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**3D Visualization of Theatrical Lighting Designs**

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**The New York Public Library for the Performing Arts, Billy Rose Theater Division**

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## **The challenge**

Lighting designs present one of the most difficult preservation challenges for archives of theatre production. The relevant documents are inscribed on various unwieldy media, such as large “light plots” (ground plans showing the deployment of lighting equipment) that are often stored rolled, and so must be temporarily flattened to view. Today, many lighting designers now draft their work using digital tools. Professional lighting designers regularly use a very specialized piece of software, Lightwright, designed by lighting designer John McKernon in the 1980s, that creates a document that resembles a kind of specialized spreadsheet for lighting hookup information. In addition, many lighting designers use Vectorworks, a design tool with some 3D features, but which is most often used by designers to create 2D diagrams of lighting and set designs. Preserving these file formats is as important, and as difficult, as preserving the physical versions of this kind of work.

Even when all of the documentation is safely preserved, studying lighting design in archives can be difficult as, in many archives, the essential paperwork is collected in different boxes and folders, and reading rooms are not designed for studying many different parts of a collection together at one time. Around ten years ago, working with Broadway lighting designer Beverly Emmons, The New York Public Library digitized a virtually complete set of lighting documents for three productions and made them accessible in the Library’s Theatrical Lighting Database. While access to these rich collections is extremely valuable to lighting designers, for many humanities scholars (theatre historians, historians of material culture and technology, etc.) a light plot from the 1970s or front elevations for set designs may not be intelligible.

In 2014, Doug Reside, the current curator of the Billy Rose Theatre Division of The New York Public Library and Gregory Lord (a Digital Humanities game designer at Hamilton College) conceived of a new way of studying historic lighting designs. Scholars and archivists often use software “emulators” to simulate older computing environments. We wondered if it would be possible to create an emulator for a theatre in which one would replay productions that had long since closed. Of course, an emulator of historical lighting designs would be similar to “previsualization” software used by some lighting designers to model new designs for collaborators. Our survey of existing software used by New York area theatre designers suggested that there remained space for the development of a new tool specifically designed to render historical lighting equipment. Further, we could not identify an open source tool that could function as a web app — a requirement in some archives in which installing proprietary software on institutional computers requires complicated exemptions to standard policies.

Lord had been impressed with the capabilities of the Unity game engine for rendering lighting effects in a variety of environments. Emmons was also interested in the project, but expressed some skepticism that current technology would be able to accurately render lighting design to the degree that the simulation would be useful. We decided to conduct a feasibility study by building a working prototype of such a tool in Unity and attempt to replicate the lighting design of several shows.

## **Environmental scan**

Although we are unaware of any attempts to emulate historical lighting designs using web-based 3D models, there are several related projects that have been published online in the last fifteen years. In 2001, Christa Williford surveyed 3D digital reconstructions of French Theatre created in a moment before 3D models could be easily displayed on the web. One of the oldest, web-based projects, David Saltz's Virtual Vaudeville project at the University of Georgia in 2004, included an impressive 3D model of a Vaudeville theater presented in Shockwave Director. An animated recreation of several Vaudeville acts were "staged" in the space and lit using digital approximations of period lighting. In the brief, mad, moment in which half of the digital humanities community was obsessed with Second Life, several recreations of the Globe and other historical theatres were constructed within the virtual world, but these served either as museum pieces or else as playing spaces for digital performance (mostly without special lighting). Hugh Denard of King's College has recently finished construction of a recreation of Dublin's Abbey Theatre in Unity, but this, again, is a project more focused on historical architecture than lighting design.

In addition to The New York Public Library's own Theatrical Lighting Design Database, there have been several archival projects which seek to preserve and make accessible the paper documents of lighting design. Lighting Designer Beverly Emmons has independently continued the work she started at NYPL in her own website, <<http://theLightingArchive.org>> which preserves lighting documents for thirteen additional shows (and includes a screenshot of an ESP Vision model of a design for the Broadway revival of *A Chorus Line*). Community-run websites such as <<http://klieglbros.com>> and the Strand Archive <<http://www.theatre crafts.com/archive/contents.php>> preserve catalogs and other information about historical lighting equipment. All of these will be useful data to use for the simulations we plan to create, but none of these provide a way to simulate what lighting effects this equipment could produce.

