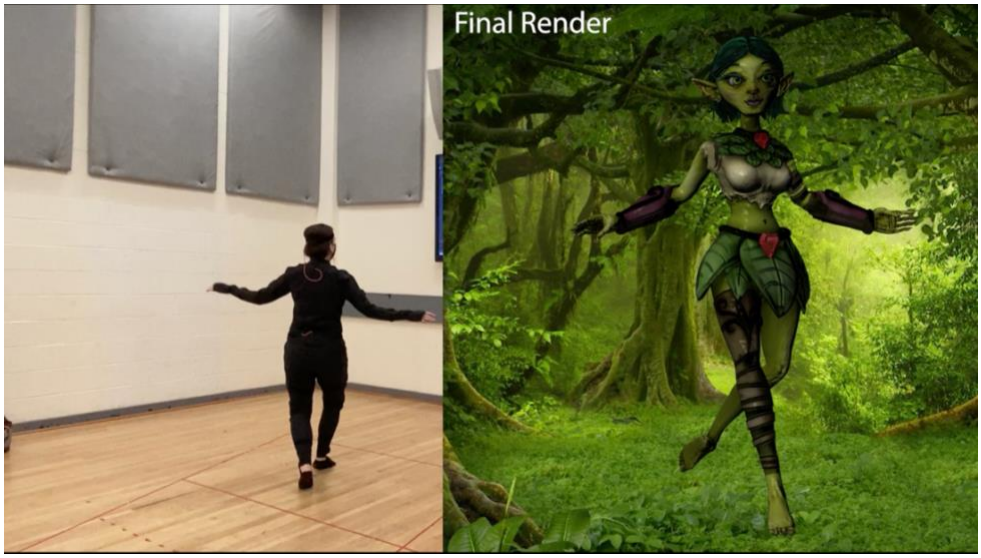

Fig. 8. *Haydn Haring as a forest fairy.*

On day one, Professor Kasra gave an introductory presentation on motion capture technology. As we suited up our first MFA actress, Hadyn Haring, we quickly realized some technical limitations of the Rokoko suit. No matter what, there will always be some lag in Maya, depending on how complex and how many polygons the character model contains. This is something the actors had to adjust to, as viewing their movement in real-time was sometimes delayed by a second or two.

In addition, the model had to be locked in place, with the "Locomotion" option turned off. Otherwise, the suit would lose track of the character's original location and the model in Maya would have a lot of lag. As a result, the character could not walk around but could only step in place. Having the "Locomotion" feature turned off led to some unique problems. For instance, squatting down looked like a jump because the hips were locked in the center of the screen. However, a jump just looked like the character was stationary on the floor. The actors quickly adapted to this limitation, modifying their characters' movements to accommodate not being able to travel far from the center or jump off the ground.

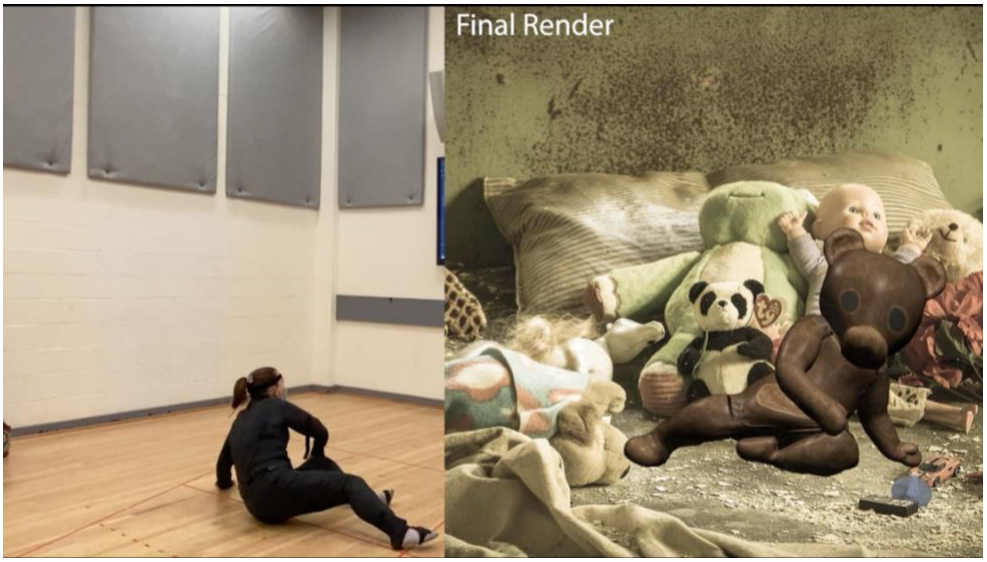

Fig. 9. *Christine Jacobs as a creepy teddy bear.*

Christine Jacobs (MFA Actor) noted in her teddy bear model that to make it more alive, she needed to utilize a lot more imagination of the character's weight and proportions:

