Virtual Teleportation of a Theatre Audience Onto the Stage: VR as an Assistive Technology

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Abstract. For more than a decade, virtual reality (VR) has been employed to enrich and heighten media experiences. Despite the recognized potential and promise of VR, and ample investment, it has yet to fully transform or replace existing screen-based experiences (e.g. film or gaming). This research forms a part of a larger project to shift VR applications beyond otherwise apparent areas of screen-based media, in order to enhance audience access and propinquity to a live performance. This study is being conducted in the field of theatre, a dramatic medium in which audience are traditionally static and where an individual's seating position determines their perceptual experience (distance, angle, lights, obstructed vs clear view). This paper introduces the broader project and its experimentation with VR as an assistive technology. The project seeks to utilize VR as a means of converting an otherwise static experience to provide collective moments of visual teleportation, onto stage, into props and on actors. VR offers a non-invasive means of introducing variance in viewer proximity or position relative to performance. This paper reports on the early development and use of a three-dimensional theatre prototyping in order to explore the technical requirements for application to a VR theatre experience.

Keywords: Virtual reality · 360-degree camera · Assistive technology · Emancipation · 3D-prototype · Perspective · Theatre · Invisible

1 Introduction

1.1 Project Scope and Aims

The scope of our first set of experiments in a broader VR-theatre project that aims to incorporate virtual reality (VR) technology into a theatre experience, is to establish functional and impactful camera position/placement that will ultimately transform, augment and enhance a static experience of a dynamic performance. The aim of employing VR is to alter the nature of audience engagement and alter their sense of presence in a positive way. Initial experiments constitute a vital first step as they provide a finite number of practical test-case results that will later be implemented in live testing in conjunction with theatre practitioners. Our ultimate aim is to have VR stimulate new approaches to theatre practice and performance by offering and empowering theatre practitioners with a means to experiment with audiences' proximity and presence. In order to achieve this aim, key parameters like camera positioning in or around the stage, relative to the performers and the number of performers on the stage will play an

K. Arai et al. (Eds.): FICC 2020, AISC 1129, pp. 1–11, 2020.
https://doi.org/10.1007/978-3-030-39445-5_36

important role. The first set of experiments sought to ascertain potential heightened and concentrated perspectives through which a two-person on-stage interaction could be experienced via VR. It is posited that through on-stage presence an audience may gain greater sense of intimacy, typically achieved in film via close up and extreme close ups, or engender new perspectives in theatre such as first-person perspective or providing perspective from an inanimate object found on stage.

1.2 Experiment

This experiment was focused on the production of a 3-D prototype of a theatre setting in order to identify possible areas for camera (and in doing so, audience) placement on stage. Charlton and Moar [3] conducted a comparable study in which they too introduced theatre audience to the experience of being inside the stage and amidst performance. They employed VR with the aim of inducing a state of deeper engagement from bodily presence. The play 'Fellow Creature', consisted of only two actors plus a camera (GoPro rig) that was placed in a central position on stage. The camera viewpoint, viewed through a Head Mounted Display (HMD), permitted audience members to experience the play amid the actors. This experiment focused on the effect of the perspective change on audience, sense of voyeurism and its similarities in theatre and VR. This experiment helped to bring audience 'onto the stage' and transform their status and role from non-participatory witnesses outside the play to co-presence. However, it simply aimed to place the audience at the center of the stage. The series of experiments supporting the current project pursue a similar line of thinking to Charlton and Moar, but with greater focus given to the technical installation and application of VR on what is the best position/angle for the camera on stage, determining the appropriate vertical height for the camera view and assessing the effect of camera movement and motion blur on audience viewing. The project also seeks to extend the use of augmented objects (AO), visible through the HMD, to enrich the setting of the performance. Finally, the current project will also examine the application of VR in two distinct theatre conditions - a more traditional theatre experience in which a story is enacted or played out uninterrupted on the stage and a devised theatre or a collective creation which emerges from collaboration and improvisation. A comparative analysis will be conducted of the relative merits of VR to both theatrical contexts.

