PepperGram With Interactive Control

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***Abstract*—A peppergram allows a user to experience a visual image floating in the air. This paper explores how to add interactive controls to a peppergram. An investigation was conducted to explore the suitability of two different integrative methods for navigating a peppergram as a multimedia presentation tool; a Myo armband, and touch screen input. These methods were used with prototype 3D visual images experienced on a high-resolution mobile tablet device. A pilot study was conducted to evaluate the user experience. We found that using freehand gesture input with the Myo could be one way to provide interaction with peppergram virtual content without requiring any touch input. These results could be used as the basis for further development of interactive peppergram displays.**

Keywords—*Peppergram, Myo Armband, Virtual Remote Control, Interaction, Pepper's Ghost, and Augmented Display.*

I. INTRODUCTION

Pepper's Ghost was invented in 1862 by John Pepper [1] to wow unsuspecting theatre going audience members. It is an illusion that creates the impression that a ghost has appeared on stage next to the actors. This is accomplished by placing a piece of glass at an angle placed between the audience and the stage, through which light is shone, reflected from an actor below the stage, creating the optical illusion (see Fig. 1). This approach is commonly known as a peppergram in the creative and information technology industries [2]. Peppergram are still used today, such as for interactive marketing at Berjaya Times Square, Kuala Lumpur and showing Dita Von Teese appearing in the Times Square Hologram, at Studio City Macau [3].

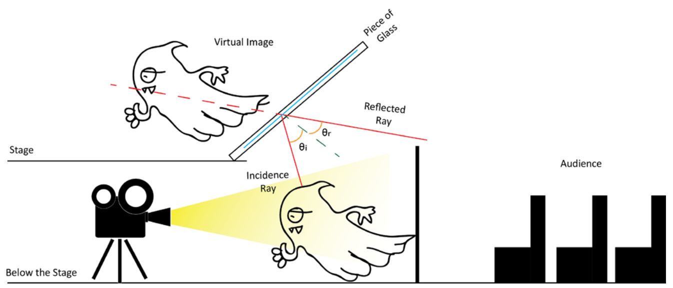

Fig. 1. Pepper's Ghost as shown in 1862.

In the rest of the paper we first describe background research on interactive peppergrams, then discuss how we implemented our system and a user study conducted with system. Finally, we finish with a discussion and conclusion with directions for future research.

II. BACKGROUND RESEARCH

Since 1862 peppergrams have been used in many settings and different form factors, from museum installations [5] to conference stages. Most recently, the emergence of smart phones, and tablets has enabled peppergrams to be delivered in mobile settings using small foldable transparent screen.

Traditionally peppergram are non-interactive, just showing prerecorded experience to the viewer. However, recently a number of companies and researchers have explored how to add interactivity. For example, PRHolo [6] have combined a 3D depth sensor with a peppergram installation to support natural gesture interaction with users. Another study has explored using an infrared sensor and Microsoft Kinect interaction with a peppergram [7]. Similarly, in the Calderan project [8] a Leap Motion Controller was used to enabled people to reach out and translate and rotate the virtual images. Thange et al. [9] show how a simple motion sensor can be used to add interactivity to a peppergram.

Real objects can also be used to support interaction with peppergrams. For example, computer vision has been used to track real cards onto which the peppergram virtual images appear [10]. Moving the cards enables the user to see the virtual content from different viewpoints. Other people have explored

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how to use external devices, such as smart phone to support touch screen input, mapping 2D input to 3D object manipulation. [11].

These systems either use embedded sensors in them or require the user to carry a handheld device, and have some limitations. For example, the viewer has to put their hands into the Leap Motion interaction volume to capture the user input. To overcome these limitations, we are interested in exploring how to use body worn devices for input, and in particular the Myo armband. In the next section we describe the peppergram prototype we developed using the Myo armband.

III. Proposed Approach

The peppergram prototype we developed was made up of stiff, reflective plastic bent into a pyramid shape and placed on a smartphone or tablet, with each of the four sides are at a 45° angle to the screen. As shown in Fig. 2 the pyramid was 3 cm x 9 cm x 11 cm in size and Figure 5 shows an image generated in it pyramid when it was placed on a tablet.

