Rundle Lantern in Miniature: Simulating Large Scale Non-Planar Displays

Shane Porter, Michael R. Marner, Ulrich Eck, Christian Sandor, Bruce H. Thomas
Wearable Computer Lab
School of Computer and Information Science
University of South Australia
+61 8 8302 3464
{shane.porter, michael.marner}@postgrads.unisa.edu.au, ueck@net-labs.de,
{christian.sandor, bruce.thomas}@unisa.edu.au

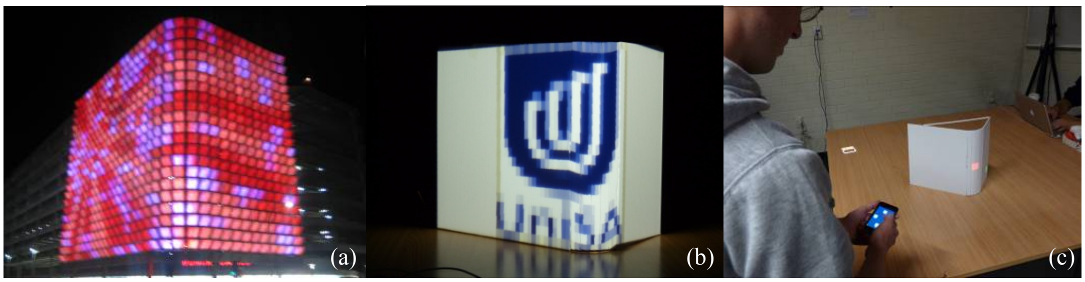

Figure 1. The real Rundle Lantern: a large-scale non-planar display (a). Using spatial augmented reality to project a texture on to a model of the Lantern (b). Playing an interactive game on the model using an iPod Touch (c).

ABSTRACT
The Rundle Lantern is a central fixture of the Adelaide CBD; a full color display four stories high, spanning two sides of a building. This paper describes our approach to rapid prototyping interactive content for use on the Rundle Lantern. We have created a physical small scale model of the Lantern, and employed spatial augmented reality to project content onto the mockup at the same resolution of the Lantern, to produce a similar appearance as the real Lantern. We developed an application to automatically quantize the pixelation of images to match the Rundle Lantern's relatively low pixel resolution. This approach allows new content to easily be developed and prototyped on a non-planar display with the same spatial proportions as the real Lantern; albeit on a much smaller scale. The prototype system is combined with software for the Apple iPhone so that interactive content can be developed. We have used our system to develop new visual content and several multiplayer games suitable for use on the Rundle Lantern.

Categories and Subject Descriptors
H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems---Artificial, augmented, and virtual realities; I.6.8 [Simulation and Modeling]: Types of Simulation---Visual.

General Terms
Design, Human Factors.

Keywords
Prototyping, Spatial Augmented Reality, Smartphone Interaction, Mixed Reality, Simulation, Large Display, Rundle Lantern.

1. INTRODUCTION
The Rundle Lantern is a major multimedia art installation in the CBD of Adelaide, South Australia. The Lantern is a full color display, four stories high and wrapping around two sides of a car park building as seen in figure 1a. The Lantern plays animations every night to entertain people in the streets bellow. This paper addresses two problems with the Lantern. Currently, the Lantern has no interactive capabilities. It is not possible for visitors in the area to interact with, or change, what is displayed on the lantern. Interactive content would increase the level of engagement visitors have with the Lantern. In addition, it is difficult to develop and prototype new content for the Lantern. As the Lantern is in a public space and is so large, testing new content directly on the Lantern is not possible. When developing content using traditional means such as 2D image editors, it is difficult to grasp how the image presented on a computer screen maps to the shape of the Lantern itself. It is also difficult to gauge the experience a visitor will have when viewing the content from different viewpoints.

The application that we have built simulates the appearance of the Rundle Lantern. It provides a method for graphic designers to test what their content will look like on the Lantern. Window contents of an open application are captured and applied to a simple 3D model of the Rundle Lantern. Designers are able to rapidly test how their content will appear, as well as provide a method for developing interactive applications. As the simulator can obtain images from any running application, it is not necessary to specifically develop custom applications for the Lantern.

