Virtual Reality for Lighting Simulation in Events

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Abstract

Lighting in events such as concerts, theatres and nightclubs is progressing massively. The technology involved is what enables the highly intense and powerful shows to stand out. In order to ensure great performances, technicians are now using light simulation tools to design, program and preview their shows beforehand. Recent applications consist of elaborate interfaces with complex tools and render engines to provide the most visual feedback in advance, avoiding production costs and stress prior to an event. However, these interfaces tend to be overwhelmingly sophisticated, requiring considerable learning efforts. Also, and despite the advancements on the visualization side, there is a lack of immersive 3D interaction capabilities, which could provide a far more realistic user experience.

This work tackles this challenge. We propose an immersive light design and pre-visualization interface, aiming to increase the preview realism and suit people with no experience in stage design. Our prototype, VRLight, couples a head-mounted display and a gesture-based interface for visualization and real-time interactive light simulation. The design and control tasks are split in order to increase creativity and focus on both sides. In the immersive environment, the director performs the design and pre-visualization routines, and complex control is externally carried out by the technician, using any light console of his preference. To validate this solution, a group of non-expert users was involved in a set of tests. Results shown that users with no knowledge prior to the evaluation could easily perform stage design tasks.

Keywords: VRLight, virtual reality, immersive visualization, stage lighting design, events.

1. Introduction

Light simulation is becoming a necessity in numerous industries. Fields such as architecture or product design now require imperative tests over illumination in their products, where lighting designers mistakes are no longer tolerated. Event lighting is no exception. In fact, concerts, theaters, festivals or nightclubs require hundreds of light fixtures to provide the intense shows we can see nowadays.

In event lighting, the existing software to pre-program and pre-visualize the lighting behavior consists of powerful rendering applications with an abundant set of tools to fulfil the designers needs. However, these tools consist of complicated user interfaces that require massive learning efforts and time consuming tasks. Furthermore, new interface possibilities such as immersive 3D environments and gesture-based devices have yet to be tested.

There are three main concerns in event lighting production: stage design, light pre-visualization and control. The existing software helps designers to achieve their goals, but in a very complex and time-consuming way. All the steps involved require a lot of interface knowledge and the wishful level of abstraction between light programming and the creative design of the show is somewhat demoralizing. On the other hand, with the light programming stage complete, pre-visualization tools now provide big help, but still in flat 3D images in 2D screens.

This project proposes an immersive virtual reality (VR) solution for stage lighting simulation, using a head-mounted display (HMD), which enables an insider point of view of the simulation, never tested in stage design. Together with gesture-based devices for interaction, this approach is proposed to deliver a more intuitive and realistic preview, reducing the learning effort with a simpler interface, in an environment with free movement capabilities for the best preview of the light show.

Throughout the following sections we present an overview of the state-of-art in lighting simulation applications, light control, user interfaces for lighting and music and immersive visualization and interaction technology. We follow with a detailed description of the proposed solution in detail. Then, a non-expert user validation is presented, using data collected from test sessions. Finally, we present an overall discussion of our work, delineating conclu-
2. Related Work

Lighting simulation was developed to fulfil the need to preview the effect of light in several environments. Having an idea of what the resulting illumination will become in certain industries, such as architecture or product design, made professionals more aware and prevented lighting issues involved in the design process. These are very good news regarding the avoidance of expenses involved in lighting design mistakes.

To correctly understand stage design pre-visualization and what is missing in visualization and interaction capabilities in this field, it is important to cover all lighting related topics, such as light control, existing lighting simulation applications and user interfaces, alongside with the immersive solutions yet to be explored.

2.1. Light control

Light control developments are growing fast. Nowadays, illumination control is provided in many different ways - regular light switches, dimmers, sensors, timers and so forth. Studies into new ways of light interaction and automation are increasingly frequent in several of industries - e.g. hotels. With the appearance of new types of lighting and controllers, researchers are now investigating new possibilities in light interaction. Magielse and Offermans studied new ways of giving freedom of control to the user in a comprehensive manner, using tangible and multi-touch interfaces. Event lighting although, is by far the most complex in the light control business, and the endless illumination possibilities available in the equipment involved - colors, intensities, directions, effects and so on. Previewing the effect of lighting on a particular event, with real-time capabilities, is now possible with specialized software - Figure 1 illustrates a music concert pre-visualization and final show. Light designers now have the tools to pre-program a show before arriving at the venue - a process that can reduce production costs, on-site time and stress, while nurturing creativity.

