
Using HTC Vive and TouchDesigner to Projection-Map Moving Objects in 3D Space: A Playful Participatory Artwork



Figure 1. Projection-mapping a moving object in 3D space.

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Abstract

We present the first public exhibition that uses HTC Vive and TouchDesigner to projection-map moving objects in real-time in 3D space. Our case study is an exhibition of the media artwork "The Playground". During this exhibition we involved the public. They found small sculptural pieces that were hidden in public areas, they brought these pieces to an exhibition space and connected them onto a central sculpture. People could also take a photo of their city environment and upload it to a webpage. When a person entered the exhibition space our system projected this person's photo onto the small sculptural piece that was in their hand. Our system tracked and projected onto this piece as it moved around an exhibition area. All of the public's photos were also projection-mapped onto a co-created central sculpture. Our contribution benefits designers, artists and researchers who want to make playful experiences that involve projection-mapping moving objects in real-time in 3D physical space using relatively inexpensive, easily accessible tools.

Author Keywords

Projection Mapping; Tangible Interaction; Art; Play; HTC Vive; TouchDesigner; Movement Tracking; Participatory Art; Digital Art; Geocaching



Figure 2. An example of one of The Playground's 10cm x 10cm laser cut acrylic sculptural pieces. This piece spells the word "PLAY".

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g. HCI): Miscellaneous.

Introduction

We present the first public exhibition that uses HTC Vive and TouchDesigner technology to projection map moving objects in real-time in physical 3D space (figure 1). We use our exhibition of the participatory media artwork "The Playground" as a case study. Through this exhibition we showed that our tracking and projection methods work well when delivered in a public context.

During the exhibition of The Playground we hid sculptural pieces (figure 2) in public spaces around the exhibition area (figure 3). Audiences located these pieces, brought them to the exhibition and slotted them onto a central sculpture (figure 4). One outcome of this project was the co-created central sculpture, visible in figures 5, 6, 7 and 8.

As a further participatory element [1], the public could upload photos of their city environment to a webpage. When a member of the public entered the exhibition space carrying one of The Playground's small sculptural pieces, any photos they had uploaded were projected onto the small sculptural piece that was in their hand. Any imagery that was uploaded by the public was also treated and projection-mapped onto the central co-created sculpture, as seen in figures 5, 6, 7 and 8.

The Playground is a work in progress. Iterations of this art installation were exhibited twice over 2017. The first exhibition was during the Melbourne Knowledge Week festival, Melbourne, Australia. During this exhibition the public found small sculptural pieces, they co-created the central sculpture and they contributed imagery that

was projected onto the central sculpture. The second exhibition occurred in conjunction with Ararat Regional Art Gallery, Australia. This exhibition involved the public in the same interactions as in the first exhibition with the addition of a customised tracking and projection system. This system is detailed in this paper. A final iteration of the artwork will be exhibited at the Asia Culture Centre, South Korea in late 2017.

In this paper we focus on the tracking and projection system that we designed for the second iteration of this art installation. We detail our use of off-the-shelf hardware and software involving HTC Vive and TouchDesigner. HTC Vive is a relatively inexpensive virtual reality (VR) hardware system that includes a low latency tracking solution. We have appropriated the Vive tracking system for this project. TouchDesigner is a node based programming application made by Derivative. This commercial platform facilitates the design of real-time generative visuals, particularly for projection-mapping environments. Using these off-the-shelf hardware and software tools, we created a relatively simple customised system that recognises small sculptural pieces and projects visual footage onto these pieces as they moved around an exhibition area.

The Playground is the first exhibition in which this type of Vive and TouchDesigner tracking and projection system has been shown to work in a public context. In this paper we detail this low cost and relatively easy to implement approach. This approach is readily applicable to mixed reality (MR) game design as well as games involving physical exertion. Our contribution benefits designers and creative technologists who want to achieve similar playful, physical experiences in a swift and relatively simple way.



Figure 3: One of the small laser-cut acrylic sculptural pieces hidden in a public space around the exhibition area.