> "Especially with these arms, it takes more to articulate them. And there's a weight thing too; I have to imagine these arms weigh more. Also, the way his head is set up, it's interesting where the [bear's] eyes are, compared to mine. My eyes are more where the nose is."

She also noted that she had to think about how the character breathes, exaggerating the motion to be seen under the teddy bear's large, padded torso.

Fig. 10. *Jack Clifford as an alien.*

Jack Clifford (MFA Actor) noted the challenges of motion capture compared to their physical mask work:

> "It's hard to match *that* [the character model] to what I'm used to doing. It's like the mask work that we've been doing, in that some masks feel easy to embody, and some are harder. And this one is much harder to find."

Cortney Lowinski (MFA Actor) remarked as Jack was portraying the alien model:

> "[This alien] is interesting, comparing your own musculature and joints to what's available to you in the character. Its overall structure is so different from our upright structure. To try to map that [to our body] and then move is so interesting."

This was a common sentiment among all the actors. However, after trying on the suit and testing where each Rokoko sensor was mapped onto the virtual character, they quickly improved their control of the model. Our suit had fixed sensors mapped to the standardized IK joints in Maya animation, but other optical motion capture techniques can be more flexible. In particular, for a camera sensor, reflective dots can be placed at non-standard points on the face/body. It could be helpful for the actors and programmers if future versions of the Rokoko suit included similar flexibility in its sensor placement.

Fig. 11. *James Stringer, Jr. experimenting with the Rokoko gloves as a robot.*

On day two, my assistant, Camilla Galavis, and I focused on trying out the Rokoko gloves. The actors learned that the gloves could handle models with varying numbers of fingers. For instance, on a cartoony, four-fingered glove (the "Micky Mouse"), the glove simply wouldn't utilize the pinkie finger's motion capture data. We hypothesized that a good use case for the gloves could be a character that was just a hand, like the Thing from *The Addams Family*. The actors noted that just using the gloves felt very much like puppetry.

Fig. 12. *James Stringer, Jr. performed stage combat as a knight with a sword.*

On this day, we also finally used a character who had a prop — a sword attached to a knight's right hand. James Stringer, Jr. (MFA Actor) could maneuver the sword live and perform stage combat virtually. He noted after his performance that:

> "It feels good, but it does need to be bigger in this for it [the suit] to pick up. Actually spreading the legs and getting the arm movements in that. It's got to be exaggerated; otherwise it's just going to look flimsy and not as strong."

Similar to how stage combat needs to be much bigger to be visible from the audience, motion capture fighting needs to be heavily exaggerated to be visible underneath the dilution of sensed movement. Adjustments need to be made to any fight choreography, like a parry needs to be further out from the body to be visible.

We also utilized this opportunity to test viewing the character model from other angles. One of the main features of Maya, as opposed to other Rokoko-compatible software, is that it allows movement of the camera. One can view the character from behind, which, as James noted, felt a more natural way to view his knight doing fight choreography. That way, his character wasn't mirrored when viewed from the front. This was an instance where not watching the monitor was more beneficial to the performance. Once James let go of watching himself in the monitor, he utilized the 3D space more, addressing enemies attacking him from all directions instead of just the front.

The character model, combined with a sword prop in its hand, exposed another shortcoming. Because of the imprecise nature of the Rokoko suit, it could not correctly determine the relative positions of the hands. Sometimes the hands couldn't connect together on the prop, both grabbing onto the sword. There would be a visible gap between the hands, despite the actor holding onto a physical prop weapon. However, stage combat could lead to other use cases of combining recorded takes. In theory, we could record both sides of a fight and then put the two characters together in the same scene – fighting each other!

