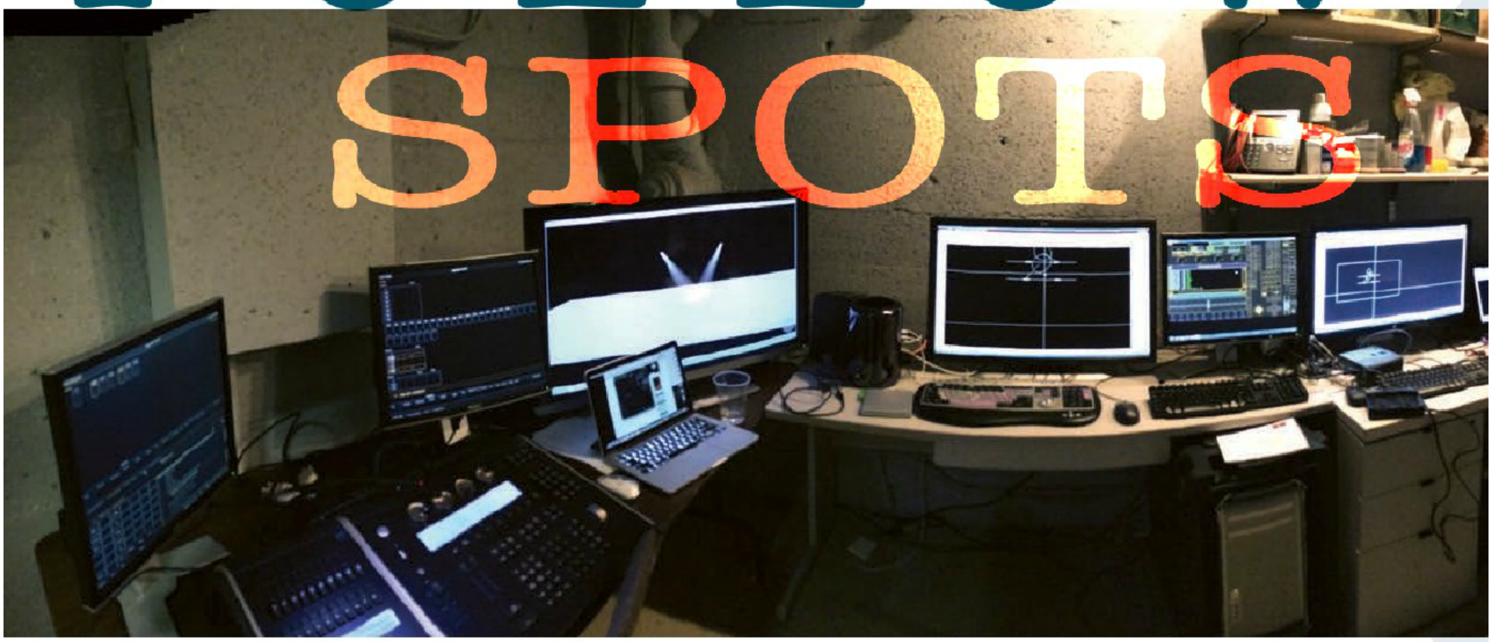
Remote-Controlled FOLLOW SPOTS

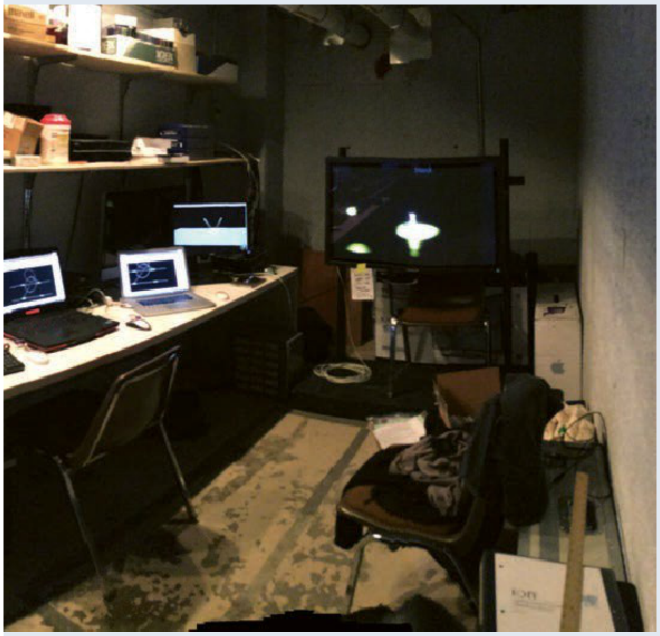


BY MATT LATHROP

The idea for this research project came to me when I began working on the lighting design for Ram's Head Theatrical Society's production of *Les Misérables* at Stanford University. *Les Misérables* is a complex show with many important characters on stage at the same time, so I thought it was critical to be able to highlight each of the characters and create separation between them physically, spatially, and emotionally. This meant that I needed to be able to light many people from a variety of angles, and I realized that the normal two follow spots with flat angles in Memorial Auditorium, Stanford's 1,800-seat theatre, were not going to be adequate.