The primary aim of the experiment reported here is to begin the process of narrowing down the number of viable camera positions that can be made available to theatre practitioners to work around, and for an audience to teleport into from a seated position. A simple stage-bound performance comprised of two actors in conversation can be captured in a finite number of angles, typically conveying 25–40° angles when a standard camera is used [5]. When introducing VR into theatre performance, the possibilities for wider perceptual field increases exponentially due to its 360-degree field of view. This brings an additional set of considerations concerning the visibility of otherwise unrevealed offstage areas such as the wings, crossovers or voms, lighting rigs and also the audience. The aim of this first experiment was to use the 3D prototype of a simple theatre-stage context to filter out a finite number of inciting camera positions, that will act as a centroid for all adjacent and approximate camera positions. Successive experiments will aim to evaluate, test and validate the impact, appeal and advantage

associated with different camera positions as well as its impact for the actors/performers. Ultimately the project seeks to explore how the addition of a dynamic perspective changes the audience experience of a theatre experience and its future evolution. The intention is to follow prototype experiments with a physically staged experiment that consists of real performers (who will also serve as research participants). The acquired camera positions will eventually be tested and evaluated by an in-house audience (who will also serve as research participants).

The prototype is designed with only two static characters placed on the stage, to mimic a real-time conversation between two actors. Since this was a pilot study the complexity of a real-world theatre performance is purposely reduced and simplified to a situation comparable to black box theatre. This experiment aimed to identify possible at pivotal or centroidal positions for camera placement to provide an inciting stage view available to all audience members seated from downstage to upstage. From initial discussions with theatre production companies based in Hamilton (New Zealand), it has been noted that employing subtle facial expressions to convey emotion or feeling is difficult in a theatre context as it is difficult to guarantee that audience will perceive them or if they will even be attentive to the particular and relevant zone of information conveying a potentially crucial aspect of the play. Also if we consider the experience of a stage show, a sports event or live concert in person compared to viewing a framed and edited version on screen, while a live experience allows the audience to experience the energy and absorb the atmosphere of an event, there is a real likelihood that smaller gestures, looks or moments on stage or on field will be lost due to audience distance and where attention is being directed. For this reason, large digital display screens have now become standard in sports or concert stadiums (even when not televised), to some extent acknowledging what is lost or missed when viewing solely from the crowd. Similarly, the application of VR to theatre provides a window of opportunity for an otherwise quiet and static audience to gain even greater intimacy via proximity and presence. Indeed, Wendell Cole writes: “since the final quarter of the nineteenth century it has been apparent that major efforts of architects and designers have been directed toward bringing audience and actors into more intimate contact with one another” [18].

In the broad context of the study, prototyping will serve as a key tool and methodology over the course of the research project – as it provides a means to evaluate and test camera use, placement and viewing prior to testing and application with real actors and viewers within a theatrical rehearsal or performance. Focus groups, workshops (testing experiment with actors), interviews and questionnaires will be used to evaluate limitations and potential of VR, at a later stage of the research. Once prototyping is completed, it will be followed by focus groups with selected theatre production company participants/artists to determine the perceived affordances of the medium and identify any significant challenges that needs to be resolved prior to adoption and application by practitioner for use with audience. On completion of focus groups and analysis of the data collected, experimental workshops will be conducted in which VR will be assimilated into theatre practice, guided by the results of prototyping and consultation with practitioners concerning the perceived need, application and challenges. Experimental workshop will aim to reach rehearsal in front of a test audience in order to assess the performance of the VR technology, actors’ interaction

with or performance in the presence of VR technology on stage, and audience engagement with VR alongside traditional viewing. Once actor and audience testing are complete, participants will evaluate their experience via a questionnaire and short feedback interviews in order to provide insights into the success of the experience aesthetically and technically, as well as the level of absorption and immersion provided by VR.

1.3 Prototype

As stated above prototyping aims to help in the evaluation, and determination of the number of camera positions that can provide a 360-degree view of the performance from the stage. Evaluation of the prototype is based on theoretical analysis of the stage and the performers placement. The findings will be further evaluated through data collection with practitioners and mock-audience during rehearsals before commencing successive experiments.

The aim is to assist the audience to achieve absorption and immersion in their engagement with theatre performance. As theatre has continued to evolve, more immersive modes of theatre have been explored. Nicola Shaughnessy suggests immersive theatre provides an idea of engaging the audience/spectator in a common shared space with performers, in doing so, submerging them in an experimental space which neglects real and fictional boundaries [14]. An example of immersive (and also promenade) theatre can be found in British theatre company Punchdrunk's adaptation of Shakespeare's Macbeth in 2011 entitled *Sleep No More*. For the New York performance of the play, warehouses in Manhattan's Chelsea neighborhood were transformed into hotel-like performance spaces allowing audience to move freely through five floors and settings, allowing them to interact with props, or observe the actors at their leisure [16]. However, like a seated audience the *Sleep No More* audience were asked to remain silent (and also masked) at all times, refrain from using phones or cameras and maintain a respectful distance from the performance. Nevertheless, a performance accessible in this way catered to senses like touch, smell, sound and physical proximity to the actors (presence). This example, experimented with the idea of group immersion or 'productive participation' drawing on audience's capacity and inherent productivity to build up the story of their own [1].