2.2. Lighting simulation applications

Lighting simulation is common in industries such as architecture or product design. These however, are easier to preview since mainly require static pre-rendered graphics. Shikder studied the performance and realism of four lighting simulation tools for ambient light in static environments - DIALux, Relux, AGI32 and Radiance. In spite of the realistic results, real-time light rendering is not possible with the software mentioned.

In stage lighting pre-visualization, pre-rendered graphics are not an option, due to the endless illumination possibilities available in the equipment involved - colors, intensities, directions, effects and so on. Previewing the effect of lighting on a particular event, with real-time capabilities, is now possible with specialized software - Figure 1 illustrates a music concert pre-visualization and final show. Light designers now have the tools to pre-program a show before arriving at the venue - a process that can reduce production costs, on-site time and stress, while nurturing creativity.

Figure 1: U2 360 World Tour pre-visualization and final show combined.

2.3. Virtual lighting applications for event simulation

When analysing the main existing tools for pre-visualization, there are three that stand out from the rest - ESP Vision, WYSIWYG and grandMA 3D. These applications provide tools from stage design to real-time lighting pre-visualization. The concert in Figure 1 was developed in WYSIWYG, using the computer-aided design (CAD) internal tools for the whole structure, and previewed in real-time with a real console sending DMX inputs, after adding all light fixtures and mapped all the channels to the console.

This type of software is capable of designing a show from scratch and solve almost any challenge in light production nowadays with powerful realism settings. However, the skills required to work with these interfaces, along with the time needed to achieve good results, make the simulation stage an intimidating and sometimes optional process.

2.4. User interfaces for lighting and music in events

User interfaces for lighting control started with hardware only, with the consoles introduced earlier in this section. Recently, new software tools came
to support, or even end the lighting desks tasks, by providing new interfaces and far more powerful ways to interact with lights, such as multi-touch controllers. Most hardware lighting consoles were emulated, which is the case of Martin’s grandMA consoles, one of the world’s top solutions, now with a virtual alternative called grandMA onPC. Multi-touch light consoles were also included in SmithsonMartin’s \( ^2 \) Emulator - the only touch-screen program that can merge the software to be controlled with the touch interface making a software feel like it was natively designed for use with multi-touch. In related businesses such as music or VJing, multi-touch solutions are also emerging \( ^3 \), although some studies reveal higher levels of performance with tangible controls \([8, 9]\) - e.g. faders, buttons.

In spite of all the new control and interface options, DMX is still the standard communication for lights. Regarding any pre-visualization software, all accepting DMX, confirms that after great learning in a specific console, technicians seem to only trust their equipment.

2.5. Immersive visualization and interaction

With powerful realism settings, endless light control solutions, and guaranteed DMX support by any pre-visualization software, immersive visualization and interaction approaches are still missing, yet using regular screens and WIMP interaction solutions. Immersive VR or gesture-based devices are used in several businesses but only few have been tested in stage lighting pre-visualization.

Visualization in VR environments can be broadly divided into two types: non-immersive and immersive. The immersive is based on the use of HMDs or projection rooms - e.g. HMDs \([10]\), CAVEs \([11]\) - while the non-immersive VR based on the use of monitors. The notion of immersion, is based on the idea of the user being inside the environment. HMDs can provide this insider feeling, which deliver an even more realistic perception of a simulation, and were never tested in stage lighting pre-visualization.

To support the immersion, post-WIMP interfaces such as gesture-based devices or hands-free interaction came to provide new ways to interact in virtual environments. Gesture-based devices are controllers that act as an extension of the body so that when gestures are performed, some of their motion can be conveniently captured by software. Mouse gestures are the most well-known example. However, devices like the Nintendo Wiimote, Sony PS Move or SpacePoint Fusion, use gyroscopes and accelerometers to allow straightforward direct mapping between device movements and rotations and corresponding effects on the three-dimensional space. With hands-free interaction though, user’s are not dependent of an hardware extension of their body to navigate or interact in the environment. Using depth sensors, infrared cameras or microphones, devices like Microsoft Kinect for full body tackling or Leap Motion for the hands can provide new degrees of freedom to the user.

