

Adaptive Projection Displays: a low cost system for public interactivity

Jenna Dundas
Drexel University
3501 Market St.
Drexel STE 220
United States of America
(19104), Philadelphia,
Pennsylvania
jd574@drexel.edu

Michael Wagner
Drexel University
3501 Market St.
Drexel STE 220
United States of America
(19104), Philadelphia,
Pennsylvania
wagner@drexel.edu

ABSTRACT

Interactive digital public displays that track viewer's position are currently inaccessible to the average consumer. Many tracking systems available on the market are prohibitively expensive and are out of scope for small business owners to purchase. A system can be devised by researching and testing various consumer level tracking technologies in a low cost and accessible manner. Microsoft's Kinect in tandem with Unity3D offers a system that is straightforward to use and allows for ease of implementation. The resulting technique can be quickly carried out to create an interactive digital public display.

Keywords

Microsoft Kinect, projection, Unity3D, low cost, public display, interactivity, computer graphics

1 INTRODUCTION

The world is growing increasingly interactive, and displays that were once analog are becoming digital. Billboards are transitioning from paper to large-scale digital displays, which allow multiple advertisements on billboard. Within these new digital displays, the ability to switch and transform the visuals is as easy as a press of the button [Bor00b]. As these surfaces are transition from analog to digital the prospect for interactive public displays, become abundantly possible. These digital public displays have the capability to develop beyond just images and words to create a lasting impression on the consumer. This development of content on these public display systems is evolving, however, developers have yet to leverage today's technology [Alt01a]. Digital public displays can become more than just digital billboards on the side of the road. These displays can be signs in storefronts, advertisements in transportation centers, and museum displays.

Although public displays are making the transition from analog to digital displays, advertisers have not

moved beyond using these display areas as more than digital posters [Bor00b]. The full potential of these digital public displays is still an open area to explore. With the growing number of these displays developing within outdoor and indoor spaces, there is lies an ability to create new experiences, which change the framework of existing public displays [Ren00a]. While public displays can further explore interactivity within digital systems, there are existing ideas of interactive systems that the public know. For example after user notices that the public display is interactive, the display should react instantly to the user, to express usability [Mül00a].

With the increased number of digital public displays growing, low cost system can be created to track the viewer and create the illusion of depth and space. Interactive three-dimensional worlds can go unexplored because of the complexity of the communication that takes place [Hac00a]. Although Cursan was talking about the interaction between digital three-dimensional object and a user, this problem manifests itself within the public display system. Previously the ability to use three-dimensional cameras was only for companies that had a large budget. However with Microsoft's introduction of the Kinect, the ability for someone to implement three-dimensional cameras grew higher than ever before.

As a result of the availability of three-dimensional cameras a low cost system can be built, that allows small business and consumers to create interactive

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three-dimensional public displays. The system is using a combination of off the shelf technology and low cost graphics engine to create an easily implemented interactive system. The system will allow producers to create displays that utilize three-dimensional graphics, light, and shadow to create the illusion of depth and space. Through this system, the three-dimensional camera will track the viewer's position and update the visuals depending on where the viewer is in relation to the display.

2 RECENT SOLUTION

Large-scale public displays have the freedom to transform the spaces around the world. As a result of the transition from analog displays to digital displays the ability to transform the content on the display allows for a number of possibility's [Bor00b]. The exploration of existing interactive displays and viewer tracking projects yields the possibilities of low-cost interactive system that explores three-dimensional graphics and light and shadow to achieve depth and dimension.

Interactive Large Scale Public Displays

Not all media facades are interactive some might transform a building, a space, or a wall in for the form of an advertisement [Fis00a]. Although these displays tend to not be interactive, researchers created a system, to explore large-scale media interaction on the facades of buildings. The project SMSlingshot transformed the building into a large interactive display, which received messages from the custom input device [Fis00a]. The display researchers built reacted to the input device rather than tracking the viewer's movement. However, they found that the users enjoyed having authority over the public display and being able to contribute to the visuals [Fis00a].

To explore the availability of low-cost technology, researchers focused on creating an interactive system that allowed many members to interact with the system. Through their exploration, they used three easily accessible pieces of technology. The researchers wanted the set up to be simple and not a complex gaming console, which resulted in their use of a camera, projector, and computer [Ozt00a]. With the technology, the researchers used multiple-human tracking algorithms to create an experience that predicts the future steps of various people, within the given camera area [Ozt00a]. Through their system, the ability to create a low-cost system for public interaction can be built. However, their system only details with two-dimensional images, mainly footsteps.