## **Narrative of project work**

### **First meeting (May 2016)**

During this first phase of the project we sought to answer the questions: "Can current web-based 3D engines (like Unity) sufficiently reproduce theatrical lighting in a way that is useful to humanities scholars? Will designers feel comfortable having their work represented by this kind of emulation?" To answer these questions, we gathered a group of lighting designers, software developers, and scholars to advise our work. Following an introduction from NEH's Office of Digital Humanities, Shannon Schweitzer—an expert in the Swedish software Capture—was added as a consultant. In addition to the features present in many other previsualization systems, Capture specifically works to maintain a database of information for simulating historical lighting instruments. In the weeks prior to the meeting, Schweitzer and his colleagues and students at Michigan State University recreated the first scene of *Sunday in the Park with George* using Capture and the digitized paperwork from Emmons' Lighting Database..

We held our first meeting in-person at the Library for the Performing Arts in May 2016, and second via Google Hangout in July 2016. Meetings were attended by members of partner organizations

and named consultants (full list included in Appendix A). Shannon was introduced at the May meeting, where he also demonstrated the software by presenting his Capture visualization of *Sunday in the Park with George*. An additional virtual model of the Vivian Beaumont Theater at Lincoln Center, created in Unity, was presented by Lord. These reproductions are used as the basis for the test of the system to see whether we can emulate lighting designs usefully in gaming software. The tool Lord prototyped does not create designs (which Capture is capable of doing) but simply imports designs that have been created with other tools (e.g. the open source 3D modeling tool, Blender).

In addition to viewing these models, attendees at the first meeting also reviewed the goals of the project. We resolved to incorporate *Capture* into the project, specifically as an input into the viewer tool Lord was developing. Schweitzer agreed to model at least two shows using Capture, and Lord would then try to import the data from the software via a viewer that connects moments in an emulated lighting design to the archival documents that describe them.

### **Project work (May 2016-February 2018)**

Over the following two years, Lord and Alex Coulombe refined the Unity tool, and Schweitzer and a team from Michigan—working with Emmons and scenic designer John Lee Beatty—reconstructed the first scene of the 1995 Lincoln Center Theatre revival of *The Heiress* in Capture. John McKernon transcribed the original paperwork of *The Heiress* into Lightwright, and this data was imported into Capture as well. It quickly became clear that the Capture data model (exported as a “comma separated values” or CSV file) could serve as a draft preservation data format for lighting designs. The ability to import Lightwright and Vectorworks files into the software suggested Capture is emerging as an ideal exchange format. Lord coded a function to pull data exported from Capture into the Unity program, allowing us to playback the lighting of *Sunday in the Park with George* in Unity.

Alex Coulombe provided the project with 3D models of two theatres: a reconstruction of Shakespeare’s Rose Theatre, and a standard proscenium theatre. These were imported into the app in addition to a very rough recreation of Broadway’s Vivian Beaumont Theatre created by Lord based on archival ground plans and production photographs. These allow the user to examine the lighting design in several different kinds of theatrical buildings, from the contemporary thrust stage of the Vivian Beaumont to the pillared, Renaissance-era Rose, to the now more standard proscenium style.

After Reside and Lord reviewed Greg’s tool, they agreed that web 3D engines were not yet capable of real-time rendering of hundreds of lights. Although Unity would enable us to deliver a web-based app, this did not allow for the nuance of real lighting — the addition of more than a few dozen lights quickly turned the stage entirely white. We did, however, find the Unity app compellingly easy to use as a quick way of visualizing lights and making minor edits to cues. Additionally, we made minor interface changes to the app to also make it available for the Oculus Rift Virtual Reality (VR) platform, allowing users to examine the lighting design in an immersive environment. The VR app requires a powerful gaming machine with a dedicated graphics card to run, and even with significant processing power could not handle the full feature set of the desktop app. It remains, though, a compelling prototype, demonstrating the power of VR for visualizing historical theatres and designs.