In 1974, philosopher Robert Nozick [12] invited us to imagine an 'experience machine' capable of artificially stimulating the brain to induce our desired experiences. As De Brigard outlines Nozick "seems to suggest that most people's intuitive reaction after considering the thought-experiment would be just like his: they would feel very little inclination to plug in" permanently [4]. Nozick posits people care too much about "living in contact with reality" [12]. The application of VR proposed in this project instead offers multiple perspectives as a witness to a dramaturgical performance taking place in front of the audience. Not confined to a seat or single position the audience, via VR, is able to employ a type of locomotion that allows them to access the stage without requiring any physical transfer (teleportation). Like Alston's notion [1] of collaborative theatre immersion, VR immersive experiences hold the potential to offer an escapist experience from within the real world, occupying the audience in a constructed

immersive experience and 'tricked out spaces' that allows the audience escape their seats and penetrate the stage as an imperceptible spectator and voyeur in a performance.

2 Technical Evaluation Criteria

A prototype was developed in 3D modelling and animation software Maya. The 3D characters and the models employed are royalty-free and do not require copyright. The 3D characters and set are retopologized and change in textures were applied as per the experiment's requirements, such as various lighting setups (spot light, area light). The benefits of a three-dimensional setup, is an infinite possible camera positions were broken down into potential camera positions that can enhance audience viewing. Considering two basic orthographic views - top view and front view, both orthographic views play a significant role in determining and drawing the three-dimensional view of any object [7]. A two-dimensional top view and front view for the whole setup and an imaginary circle around the two characters was developed, as shown in Fig. 1. The imaginary circle is formed by the camera when it is revolved around, with the performance as its center. This provided two variables 1. The center of the circle which will be the focal point and 2. the radius of the circle which will be the focal length of the camera. Still, there are infinite possible camera positions along the circumference of the circle. The circle is divided into four equal quadrants with respect to the straight line between the two characters. Since all four quadrants are identical, I have taken the first quadrant (0–90°) as my sample. This reduces the number of camera position to a finite number, unlike the previous scenario of all four quadrants.

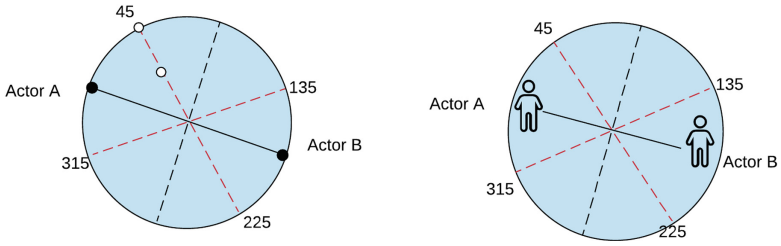


Fig. 1. Top view and front view of the performance space to breakdown the camera placement position

By evaluating the single quadrant, the best camera position inside the quadrant can be determined. Using the same principle, the camera positions in the other three quadrants can also be determined. There are two possible ways to determine the best camera position. Since it is considered as a defined shape quadrant, the centroid of the quadrant would serve as one of the best possible positions for the camera.

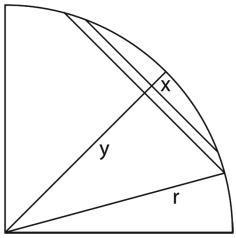


Fig. 2. Quadrant 1 - 0 to 90°

A single quadrant from the entire circle is considered, as shown in Fig. 2. Considering an infinitely small horizontal strip of thickness 'dy', at a distance y from the base.

The length of the strip will be 2x.

The moment of all such strips of the semicircle about the base divided by the area of the semicircle would give us the distance of the centroid from the base.

$$\bar{y} = \frac{4}{\pi r^2}\int_0^r 2xydy$$

By Pythagoras theorem, $x = \sqrt{r^2 - y^2}$

$$\bar{y} = \frac{4}{\pi r^2}\int_0^r 2y\sqrt{r^2 - y^2}\ dy$$

$$= -\frac{4}{\pi r^2}\left[\frac{2}{3}\left(r^2 - y^2\right)^{\frac{3}{2}}\right]$$