Conveying interactivity of the system can be one of the more troubled aspects of interactive public displays. Researchers found that an interactive system that through the use of mirror images of the participants

the recognized interactivity faster than a call to action did [Mül00a]. To create the shadow of the public viewer, researchers developed a system that used Microsoft's Kinect to track the viewer and create their shadow. Through this system, they found that an interactive system should convey interactivity and instantaneous communication, or the system will fail [Mül00a]. Public interactive systems have the potential to be engaging and fun. However, these systems need to take into account how they are calling the viewers to communicate with the system. As result researchers found that systems could be interactive as soon as someone comes into contact with the display, are the most effective and attention grabbing. The Focus was mainly on digital representations of the viewers, and not on creating three-dimensional worlds that are affected by the viewer and how the viewer might perceive this.

Digital Displays that Utilize Tracking Technology to Engage an Audience

Stookie is an interactive animated artwork that utilized three-dimensional projection mapping techniques [Jun00a]. Researchers on this project produced a head statue, which was built in a neutral facial position. This neutral position allowed them to then exploit three-dimensional projection mapping, to change the facial expressions and eye movement of the statues [Jun00a]. Through use of the Kinect, the researchers were able to create an interactive three-dimensional mapped experience for viewers. This system would update the eye position of the statue based on the movement of the public, and would call different animation states to convey emotions.

With consumer tracking technology, researchers created a system called FRAGWRAP. Through this system developed, researcher projected images on to a bubble that was infused with fragrance. As a result, they created the concept of scent mapping, which maps scent and visual information onto a physical object [Kyo00a]. Within this system, the researchers developed a method of tracking the position of the bubble and updating the projection mapped image to accompany the bubbles movement. By using the Kinect from Microsoft, they were able to use the RGB and depth camera to project images on the bubble and modify them in real-time [Kyo00a], and unity3D for the graphics. In addition to the Kinect system, they used Processing to implement form and location control [Kyo00a]. The ability to track objects and use projection mapping to display visual data is realized, through this project.

SnowGlobe is a spherical display that focused on creating an interaction with three-dimensional objects [Bol00a]. Through this display researchers successfully tracked the head of the viewer using a Vicon

motion capture device, this data was used to maintain motion parallax of the three-dimensional object in the display [Bol00a]. To track the head of the viewer researchers created custom glasses, which had three reflective infrared markers to track the location of the head [Bol00a]. Through this product, the researchers were able to exploit the tracked data and use it to create the parallax in the three-dimensional image. Additionally within this system the user had the ability to interact with the three-dimensional model that was displayed on the spherical surfaces. The researchers focused on creating a digital object that provided for one to completely walk around it, with the use three-dimensional projectors. The projection display was a spherical object that reflected a projected data off the hemispherical mirror, this allowed for a seamless curvilinear display surface [Bol00a]. This experiment in tracking with spherical display, show how tracking technology can be incorporated within in a public interactive system that explores light and shadow to create the illusion of depth and space.

3 PROPOSED SOLUTIONS

Currently, there is software and hardware that tracks people based on a number of different factors. Through the exploitation of existing software and hardware, the system can be devised that will update the projected artwork and create a visual parallax between the viewer and the projected display. A low cost responsive public display system can be created that will adjust depending on the viewer's perspective by utilizing off the shelf technology. The user's experience will change depending on the place the viewer, in relation to the display. The projected images will be adjusted depending on the viewer's position to achieve appropriate visual parallax for the viewer. The projected images will give the illusion that the digital imagery projected is behind the surface structure. Through the visuals depth and dimension will be exploited to fabricate a lasting impression on the viewer.

The proposed interactive system can be operational, utilizing four different components. Each of the four components of the system is easily accessible to obtain, and foster a low budget. The four components are tracking hardware, a graphics engine/scripts, computer, and a display unit. To built the responsive interactive system that reacts to the viewer's movement, one can utilize the combination of these four elements.

4 EXPERIMENTAL RESULTS

By researching into various tracking displays, and interactive public display system a select few products were tested further. These products were webcams, Microsoft's Kinect, and Vicon's Motion Capture cameras.

The three devices were evaluated on accessibility, volume of tracking area, and portability. Through the exploration of these products, the best product in the three categories was implemented into the end system.

Test of Off Shelf Technology

With web cameras, the tracking capability was remarkably good. However through the system of using FaceAPI and Unity the tracking area the viewer could be in was limited to very close to the camera area. The tracking area only included a less than a foot away from the camera and to the left and right. Additionally through this set up the system's graphics would become jumpy and jittery in comparison to other product's results. Although the tracking area was minimal in comparison to other products, the webcam is cheap and portable. The tracking area within the webcam was this technology's downfall, to be incorporated into the system.