Fig. 13. *James Stringer, Jr and Christian O'Neill performing a scene together. Inhabiting this fantastical, long-legged monster is possible thanks to computer animation.*

By day three, we fully tested the Rokoko suit to its limits, trying out every possible suit/glove combination we could imagine. For example, we let three actors control one body: one on each glove and one wearing the suit. They performed a short monologue where the gloves were the devil and the angel on the shoulders of the body. For the next use case, though challenging and impractical, we had one person wearing the gloves and another wearing the suit — but both were connected onto the same character model. This is a common technique among puppeteers, where multiple people operate the limbs of a single puppet. However, because the Rokoko suit works based on relative location, it was difficult to interpret the data from two different body locations. As well, the suit is only so good at fine detail movement. The character couldn't accurately do small, simple tasks — such as flipping a coin.

Finally, we increased the length of our motion capture recordings drastically, from just a few seconds to over a minute at a time. The Rokoko suit could handle longer recordings, but some sensors would lose calibration mid-recording. For instance, a hand could just fall off calibration in the middle of a take. Additionally, after the conclusion of a recording, it took about a minute for Maya to catch up and key all the recorded frames in a

given recording. We used this time as a moment for the actor to rest and discuss how the recording went before we could view it.

In conclusion, after a week of motion capture experimentation, the actors felt excited by the opportunity and the experience they gained from these workshops. The full potential of being "anyone, from any angle" took hold of us, and I continued to bring in new models for the actors to try out as the week progressed. The actors noted how this experience reminded them a lot of puppetry, and the challenges were similar — Like where should the actor look? At their scene partner or at the puppet [monitor]? How does the actor navigate the character's relationship in the scene and interact as the puppet character? These are some further explorations for an actor interested in pursuing motion capture performance.

Post-Production

After the workshop, I staged the motion capture data with lighting, sets, and a moving camera. One advantage of Maya is that, after recording the movement, an animator can tinker with the scene all they want — adding in different lighting, additional props in the character's hands, or even switching out a character model's skin altogether. The final footage can be set precisely to the client's desires, testing out single rendered frames until it matches the desired look. Next, I proceeded to render out every frame of the actors' performances and edited them side-by-side with footage of the corresponding actor in the suit.

Something very peculiar I noticed only after lining up the rendered animation side-by-side with the workshop footage was how *off* the recorded motion was. For instance, I'd call "action" in the video, but the recorded animation would only start a few frames/seconds later. Then, the animation would end far before I yelled "cut" in the footage. It seems like there's a noticeable delay in the actual recording of frames, for which one would need to keep an eye out when creating a bigger production. Additionally, I had to *slow down* the rendered

animation to align perfectly with the actor's movement in the video — by exactly 70%. This was shocking, as it meant the animation was playing much faster than the actor's original speed. I assume this is due to the lag of recording, that the program was simply skipping frames to keep up with the real-time movement. Nevertheless, this is something to keep in mind when conducting motion-captured performances.

Takeaways and Implications

Observations & Potentials

- The Rokoko Suit is easy to learn and understand.
- The suit can be easily implemented in a small studio or classroom setting.
- The suit is affordable for the consumer (compared to other systems).
- The suit faithfully captures large and bold movements.
- Motion capture allows the actors to portray any kind of character: human, nonhuman, or imaginary, with varying proportions, dimensions, and appearances.
- The character model can be viewed from any angle or mirrored.
- A character's size and proportions can be changed during the performance. (For example, the shrinking of Alice in *Alice in Wonderland*.)
- Any feature of computer animation can be implemented into a theatrical production via video projections or virtual reality (Camera angles, cuts, sets, lighting, etc.)

Challenges & Areas for Improvement

- The suit is not good at capturing delicate movement due to its relative-motion sensors. (For example, it was challenging to capture a hand flipping a coin.)
- More accurate motion was recorded only when "Locomotion" was turned off, and the model's position was locked in place.

- Movements in the vertical and horizontal axes were limited because the suit can only wander off so far from the center calibrated point (such as the glitchy-looking jumps).
- The suit is sensitive to electromagnetic interference and will result in faulty sensors.
- The suit needs to be recalibrated very often, leading to trouble at the end of long recorded takes.
- The Rokoko system is not made to have one actor wear the gloves and another actor wear the suit – the software found it challenging to combine both sensor inputs onto one model's body.
- The display of the 3D model's movement had a slight delay, which took some adjusting for the actors. In some circumstances, we had a better outcome if the actors didn't look at the screen while performing.
- This is one of the first generations of this suit, and the company acknowledges they're still working to resolve these setbacks.