## **Final meeting**

On March 9, 2018 the team held its final meeting and hackathon to review the work we had accomplished thus far, and attempt to reconstruct a new lighting design using the techniques we had developed over the course of the funded period. We reviewed the reconstruction of the set of *The Heiress* with the original designers and looked at the tool built by Lord in Unity. We also reviewed the video recording of the production in the Theatre on Film and Tape Archive for comparison's sake. The general consensus amongst the designers was that the video documentation was the best record of the original show, but that the recreation in Capture was of some value for the way in which it allowed users to view the scene from different angles not captured by the video. There was also a strong feeling that the design could not be fully recreated without a representation of the performers who serve as the focus point of many of the lights, and their costumes which often affect the choices made by the other designers. Recreation of human-like figures that can move realistically through the set and lights was outside of the scope of this project, but the designers strongly believed this is necessary to fully understand the lighting design.

The team also reviewed Lord's new open source Unity-based tool for visualizing designs on multiple platforms. While the group was generally impressed with this prototype and reacted especially positively to the ease with which Lord's interface allowed the user to move about in the theatre to view the design from multiple perspectives, it was generally felt that the app could be most usefully developed as an educational tool or game for students learning about lighting design for the first time.

## **Hackathon**

Following the meeting, NYPL hosted a Hackathon for lighting designers and software developers interested in experimenting with our tools and processes. During the Hackathon, most of the participants attempted to recreate the original design of *Sweeney Todd* with original lighting designer Ken Billington using scans of the archival paperwork. Several participants modeled sets using computer-aided design (CAD) software such as Autodesk and Sketchup. Billington worked closely with Shannon Schweitzer to recreate the lighting in Capture. During the day, the participants could interact with Lord's app in VR using the Oculus Rift and watched the Theatre on Film and Tape archival recording of the original production of *Sweeney Todd*.

By the end of the day, most of the lights were hung and a good portion of the set had been recreated. The process of recreating the lighting design virtually while the original production played on the monitor also led Billington to recall the process of creating the original production and share his memories as the team worked. Many participants felt this was one of the most fascinating parts of the day. Unfortunately we did not record these stories, but there was interest in repeating the experiment with another show in the near future, possibly with microphones at the ready.

## **Future plans**

The educational possibilities of Lord's Unity app are intriguing. While the team agreed that it could not compete with Capture as a professional visualization tool, the ease with which one can

simulate fairly complicated lighting designs, and its ability to import existing lighting designs from Capture suggests enormous potential for students learning about lighting design. Designs created in Capture could be imported into the app and dissected to learn about the decisions professional designers might make, even if the simulation of the lights in the app are not an entirely accurate representation of the way they might have appeared on stage. Reside and Lord are currently in very early discussions with several funders of video games to investigate whether there might be interest in funding the further development of the app along these lines.

Additionally, the process of recreating *Sweeney Todd* led Schweitzer and Billington to consider the possibility of recreating *Fiddler on the Roof* from the extensive archives in The New York Public Library's collections. This time, more members of the original team (possibly lyricist Sheldon Harnick and producer Hal Prince) would participate, and their conversations could be recorded as a way of capturing an oral history of the creation of the musical that could exist alongside the recreation. Initial plans to document a new regional production of *Age of Innocence* at Hartford Stage with project participants and scenic designers John Lee Beatty and Kacie Hultgren using Capture. Capture staff have agreed to help by adding new lights to the software whenever needed and working with project participants as the experiment continues.

## Conclusions

Among the scholars, developers, and designers assembled at the final meeting, there seemed to be a general consensus that neither Capture nor our app, in their current versions, can compete with a good video as a means of documenting lighting design. However, there was a sense that the visualizations (or re-visualizations as one participant dubbed the historical recreations) could be useful when no good video existed. While the VR possibilities and the simple interface of Lord's Unity app were particularly appealing to the group, the consensus was that there was no compelling need to continue to develop the app as an open-source alternative to Capture. Unless the software finds an active open-source development community, there will be no resources to maintain the tool as technology changes, and unlike other open source products (e.g. GIMP, Blender, Firefox, Ubuntu), the user-base for a program like Capture was considered to be limited and so unlikely to attract the kind of volunteer work required to maintain large open source projects. Capture's basic license is relatively inexpensive (roughly \$500 for an educational site license), and there is a free viewer that works on all platforms. At present the likelihood of the continued availability and maintenance of Capture seems more likely than continued community support and development for our app. Although, as with any commercial product, there is some concern about the long term sustainability of data created with the tool once support for earlier versions lapses, the company does provide a variety of means for exporting most of its data into open formats.