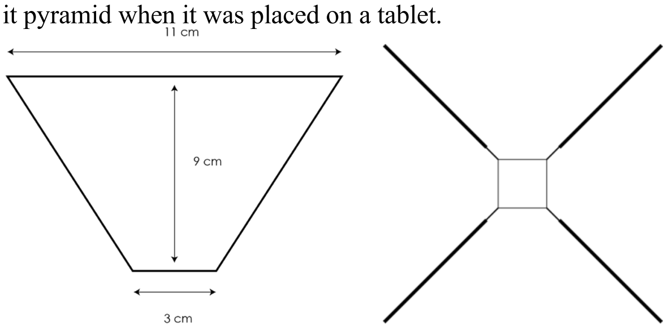


Fig. 2. Dimensions of the peppergram pyramid.

Fig. 3 shows how the peppergram on the tablet worked. Light from graphics shown on the phone screen bounces off the plastic pyramid and is reflected to the viewer's eyes. The plastic is transparent so the viewer can also see through the peppergram, so the virtual model shown appears to float in space within the pyramid

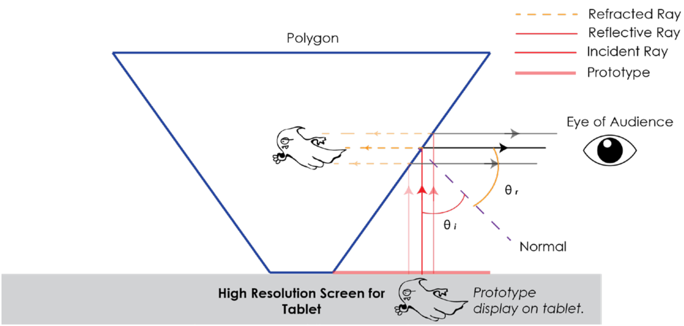
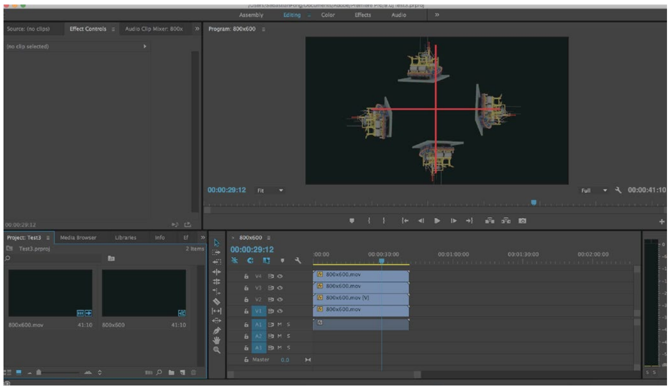


Fig. 3. Viewing an image inside the peppergram.

The tablet device used for our study was a Microsoft Surface Pro 4 with a 12.3 inch display and a resolution of 2736 x 1823 pixels (267 PPI). On the Microsoft Surface Pro we showed videos of 3D objects, edited and placed in four different rotations, one for each face of the peppergram. Fig. 4 shows a screenshot of Adobe Premier Pro application, creating a four-face video used for prototype demonstration, and Fig. 5 shows the final view of the 3D model in the peppergram.



In order to add interaction to the peppergram, we used the Myo armband as a gesture controller to remote control the video played in the VLC Media Player. Fig. 6 shows the Myo Armband and Fig. 7 the gestures for controlling the armband and mapped onto video controls. In this case the 'Finger spread' gesture is assigned to the Play/Pause function, 'Fist' to control the volume and "Rotate" to adjust the volume up and down, 'Wave Left', to rewind the video, 'Wave Right' to fast-forward the video, and finally the, 'Double Tap' gesture was mapped to the timed unlock. As a result, this provides users with some level of control over for the peppergram illusion.