I discussed this idea with associate lighting designer James Sherwood, a co-contributor on the research project. We considered the possibility of placing follow spots in each corner of the stage. While this would have made it possible to pick out individual actors and give them varying looks, we understood that erecting scaffolding for follow spot platforms or using in-air chairs was a safety issue with our student follow spot operators.

Once we realized that we could not have human operators where we wanted the fixtures, we began investigating the idea of remote-controlled fixtures. We recalled that the ETC iRFR iPad app had the ability to control moving lights using touch. As a simple test, we used the app to try to control Rosco I-Cues. While the app is a great tool during focus, we found that the motion was simply too jagged for live control. We also looked into various joystick-based options, but since joysticks control the light in terms of pan and tilt, it was nearly impossible to use the joystick from anywhere other than right behind the light. For example, if an operator sees an actor moving in a certain direction on stage, their instinctive response would be to move the joystick in the direction the actor is moving relative to the operator. However, in the case of a joystick controlling follow spots, the operator has to move the joystick in the direction the



A panoramic view of the testing setup.

actor is moving relative to the fixture. Since our goal was to allow the operators to be in a convenient location away from the fixture, we needed a control system that operators could understand easily, without having to think on the fly.

We also explored replacing human operators with a computer tracking system. Companies are doing an abundance of research on computer tracking, but to date these systems typically are incredibly expensive, starting around $80,000. They also do not typically allow for certain actions, such as smoothly switching from one actor to another without dimming the fixture. This is a simple task for a human operator, but trying to train a computer to make a transition look "nice" is a monumental task. So for both monetary and design reasons, we determined that tracking solutions were not going to be feasible.

As an alternative, I decided to try using moving head fixtures as follow spots, controlling them live using wysiwyg Perform, the lighting design previsualiztion and rendering software from CAST Software. Traditionally, moving head fixtures have had limited use as follow spots because they typically require pre-cuing. This means an actor must hit the exact same spots on stage every night, moving between spots in a consistent predetermined pattern. This is simply too much to ask of an actor, which is why theatres still have follow spots. But wysiwyg Perform, while normally used for previsualization of lighting cues to cut down on in-space setup time, has a communication protocol called AutoFocus. AutoFocus allows you to move fixtures in the software, communicate that information to the lighting desk, and send it to the actual fixtures. Operators use this feature to quickly transfer looks from the software to the lighting desk, but it can be leveraged to control the fixtures in real time. This means that rather than having people operate follow spots, wysiwyg operators can instead scroll around a 3D model of a theatre and point a lighting fixture wherever they want. Theoretically, this could allow designers to harness all of the flexibility of a moving head light, including the ability to light a moving actor, and would eliminate the safety risks and time needed to put follow spot operator platforms in space.

To see if wysiwyg Perform, could provide a viable solution, I began communicating with CAST Software. In their response to my initial e-mail query, CAST said they thought the idea was technically possible but would require specific equipment, namely, individual licenses of wysiwyg Perform for each operator, a console from MA Lighting to interface with wysiwyg, and of course, moving lights.

Michael Ramsaur, lighting professor and director of production at Standord, and the professor oversseeing my research project, was tremendously helpful in acquiring this specific equipment. We searched both within the university and externally for support and found many people who were excited about our project's potential. We applied for several grants at the university, but were rejected for various reasons. Ultimately, we received funding from the Office of the Vice Provost for Undergraduate Education. This support from the university made it easier to obtain lighting industry support for the project, including generous help, guidance, and donations from CAST Software, Elation Professional, Golden Sea, ACT Lighting, and from Nils Thorjussen, co-founder of Flying Pig Systems.

As testing began, we created a checklist of key benchmarks to ensure the technology was ready for our show:

1. confirm that multiple instances of wysiwyg can communicate with a single console;
2. ensure that the console outputs data from all instances of wysiwyg simultaneously;
3. test if operational control is smooth;
4. investigate how pan lock of moving fixtures would manifest in our setup;
5. determine the best control interface.

Testing

In order to complete the checklist, the testing was broken up into several phases. We selected a specific focus for each phase, and we tested for that focus in isolation. The order of the testing was as follows:

1. communication testing (setup and patching, virtual control test);
2. sending data to fixtures (fixture control test, network test);
3. controllability test (control interface testing, usability testing).