Leap motion’s capabilities were already tested in a stage lighting environment by Apostolellis et al. \([12]\) in an attempt to prove that it would outperform the mouse for the integral tasks of position and rotation of light fixtures. However, he did not support the hypothesis with the mouse performing significantly better, both in terms of completion time and angular and position errors.

In conclusion, there are powerful lighting simulation tools for event pre-visualization but the learning curve is overwhelming, mostly due to interface complexity. On the other hand, great interfaces are emerging for light control, such as multi-touch devices, but the main concern in pre-visualization is to accept any hardware or software console using the DMX communication protocol. With this option, every event light controller is capable to perform in the preview stage. Finally, visualization still relies on regular screens based on WIMP, leaving immersive visualization and interaction yet to be explored.

3. VRLight

VRLight is a prototype software developed from the investigation on existing lighting pre-visualization tools, immersive visualization devices and gesture-based interaction approaches. This virtual reality solution for lighting simulation in events combines all these new technologies, with the two main highlights being simplicity and interaction.

3.1. Conceptual description

This prototype separates the artistic task from light control, allowing the director to focus only on light fixture choosing, placement and aiming in the immersive environment. The entire light control backup is provided by a light technician, working with any light controller device of his or her preference. Figure 2 shows an concept overview of the work process.

Using a head-mounted display, the designer gets an immersive view of the virtual environment where all the action is taking place. With a pre-modeled scene ready - e.g. theater, club, etc - the user handles a gesture-based device to allow movement and light editing. By communicating with the light technician, who follows the process on a separate screen, the director can demand any light parameter change to obtain real-time feedback of the setup behavior and make fixture changes or aim lights in
different directions, all in real-time and with free movement in the scenery. This unique approach lets the user intuitively experience the light show from any location, from either the crowd’s perspective, the musicians’ or any other desired view angle.

3.2. Architecture description

VRLight was developed in Unity3D game engine thanks to its powerful 3D environment for modeling and the script-based logic for all operations, which allowed a great level of abstraction and powerful real-time rendering. The application runs on a single computer and connects to an input module for interaction and light control and an output module for visualization in two different devices (Figure 3). All light fixture resources are stored in a data folder containing the light modules and their behaviors. Also, a config file is used for both loading and saving the lighting rig for further work. This file keeps the fixture list, DMX channels and light orientation in the environment.

Input module is divided in two different components - interaction and light control - carried out by a light designer (director) and a light technician respectively. To interact in the environment - light editing menus and user movement - the designer uses the SpacePoint Fusion. This gesture-based device was chosen thanks to its very stable gyroscope component which allows one to add a cursor in the 3D environment using the pitch (X-axis), yaw (Y-axis) and roll (Z-axis) values. As far as light control is concerned, VRLight is ready to connect to any controller having the DMX communication protocol. From simple DMX software running in the same machine to complex light consoles with a DMX-to-USB device or wireless connection to the computer, the application is ready to read any desired input. DMX and the detailed connection to external controllers is explained in section 3.4.

Output module provides visualization platforms to the designer and the technician. It is composed by the Oculus Rift HMD for immersive visualization and an external monitor for the light technician to acquire feedback from the simulation. The headset provides an insider view of the scene, with the immersive feeling allowing head movement in any direction or axis. The monitor displays a variety of views to the scene, allowing the technician to follow the preview from the most suitable angle.

3.3. Immersive visualization and interaction

VRLight provides a unique experience when it comes to lighting pre-visualization. Immersing in a modeled scenery and previewing the light with a VR headset lets light designers step inside their venue, test the lights and ensure a perfect performance as if they had been there before.

Visualization is achieved with the Oculus Rift headset, connected to the core using the Unity3D plug-in from the Oculus SDK. Due to the danger of hitting something while using this device, it is impossible to wear it and walk around the room, since an HMD doesn’t allow to see other than the virtual environment. For this reason, the light designer interacts while sitting next to the light technician. Although this may seem to impose limitations in what concerns movement inside the scene, the user has two different options when using the SpacePoint gyroscope, explained in section 3.8.