The biggest preservation risk of using Capture for documenting designs lies with the proprietary data Capture maintains about the qualities of the lighting equipment used. Exports from Capture may, for instance, indicate that a Rosco 68 filter is used in the light, but the color of this particular filter is not represented in the exported spreadsheet. Fortunately, the Capture team licenses a database of basic information about a wide variety of lighting equipment, Atabase, that might be used by a future

iteration of our prototype for users who wish to subscribe to the service (<https://www.atlabase.com/>). This database is accessible to users of Capture, but can also be licensed for use in apps like Lord's prototype. Thus, though access to the data is not free and open, it is at least separable from the Capture interface and is exportable (with a license).

In addition, Beverly Emmons has been working with an archive of historical lighting equipment at the University of Pennsylvania to capture and document color wavelength data from these rapidly disappearing machines. Sadly, there is not currently a way to make use of this level of detail in either Lord's Unity app or in Capture. Fortunately, a representative from Capture, Vangelis Manolis, attended the final meeting and expressed his willingness to add new information about equipment to the database, thereby making it available to all users of Capture.

### **Final thoughts**

We set out to determine whether current digital 3D platforms are sufficient to recreate historical lighting designs, preferably on the web, to the satisfaction of the scholarly and lighting design community. The answer seems to be "no," especially in the case of web platforms. The processing power required to represent hundreds or thousands of dynamic light sources requires a powerful, dedicated graphics card, and browser-based platforms cannot assume such hardware exists on client machines.

On an installed app such as Capture or the desktop version of our Unity app, the recreation is more faithful, but not so faithful as to replace archival video for designers and scholars. Still, for shows without archival video, recreations in visualization tools may be useful, and the act of recreating a show in these tools may serve as a useful memory prompt for oral histories.

**Deliverables** (More files may be added to these repositories over time):

**Source Code for Lord's app:**

<https://github.com/gplord/TheatricalLighting-Desktop>

**Working Builds of app:**

<https://drive.google.com/open?id=1dkbF6VRmeeau6FkH7AAYz4wavKoBHhNI>

**Reproductions in Capture:** <https://drive.google.com/open?id=1jJyxjulaXtYBj8P3GDwDOM1gv59ByjbM>

**Publicity:**

<https://www.theatlantic.com/technology/archive/2016/03/theater-history/475293/>

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**Attendees at May 2016 meeting**

Co-Principal Investigators

Doug Reside, Lewis and Dorothy Cullman Curator for the Billy Rose Theatre Division, LPA

Gregory Lord, Hamilton College

Library staff

Sharon Rork, Librarian, LPA

Susan Malsbury, Digital Archivist, Archives Unit

Sarah Mackowski, LPA Intern (University of Maryland)

Lighting Designers

Alexa Antopol , Fisher Dachs Associates

Ken Billington, lighting designer

Beverly Emmons, lighting designer

Susan Hamburger, lighting designer, NYU Tisch and the Julliard School

Vivien Leone, assistant lighting designer

Richard Winkler, lighting designer

Shannon Schweitzer, lighting designer, Michigan State University

Scholars

Eileen Curley, Marist College, Editor-In-Chief of *Theatre Design & Technology*

Stephen Di Benedetto, University of Miami

Elizabeth Christin Essin, Vanderbilt University

Software developers/Designers

Mac Smith, software developer/designer

Alex Coulombe, Fisher Dachs Associates

John McKernon, Lightwright, lighting designer

Asher Robinson, designer

Ben Schwartz, video/graphic designer

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Ken Billington, lighting designer

Beverly Emmons, lighting designer

Shannon Schweitzer, lighting designer, Michigan State University

Alex van Blommestein, scenic designer, Michigan State University

Scholars

Stephen Di Benedetto, University of Miami

Software developers/Designers

John McKernon, Lightwright, lighting designer

Vangelis Manolis, part owner Capture Ltd, part owner AtlaBase Ltd, Lighting Design MA

Allison Sommers, the Orpheum Circuit video game/widow of lighting designer Richard Nelson

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### **Attendees at March 2018 Hackathon**

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Jake DeGroot, lighting designer

Kacie Hultgren, scenic designer

Shannon Schweitzer, lighting designer, Michigan State University

Alex van Blommestein, scenic designer, Michigan State University

Sarah Beth Weintraub, lighting designer

#### Scholars

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