The Myo armband works by using proprietary EMG sensors, which are built into on the armband. The Myo armband measures electrical activity from muscles to detect five hand gestures [12]. Using a 9-axis IMU (Inertial Measurement Unit), it also senses the forearm motion, orientation and rotation. Developers can combine the pre-set gestures with arm motions to create new gestures. Developers are also able to access the raw EMG data from the Myo to create their own custom gestures. A custom calibration profile tool in the Armband Manager of Myo Connect allows users to record their own motions that map to the four EMG-based gestures. The Myo armband transmits gesture information over a Bluetooth Smart Connection to communicate with compatible devices [13].

The Myo can be used up to 15m (50ft) meters away from the peppergram, so there are several advantages in using Myo for interactive control of the peppergram display. The wireless capability makes it easy to operate and users are able to gain control at a distance away from peppergram. This mean that it is especially suitable for a group presentation where viewers can experience the visual effect of peppergram while a presenter controls the floating object without physically touching the display surface or being in the way of the viewers. Moreover,

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the Myo and peppergram are portable and hence can be used anywhere.

Fig. 6. Myo Armband.

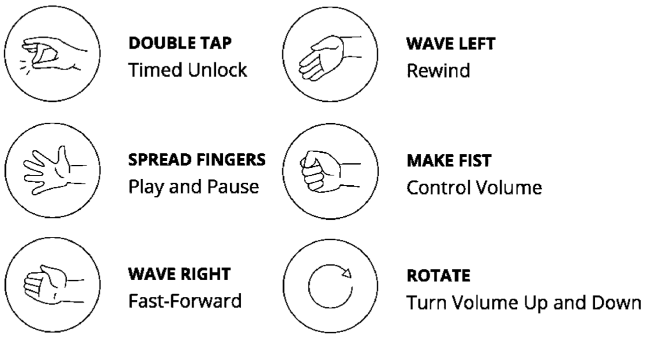

Fig. 7. Armband control with options of gesture input.

In addition to the Myo input we also used a simple touch screen controller to interact with the virtual peppergram video content. The use of a touch screen input requires the user to touch their finger onto the display screen of the tablets. In this case, the user can touch on menu bar buttons of the VLC video player application to control the interactivity of the content, such as the play/pause button, rewind, etc.

IV. User Study

A pilot study was conducted to evaluate the Myo technology for gesture interaction with the peppergram and compare it to the more traditional touch input. A set of 20 participants were involved in the user study, 16 males, and 4 female ranging in age between 18 to 23 years old, 24 to 29 years old, and 30 to 35 years old, *(SD=3.30)*. The focus of the user study was to measure the usefulness of the interactive control capability with the peppergram display. Participants were requested to wear a Myo armband device on the arm, and look 90° degrees towards peppergram pyramid to see the illusion, and perform some hand gesture to control the movement of illusion.

The experiment had two conditions: C1 Touchscreen: using touchscreen gesture controls, and C2 Myo: using Myo armband gesture controls. Each participant experienced both conditions in a counterbalanced order.

In the Touchscreen condition (C1), each participant was briefly taught how the touchscreen worked on the tablet by touching functional buttons in the application. Participants also tried perform scrolling to the left and to right of the taskbar in VLC Media Player application.

In the Myo condition (C2), before performing any hand gesture, each participant was briefly taught about the Myo armband and peppergram history and theory. Fig. 8 shows a participants testing the Myo armband and peppergram. An experimenter explained the process and provided a complete demonstration of the Myo Armband hand gestures.

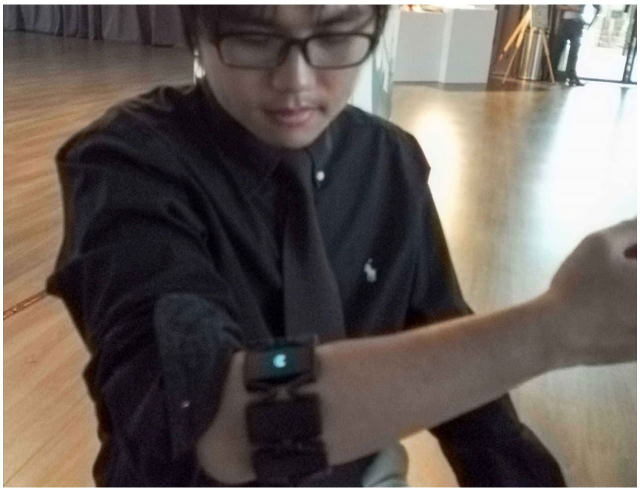

Fig. 8. Participants testing the Myo Armband and PepperGram.

