Farewell to Dawn: A Mixed Reality Dance Performance in a Virtual Space

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Figure 1: *View of the virtual stage for Farewell to Dawn*

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1 Introduction

Farewell to Dawn is a mixed reality dance performance which explores two dancers' voyage from a physical space to a virtual stage and back, as the day passes before them.

The major challenge in enabling theatre in virtual spaces lies with the interface, as the default means of interacting in these worlds is unnatural, unfamiliar and non-intuitive to the theatre practitioner. This makes effective theatrical expression cumbersome and difficult. The system addresses these shortcoming through an intuitive interaction model based on processes and interfaces used in a real physical theatre [Geigel et al. 2011].

Farewell to Dawn was performed in April 2016 at Nazareth College, Rochester, NY. The complete performance can be viewed at https://www.youtube.com/watch?v=smYdab1V5og.

2 The Mixed Reality Stage

Performance of the piece is achieved using the *Mixed Reality Stage*, a VR theatre platform that integrates motion capture and augmented reality (AR) with a distributed 3D gaming engine (Figure 2).

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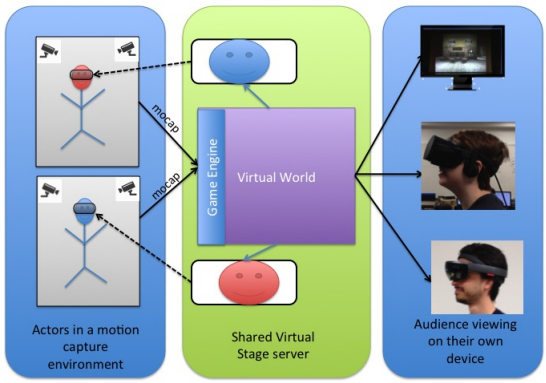

Figure 2: *System Architecture of the Mixed Reality Stage. The blue user in the figure views the body of the red users avatar through AR glasses and visa versa. Audience members can view the stage from a seating position in the virtual space.*

At the heart of the system is the stage server, which uses a distributed gaming engine to manage all of the assets, motion, and media involved in a production. Specific clients communicate with the server, allowing for interaction and presentation of a rendering of the virtual stage based on the role of the participant in the production.

The physical space in which each dancer performs is encased within a motion capture environment allowing the dancer's motions to be transferred to an avatar on the virtual stage. Each dancer is also equipped with an augmented reality headset through which she can view the virtual world from the perspective of their avatar. Using the orientation detected by the motion capture system, the view of the virtual world is optimized and personalized based upon the position of the dancer's avatar in the virtual world.

The devices and technologies used in our prototype implementation are listed in Table 1.

Table 1: *Technologies utilized in our prototype implementation*

feature	technology
Stage Server	Unity 5
Motion Capture	networked Microsoft Kinects
Augmented Reality	Epson Moverio BT-200

3 Performing in a virtual space

Avatars are represented on the virtual stage as point clouds of light, which are controlled in the physical space by actors in a motion capture environment. The use of realtime performance capture is essential as this is the natural means by which performers are familiar when expressing themselves on the stage.

As we will need to track the position of the actor's representation on the virtual stage, a mapping from the coordinate system of the physical motion capture space to the corresponding space on the virtual stage must be carefully defined. This mapping, as well as the physical configuration of the capture space, is passed to the system which uses it to transform the motion appropriately.

Effective theatrical expression in the virtual space requires that the actors feel that they are present on the virtual stage as they perform [Reeve 2000]. Towards this end, actors can view the virtual stage from their avatars perspective through augmented reality glasses (Figure 3). The use of augmented reality (as opposed to immersive VR) is preferred as the performer will not only require to be present in the virtual space but, at the same time, must be cognizant of their own physical environment.

Figure 3: *View of virtual stage from a dancer's perspective. This view is displayed through augmented reality glasses.*

4 Lighting and Staging

Stage elements, sets, and props, are created using standard 3D modeling tools and imported into the VR engine.

Keeping with the theatrical metaphor, the system defines a virtual dimmer/patching system allowing for control of lighting on the virtual stage using the same interface used by theatre professionals in a physical theatre. In our prototype implementation, we utilize the DMX512 based lighting application LightKey[1] in conjunction with the Open Lighting Architecture [2], for transfer of DMX512 lighting data to control lighting in the virtual space (Figure 4).

[1] http://www.lightkeyapp.com/

[2] https://www.openlighting.org/ola/

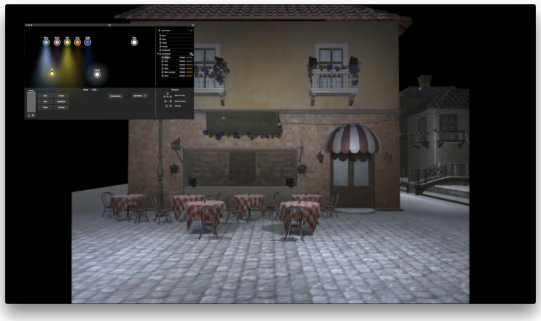

Figure 4: *DMX control for lighting on the virtual stage*

5 Recording and remote viewing

The final rendering of the virtual stage is created in realtime by the gaming engine based on the time varying "state" of the stage elements (actor positions and orientations, placement of the props, lighting, etc.). During a performance, these state parameters can be time-stamped and saved, allowing for a recreation of the theatrical experience at some future time.

Our initial production was realized on a physical stage with the virtual world, viewed from a single perspective, projected on a large screen behind the dancers. In the spirit of pure Virtual Theatre, where audience and performer need not be in the same physical space, we are currently exploring alternative means of delivering the performance to remote viewers, including the use of VR and AR head mounted displays, to provide a more immersive experience to off-site audience members. These same methods can be used to allow viewers to "play back" a recording of the captured performance [Caputo 2016].

Figure 5 shows the playback of "recorded" dancer motion in an augmented reality environment.

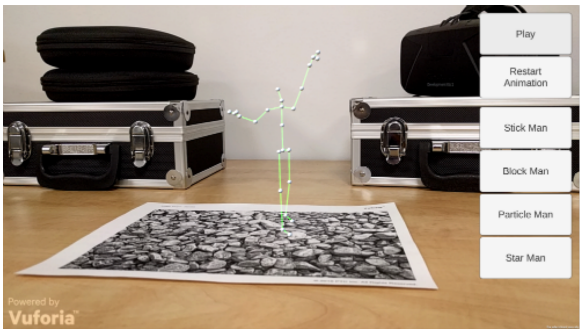

Figure 5: *Using AR to view a playback of the performance*

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