Interaction in the immersive environment involves user movement, light fixture selection and aiming - e.g. select and aim different spotlights to the elements of a rock band and preview the results from several perspectives. The SpacePoint is used as a pointer controlling a cursor drawn in the scene for the three tasks - different cursor models for each task, explained in section 3.7. The cursor position is obtained by shooting a raycast from the user’s position with the SpacePoint’s forward vector direction. In the hit point, the cursor is drawn. By default, the device’s zero orientation is to the North, meaning that if the user is sitting facing South, the cursor is still pointing North when the program starts. To correct this issue, a calibration is automatically
made by adding the needed rotation to the SpacePoint object, every time a cursor is needed.

3.4. Connection to external light controllers
Light control in show business is the process of changing the light behavior, depending on several factors such as the course of a theater scene or music animation. Regarding the thousands of hardware and software options available for light control nowadays, which may depend on light technicians’ preference or the scenery’s complexity, our prototype soon showed the need to accept the universal communication system for light control - DMX, the standard protocol in stage lighting and effects.

Nowadays, DMX can be used to control both real and virtual lighting rigs (Figure 4) which opened up new possibilities for software applications. Virtual consoles are now an option for light control and the design and preview tasks can now be supported by the chosen hardware or software to be used further in the shows.

Before focusing on light controllers and the stage design process, it is important to understand how DMX works in pro lighting nowadays. A light fixture contains one or more controllable parameters, all listening to a different, but consecutive DMX channel. The only thing that can be setup in the light equipment is the first channel to be reading from - which will control the first light function. The fixture will then set the next channels to the following parameters. In a light console, typically, the leftmost channel is the zero channel.

In VRLight, when adding or editing a light fixture, the user can also select the first channel to be reading from. In the light editing menu - explained further in section 3.7 - in spite of choosing only one channel, the label output always shows the first and last channels to inform how many parameters control each fixture. This is one of the most convenient features for stage light design, since the usual stress prior to an event is reduced with the entire DMX mapping being setup before the show.

3.5. Real time light control
During light design, the ability to perform light changes to obtain feedback is a big advantage. This feature is even more interesting if both design and control are made at the same time. With real-time lighting preview, the director can confirm the final behavior while selecting a fixture’s position or aiming a spotlight.

In VRLight, real-time light control is achieved by reading external DMX inputs into the scene. Lights being inserted in the environment are automatically fetching data from the DMXReceiver. The script stays active during the whole interaction, ensuring that even in light editing mode, the light technician can send any DMX input to the scene, if asked by the director. With this ability, the design can carry on without regular stops to preview lighting behaviors in the current positions or settings. This option removes any independent processes for light editing or preview, since they all run at the same time.

3.6. Virtual stage environment
VRLight works with pre-modeled sceneries - theater, tv set, nightclub, bar, etc - and provides a variety of stage light fixtures to be installed in the virtual venue. For prototyping purposes, the stage model was thought to be simple and intuitive for the user, not disregarding the realistic features. It consists in an open-air structure with three central bars (metal cylinders) for light fixtures, representing the usual stage lighting truss. The stage model is illustrated in Figure 5.

On the stage floor, a rock band stands over the wooden texture to serve as an example model of a show demanding appropriate lighting. The initial environment shall contain this and every asset of the final show so, with all the models placed, lighting will be the only concern for the light designer. To complete the environment, other common elements were added to provide the most realistic feeling. The crowd facing the stage can provide light feedback such as how light illuminates the audience or how would it be the light show seen from the center of the crowd. The model is finally enriched with typical elements such as speaker arrays, stage monitor speakers and crowd barriers. All these assets will diffuse and/or reflect the light, making them essential to a successful design.

VRLight’s pre-modeled stage allows light fixtures in nine predefined positions, called slots. A slot is
the parent object of the light fixture. When selecting new equipment in the light editing menu, a new instance of the fixture object is added as a slot child, and the slot stores all related options, such as the light editing menu and data for the corresponding fixture. In this prototype, each of the structure’s central bars contains three slots. These slots are the starting point for light design in the prototype.

3.7. Light design
Stage lighting has endless fixture options nowadays. From light projectors to lasers, with single behavior or multiple effects, there is a solution to almost any design need. Our prototype contains a short but representative group of light models ready to be used but, regarding the countless options, it is scalable, accepting new fixtures in a very easy process. Adding the 3D model, materials, behavior script and textures to the resources folder, automatically presents the new fixture in VRLight’s light editing menu list.