In each condition, participants were asked to look at the peppergram and perform interaction with Myo hand gestures, or touch screen input. After each condition, we collected participants' feedback on how easy it was to use the control technology (either Myo or touchscreen input). This was done by collecting qualitative feedback responses to the questions shown in table 1. Answers where captured on a Likert scale of 1 to 7 in which 1 was "Strongly Disagree" and 7 was "Strongly Agree". After both conditions we interviewed participants for more feedback about the controls. Our key interest was to understand the perceived ease-of-use and usefulness of the armband by the participants, and how they described their experience with the peppergram.

Table 1: Survey Questions

Q1	I found it easy to use
Q2	I found it natural to use
Q3	I found it reliable
Q4	I found it physically challenging
Q5	I found it mentally challenging
Q6	I found it useful

Fig. 9 shows the average results of the C1 and C2 survey questions. Overall there was no difference in the responses to the survey questions between the Myo and touchscreen input in terms of perceived ease of use (Q1) and usefulness (Q6), but there was in the questions relating to physical (Q4) and mental (Q5) challenge, how natural it was to use (Q2), how reliable it was (Q3), and how challenging (Q4).

A Wilcoxon Signed Rank test was used to analyze the results to check for significant difference between the results of the using the touchscreen gesture control (C1) and the Myo armband gesture control (C2). For Q1, using a one-tailed test we found that participants felt it easy to use the touchscreen gesture control with no significant difference between conditions, $Z = -1.223$, $p = 0.111$. For Q2, finding the gesture natural to use, there was significant difference between C1, and C2, with $Z = -2.103$, $p = 0.012$. There was also a significant difference between conditions it terms of how reliable participants felt each condition was (Q3), Z = - 1.712, p = 0.004. In terms of the physical challenge (Q4), participants felt that the Myo armband (C2) was significantly more challenging (Q4) than the touchscreen (C1), Z = - 3.059, p = 0.001. Similarly, C2 was felt to be more mentally challenging (Q5) than C1, Z = - 2.48, p = 0.007. Finally, there was no difference between the conditions in terms of usefulness. (Q6), Z = - 1.192, p = 0.117. Overall, these results show that the touchscreen gesture interface was better than the Myo gesture input.

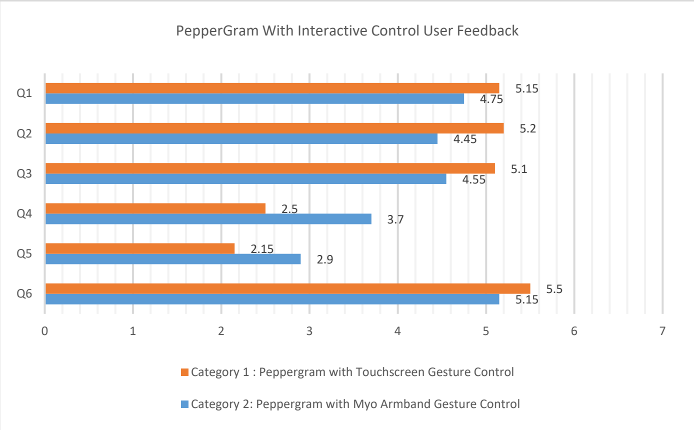

Fig. 9. Average results of C1 and C2 survey questions.

We also asked participants the following questions about the peppergram experience, using a Likert scale rating from 1 to 7 (1 = Strongly Disagree, 7 = Strongly Agree):

QA – How much experience do you have with Peppergram?
QB – Do you feel the level of details or display resolution is important to you?
QC – Do you feel the users' ability to interact with display content is important?