Related Work

The Playground is situated in an interdisciplinary field of game design and art practices. These practices involve a “playable cities” ethos [12] and participatory media art methods [1].

Related Game Design Work

Cities have been widely used as playgrounds for game activations as seen in works that borrow from geocaching techniques [12]. The concept of a playable city has also been extended into the field of participatory art [1, 3]. Virtual reality techniques have been explored widely for application in game design [3, 6]. And indeed exertion games, those that involve physical activity, are gaining traction within the game design community [10, 11].

Related Work in the Field of Art

Some interdisciplinary art methods feature participatory or co-design approaches that involve the public working alongside artists to deliver creative and cultural projects [1, 2]. These practices often connect with early community art methodologies [2]. Some contemporary art practices involve virtual reality techniques in order

to engage audiences in uncovering new visual and conceptual levels of visual art [6]. Artists are also using technology to intrinsically involve the public in participatory art methods [15].

Related Work Utilising Similar Technologies

TouchDesigner has been used in conjunction with a Microsoft Kinect system to track helium and smoke filled bubbles and to project moving imagery onto these bubbles in a 2D framework [4]. HTC Vive and TouchDesigner have been used to track and project onto objects that are moving in 3D space in a studio environment [9, 16]. Interactive projection mapping systems have also been created to extend a user’s experience of virtual and augmented realities [7, 8, 17]. We drew from this prior work when designing our tracking and projection system.

CONTRIBUTION

We present a novel tracking and projection method that has been shown to work in a public exhibition. This method may benefit game designers who seek to personalise user experiences and explore new mixed reality techniques, and artists who wish to use technology to create deeper connections between their artwork and the general public.

Early Experiments: The Playground Exhibition One

For our first exhibition of The Playground we used art and play methods [1, 2] to engage the public in co-designing a technology sculpture. This exhibition was for an urban Australian audience in a capital city. For this exhibition we created 700, 10x10cm laser cut acrylic sculptural pieces, as seen in figure 2. Each of these pieces displayed a typographically designed

word; for example figure 2 shows the word "PLAY" and figure 3 shows the word "SEE". We made five different words in total: PLAY, ART, SEE, HEAR, FEEL. These words were intended as descriptions of the type of interactions we were encouraging. That is, we hoped the public would engage in a playful art interaction that heightened their sensory awareness of the environment that surrounded them.



Figure 4: An audience member slotting their small sculptural piece onto the central sculpture. Numerous long grooves were cut into the exterior line of the central sculpture. These grooves allowed the public to easefully slide any of The Playground's small pieces onto the exterior of the central sculpture and thereby play a part in co-creating a new artwork.

In order to find these small sculptural pieces, the public engaged in a treasure hunt [12]. They could do this by using our paper-based treasure map or by following clues we released on social media. They then brought their small sculptural piece to the exhibition space and slotted it onto the central sculpture (figure 4).

During this first exhibition the public could also upload photos of their city environment to a customised webpage. The webpage and all of the associated promotional materials instructed the public to take photos that show the "play of light on an architectural or environmental surface". We encouraged them to take close-up photos that show the textures of their city environment. Once uploaded, these images were approved by one of the designers and directed to a folder within our TouchDesigner system.

All of the photos that were uploaded were projected onto the central co-created sculpture. Our system automatically treated each photo by applying visual filter effects within TouchDesigner in real-time. Our system randomly displayed all of the image contributions, this, combined with the real-time effects generator, meant that the projection-mapped visuals were always different. The exact same imagery was never seen twice (figures 5, 6, 7, 8).

The Design of Exhibition Two: Technical Details of the Tracking and Projection System

During the second Playground exhibition we utilised our movement tracking system. This exhibition was for a regional Australian audience. We invited the public to find small sculptural pieces that were hidden around the small city's main street. Once they located a piece the person then brought it into a vacant shop front on the main street. We housed the exhibition in a shop front in order to involve the broadest possible audience.