1. Communication Testing

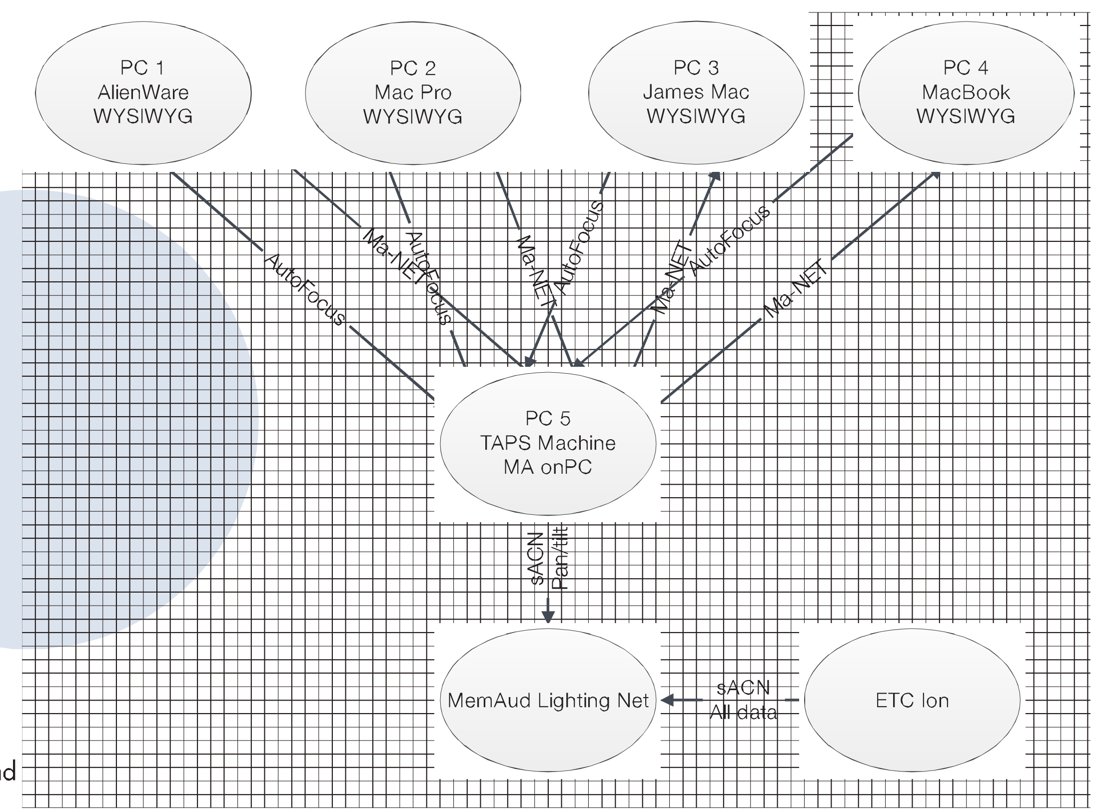
The setup for the communication testing included five computers and an ETC Ion. The five computers consisted of three Macs running Windows under Bootcamp and two PCs. One of the computers ran grandMA onPC2 software from MA Lighting to give us the ability to utilize wysiwyg Perform's AutoFocus function. The other computuers ran wysiwyg Perform R32, with grandMA AutoFocus drivers installed. We set the computers to listen for EDMX (Ethernet DMX) and networked them through a wired switch to the Ion. We employed static IP addresses to ease the networking process.

Initial Setup and Patching

Once we networked all of the computers properly with static IP addresses and configured the grandMA AutoFocus drivers, we set up the grandMA onPC2 software. After connecting just one PC to the grandMA onPC2 software, we encountered an issue. Adding lights to a pre-existing layer in grandMA onPC2 caused wysiwyg to lose control of the fixtures. It was unclear if this was a software issue or an operator error, so, to work around the problem, each time we patched new fixtures, we added them to a new layer.

Since the operators were far more familiar with the Ion for programming, we wanted to have the Ion console control all aspects of the moving fixtures except pan and tilt. In other words, the grandMA onPC2 software would only broadcast the pan and tilt values from wysiwyg. During the setup process for preprogramming, we attempted to use AutoFocus to control fixtures patched to the EDMX universe, and we could not seem to make this work. We discovered that we could not control the moving head fixtures from the Ion because the fixtures must be patched to a non-EDMX universe for AutoFocus to work. We eventually solved this problem by "double-hanging" the moving head fixtures (one on top of the other in software patched separately) so that one could work with the Ion and one with grandMA onPC2.

Once we patched the MA software correctly, we added computers one by one. Each time a new computer was connected, the fixtures spun around then went back to the previously set position. We deemed this issue, while possibly problematic if a computer fails mid-show, unavoidable and ultimately inconsequential. Once three of the computers were connected with the same show file loaded and the MA software patched, we began testing control over the actual fixtures.



A signal diagram of the connections among wysiwyg, MA onPC, the lighting network, and the control console.