Vicon's motion capture cameras are one of the best three-dimensional cameras currently on the market today. However, this product is expensive and not viable available product, to the average consumer or small business. As a result of the price and accessibility the Vicon's camera, their product was not an option for a low-cost interactive system.

Within the last few year's one consumer product has revolutionized gaming, interactivity, and interfaces around the world. Microsoft's Kinect is one of the first consumer level three-dimensional cameras that use infrared light and sensors to gain the location of the viewer and several other positional data from them. This camera is not only affordable to consumers and small businesses, it is easily available and reasonable in price, if someone would like to buy one. Microsoft's Kinect can hang, place, or move easily in comparison to other three-dimensional cameras. They are lightweight, small, and compact. As a result of this, they can easily be packed and transported to various locations. Additionally this camera gives a larger tracking volume than the area a webcam could achieve. As a result of these factors, the Microsoft's Kinect was the choice product to use within this system.

Prototype System

The system contains four elements a tracking device, a computer, a graphics engine, and a display unit. To build a system with a low budget, the rough system respectively used Microsoft's Kinect, a free version of Unity3D, Microsoft's SDK, a free script package called Kinect with MS-SDK, a few custom script, a laptop, and a projector. The final cost to gather these factors vary depending on the type and quality projection display system is employed and the availability of a laptop

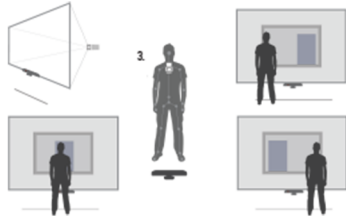


Figure 1: Prototype display process

computer. However, the cost can slide between 400 dollars to 1000 dollars.

The rough system tracks a user using Microsoft's Kinect infrared emitter, and sensor. Through this infrared light bounces off the viewer to locate the position of their body to the Kinect. Once the position of the viewer is found through the Kinect. The skeleton data is brought into Unity3D using Microsoft's software development kit and a script package that bridges the software development kit and Unity3D. Once this data is brought into the game engine, a custom script is applied to the camera. This script takes the place of the viewer's center chest, and updates whenever the viewer moves in relationship to the visuals. The viewer can move forward, backward, right, and left and the visuals will update with appropriate parallax depending on their position. Additionally another addition is the resetting of the scene once the viewer has left the volume of the Kinect tracking capabilities. Through the use of unity3D one can use three-dimensional graphics, light, and shadow to fake the illusion of depth and space in a location that does not have any.

Graphics Engine

Through this interactive art piece, the goal was to create a design that could be easily replicated for anyone to incorporate within his or her own particular projects. As a result of this the project focused on finding an existing method for graphics, rather than trying to write a custom graphics engine. With these features in mind, one option came to mind. This graphics engine is called Unity3D, which is commonly used as a gaming engine. However, the program is robust and allows for the convergence of different projects and ideas that go beyond a gaming environment. Through this product, the ability to create real-time graphics became straightforward, and simple to be incorporated into an interactive art piece.

The exploitation of this existing product allows for a designer to utilize existing features of the program. For example, the ability to light the scene and use several different rendering techniques have been created already, and can be easily incorporated to create a higher quality image than one might be able to do when working on their own person graphics engine product. One



Figure 2: Prototype System

of the downfalls of this graphics engine is that some results are only available within the pro version of the product. However, the completely free version, that anyone can download and use, is one of the best things about this product. Essentially the free version of the engine is the same as the professional version, just with a handful of features not included. Features that are included in the professional copy and not within the free copy are fog, rendering effects, different types of shadows, and image effects. However within the free version the designer can only use hard shadows within a directional light, which gives the designer some freedom. However, this freedom does not compare to the flexibility to create effects within the professional version.

Scripts

To work with the Kinect within unity3D, there is a small set up that one needs to do to start working with the product. Within this interactive art piece, the project relied on a few different components. For example the Microsoft software development kit (SDK), the script that bridges communication between the SDK and Unity3D, and a custom script.

Microsoft's Kinect Software Development Kit

Through Microsoft's website, they offer a software development kit also known as an SDK for free download on their website. This SDK is only for windows based machines, and uses C++, C#, or visual basic to create Kinect based applications. Through this SDK, the data from the Kinect is brought to the computer. Additionally through this SDK the drivers for the device are installed, this way the Kinect can communicate to the computer.