Figure 5. The central sculpture was created from laser cut acrylic. It was made up of 1m x 1m letters that were 4.5mm thick. The large sculptural letters spelled the word "PLAY".



Figure 6. The public could add small sculptural pieces to the central sculpture. They could slot their piece into one of the many long grooves that had been cut into the exterior line of the large "PLAY" letters. Alternatively, the public could connect their piece to another small piece that was extruding from the sculpture. The small sculptural pieces connected securely to each other and connected securely to the central sculpture. By doing this, the public created the shape and overall appearance of The Playground sculpture.

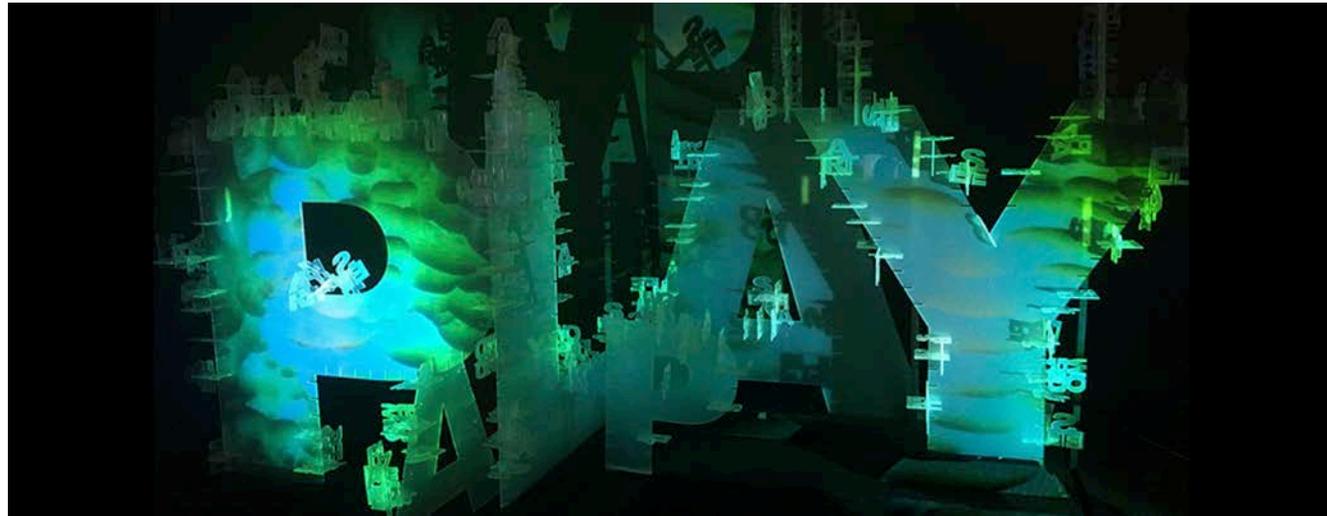


Figure 6. The audience could upload photos that featured the play of light on their city environment. These photos were then treated and projected onto the central sculpture.