Reflection on the Motion Capture Workshop

During the workshop with the MFA Actors, several use cases were successful, but some were less so. We were able to become a variety of characters that had no relation to the human form (such as the alien and long-legged monster). The alien, in particular, was most impressive because it had extra joints in its legs, appendages (like a tail), and nonhuman proportions. But thanks to clever mapping of the Rokoko Suit's sensor points to the alien's IK skeleton, I was able to achieve convincing movement. These supernatural characters highlighted a main benefit of motion capture: an actor can be anyone, from any angle, from anywhere. Regardless of an actor's size, gender, and physical capabilities, they are no longer bound by the limitations of reality on the square of a stage. Motion capture can enhance and amplify any performance, allowing the actor to put on any imaginable costume.

Some actors mentioned that this experience reminded them of puppetry work they've done in the past. Motion capture raised similar challenges as puppetry: Where does the actor look? Who is the scene partner? And how do the actors navigate their relationship in the scene while embodying the puppet character? However, I believe that motion capture bridges the gap between mask work and puppetry for an actor. Mask work uses the body to morph into the physical mask/costume one puts on. Actors can change their outward appearance, but they cannot escape the limitations of their physical dimensions. Meanwhile, puppetry is animating a different object, separate from your body. Motion capture represents both. An actor can fully animate a being separate from themselves, utilizing their body's motion to become the character. However, in motion capture, an actor can entirely escape the bounds of reality, playing a character of any proportion, dimension, and appearance.

Concluding Thoughts

This suit was designed and marketed mainly for three-dimensional animation. My workflow, including setting up a monitor of real-time feedback to the actors, optimized production for the medium of film. When actors see themselves and get immediate feedback on how they're doing, they quickly make self-adjustments and can do multiple retakes. That way, in post-production, animators won't have to go back and adjust their performance later. This pipeline is not possible with existing camera-based motion capture systems, which take months of post-production and clean-up after the recording. If the suit were more accurate with fine motor movement and needed less continuous calibration, it'd surely be a success among higher-end film studios as well. My pipeline is a twist on today's conventional filmmaking process, which takes months to go from a green screen to the final product.

Motion capture also has endless opportunities for theatrical productions. Any feature of computer animation can be implemented into a theatrical production via video projections

or virtual reality. Now that the camera and lighting can be animated in the virtual world, video projections can give the audience a point of view that wouldn't be possible from their seats in the house, incorporating any camera movement. For example, we could actually see Alice shrink in *Alice in Wonderland* with a simple dolly out. People are so used to the language of film that they will connect immediately to seeing it portrayed on a stage. Another benefit of motion capture is that a theatrical production can virtually design and plan most of a show. The director and actors can block out most of the show, saving on money and time. The set, costume, lighting, and sound can all be designed within the virtual world and interacted within it long before construction is completed. The director can have a good idea of the final product without using a large rehearsal space. Motion capture is an excellent tool for collaboration, alignment, and refinement in the production process.

Finally, motion capture is an excellent tool for educational settings in schools of Drama. This paper demonstrated my personal pipeline for hosting a motion capture acting workshop so college educators can use this workflow in the future. Online public personas are now a performance, and motion capture will grow in popularity for personal uses, such as social networks and gaming. There is still much research to be done in this field — exploring how a user could interact with virtual objects in real-time, methods of incorporating a motion capture character into a theatrical space, and of course, making sure these technologies are accessible for artists and educators to use. Therefore, now is a critical time to research and enhance the usability of these tools for motion capture performance.

Documentation

The final animated renderings, side-by-side with our workshop:

https://youtu.be/XXPJF4E0wOo

A longer, behind-the-scenes video of the workshop process (6 hours of our workshop condensed into 38 minutes):

https://youtu.be/7CfY2c2IJR8

Acknowledgement

Special thank you to Professor Mona Kasra, Professor Colleen Kelly, Camilla Galavis, and all the MFA Actors at the UVA Department of Drama (Jack Clifford, Auntais Faulkner, Haydn Haring, Christine Jacobs, Cortney Lowinski, Christian O'Neill, Brian Willis, and James Stringer, Jr.). This deep dive into the world of motion capture would not have been possible without you.

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