The Digital Theatre: Utilizing Computer Science to Create an Emotional Aesthetic Within a Live Performing Arts Setting

A Technical Report submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Computer Science

Jeffrey Lionel Mouritzen

Spring, 2023

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

Advisor
Briana Morrison, Department of Computer Science

The Digital Theatre: Utilizing Computer Science to Create an Emotional Aesthetic Within a Live Performing Arts Setting

CS4991 Capstone Report, 2023

Jeffrey Mouritzen
Computer Science
The University of Virginia
School of Engineering and Applied Science
Charlottesville, Virginia USA
jm8gw@virginia.edu

ABSTRACT

For the UVA Drama Department production of *When The Rain Stops Falling* (*WTRSF*), show designers were faced with the unique challenge of incorporating *extensive* use of projection technologies into a production written without such technologies in mind, on a level that had yet been done at UVA. Projection designers, technicians and operators, including myself, were tasked with developing and programming a sequence of projected videos onto the theatre set in a way that both fit the creative vision while adhered to the limitations of the technologies at hand. Our success in bringing the vision to life lay in our collaboration, our resourceful use of programming techniques to lessen technical operation stresses, and our ability to adapt quickly when faced with technical challenges. While there are still ways the process could be improved in the future, we feel satisfied with the success the show received, and believe the creative vision was delightfully actualized. We are confident that this technology can continue to enhance the performing arts when used correctly and purposely.

1. INTRODUCTION

In the fall of 2021, I was given the opportunity to work with Mono Kasra, an Associate Professor of Digital Media Design at the University of Virginia Drama Department, to design and engineer a sequence of videos and images that would be projected onto the set of the then upcoming UVA Drama production of *WTRSF*. This sequence of projections was to span the entire 2-hour long show, and take up most of the background that the audience could see when they watched the stage. The sequence had to be controlled and operated to adhere to the ever changing pace of live theatre, work with the space being projected to, work efficiently with the technologies at hand (such as the projector), be able to change and be edited on a moments notice, and be easy to operate in conjunction with other technologies at use (including lights and sound).

The bringing projection art to this show would prove to be considerably ambitious. It was early in the design process that the director came to the consensus that projections for this show should not simply aid the story narrative, but instead *construct the aesthetic*. The projections were expected to be enormous, taking up far more space than anything done in the Culbreth theatre prior. If the projections were distracting or riddled with technical errors, it was going to be so visually apparent that it could very well ruin the show. It was important for the designers and operators to take the work seriously and collaborate heavily throughout the entire production process, from the first inception to the final curtain call. We were prepared to throw everything we had at this engineering challenge, to produce the creative vision we wished to achieve.

2. RELATED WORKS

To understand the development process behind creating a projection-heavy theatrical production, it is important to comprehend the technology's past use and development in the performing arts industry. Hopgood (2021) provides is a comprehensive guide that covers the basics of projection technology to the latest developments in projection mapping and interactive installations. He includes interviews with leading projection designers from Broadway and regional theatre, providing insight into the creative process behind stunning projection installations worldwide. Throughout the book, the author emphasizes the importance of computer science in projection design, arguing that advances in computer technology helped revolutionize the field. He discusses the software tools and programming languages used in projection design, such as Isadora, TouchDesigner, and MadMapper. My project utilizes Hopgood's guidance to better understand the most effective way of using projection technology within a theatrical production.

In addition to understanding the creative process, it is essential to understand the CS-related system that UVA uses for productions, particularly the software Isadora. Isadora is a visual programming tool that enables real-time interactive multimedia performances and projections. Throughout the production, I consulted Isadora tutorials to find solutions to programming challenges. The Isadora website provides detailed documentation, tutorials, and a community forum where users can share experiences and ask questions. Additionally, various video tutorials on YouTube from TroikaTronix demonstrate using Isadora to create specific installations and performances, take advantage of inputs and outputs, and realize one's creative vision (Martin, 2021).

3. PROCESS DESIGN

The process design for this project is described below.