Five different light fixtures were chosen to represent the main lighting solutions available nowadays - labeled in Figure 6. These five fixtures represent different types of solutions used in stage lighting nowadays. They cover light effects like flat light beams, strobing lights, lasers and shaped or moving beams. Regarding the visual feedback for each luminaire, different approaches were taken, depending on the unit. Fixtures containing defined light beams - Par LED, Gobo Projector and Mac 250 were developed using volumetric light shaders to create the light beam effect. An animated texture adds the smoke/fog animation which helps turning the beam visible. Changing at a constant speed, the texture creates the wind effect on the smoke hit by the beam, adding realism to the visualization. Color, strobing and intensity effects were addressed accessing the fixture’s light materials and changing them according to the DMX value read from the DMXReceiver script.

Virtual fixtures contain a behavior script attached which runs for as long as the equipment is installed in a structure slot. The script contains all the information needed to provide the unit’s operations, translating DMX values in virtual lighting action. At every program cycle, if a new DMX input is received in the DMXReceiver, all the light parameters are updated by the script.

Light fixture choosing, channel selection and light aiming are all done using the light editing menu (Figure 7). This is called by left clicking the SpacePoint device and selecting the corresponding blue sphere attached to the desired slot. A simple interface is provided in the light editing menu. With very few options, the susceptible lack of editable features is due to the DMX protocol, responsible for all fixture’s behaviors in pro lighting. This way, any light parameter other than aiming - how the equipment is installed in the structure to point in certain direction - is controlled in the console. The menu ended up needing only 6 buttons for three main sections - fixture selection, light aiming and menu closing. To aim a light fixture, a shooting target cursor is provided, as a metaphor for where the light will shoot its beam. Together with the cursor, the corresponding fixture’s light beam(s) will follow where the user is pointing in the scenery.

3.8. User movement
One of the most important pre-visualization goals in every industry is to provide as many preview angles as possible. Enabling total control from which position to look to an object, drawing, lighting environment or any other is the key to a successful preview. In VRLight, since user immersion lets the designer step into the virtual environment with an headset to look in every direction, it was crucial to allow full movement inside the scene. SpacePoint gesture-based device was the solution, delivering two different movement approaches - the Change Position Menu and Joystick Mode.

Using the SpacePoint device, the Change Position Menu is accessed by clicking the right button and closed by clicking anywhere outside of it with any button. This menu (Figure 8) is split in two sub-menus. The left menu - Movement - contains three movement options to choose the user’s exact position. The right menu contains the Virtual Fixtures list. The menu can be closed by clicking anywhere outside of it at any time.

Figure 6: VRLight’s fixtures.  
Figure 7: Light editing menu.
location, rotation or height. The right menu - Go To - provides predefined positions which will move and rotate the user to the exact named location - Stage, Behind Crowd and Previous Position.

In the Movement menu (left side), the **Point and Go** button activates a *point to where he wants to go* mode, also studied by Cabral et al [13]. The SpacePoint cursor model is replaced with a 3D human stick standing on a blue disc with an arrow attached (Figure 9). This model represents the user and its next location and orientation. Also, the user’s height is increased to allow a better view over the scenery and increase pointing precision.

The **Joystick Mode** is based in the typical joystick hardware interaction. The three SpacePoint’s axis are used to move (X and Z) or rotate (Y) the user. Holding the right button, starts the joystick mode and registers the device’s orientation at the click moment. Calculating the difference between all further SpacePoint orientations and the first one provides the speed values in all directions and the user position is changed accordingly.

This approach showed some limitations that are not found in regular joysticks. Being the SpacePoint hold in the hand, the intention to rotate and move forward at the same time accidentally lead to undesired Z rotation, caused by thoughtless arm or hand movement. However, this option was not discarded since the point and go method - explained in the previous section - is not ideal for very short movements - e.g. drummer is obstructing the view and only half a meter to the left is necessary to solve the problem. With the point and go approach, the user would have to look and point to the ground, half a meter to his left and be very precise in choosing the correct location to avoid new obstacles. In joystick mode, a slight left rotation in the Z-axis to his left and the user starts moving to the left until the button is released. Less steps are involved and the feedback while moving allows to choose the exact position and stop anytime by releasing the joystick button.