Control Test

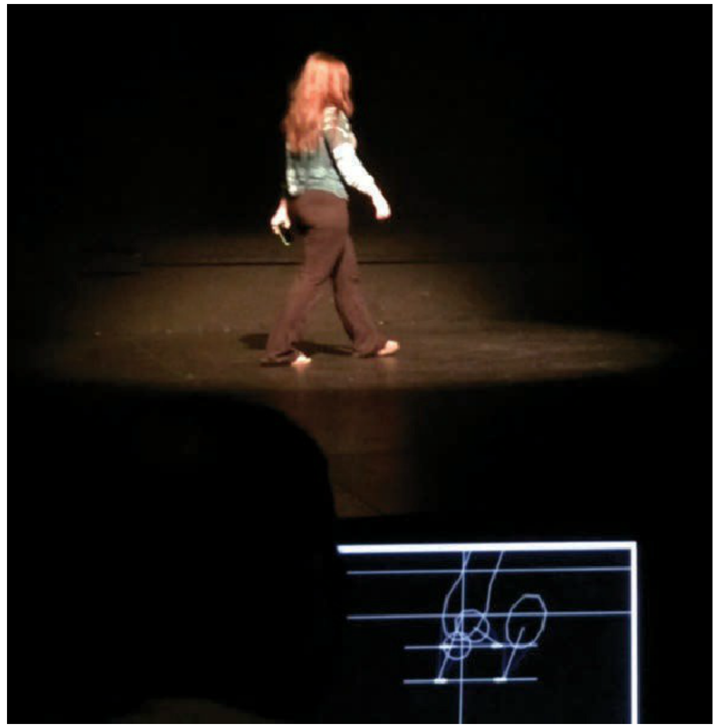
Each computer was able to grab different fixtures and control them independently. We completed the test with virtual VL3500s because we had not received the beta Elation fixture profiles. The movements of one operator updated on all other instances of wysiwyg and the grandMA onPC2 software with no noticeable lag or jagged motion at reasonable speeds. What happens when two operators grab the same fixture? We tested this in case it ever happened during a show and discovered through experimentation that MA consistently gave control to the second operator to grab the light. Our testing also determined that pan lock (a moving light can only turn a certain number of degrees before it must go through its yoke to keep rotating) was a non-issue for the project since the fixtures only turn a maximum of 90 degrees in any direction from home. Pan lock might be an issue if the moving light needed to illuminate areas 360 degrees around itself. We did encounter a more troublesome issue, however: if the color of the beam was changed on the console, it would also change the color of the wireframe light beam displayed in wysiwyg. This made the beams incredibly difficult to see when the lights were set to any saturated color. However, even with these issues, this control test successfully demonstrated, before even interfacing with a single fixture, that multiple instances of wysiwyg could talk to a single console, pan lock would not be an issue for this project, and wysiwyg was able to send a steady stream of data to the MA software, ensuring that motion would not be jagged.

2. Sending Data to Fixtures

For this test we added an MA 2Port Node to the network, which allowed for output of a signal other than MA-Net. To represent the Memorial Auditorium, we used the much smaller Piggot Theatre's lighting network. On this network there are four Rosco I-Cue moving mirrors on Source 4s with Sea Changers. This allowed us to simulate most of a moving head light's functions.

Since we used an actual space to see the Ion control board output, we disabled the EDMX reception on all the computers so that the computers could listen only to the grandMA onPC2. In addition to testing the viability of sending data to the fixtures in real time from wysiwyg, this test also represented a small-scale model of our final network setup. Since the operators were not familiar with the MA software, they wanted to make the grandMA onPC2 just a translator for Pan/Tilt values between wysiwyg and the sACN network. To accomplish this, we used sACN priorities to give the Ion control board a higher priority on the network. That way, any addresses that were not patched in that console (in this case the pan and tilt addresses of the moving fixtures) would instead receive information from the MA software. The signal diagram demonstrates this.

We patched I-Cues to the grandMA onPC2 software and Sea Changers to the ETC Ion. We patched the dimmers on both boards. We used this type of patch to simulate the splitting of DMX channels between the Ion and grandMA onPC2 that we planned to incorporate in Memorial Auditorium so that the Elation fixtures received the correct board's information for each DMX channel. We used the MA 2Port Node purely to unlock outputting parameters in grandMA onPC2; it did not function as a sACN-to-DMX converter since the theatre had all the nodes already installed for this purpose.



Initial testing of the system in the Piggot Theatre.

Control Test

Once we properly configured the node, we set up and patched a wysiwyg demo file for the small theatre. The I-Cues could be controlled with good precision and no notable lag. This test verified that the console could output the data sent to it by multiple instances of wysiwyg communicating with it at once, another item on our checklist.

Networking Test

Since we had disabled EDMX reception in wysiwyg, we realized that wysiwyg got all of its information about the status of the fixtures from grandMA onPC2. This meant that an "at-full-and-open-white signal" could be sent from the MA control software to wysiwyg, and since the Ion had precedence on all these values in the sACN network, the signal would not affect any of the actual fixtures. In other words, the fixtures would only read pan and tilt values for each fixture from the MA control software regardless of what other signals the grandMA onPC2 sent out. This meant we could send wysiwyg other signals about the fixtures that would be ignored by the actual fixtures. An operator could control both intensity and color from the Ion while moving the fixtures with wysiwyg. This closely mirrored what the network setup would be once the project got into the auditorium. The testing afforded us confidence that the software would work as we expected.

3. Controllability Test

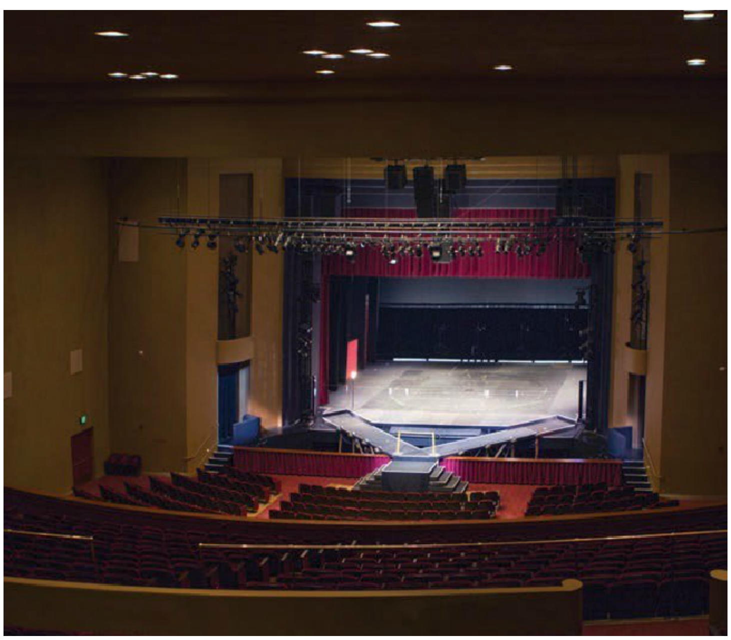
By the time we began the controllability tests we had received the Elation Platinum Spot 35 PROs moving lights and we were testing the system in Memorial Auditorium. Since we had verified that using multiple licenses was possible, we stripped the testing network down to just the Elation lights and a single computer for simplicity. The focus of this test was to find out if operators were actually going to be able to control the fixtures in Memorial Auditorium and how best to control them. We cut out the Ion entirely and used the MA 2Port Node to directly output DMX.