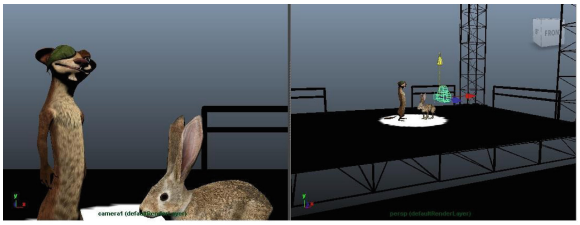
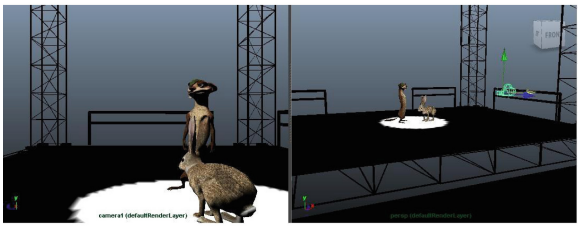
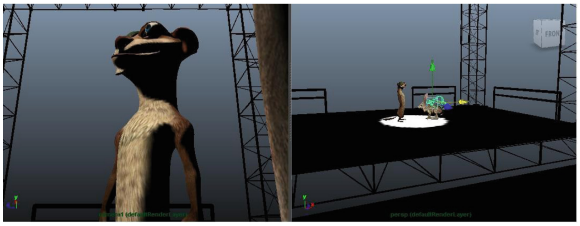
$$= -\frac{4}{\pi r^2}\left[-\frac{2r^3}{3}\right]$$

$$= \frac{8r}{3\pi}$$

So the centroid would be (0, 8r/3 π). The other possible position would be at an angle of 45° at the edge of the circle [5]. The best positions for the other quadrants can also be determined the same way. Using this method of calculation, there would be eight possible 'optimal' positions from the top view.

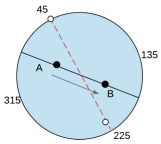
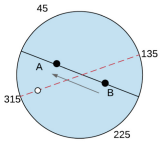
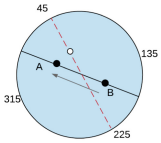
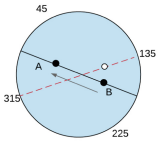
Similarly, with the same calculation, the best position from the front view can be determined, and it will be four positions, unlike top view since the other four positions in quadrant 3 and 4 will fall beneath the ground. When the findings of the top view and front view positions are correlated that results in eight possible positions, which will be evaluated further in the successive experiment using real-time stage, actors and theatre practitioners. Some of the camera positions that have been tested using the prototype are tabulated in Table 1.

Table 1. Various iterations of camera position from the prototype design

	Camera on the front of the stage
	Camera on the side of the stage (45 degree)
	Camera on the person for perspective

Evaluation of filmed theatre or live performance or music concert provides useful information regarding traditional camera positioning and camera angles that audience may be familiar with. In order to add a layer of filter with the concluded results of the camera placement, a video analysis of the 'Hamlet - Rehearsing the sword fight' directed by Robin Lough was done [10]. The reason for the choice of this particular piece of artefact is because it stands in the similar interest of this research and similar to the type of experiments which are proposed further in the research. The sword fight takes place between two characters within a defined circle in the stage, restricting many complex movements. The two characters, Kobna Holdbrook-Smith and Benedict Cumberbatch are represented as character A and character B respectively. The analysis result of the '*Hamlet - Rehearsing the sword fight*' is tabulated in Table 2.

Table 2. Findings from the analysis of '*Hamlet - Rehearsing the sword fight*'

Camera Placement	**Camera Height**	**Action/ performance**	**Representation**
Shot 1- Left of Character B	Eye level	Character A is attacking and advance, character B retreating	
Shot 2- Right of Character A	Eye level	Character B is attacking and advance, character A retreating	
Shot 3- Left of Character A	Mid level (to focus the hand movement and sword) (Character B is right handed)	Character B is attacking and showing some sword skills	
Shot 4- Left of Character B	Eye level (to show the facial expression)	Character A advancing aggressively	

When comparing the findings from this analysis of *'Hamlet: Rehearsing sword Fight Analysis*' against findings of the prototype experiment, it coincides with most of the valid camera placement. However there are a few more new interesting camera positions and placements found in the analysis and in the prototype. All of these camera placements will be put to test in the successive physical experiments to derive a better understanding and usage of VR 360° camera in theatre performance.

Audience experience of fictional events or a performance can be altered radically when it is conveyed from a first or second-person perspective, point of view (POV). A subjective experience is widely accepted as spontaneous and distinct [17]. Indeed, the subjective or first-person POV is often used to emphasize reactions and response to a protagonist, instill immediacy and connection, and garner empathy from an audience [9]. The idea of permitting an audience to experience a close-up camera position or a first-person POV opens up the possibilities of theatre benefitting from cinematic insights.