Considering the pros and cons of this movement approach, user tests were carried out to determine the need for such option. Users with previous joystick experience agreed in leaving this option available. Some tests were even complete using this mode only, although the limitations.

4. Validation

In order to validate our proposal, it was necessary to conduct a set of user tests. Despite the importance of lighting experts participation, which could not attend on the testing period, VRLight exposes new interaction paradigms suitable to be tested by anyone. Validating with non-experts could demonstrate how simple can the interaction be, even without any knowledge in this field.

Being VRLight a first prototype, with big focus on immersion and interaction, it still is far from the complexity and learning effort required by the commercial software available. Validation against existing tools could not be done in time and was set as the future work in VRLight’s development.

The tests were structured in two stages: three interaction tasks in VRLight’s environment, followed by a survey to rate the prototype’s ease of use and a comments section for optional suggestions.

4.1. Testing setup and user profile

Tests were conducted in a closed environment at the Instituto Superior Técnico in the Taguspark campus. A single laptop computer was used with VRLight for visualization and interaction, together with an external light console software to send DMX inputs to the virtual lighting rig. For visualization, an Oculus Rift headset was ready for the user’s tasks as show directors, and an external monitor outputted the technician’s view, with this control task being carried out by our group. User interaction was made through the SpacePoint Fusion controller and the light control using an iPad running a multitouch light console connected wireless to VRLight. Figure 10 illustrates the setup described during a user test.

A group of 20 users, aging from 18 to 40 and mostly male (70%) were present in the test stage. Only 25% had tried HMDs before, all of them in Taguspark’s development or testing environment. Regarding stage lighting knowledge, only two users
(10%) had previous DMX experience but none of the participants ever used a stage lighting previsualization software before. In gesture-based devices experience, 55% had tried at least one gesture-based device, and 90% used a joystick before.

Having in mind the low level of stage lighting skills, a brief DMX introduction was given before the tests, ensuring the same level of knowledge needed to understand the light editing menu.

4.2. Tasks description

Three main tasks were chosen to validate VRLight’s capabilities for stage lighting design. These three tasks can be split for two different purposes: user movement - first task and light editing - second and third tasks. Users were requested to put on the Oculus Rift headset and hold the SpacePoint in their hand. Already seeing the environment, one minute was given for each user to know and understand the menus and movement modes available in the prototype. The tasks were explained after the first minute of experiencing VRLight, without removing the headset.

Task 1 - User movement - This task involved moving the user to 4 pre-defined positions, using any of the movement options available - Point and Go, Joystick mode or both combined - and in the fastest time possible. By analysis of the informal tests during the development, it would not help testing the Point and Go movement against Joystick mode due to this second’s limitations.

Task 2 - Adding light fixtures to an empty structure - The second task was created to validate the use of the light editing menu, specially the fixture picking section. Although this specific job is part of each one’s creativity, being part of a timed test, the list of fixtures to add to each slot was previously defined to keep the exact same task to every user. The list was communicated during the test by a member of our group. The task’s elapsed time was registered for each user.

Task 3 - Aiming lights to the band members - The third timed test consisted in aiming nine Par LED projectors to the five members of the rock band standing on stage. With nine fixtures to five elements, users were allowed to choose which models would have more than one projector aimed to their position. However, no fixture could be forgotten, neither a band member could be left without illumination. Figure 11 shows the stage before and after the task is complete.

4.3. Experimental results

At the end of each user test, all execution times and questionnaire answers were recorded. The time values were analyzed and provided information about the prototype’s capabilities in average time to complete tasks and best movement method. The questionnaire obtained user evaluation of the prototype’s ease of use using Likert scales mostly.

Task results

The three tasks were completed by all of the participants in the tests. With all three tasks being made in under three minutes each, results show VRLight’s capabilities to perform simple stage design without great difficulty. Time values could not be compared with other applications yet.

In the movement task, the chosen method to perform this test was registered to validate which is the fastest option. Users could choose between using Point and Go, Joystick mode or both combined. Time results are charted in Figure 12. The main focus goes to the Point and go method, when compared to its combination with the Joystick mode for slight position corrections. Users who used both methods combined did an average of 1:51, 21 seconds less than the average Point and go users.