Control Interface Testing

In all previous testing, we used a computer mouse to control the fixtures, but we wondered if that was really the best way to control the fixtures. To find out, we gathered a variety of computer control interfaces.

First, we tried a joystick. As these are widely used for precision control, such as cranes and cameras, the thought was that a joystick might be ideal for controlling a moving light. However, we discovered that these were much more difficult to use than mice. With a joystick, all your movements are relative, and there is no way to make a direct movement. As a result, the control became mushy and constantly overshot or undershot the target. Oftentimes if an operator lost an actor, the actor would have to stand still momentarily while the operator focused the light on him again.

Next, we tested iPads as oversized track pads. While this seemed promising, many operators struggled to control the fixtures accurately. It was clear that if we were going to choose this control method, we would have to train each of the operators extensively. The iPads were also unreliable since they interfaced over Wi-Fi.



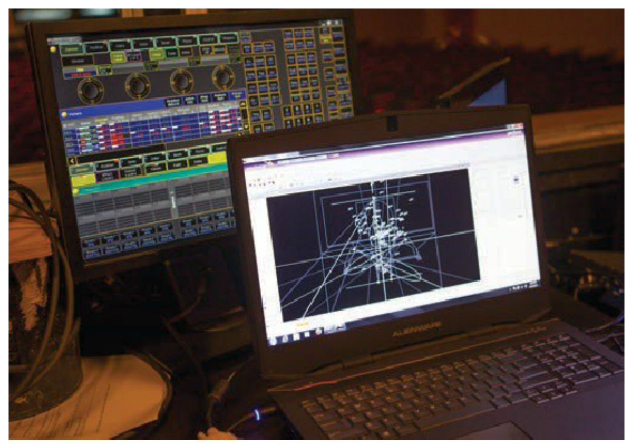
View from the house right follow spot booth in Stanford's Memorial Auditorium.

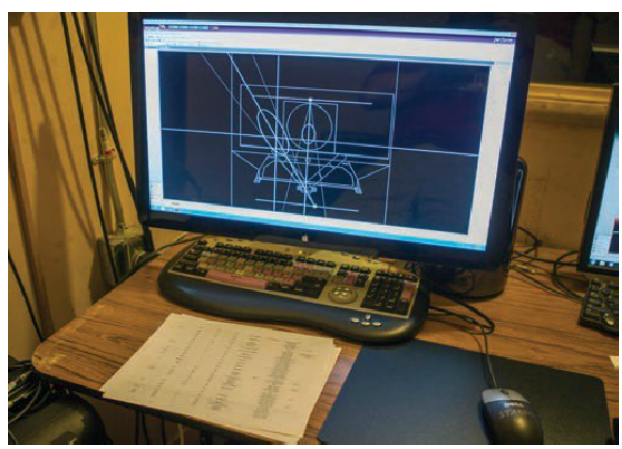
Third, we tried graphic tablets, specifically pen tablets made by Wacom. These were incredibly intuitive to some people, and those people were really adept at controlling them. However, this was not true for everyone, and again, there was not time to train the people not already proficient at using one of these tablets. Another downfall of these tablets was their extremely high cost in comparison with computer mice.

Ultimately, we decided to stick with mice as most of the operators were familiar with them, and both sharp and smooth movements could be accomplished easily. Mice are also inexpensive in comparison to other options. We realized that investing in gaming mice with variable dpi was a huge help to operators, as they could adjust the sensitivity of their mice on the fly. This way the operators could follow someone running and just as easily follow someone making small subtle movements. This answered the final question on the checklist: the best control interface is a variable dpi gaming mouse.

Usability Testing

This was the final test and consisted of the exact same setup as the previous test. However, in this test we moved the control system around the theatre to find the best location for operators. We realized that in order to follow someone successfully, the operator needed to have a good vantage point for viewing the stage, where he or she could tell how far up or downstage the actor was. The





Above, the computer running MA on PC; *below*, one of the five follow spot computers running wysiwyg.

balcony provided this view for us, but in general an operator just needed to be able to see the floor. We also noticed that as the actor got closer to the fixture, controlling the light became more difficult for the operators because they needed to move the lights through more of their range in order to keep up with the actors.