2. RELATED WORK

The ability to efficiently test specific designs is very desirable for the Rundle Lantern system. This design philosophy was demonstrated by Apperley and Spence [1], who promoted the idea when developing new techniques for visualizing information on a computer. Due to the graphical limitations of the computers available at the time, they had to improvise by substituting a computer screen with a newspaper. By warping the newspaper, they were able to demonstrate their techniques with a very low cost. This view of effective prototyping was also shared by Buxton [4]. Following this approach, simulating the appearance of the Rundle Lantern using a low fidelity model is an effective method to rapidly prototype content that would otherwise not be possible.

Rapid prototyping is common for industrial designs, and investigations by Ohshima and Yamamoto [5] used Augmented Reality (AR) to evaluate the interiors of automobiles. A physical model of a car is overlaid with a 3D version viewed through a head mounted display (HMD). If a feature needs to be added to the design, then the 3D model can be changed very easily and viewed through the HMD.

Our simulation software is a Spatial Augmented Reality (SAR) system based on Shader Lamps [6]. Shader Lamps uses digital projectors to alter the appearance of objects. Objects are represented as appropriately textured 3D models. Calibrated projectors are used to project the textured 3D models so they appear in situ on the physical object. Several interactive SAR systems have been developed. [2] allows a user to digitally paint onto physical objects. [7] animates textures to give the appearance of motion in an otherwise static scene. Our system uses the calibrated projectors to project onto the mockup of the Lantern as shown in figure 1b and c. However, we are using SAR to simulate a non-planar, dynamic display on the model, rather than change the material properties of the object.

Projector based prototypes have also been used by Blasko et al [3] to explore new wearable computing devices. They proposed a wrist-worn 2D display with a novel interaction concept of pulling a string out from the device. The string itself is a one dimensional input and output device for displaying additional information. The proposed design of the string is to display information using embedded LED's. SAR technology was employed to simulate this effect in a quick manner, without having to construct complicated prototype hardware.

3. MOTIVATION

The Rundle Lantern currently only displays non-interactive content such as images and animations. Our initial motivation was to develop dynamic content that would allow users to interact with the Lantern. Interactive content would be more entertaining than the pre-compiled content and would allow the Lantern to provide a more engaging experience for visitors. To allow us to develop interactive content, it was necessary to create a program that would simulate how this content would look when shown on the Rundle Lantern.

3.1 Simulator Design

By simulating the features of the Rundle Lantern, we enable designers to use their traditional methods of creating content through programs such as Photoshop[1] or Adobe Flash[2]. They are able to see how their content would look on the Lantern, and modify it in real time. This is a very quick and cheap method of testing the appearance of content.

The first main feature is the resolution of the overall display, which is fixed at 68 x 21. The Lantern was developed as an art installation, not a high resolution display, which is why the resolution is so low. Highly detailed images cannot be displayed effectively at this resolution. This creates the need for specialized content that can still be entertaining at this size.

The second feature is that each panel is split vertically into two pixels and can display two different colors. These colors mix with each other in the middle of the panel, which creates an effect that is hard to account for when designing the content. This effect can be replicated in an OpenGL fragment shader so that people can use our simulator to see what their design would look like in real life.

The Rundle Lantern is a non-planar display spanning two sides of a building. Visitors to the Lantern have different experiences depending on their point of view of the display. Any prototype should also be non-planar so that this experience can be simulated. SAR is an ideal candidate for this type of prototype. A low fidelity physical model that approximates the Lantern can be used, with a projector being used for the display. This greatly reduces the complexity of the model, as electronics and small displays do not need to be embedded inside.

3.2 Interaction Design

Interactive content on the Lantern should engage the people in the immediate area around the display. Our first idea was to place some custom built hardware in Rundle Mall, which is the area with the best viewing position of the screen. This would enable interested people to interact with the Lantern. However, creating a robust outdoor installation containing a touch screen or other input devices would be prohibitively expensive. Furthermore, it would require regular maintenance and would be difficult to extend and modify as needs change in the future.