Tasks two and three revealed the ease of use of our prototype in light fixture editing, with every user finishing the task in under 2:15 average. With nine slots to add or aim fixtures, these values may not represent much without comparing with other tools, but are significant enough to validate that each slot takes seconds to edit and all users were capable of finishing the tasks proposed.
Figure 12: Movement task times using three different approaches.

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**Questionnaire results**

In the questionnaire answered after the three tasks, users analyzed VRLight’s features in terms of ease of use and importance to the interaction.

To survey the users’ favorite movement method, a five-point Likert scale was used to rate each approach in terms of ease of use. The Wilcoxon test was used to verify the statistically significant differences. Users strongly agreed that the **Point and go** method was the favorite of the two \(Z = -3.564; p = 0.000\). However, when questioned about combining the two approaches, 45% of the users agreed that both methods combined was the better option, confirming the advantage of using the Joystick mode for small location corrections. A text section was added for comments in both movement techniques and 40% of the inquiries suggested sensibility calibrations in the Joystick mode.

Still in user movement, it was asked about the **view height** and **predefined positions** importance to the interaction in the prototype, using a four-point Likert scale. All users (100%) considered important (or very important) the existence of those features in VRLight. In a comments section for missing predefined positions, 15% suggested a "first row" position - in front of the stage.

In the survey’s light editing section, using the four-point Licker scale (from difficult to very easy) for menu access and button hits revealed 90% and 75% very easy, respectively. None of the users classified the previous options as difficult. As for light aiming, some users (30%) considered the task difficult, mostly due to a bad location from where the user was aiming the fixture during the test - as confirmed from the checkbox options in the following question, used to define the biggest issue that caused difficulty in the task.

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**5. Conclusions**

Immersive visualization and interaction is a relatively new option in virtual reality systems nowadays. Several industries still make use of WIMP interfaces on regular screens to do their design work. The advantages of stepping inside the virtual environment using new interaction paradigms is not yet a possibility in multiple design and pre-visualization solutions. Stage lighting simulation is one such case.

VRLight exposes an immersive virtual reality solution for lighting pre-visualization in events. This prototype - with the interaction illustrated in Figure 13 - introduces the HMD for visualization and gesture-based interaction devices in lighting simulation, which have never been tested before, and may represent an important step for designers and technicians in this field. On the other hand, this solution keeps the best of lighting technology available, by supporting the DMX communication protocol and a scalable approach, enabling easy addition of any new light fixture models to the software. VRLight accepts any type of light consoles, hardware or software, allowing the use of the final gear in the preview stage. Such advantage allows technicians to perform console programming while directors pick the best fixtures to the stage structure, all with real-time pre-visualization.

Creativity and focus are increased when unconcerning the director of complicated interface issues, leaving light fixture selection and aiming as the only focus in the design. With the communication approach, any light parameter changes are demanded by the director to the technician, who uses his console to send DMX inputs to the environment.

On the interaction side, the reduced complexity in light editing and movement interfaces lets the user feel increased involvement in event production. The sense of being ”inside” the venue with the SpacePoint gesture-based device to move and edit light equipment with simple interfaces and tools raises stage lighting production to another level.

To validate VRLight’s ease of use, it was challenging to test the non-experts capabilities to perform stage design tasks in our environment and impose that this prototype’s simplicity should deliver an effortless VR solution to perform stage lighting design and pre-visualization. The goal was achieved with all the participants in the user tests stage being able to finish the three proposed tasks. Testing

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**Figure 13: VRLight interaction.**
VRLight against existing tools is one of the future works set to this project.

6. Future work
In the prototype presented in this thesis, there are some aspects that, in spite of being the main focus of this work, are worth of improvements or could lead to interesting future work. Those are: compare VRLight with existing tools (when the level of options is suitable to set against other software), testing the prototype in a real scenery, adding more light fixtures and no slot limits, wireless gesture-based devices and the walk-in-place approach for movement. This last one, emerging recently in immersive solutions, may bring a new level of freedom to the user, simplifying the overall interface and enabling real user movement, which increases the immersion feeling. These functionalities raise a whole new set of challenges to be tackled in the future.

References