Implementation

Once we completed testing, we began implementing the technology for the production of *Les Misérables.* We thought this would be a relatively simple process, but we found out that there were still issues to be addressed when scaling up the technology.

Booth Setup

For the production, we determined that the follow spot operators should be inside the follow spot booths in the auditorium. We placed two computers in each follow spot booth above the balcony and put the computer that ran the grandMA onPC2 application in the main control booth on the orchestra level. We chose this location so that the stage manager, light board operator, and person monitoring the follow spots could communicate easily and quickly resolve any problems without going to the balcony level. When deciding which of the moving lights would be controlled, we favored the Elation fixtures because of their superior controllability. We placed two Elation spots on the front of the house bar and two on the booms just downstage of the proscenium to provide sidelight to actors downstage and front light to actors upstage. We also retained control of the VL3500 upstage center to provide backlight anywhere on the stage. We assigned each operator control of the specific spots he or she would be responsible for controlling during the show. Since we had five moving lights and two traditional lights, but only five operators, we had to carefully plan which operators would need access to which follow spots during our cuing.

Since each computer was unique and had a different monitor, we spent time setting the mouse sensitivity and speed for each computer so that the operators would never need to physically lift the mouse to position it anywhere on the screen while still maintaining the ability to make subtle movements. We also discovered that using large mouse pads helped in this regard since the operators have more space to move before needing to lift the mouse. During this process, we discovered that enabling the ClickLock mouse feature in Windows allowed the operators to control the light without constantly holding down the mouse button. Instead, they selected the beam, held the button for a second before releasing, and the computer would continue to hold the beam until they clicked again. Operators found this much easier than holding down the mouse button.

Networking

Networking in Memorial Auditorium turned out to be the greatest complication that did not appear in testing. We spent a considerable amount of time making our gigabit switches work for this project. The settings on all of the switches used had to be customized. We used unmanaged Netgear switches with customizable settings. After hours of trial and error testing to find a combination of settings that gave us a stable network, we assigned each switch its own static IP address within the IP address range of our local network. Each component connected to the network used these customized IP address and submask net settings. We also disabled the IGMP on the switches. IGMP prioritizes the order in which signals are sent over the network. The protocol used to send signals, sACN, has a built-in version of IGMP. If we enabled IGMP on the switches, the network became unstable. There was also so much data being sent over the network that we had to use gigabit networking. While the system may have worked without this, MA does not recommend it. As a final note, we recommend Windows 7 for this setup. Most of the software must be run in compatibility mode if using newer operating systems.

Training Operators

We needed to train our operators to use this system in a way that made sense to a traditional follow spot operator. We translated concepts of traditional follow spot usage into this new method of fixture control. Like any other cue, the stage manager called standbys and gos for operators. A designated follow spot coordinator dealt with the seven spots, as there was a great amount of information to relay to spots in a short span of time. Every spot had a customized wysiwyg file with the focus points relevant to its assigned lights. The spot operators received the relevant focus point with sufficient time for them to set their fixtures and start following a subject. We programmed the follow spots themselves into light cues, with color and beam size preset, so that the operators could focus on movement. We gave the operators careful directions so that when the stage manager called the cue, they knew to start following their subjects.

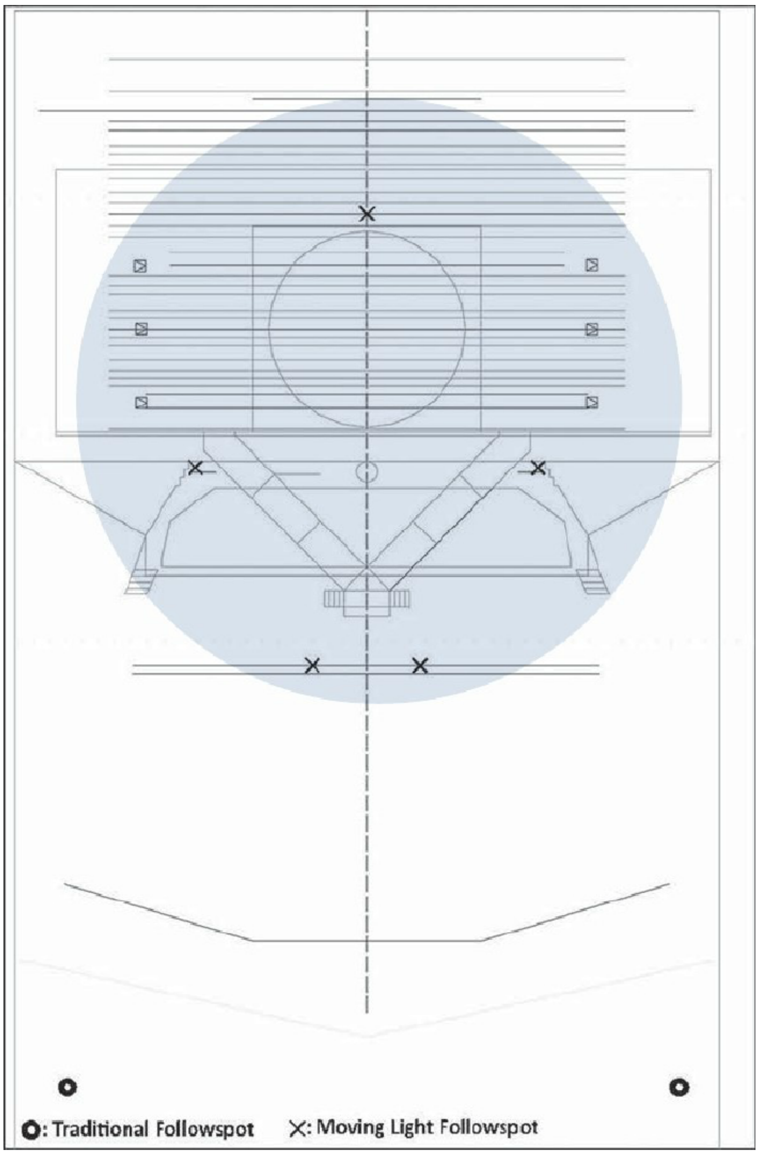
We developed a detailed structure for operators to follow. First, we created focus points in wysiwyg for every pickup in the show so that the operators could use these points. When the follow spot coordinator warned operators of upcoming cues, he used focus points and fixture numbers. Operators then selected the desired fixture and moved it to the desired focus point while it was still off. For operators, we equated this process to moving a follow spot into a general area (SL, SR, US, DS) where the pickup would happen. With the fixture on its focus point, operators selected its beam in wysiwyg and took full control over the fixture. Then they waited for the beam to come up. When the cue was called, and the board started bringing up the light, operators made sure the beam of light was correctly focused on the actor, they followed their actors during the cue, and once the beam went out, operators deselected the beam.