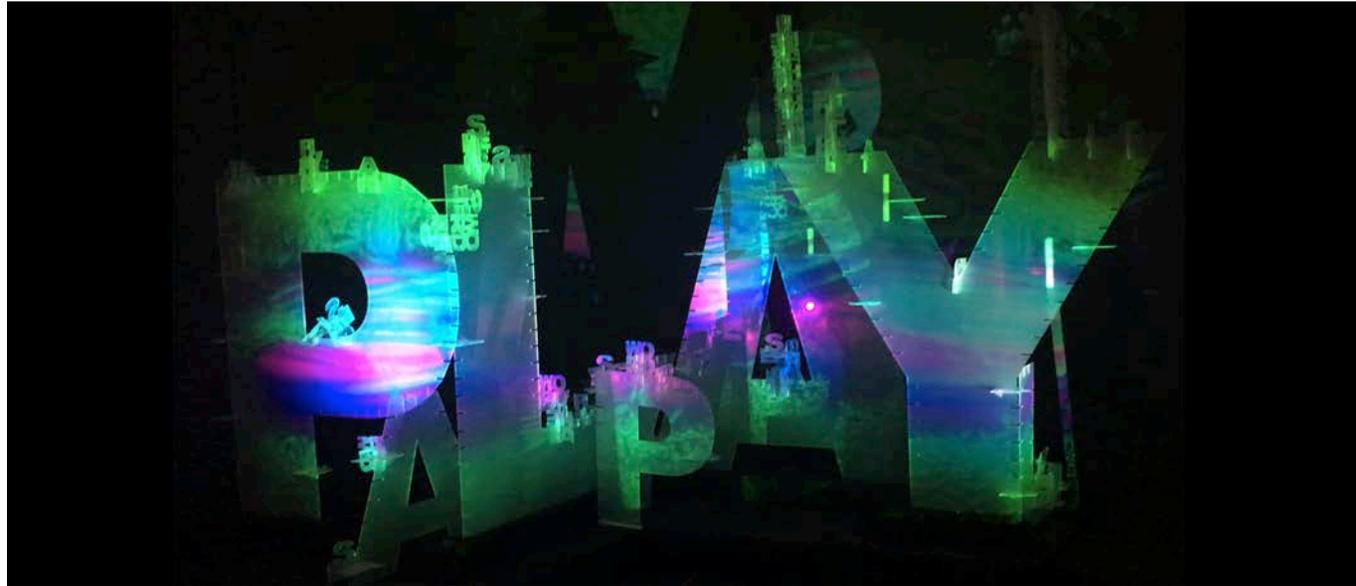


Figure 7. The uploaded photos had a large effect on the visual appearance of The Playground sculpture.





Figure 8. Our custom made movement tracking handset. It featured a HTC Vive Tracker; this piece of hardware is visible at the base of the above handset. We attached a timber cylinder to the top of the tracker so that users could hold the handset. We attached a wooden cross-piece and two clips to the top of the handset so that users could easily "slot on" their small sculptural piece. When a small sculptural piece was slotted onto the top of our handset we could track its location in 3D space, and project onto the piece as it moved around the exhibition's tracking area.

Details of the Audience Interaction

Each of our small sculptural pieces displayed an individual number (as seen in figure 2). When the public found a sculptural piece they could take a photo of their city environment and upload this, alongside their piece's individual number, to a webpage.

When a person arrived at the exhibition space we manually entered their piece's individual number into our TouchDesigner system. The system then recognised any photos that had been affiliated with this piece. The person could then slot their piece onto our custom designed handset containing an HTC Vive tracker (figure 8). When the small sculptural piece was slotted onto this handset we could track its location and project onto it in 3D space (figure 1). Our tracking and projection system comprised two VIVE lighthouses and one Vive tracker. The tracking and projection area for this second exhibition was 5.5 meters x 1.5 meters. One person at a time could engage in this interactive activity.

Following this initial movement tracking interaction, the public could slot their piece onto the central co-created sculpture (figure 4). Any photos that were uploaded were manually checked for appropriateness, as this artwork was aimed at audiences aged 13 and above. The photos were then sent to a folder in