3.1 Review of System Architecture

Not all details are provided to me about the UVA Culbreth Theatre's projection system, since I only worked as an assistant designer and operator. The setup has also been deconstructed to some extent to accommodate other shows in the space. Nonetheless, I am familiar with enough of the setup to offer some insight into the physical setup, with help from Hopgood (2022).

The projector used was an EB-PU1000 Series Epson projector capable of up to 10,000 lumen level projection. It shot rear projection from the back of the stage to avoid projecting images onto actors and set pieces. Projections were cued and operated by an operator working backstage on an iMac computer. Other technical operators for light and sound were stationed in the tech booth behind the audience. Communication between the operators and stage managers was through the theater's centralized wired communication system. The projection crew typically used Isadora software, while sound and lighting crews used more generalized software like QLabs. Although the varying software could accomplish similar tasks, the differing developmental processes for the lighting, sound, and projection crews caused variation in the operation of each tech element. It was, therefore, infeasible to integrate cues into one singular application during the final tech weeks.

3.2 Client Technical Needs

When the artistic staff of *WTRSF*, led by artistic director Marianne Kubik, committed to using a high degree of projections, the success of the show began to depend on a number of requirements. Twenty-two distinct scenes needed to be covered with videos and special effects in a way that fit the creative vision and scene aesthetic, and each scene transition had to be smooth and dynamic so as not to distract from the action on stage. The videos had to be high definition to justify the large screen they were being put on, meaning they were highly demanding of good performance from the hardware system in place. Technical glitches or other shortcomings were unacceptable, as they would take away from the immersive performance. The content and cues related to the projections for each scene had to be consistent and repeatable for all the shows, but also had to allow for variability and adaptability based on the pacing of the live performance. To add to the complexity, the programmed projection sequences and videos used had to be capable of being edited if necessary up to the day of the show. Such changes may include anything from adjusting video cropping and framing on the screen, to additional projection mapping and keystoning, to outright changing videos that do not quite fit. Last, the whole projection system had to be integrated with other technical elements (such as sound and lighting), performance elements (like actor blocking), and confidently managed/cues by stage manager Kathleen Mueller.

3.3 System Limitations

Designers and operators had to creatively work around two major limitations. First, there were computational limitations regarding live video rendering. The iMac system that fed the projector its images was indeed powerful, but the maximum load level could potentially be exceeded if the videos and projection sequences were excessively complex and resource demanding. In extreme cases, it could cause the projector to lag out, or even cause the Isadora software to crash. The second major limitation was the hardware cabling and setup of the projector. The cabling was limited, both by design (shorter cables meant less harmful latency between the computer and the projector) and because projection resources were slightly more limited (as compared to the lighting setup, which was used more frequently in that space). This is why the projection operator worked backstage—the rear projection setup did not allow for the operator to be as far away as the tech booth.

3.4 Challenges

When programming the projection sequences, balance had to be struck between the system limitations and the creative vision. Our first challenge was that the load limitation caused significant fluctuations in performance, requiring a reconsideration of computational resource use. While the programmed sequences worked well on smaller screens, everything was scaled up dramatically when done on the mainstage. Videos had to be crisp and high definition, and all videos and scene transitions had to be free of lag and buffering. During tech week, we found that lag and buffering noticeably persisted due to a high load level, which originated from poor computational resource management during the earlier stages of programming. This was most apparent during scene transitions, where the “framing” of the projected video was meant to change through the use of clever dynamic video cropping, all while the video would transition to a different video of a different setting. To achieve this, multiple overlaid videos with changing crop values were programmed to play at once, allowing for a seamless transition. Once scaled up, however, playing multiple videos was infeasible as it would cause the load level to skyrocket, overwhelming the system and causing the projections to be laced with distracting stuttering frames (as shown in Figure 1).