One major difference for operators between traditional follow spots and this technology was that they could not see where their moving light was pointing before the light came up, as one can do by looking looking down the barrel of a follow spot. This meant that the pickup points had to be very accurate and operators had to trust that they were very close to where the actor would actually be standing.

Results

By opening night of the show the operators were as proficient with our remote-controlled follow spots as they were with traditional spots. There were no major issues with the system or network during the run of the show, and the overall design of the show received praise from Professor Ramsaur for the subtle changes of angle and intensity in the follow spots that were made possible by using moving lights.

The reaction from both the academic and industry communities was overwhelmingly positive. From the academic side, Vice Provost Elam said, "In terms of aesthetics, [the project] provided a wonderful platform of visual story telling." He also went on to say, "The project truly expressed the connection between computer science and technical theatre creation." On the industry side, Nils Thorjussen, co-founder of Flying Pig Systems and a Stanford alumnus, saw the show and took a tour of the technology. He said, "The show lighting was beautiful, and precise control over the spots integrated them seamlessly into the action. The control interface was simple to use; I can easily see this becoming a standard part of every designer's tool kit." Gil Densham, CEO of CAST Software, who saw a video of the remote-controlled follow spots in use during *Les Misérables,* said, "It was hard to tell that it was not a real follow spot." (See https://www.youtube.com/watch?v=_tDtg8PY7o0)



The five Xs are the positions of the moving light follow spots, while the traditional follow spots are in the booths above the balcony.

Review

The project represents a success for us, and we hope that both academia and the lighting industry will support this technology. Huge advantages potentially exist for everyone from designers and technicians to producers and directors. That said, some complications remain in the current implementation. After talking with our spot operators, industry professionals, and various companies, we believe these need to be addressed before our system is viable for the general lighting community.

Advantages

The advantages of this technology are numerous and could solve many problems. We can break these down into the three categories: design, safety, and production.

As a designer, I was very happy with what I was able to accomplish with the remote-controlled follow spots. For this show I had a total of seven follow spots (five moving head fixtures, and two traditional spots) and five operators who floated between different fixtures. The wysiwyg control system allowed me to expand the number of follow spots I could use for a show as complex as *Les Misérables* because it let me control moving lights in my lighting rig as though they were follow spots. And, having more follow spots meant I could light more actors at once, giving me greater freedom to create interesting compositions with light when the stage was full of actors.

Lighting numerous people on stage was not the only advantage. The ability to light a single actor from a variety of angles, and even change angles during songs, allowed me to make more subtle changes in the lighting during some numbers, mirroring the various emotional shifts in the characters. These options were powerful tools in the more intimate numbers. Live-control follow spots allowed me to more closely mirror the actors' emotions and support them with light coming from a variety of angles to match the scene and mood.

As a designer, I also appreciated the consistency and flexibility of the moving head fixtures compared to traditional follow spots. With traditional follow spots you are limited to around seven gel frames, and you have to rely on an operator to set the intensity and beam size. Using moving lights, you get full CMY color mixing and precision control over intensity and beam size. These precise controls allowed for subtle changes in the follow spots, which, in my opinion, is invaluable to a designer.

From a safety standpoint, remote-controlled fixtures can eliminate the need for follow spot chairs and follow spots on top of scaffolding. With live fixture control technology, there is no reason for operators to be placed anywhere hazardous. In fact, they could sit just about anywhere as long as you can implement a properly situated, low-latency camera for the operators to use.