Fig. 10 shows the average results. Only a few participants had experience with peppergrams (QA). More than half of the participants agreed that the level of details or display resolution was important (QB), and most strongly agreed that the ability to interact with the displayed content was important (QC).

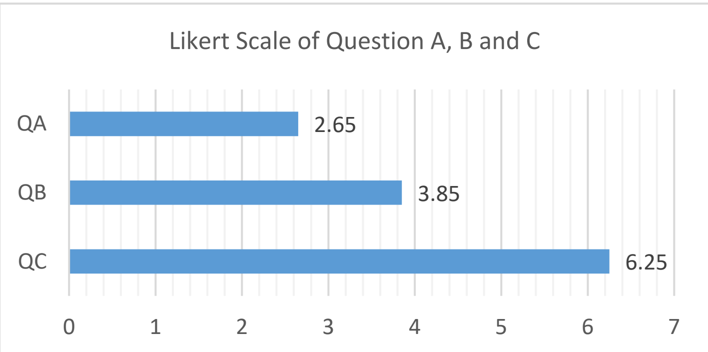

Fig. 10. Average results of QA, QB and QC survey questions.

We also asked participants for their comments or suggestions on the peppergram and controls. Some users said that they found the peppergram an interesting technology, with comments such as *"... interesting, I have never seen a peppergram before..."*. However, they felt the peppergram could be improved in number of ways, such as *".... peppergram can be improved, by creating a bigger virtual illusion...",* They also felt that there could be enhancements to the gesture controls used, with comments such as *"... more features of armband could be more utilizde such as zoom in, and zoom out of the illusion/video prototype..."*

We observed that the participants who were are new to the armband found it challenging to control and repeat the hand gestures. Another difficulty experienced by the users is that Myo becomes locked once a gesture is performed, and users need to perform an unlock gesture in order to perform another input gesture. Many inexperienced users ended up being locked and spent a lot of time to unlocking the Myo without successfully controlling content shown in peppergram. This situation may be overcome with practice, enabling the user to gain confidence in operating the armband input for the peppergram.

V. Discussion

Most of the experiment participants felt that they were extremely familiar with the touchscreen input as they all had personal mobile devices with touchscreens. However, the Myo armband gesture control was new to all participants. Despite this, participants felt that there was no difference in perceived ease of use and usefulness between the touch input and Myo gesture input. This is a positive result that shows the devices like the Myo could potentially be used for interactive control for peppergram experiences.

However, most users felt that using the Myo armband was more physically challenging compared to the touchscreen input. One of the reasons for this is that different users produce different nerve muscle signals and so each user should carefully calibrate the Myo before using it. Different people also have different body size types that might affect the reading time recognition delay. For example, thin people often have small forearm muscles. Using the Myo also requires performing a range of different hand gestures that require more physical input than simply touching a screen.

However, in the future the Myo armband could be reliable and natural to use and reliable. For example, the armband could be improved for better hand gesture recognition. Through this research, interactive control could be more improved, and it could be more easy to correctly recognize the hand gestures.

VI. Conclusion

In this study, we added interaction control to a peppergram using a Myo armband control. The use of the Myo armband was compared to more traditional touchscreen input. It was observed that participating users were comfortable close to the touch screen. Participants also made several good suggestions for improving the technologies such as better gesture recognition, and reducing the recognition timing delay.

The perceived ease-of-use and usefulness of the armband control was found to be no different to the familiar touchscreen input when using the peppergram. Participants described what they thought the advantages were of armband and touchscreen input, and they also mentioned areas for further improvement. For example, accessing the EMG readings, gives the possibility to further extend the set of supported hand gestures by creating a self-written hand gesture. Using this it might be worth considering a different type of unlock pattern for the timed lock in the Myo armband.

In the future, we would like to further improve our efforts in designing the peppergram content that works with different degrees of controls and explore improved approaches of using interactive technologies. The visual attention required, as well as the social acceptance of possible interactive control technologies should be examined, especially in contrast to other technologies such as speech recognition, and eye gaze input.

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