Figure 1. Isadora Performance Lag

Another technical challenge was the complexity of the sequences, in the sense that it was difficult to manage from the perspective of the stage manager. Since the projection operator was physically separated from the other crew members by the system hardware limitations, all cueing had to be done over wired communication devices. The operator could not see the action on stage and could not use their own judgment when cueing scenes; they had to rely entirely on the callouts of the stage manager. If excessive operator interaction was required when controlling the programmed sequences, the stage manager would get overwhelmed and make mistakes. Kathleen Mueller, our stage manager, was in charge of the callouts for all tech elements, including lighting and sound. Even with a cue sheet in front of her, it was very difficult to say all of the cues over the microphone in time. This challenge came to light especially during tech week, as the separate cues for all the technical elements finally came together for the first time. At this point, we were not confident that our program was sufficiently user friendly and consistent enough to be done without human error.

3.5 Solutions

Under a very limited timeline, we, as computer science and theatre tech experts, were tasked with editing our projection program to address the concerns. Our first challenge was reducing the computational load to achieve stutter-free projections. We reworked sequences by limiting the use of multiple media players using up CPU space. Transitions would no longer feature overlapping videos that ended up "chasing" each other due to lag. Instead, sequences were designed so that the frame changes happened independently from the video changes, and the video changes would fade in and out to ensure only one video was using computational resources at any given time. This freed up the processing power significantly, which allowed for smooth stutter-free transitions between settings. Unfortunately, the solution also conflicted with the original creative vision somewhat by reducing the level of dynamism in the transition. Changing videos by fading to black was not as compelling as seeing the video metamorphose before one's eyes, but the creative sacrifice had to be made in order to fix the more distracting issue, based on the system limitations and time constraints.

The next challenge was to simplify and automate the projection sequence as much as possible, for the sake of reducing human intervention and potential human error from Mueller or the projection operators. Cues were cut and combined, as well as synchronized (wherever feasible) with the newly available lighting and sound cues through the use of timing operations. These changes meant that less callouts from the stage manager (and button presses from the operators) were necessary, which drastically reduced opportunities of human error. It was still not ideal to physically separate the projection operators from the other crew members and rely on such a fragile callout system, but our changes allowed for more confidence nevertheless.

4. RESULTS

After all the necessary edits and changes were made, our programming solution consisted of only 25 cues and button presses.

The load of the program at the most intensive moment (a quick, full screen scene transition about halfway through the show) was reduced by over 40%. The show ran for six nights, during which the projection system operated phenomenally without a single noticeable technical fault. Despite the slight changes to the original creative vision, the show was a significant commercial success in Charlottesville, and received much praise from theatre critics for its impressive use of projections. No equipment upgrades were necessary, meaning technical production costs were overall lowered due to our successful programming solutions. Not too bad for the largest projection design undertaking in UVA theatre history.

5. CONCLUSION

This experience has proven to me that large-scale projection use in the theatrical space is feasible and rewarding, allowing for a uniquely breathtaking theatre experience. It demonstrates that the intersection of computer science and the performing arts can elevate the art form in new, exciting ways with minimal drawbacks. The success of *WTRSF* cements this technology as an exceptional storytelling device that will almost certainly see use in future theatrical productions at UVA. From a personal perspective, it was very rewarding to have utilized my computer science background to develop engineering solutions to the problems we faced, and I am confident that I am prepared for my next endeavor into the technological world of projection design.

6. FUTURE WORK

It is my suggestion to the UVA drama department that improving upon the limitations of the hardware within the Culbreth theatre be the next step forward in preparing for another projection-related project. Even though we were able to work around it, it is not the most feasible solution to have the projection crew separated from the rest of the crew, particularly in the case of an emergency. I would also suggest that computational hardware like the iMac would benefit from an upgrade, so that technical performance issues do not detract from the creative vision moving forward. This technology has a lot of potential, and I cannot wait to see it be further utilized and improved upon in future productions.

REFERENCES

Hopgood, Jeromy. (2022) The Projection Designer's Toolkit. Routledge, Taylor & Francis Group, New York.

Martin, Monty. (2021) Isadora 101. [Tutorial series, TroikaTronix] https://support.troikatronix.com/support/solutions/folders/13000017887

Oliszewski, Alex, et al. (2018) “Chapter 3: Digital Media Design Process And Workflow.” *Digital Media, Projection Design & Technology for Theatre*, Routledge, Taylor & Francis Group, New York.