I believe show producers could also realize benefits from the use of this technology. While in the production of *Les Misérables* the use of this technology increased the number of other students we brought on as follow spot operators, this would not always be true. Since a show no longer would need a one-to-one relationship between spots and operators, in many shows this technology could actually reduce the number of operators needed. In fact, since operators can switch between fixtures, a show needs only one operator per spot in use at a given time. Also, while many of these advantages can be obtained with tracking technologies, live fixture control technology as I have presented it has the potential (with support from the industry) to be significantly less costly to implement, especially for shows with shorter runs or those on tour. When Tony Award-winning Broadway producer Dori Berinstein saw the project, she said, "The promise of [this] invention is staggering. It was clear to me when Matt walked me through his lighting vision for the future, that with additional time and resources to develop his idea, Matt would be able to produce a breakthrough, cost-efficient lighting package that could change the way we do business." While I do predict that the implementation of this technology would require more money than a design that used purely traditional follow spots in existing locations, in most cases it would provide the designer more than enough flexibility to justify the increased cost, especially when compared to the alternatives for obtaining this level of control over spots.

Challenges

This technology worked well for us, but even *Les Misérables* represents a laboratory setting. We enjoyed the benefits of donated equipment, plenty of time to fix issues, and a thorough understanding of the underlying technology. The question remains, will this work for others? A few stumbling blocks remain that could hold back this technology from being implemented in other theatres or shows.

The greatest challenge with the setup, as it stands now, is cost. But as I mentioned above, we hope private industry will supply the needed support to make this a cost-effective option. Currently a full perform license of wysiwyg is required for each computer used to control even one moving light. This is beyond the means of most theatres. CAST Software expressed interest in figuring out how one product could be used to control multiple remote moving lights, which could save users money. Perhaps a user could lease a software license for shorter periods of time appropriate to the run of a show. Also, since we were more comfortable using an ETC Ion, we required two lighting desks, an ETC Ion and grandMA onPC2. While grandMA onPC2 is free, it did require the use of a two-port node to allow us to output other signals than MA-Net. Others may choose to experiment with other console setups, but we chose this setup based on the recommendation of CAST and the technology we already owned.

Using this follow spot method in its current form also takes time. The amount required for setup and networking varies based on experience with the underlying technology, but not all things can be done quickly. For example, the process of adding focus points to wysiwyg based on actual positions in Live View is cumbersome. To optimize this process, a user could employ a grid instead of individually created focus points or simply use the console to record the positions of the lights for pickups. We chose to do the pickup points in wysiwyg to avoid having more than one control cue list or interacting with MA (since we did not have a command wing). Another time factor to consider is that during rehearsal, the operator must take time to set color and beam palettes of all the follow spots. Recording these takes more time than simply communicating to a traditional follow spot operator to change the color or iris to a certain size. The added programming time should decrease as consoles continue to improve their control methods for intelligent fixtures.

I believe there are several ways wysiwyg software could be optimized for follow spot control. What follows are several ways a user could optimize the software to improve the control process.

One problem operators had was selecting their beams. There are two ways I see to address this issue. Simply increasing the size of allowable error would help tremendously. But a better long-term solution would be to implement a hotkey. The operator could simply press a keyboard button and the mouse would move to the correct location and lock onto the desired beam. The operator wouldn't even have to look at the screen.

Operators also struggled to deal with focus points. For example, you cannot create new focus points in Live View. You must move the beam to a target location, record the X and Y values, then go into CAD View, and finally place the focus point. You also can't turn off snapping to these points in Live View, which can make control choppy. This effect was so apparent that we actually turned off the focus points layer and instead selected Focus Points in wysiwyg's drop down-menu in Live View to move the lights to the target point.

Furthermore, gaining the ability to lock off certain fixture values in wysiwyg would be helpful. This was not an issue for us as we had two consoles. The MA console simply sent the values we wished to lock off to wysiwyg. However, if you desire to use the MA to control all of the lights in your rig, you would encounter an issue with the beams not showing up until the fixture was actually turned on. The color of the beam can also make it hard to see. For this reason, we set the lights to open white.

Finally, giving operators easy control over the iris would dramatically reduce the time required during rehearsal to set the moving lights in the console. Ideally, operators could control the iris using something like the scroll wheel on the mouse, making it is an easy process to adjust the iris as they move the follow spot.

Additional Work

After communicating with others around the industry about this project, my team and I have come up with some additional goals we would like to tackle that may expand the usefulness of this technology. First and foremost, we wonder if similar success could be achieved without locating the operators in the back of the house. Would a video feed placed at a similar angle be just as effective, allowing the operators to be out of the way? This option would be a tremendous help for shows not taking place in a proscenium-style theatre, or in theatres with limited booth space. We wonder if this video feed could even come from a camera mounted directly on the fixture. You could even superimpose crosshairs on the image so the operator knows precisely where the light is pointed.

There is plenty of additional work needed in order for this technology to become simple and effective for the larger lighting community, but none of the challenges requires a difficult fix. Each simply requires key people to make the decision to implement them. For the price, such a system could provide designers with unprecedented levels of control over their spots. In terms of both cost and safety, it could become a fantastic alternative to tracking technologies and follow spot chairs. ❖

Matt Lathrop is a junior at Stanford University majoring in computer science and minoring in theatre and performance studies. Combining his interests in technology, especially new technology, and the arts has been an important part of his academic journey. He is currently working on a project to create a low-cost LED wall controlled by Arduino microcontrollers.

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