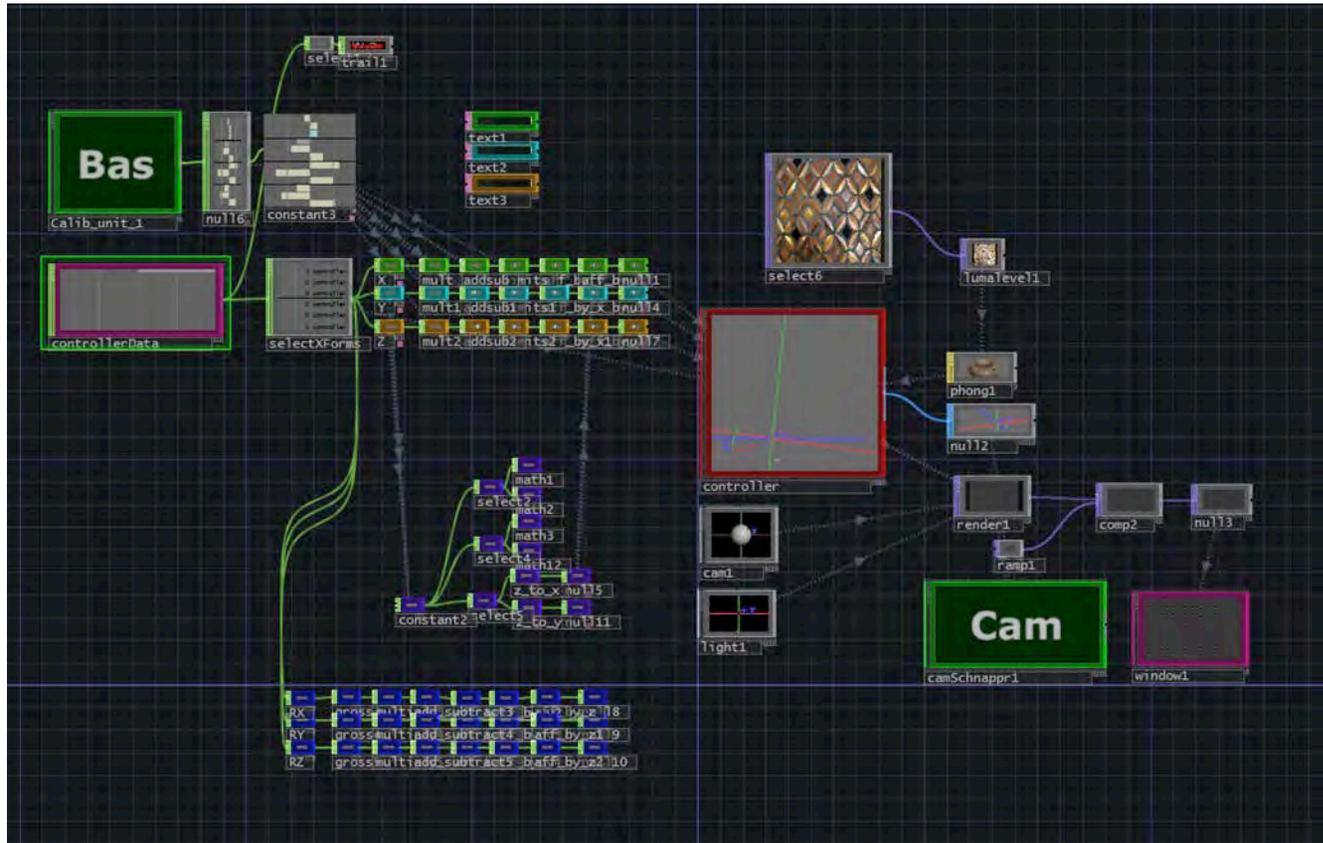
TouchDesigner. TouchDesigner randomly selected the order in which the photos were projected onto the central sculpture. TouchDesigner was programmed to automatically modify the photos, applying customised effects in real-time. That meant that the projected imagery was not on a 'loop' but was generated in real-time from a pool of visual assets created by the general public.

The total area for this second exhibition was 6.5 x 13 meters. The co-created sculpture was situated near the shop's front window. Blackout curtains were drawn over the windows during the day in order for people to come into the shop to view and interact with the projection-mapped exhibition during daylight hours. When the exhibition closed at night we opened the blackout curtains allowing the public to view, through the shop's window, the changing shape of the projection-mapped visuals on the central sculpture in the darkness of night. We ran the TouchDesigner system for 20 hours a day for the duration of the exhibition to enable the maximum public engagement with the work.

Technical Details

There were two parts to our TouchDesigner system for this exhibition. The first part involved a TouchDesigner network that ran our tracking and projection area. The design of this first network is visible in figure 9.

Figure 9. A screen shot of the TouchDesigner network that ran The Playground's projection and tracking area.