Kinect with MS-SDK

Through the Unity asset store, there is a free package that bridges the Microsoft SDK to Unity3D. This way someone can use the skeletal data, depth data, gesture, and other information the Kinect offers to explore. This method was the best way to bring this data into Unity in comparison to other methods, and other various scripts available on the Internet. Through this package, there are a number of scenes that explore different aspects of data found from the Kinect. Through this interactive

art piece the use of the pointman script was the main source of information for the position of the viewer.

Custom Script

Although Microsoft's SDK and the Unity3D extension allow for skeletal data to be brought into the graphics engine, there is still one last step. This last step is a small script that is applied to the camera within a given Unity3D scene, that updates the camera site depending on the viewer's position. What this script does is take the position of the of the placed pointman center shoulder joint and translates this position to the camera position. Through this script the camera gets x, y, and z values for its position within a given scene. By giving the camera x, y, and z positions this allows the viewer to move left, right, forward, backward, up, and down with the visuals updating accordingly.

Additionally to the giving the camera movement through the body position of the viewer the script can increase or decrease the amount of movement the camera does is response to the viewers movement. This allows for a designer to decide how much or how little their designs will react to the viewers of their final designs.

This script also gives the designer the option to put the distance the Kinect is in front or behind the display screen and have there visuals be pushed back in space depending on the inches the give. To accomplish this, the designer must create their visual assets and then combine them into a unity prefab, and place it within their resources folder. Once the prefab is created a designer can drag the prefab into the given place within the unity script. The script takes the given inches the screen is and converts it to meters that are the starting unit of the graphics engine. After it converts the inches to meters it places the artwork at that given spot in the three-dimensional space.

Environmental Issues

Microsoft's Kinect the display system can be easily implemented as a low cost interactive public display system. However, within the confines of using a Kinect and a projection based display system the best environment for the system is within indoor or low light environments. While using projectors allows the producer to create a large display image cheaper than buying a large LCD monitor, the visual quality of the image diminishes when light floods the projection area.

Applications

With digital displays increasing with numbers throughout everyday life, the ability to create interactive displays is growing with the amount of displays transitioning from analog to digital. The process created for this

interactive art piece can express how digital public displays can utilize existing technology to create the illusion of depth and space. The set-up of this art piece explores the use of light, motion, and space to create the illusion of depth where there is none in the actual display. This effect is created by tracking the viewer's location and updating visuals depending on their place within the space in relation to the display system. Three areas retail, advertisements, and historical reconstructions can explore the use of this system further.

Retail

The resulting idea can be applied to retail conditions in two different manners. The first manner ins which this process of creating and interactive display can be used to create a look and feel for the store logo, within their storefront. The interactive display can take the form of a logo in front of visuals that match the store's design image. Through this the logo can be in front of the graphics and appear as though it is jumping off the front of the digital display setting.

Secondly retail can utilize this process by allowing people to visualize the product within various different conditions. For example, a consumer can have a picture of their living room and place a particular product they are thinking of purchasing within this three-dimensional world. Unlike other retail options, the consumer and experience it on a visual and spatial level. Through this system the graphics can promote a product, an image, or a feeling that the designer is trying to convey to the users.

Advertisements

One encounters a number of different displays, which range from digital ads on computers to ads on the street or transportation system. Through utilizing this tracking framework for ads information can pop out to the consumer that the marketer would like to emphasise, rather than relying solely on visual structure of the graphic design to push their marketing message to the consumer. Through the use of the three-dimensional effect brand names and core information can be pushed forward in the space emphasis importance to the viewer, where the less important information can be pushed visually back in space.

Digital Reconstructions

Through the formation of this interactive art piece, the use of the process can be applied to historical digital reconstructions. This digital diorama can be placed within museums to allow visitors to experience worlds, which they would not able to experience without the digital reconstruction. The advantages to the digital version of this versus the recreation of the situation in real life is the ability to the museum to make updates

and changes to situations that might change depending on new information arises about the history of the situation or artifact.

5 CONCLUSION

Through the formation of this interactive public display system, the design will be actualized to update three-dimensional images based on viewer's location. The interactive system will focus on fostering a low-budget, in hopes of allowing anyone to create a three-dimensional interactive public display system. Through using products like Microsoft's Kinect and Unity3D, this method is accessible to the general public. The interactive system has applications in advertisements for small business, art exhibitors, and historical reproductions of environment. Through this interactive system, the visuals will be more interactive and engaging than a poster with visuals. The interactive system will actively mediate the viewer's world, and allow for digital displays to become three-dimensional rather than digital poster displays. The system will utilize three-dimensional graphics, light, and shadow to create the illusion of depth and dimension on a flat surface. Through this system, an immediate reaction to the viewer will allow the display to communicate its interactivity to the public. As a result, this will drive attention to the display and potentially to the store or exhibit.

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