

Never Tell the Trick: Covert Interactive Mixed Reality System for Immersive Storytelling

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Figure 1: Overview of immersive gameplay in MR environment

ABSTRACT

This study explores the integration of Ultra-Wideband (UWB) technology into Mixed Reality (MR) Systems for immersive storytelling. Addressing the limitations of existing technologies like Microsoft Kinect and HTC Vive, the research focuses on overcoming challenges in robustness to occlusion, tracking volume, and cost efficiency in props tracking. Utilizing UWB technology, the interactive MR system enhances the scope of performance art by enabling larger tracking areas, more reliable and cheaper multi-prop tracking, and reducing occlusion issues. Preliminary user tests suggest meaningful improvements in immersive experience, promising a new possibility in Extended Reality (XR) theater, performance art and immersive game.

Index Terms: Human-centered computing—Human computer interaction (HCI)—Interaction paradigms—Mixed / augmented reality; Human-centered computing—Ubiquitous and mobile computing—Ubiquitous and mobile computing tools; Applied computing—Arts and humanities—Media arts

1 INTRODUCTION

In the context of immersive content, such as theater and performance art, losing awareness of the ‘real’ world is a critical aspect of immersion. [7] This is achieved by seamlessly integrating technology within the performance.

Immersive theater are characterized by expansive stage, installations for scenic design, performers in creative costumes navigating complex paths, and the use of multiple props. Although technologies based on the Time-of-Flight (ToF) principle using infrared light like

Microsoft Kinect and HTC Vive have been employed in this field [6], they face three primary challenges for immersive theater:

Robustness to Occlusion: Sensors can not be concealed in props or costumes. The abundance of stage installations for scenic design limits the movement of actors, as they cannot be tracked when walking or hiding behind them [6]. Furthermore, Kinect struggles when actors are wearing unconventional costumes [8].

Tracking Volume: The tracking range of current solutions is limited, restricting performers’ space [3] - Azure Kinect has a maximum of 3.5m [6], and Vive Lighthouse 2 covers 100m² [2].

Cost of Tracking Multiple Props: The high cost of tracking devices makes tracking numerous props financially burdensome.

Meanwhile, Ultra-Wideband (UWB) technology emerges as a promising alternative for large-scale tracking [5]. This poster aims to broaden the expressive capabilities of immersive theater by embedding UWB technology into Interactive Mixed Reality (MR) Systems.

2 IMPLEMENTATION

2.1 Immersive Stage Design

The performance stage, featuring MR systems, spans an area of 1042cm in width and 1044cm in depth, affording ample space for performers, which is vital for natural interaction [3]. It is equipped with two 4K projectors for front and floor projection - Christie Mirage 304K and Boxer 4K30, both offering brightness of 30,000 center lumens, ensuring a vibrant and immersive experience.

2.2 Tracking System Design

The UWB system was constructed using the Pozyx Creator Kit, priced at 1350 Euros, including 4 fixed (Anchor) and 6 rover (Tag) transreceivers [1]. This setup presents a cost advantage compared to assembling an equivalent system with Vive Tracker 3.0 units, priced at 154 Euros each, and Base Station 2.0 units, at 245 Euros each, which together would total 1904 Euros [2].

4 anchors are installed on the battens of the stage, and one main tag is connected to the main computer via arduino uno and three tags are in the props. The main tag gathers location of three tags and sends the data to the Unity via serial communication [4]. This 4 anchor system can cover up to 400 – 800m² space [1].

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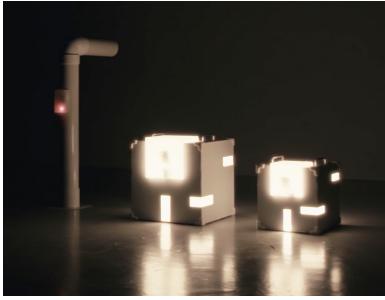


Figure 2: 3 performance props with concealed UWB sensors

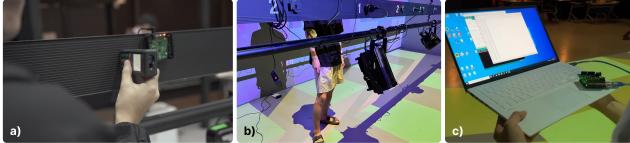


Figure 3: Process of measuring, installing and testing the anchors

While installing and configuring the system, four anchors at a distance of three meters in a square configuration didn't cover all 10m*10m area. Throughout the trial and failure, the tracking area was improved to fit the environment by reconfiguring the anchors to form a 755cm*570cm rectangle.

Through a bidirectional ranging strategy, it measures signal ToF between the TAG and ANCHORS, accurately calculating the TAG's position. An inbuilt Inertial Measurement Unit (IMU), which includes accelerometers, gyros, and magnetometers, which contribute to a positional accuracy within 320 ± 30 mm and easily can become lower to 100 ± 25 mm [4].

2.3 Application



Figure 4: Cube augmented with projection and recognition boundary

For the system application, interactive MR performance involving puzzle element was created with 3 props - or 'cubes' and using Unity. Each cube contains a Pozyx tag inside the acrylics and wooden body for position tracking. Contrast to the vive tracker, these tags were able to be hidden inside the props thanks to the UWB technology.

Being physically present in the stage, props foster a sense of spatial immersion by allowing users to navigate the expansive environment. These cubes also serve as key elements of a puzzle, with their placement within designated graphics areas triggering progression to the next stage or scene.

To preserve location data reliability, location toggling occurs only if the TAG remains within the area for a minimum of 100 frames. Given the cube dimensions (the largest being 40*40*40cm) and Pozyx's positional accuracy (ranging from about 100-300mm [4]), a toggle location area of 65*65 cm is designated for each cube.

The system and content were experienced by 54 individuals who successfully completed a 15-minute play session. Among them, 45

are students and alumni of the Art & Technology program at Sogang University, aged between 20 and 29. Their feedback highlighted the enhanced immersion ('I didn't know how it worked, I was just amazed'), interactivity ('It was so natural and amazing to see the graphics change according to my perspective and to move the box to progress to the next stage'), and naturalism ('I usually feel motion sick in VR, but it was nice to not have motion sickness while actually walking'). These improvements in 3D environments are achieved thanks to fewer limitations than traditional tracking systems. This information was translated from Korean using Google Translate.

3 CONCLUSION AND FUTURE WORK

An Immersive MR System for a 10m*10m stage and performance was devised, incorporating UWB sensors for the Robustness to Occlusion, Increased Tracking Volume and Low Cost of Multiple Props Tracking.

The system and content have been tested and played by 54 users who participated as performers, successfully completing the game experience from start to finish. This validated the concept of using UWB for tracking within MR systems.

The findings highlight the advantages of UWB: expanded tracking range, robustness to occlusion and multi-object tracking, opens the door for dynamic, collaborative, and expressive theater and performance. This is a crucial part in fields like immersive storytelling, XR theater and performance, enabling unrestrained creative expression in areas such as stage size, scenic design, costume, actor path, etc. The technology supports multi-user tracking without occlusion and utilizes a large space, effectively eliminating spatial constraints.

Through such a covert interactive MR system, the range of expressions possible in immersive theater has expanded, leading to the potential emergence of new and more immersive and seamless content, especially in the field of immersive game and XR theater.

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