Smart phones with integrated wireless capabilities are becoming more and more popular. Phones and PDAs are an ideal platform for interacting with the Lantern. A dedicated installation is not required, as visitors would be carrying the device with them anyway. We decided to create simple interactive games that would demonstrate the capabilities of an interactive Lantern. The system requires only a wireless access point and an installable application that can be delivered over the internet. A simple smart phone application for the Apple iPhone and Java Mobile is fairly easy to implement. The result is cheap to run and can be secured against vandalism more easily than custom hardware.

[1] http://www.adobe.com/products/photoshop

[2] http://www.adobe.com/products/flash/

Figure 2. Stages of the simulation. Original logo in a picture viewer program (a), scaled down to the resolution of the Lantern (b), and applied to a model of the Lantern through the use of SAR (c). The scaled texture is also used in the simulation application.

4. IMPLEMENTATION

Our implementation consists of three important parts. The simulator application captures and converts an image from an open application and shows what it would look like on the Rundle Lantern. This can be visualized as either a desktop application, or projected directly onto a model of the Lantern using SAR. The smart phone application allows users to interact with our SAR system through an Apple iPhone.

4.1 Desktop Simulation

Our simulator has been developed as a C++ application running on Linux. When running, the software continuously captures the content of an open application and modifies it to appear similar to how it would look on the Rundle Lantern as shown in figure 2a and b. This program creates a window for the user to view the simulated model of the Lantern.

The first step of the process is to capture images of the selected window as seen in figure 2a. These images are scaled down to the small 68x21 resolution, which is the resolution that is used by the Rundle Lantern. This is done in Linux by using several methods from the X Server program. The main function we use is XGetImage which grabs a section of the user's current desktop and converts it into an image. This method saves the pixel values of a window to a XImage object. The image can then be accessed through an array stored in the XImage object.

This image data can then be used as a texture by OpenGL. We call this method every frame, where a new image of the open window is formed. This can be a problem when a user selects a window with a high resolution, since it has to record a large number of pixels and copy them into memory. The size of the selected window has the greatest impact on the performance of the simulator.

Once the image of the running program has been captured, the application scales the image to the desired resolution as shown in figure 2b. A box filter is used, which averages the colors of several neighboring pixels and combines them into one pixel. Using this technique over the whole image reduces its resolution which is currently set to 68 x 21 in order to simulate the image that would appear on the real life Rundle Lantern. These dimensions could be changed to suit a display with a different resolution. The scaled image is then applied to an OpenGL texture, which is then applied to the model of the Rundle Lantern.

4.2 SAR Simulation

The desktop simulation can give the user a sense of how content will look at the resolution of the Lantern, but cannot simulate how content will be experienced on the non-planar display of the Lantern. To solve this problem, we have used our existing SAR infrastructure to project the content onto a physical model of the lantern as shown in figure 2c.

We have created a scale model of the lantern from white plastic board, with dimensions of 32x35x21cm. A single projector is used to project images onto the model. An offline calibration step finds the intrinsic and extrinsic parameters of the projector. Once the properties of the projector are known, these can be applied as an OpenGL projection matrix and transform. If the position of the mockup is known, the projected image will appear correctly on the mockup.

The SAR simulation replaces the final stage of the desktop simulation. The images are captured and transformed as before, but instead of displaying the texture in a separate window, it is projected onto the mockup of the Lantern that we have constructed.

4.3 Smart phone Interaction

To simulate the possibilities of user interaction with smart phones we decided to use already available solutions that we assembled for a rapid development process. We used several Apple iPhones to connect to a local wireless network and to act as controllers for our SAR applications as shown in figure 1c. The iPhones communicate with the demo application using the OSC protocol[3], which was developed to allow remote control of audio-visual software. The protocol is a standard for exchanging real-time controller data in a point-to-point network setup within open source multimedia applications.