As cinematographer Benoit Delhomme explains, when discussing his approach to filming *At Eternity's Gate*, a biographical re-imaging of Vincent Van Gogh: The camera "can be like a microscope. The way I was using close-ups in this film was to capture van Gogh's soul … The face becomes a landscape. What is more interesting than the face? So much to see in the face." The introduction of 360-degree view from a character's perspective will only enhance the audience's experience and involvement [6]. Theatre is often conceived as a 'third-person' art form in which 'on stage' characters do not see, they are typically seen. POV through VR is a means for the audience to teleport into the actor's space and adopt a similar perspective thus also gaining a psychological reading. Since individual audience typically consume performances from a single position, this project helps to amplify the idea of liberation from a single site and consider when it is most effective for freedom to be given [13]. Individual immersion via VR intends to heighten spatial presence and give prominence to the feeling of 'being there' or the illusion that what is happening is occurring to the spectator as much as the performer [15]. Even though this idea of audience spectatorship would be considered unorthodox, particularly when contrasted with traditional spectatorship, it has been explored as a topic of discussion for some time, seeking to open the door for experimentation in theatre performances [6].

Camera placement could become highly valuable as a means to allow the audience to interrogate, study and relish the drama and intensity of any performance [8]. Studies show that multiple camera placement is vital for Image MAGnification (IMAG) in any stage performance. The purpose of Image MAGnification is to magnify the person's "image" so people farther from the stage can more easily see them [19]. This is one of the reasons, various camera positions and composition rules have been followed for recording stage performance. Some of the basic camera positions followed are close in on a subject, closeup headshots - to capture facial expressions, moderate close-ups - to capture body language and movement, wide angle shots in combination with a low angle to create a more dynamic feel of the entire stage, triangle or split group formations - to capture group performance [8]. These findings from the existing literature coincides with majority of the results from this experiment. All of these camera positions will be examined and evaluated with a physically staged experiment that will consist of real performers (who will also serve as research participants) under various evaluation criteria of the number of performers, lighting setup, nature of performers (height, age, sex) in the successive experiments and the effect of application of VR in theatre performance will be evaluated.

3 Conclusion and Findings

The fundamental purpose of this experiment was to begin examination and evaluation of the infinite number of (stage 1) camera positions and filter them to a finite number, which has been achieved. Since the acquired camera positions for an inciting viewing are finite, we can proceed to further check the actual viability of the camera positions in the subsequent experiments. Charlton and Moar [3] have already conducted a similar experiment to examine the effect of having a static 360-degree camera at the center of the stage. However, in this scenario there was no defined or specific reason for the

selection of the camera placement, as they were aiming to examine the invisible, passive, voyeuristic viewer 'in the room' whilst a dramatic scene unfolds. The present work stands in contrast to Charlton and Moar's work as it focused more on determining a viable or centroidal camera position and inciting a view from inside the stage. This research will not only prompt the audience to explore the performance and construct their own impressions of performances but also help to evaluate how the virtual presence of an audience can induce a sensation of being inconspicuous yet close at hand [11] and quite removed from the audience. From this experiment eight positions from an orthographic view, camera positions from the actor's perspective, were identified to offer a change of perspective to an audience, emancipating the story from a single-perspective experience.

Future audience that experience VR immersion during a live dramaturgical performance will be introduced to a different modality by which a performance is conveyed. Moving forward, we aim to examine how such dynamic perspective changes in a theatre performance, will effect and affect both performers and audience and whether it is to the benefit or detriment to a theatre experience.

4 Reflections

From a media technician perspective, it is very intriguing to investigate the affordances that the VR medium possesses, and how that can be applied to a more traditional and historical storytelling medium that conventionally has its audience wedded to a single space. There is some significant technical testing and research being conducted on VR by the British Royal National Theatre who are exploring the use of VR studio to develop dramatic models for viewing in the 360° medium. [2]. However, very few theatre practitioners and performers to-date have been given the opportunity to expand their practice by moving the audience to view a performance from different vantage points throughout a performance and the opportunity experiment with this technical opening. It is our hope, that if the risk of investing in the application of a new technology is broken down, testing is completed on small units of activity/presentation with convincing findings, and presented linearly, then adoption of VR might happen sooner. By exploring and evaluating VR, and promoting prototyping as a pre-production practice prior to testing within theatre practice, it is hoped that VR might assume a role in the process of theatre practice.

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