In order to track and project onto the small sculptural objects in our exhibition's tracking and projection area, we used the Vive lighthouse sensors to locate and follow the Vive tracker (figure 1) that was attached to the base of our custom made handset (figure 8). We then sent this data to TouchDesigner. We sent the information about the position of the Vive tracker to the pink box visible in the upper left hand side of figure 9.

We calibrated this data in order to define the size and shape of the tracking and projection area. This calibration system is seen in the series of horizontal green, blue and orange boxes in the middle left of figure 9. The geometric dimensions of the handset were housed in the large red box visible in the centre right of figure 9. We used these dimensions to make a virtual model of our handset. We then used the TouchDesigner

tool "Camsnapp" to indicate the position of the real handset relative to the projector. We applied the information about the position of the real handset to our virtual model. The Camsnapper tool is visible in the green box on the bottom right of figure 9. We could then match the position of the virtual handset to the real handset and project an image onto a small sculptural piece that was slotted onto the real handset. This allowed us to project onto a specific sculptural piece as it was moved around the tracking and projection area.

The second part of our TouchDesigner system involved a network that projection-mapped the central sculpture. To build this network we used the TouchDesigner tool called "Kantan Mapper". We used this tool to make a framework for the projection-mapping of the large sculptural letters that spelled the word "PLAY" (figure 5-8). In doing this we made a diffuse lightspill effect by mapping an area that was slightly larger than the outline of the sculptural letters. We then adjusted the edge of the projected imagery so that the edges of the imagery faded to black. This effect softened the edges of the projection mapping, providing an aesthetic shadowing on the walls and roof surrounding the sculpture (figures 5-8).

Lessons Learned

We learned that the tracking and projection system that we made in TouchDesigner worked well in a public context (further details in the following "limitations" section). Designers who work in virtual and mixed reality can potentially learn from this project and use the "Camsnapp" tool in TouchDesigner to calculate the relative position of projectors to trackers in order to project onto moving objects. This simple method may

be a viable alternative to using other software (such as Unity), in order to projection map moving objects. Ours is a relatively easy way to implement a tracking and projection system.

We only had a 5.5 x 1.5 meter tracking area for our second exhibition. This was effective but it did not allow us to test how large we could make the tracking area. In our next exhibition we hope to expand the size of this area and therefore test this system within a larger space. Having more space would allow us to extend the audience's experience of the tracking and projection aspect of this work. A larger area would provide audiences with opportunities to move around the tracking area in a wider variety of ways.

We also learned that if someone opened the black-out curtains that covered the shop windows during the day, this caused a change in the exhibition's lighting conditions. This change sometimes resulted in the tracking system needing to be recalibrated. If designers were to create a tracking area that had consistent light conditions this would provide the best results.

Finally, the central sculpture changed shape quite dramatically during the exhibition, due to the public adding on their small sculptural pieces. As a consequence, the projection-mapping needed to be adjusted daily in order to accommodate the changing shape of the sculpture. In response to this we will develop a Kinect system for our next exhibition. This system will track the main sculpture and automatically adjust the projection-mapping in response to the changing shape of the sculpture over time.

Limitations

We acknowledge limitations to our approach. We used HTC Vive lighthouses; these laser emitting hardware devices require a direct line of sight between the lighthouses and the objects being tracked. Occasionally, due to the way in which an individual carried our handset, the lighthouse could not locate a person's small sculptural piece. This problem was automatically rectified when the person moved and restored the line of sight between the handset and the lighthouses. Optical trackers can often have occlusion problems, but this was not a common issue in our scenario, our Vive-TouchDesigner approach worked well.

Conclusion

The Playground is a playful art-technology activation that showcased a cost-effective and relatively simple tracking and projection system. This system worked well when used as part of a public exhibition. Our contribution involves detailing the design of this system, in particular how it projection-maps moving objects in real-time in 3D physical space. This system may benefit game designers who want to use mixed reality techniques to personalise user experiences and artists who wish to use technology to create deeper, personal connections between their artwork and the general public.

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