Mrmr[4] is installed on the iPhones to provide the user interface. Mrmr is an experimental extension to the OSC Protocol. It defines a common set of OSC message semantics to make implementations compatible. It also specifies how to discover available Mrmr servers and how to provide user interface templates from them to gain a zero configuration setup. The client implements a simple GUI specification language that is sufficient to create a simple demo game controller. We configured the client to directly talk to the demo application over a wireless network. Furthermore, we created a simple user interface template containing four buttons as a game controller and uploaded it to the mobile devices. After the setup was complete, the game controllers sent their data as OSC Packets to the demo application server.

[3] www.opensoundcontrol.org

[4] http://poly.share.dj/projects/#mrmr

4.4 Example Applications

To demonstrate interactive content, we have modified existing games that can be played on low screen resolutions for the Lantern. To implement the demo we used the Python programming language, together with the simple game toolkit Pyglet[5] and the OSC library.

We reviewed a number of existing open source game examples and decided to rebuild the two famous titles: Pong and Snake. Pong is a two player game of simplified table tennis, with each person controlling a paddle on either side of the screen. In Snake, the user controls a computerized snake that grows longer by eating food.

Due to the limitations of the screen we had to tweak the internal logic of the games to make them work well with a resolution of 68 x 21 pixels as well as fixing timing issues that arise from the smaller number of available squares that you can move to. Within the demo application main loop, we converted the incoming OSC events to characters understood by the game logic to process the user interaction. After several iterations, we had two working demo games that could be played on the simulated Rundle Lantern.

There are several applications that work effectively with the simulator. The first is a GNU Image Manipulation Program[6]. By selecting the image editing window to be shown on the Rundle Lantern, a user can draw on the canvas, and this will be reflected on the model. This is a quick method of making the Lantern interactive. It could also be used by designers so that they can create content for the Lantern in real time.

The second simple application is a media player visualization of the currently playing music. This feature is built into many audio applications and can be effectively displayed on the Rundle Lantern. The visualization is controlled by the music, and changes with the sound. This effect is convincing, even at the tiny resolution of the Lantern. This could allow people to play their own music for the Rundle Lantern, and entertain people on the street with the visualization. These two tools are readily available and are examples of how our system can be used to simulate an application's appearance on the Lantern.

5. CONCLUSIONS

We have described our approach for rapid prototyping new, interactive content for the Rundle Lantern, a four story high, non-planar display in the Adelaide CBD. Testing new content directly on the Lantern is not possible. To solve this problem we have created a small scale mockup of the lantern. A simple mockup of the Lantern's shape has been created, with the content being projected onto the mockup using SAR techniques. This approach allows new content to be prototyped on a similar non-planar display to the real Lantern, without the need for any complex electronics to be embedded into the mockup. In the future we could create a larger mockup to increase the spatial nature of the display by using multiple projectors.

Our system currently uses a simplified model of the Lantern's visual capabilities. We would also like to extend this model through the use of GLSL fragment shaders. In addition to displaying content at the correct resolution, we would like to model the pixel bleed, gaps between panels, and color gamut of the Rundle Lantern. We would like to add the effect that ambient lighting has on the Lantern, but it is hard to model since it depends on several variables such as the weather and time of day.

If we were to deliver a system that would use some form of interactivity, we would need to extend our current work. First, there is a broad variety of available cell-phones as well as other mobile devices like the iPod Touch. The user interface application needs to be developed for multiple platforms, such as the Apple iPhone OS and Java Mobile. We could then customize the interface for several different device categories. For example the keypad could be used if there is no touch screen available or if the screen is too small. Second, a secure and stable network infrastructure needs to be setup. Third, a full implementation of a Mrmr like system needs to be written as a toolkit. This would include easy to use development and deployment tools, ready to use building blocks and some logic to regulate and restrict the access from discovered devices in a meaningful way. Finally, some artists may want to use this toolkit to make interactive artwork, installations or games. We are currently working with the Adelaide City Council to further develop our interactive games for use by the general public on the Rundle Lantern.

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[5] http://www.pyglet.org

[6] http://www.gimp.org