GlobalFestival: Evaluating Real World Interaction on a Spherical Display

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ABSTRACT
Spherical displays present compelling opportunities for interaction in public spaces. However, there is little research into how touch interaction should control a spherical surface or how these displays are used in real world settings. This paper presents an in the wild deployment of an application for a spherical display called GlobalFestival that utilises two different touch interaction techniques. The first version of the application allows users to spin and tilt content on the display, while the second version only allows spinning the content. During the 4-day deployment, we collected overhead video data and on-display interaction logs. The analysis brings together quantitative and qualitative methods to understand how users approach and move around the display, how on screen interaction compares in the two versions of the application, and how the display supports social interaction given its novel form factor.

Author Keywords
Spherical Displays, Human Computer Interaction, Multi-touch Interaction, In the Wild Evaluation.

ACM Classification Keywords
H.5.2 Information Interfaces and Presentation (e.g. HCI): Evaluation/Methodology.

INTRODUCTION
Spherical touch-sensitive displays create new opportunities for social interaction in public spaces. The shape of a spherical display allows users to face each other and maintain eye-contact during interaction, creating a different social dynamic than at a flat display. There is also no intrinsically defined front or centre of the display, offering different views from different viewing angles. This creates shared and private areas of the display given users' varying perspectives. Spherical displays can be placed in the middle of a walkway, targeting flows of pedestrian traffic and allowing users to approach from any direction.

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Figure 1. The GlobalFestival spherical information display attracts visitors at an international music festival.

In order to realise the possibilities of spherical displays, we must understand how users discover interactivity and explore content on the display. Although some work has been completed comparing how users approach cylindrical displays as compared to flat displays [5], little is known about how spherical displays are used. These displays create a different dynamic than cylindrical displays because of the additional content on top of the display and visibility over the display. Previous work has shown that the visibility of others gives passers-by more cues on how to interact [24]. For example, Figure 1 shows two people interacting at the display with a third spectator opposite them. Could the increased visibility of other users increase the attractiveness of spherical displays and mitigate social inhibition?

The usability of different interaction techniques on spherical surfaces is also relatively unknown and likely has different issues than comparable techniques on flat displays. Benko et al describe how basic multi-touch gestures such as drag, pinch, and rotate might work on a spherical surface given discrete content [4]. However, these gestures become problematic on a display with continuous content that wraps seamlessly around the display. For example, if you zoom continuous content on a sphere, what happens on the opposite side? Even for simple dragging gestures, how should continuous content move across the display, which axis gives the best control, and what limitations or physical metaphors could be used to increase usability?

In this paper, we evaluate two touch interaction techniques and on a spherical display through an in the wild deployment. The display was situated in a concert venue during an international music festival over four days. The GlobalFestival application displayed a stylised globe with artists from the festival pinned in their hometowns. The study used two versions of the application for a comparative evaluation of two on-sphere control techniques. This included a version with Spin+Tilt and Spin Only manipulation of on-screen content. Our main motivation in completing this study was to determine if small changes to on-screen interaction would increase the time spent at the display. Secondarily, we hoped to gain new understanding of the social aspects of interaction at a spherical display. The results bring together data from manual analysis of overhead video, automatically generated behavioural maps using pedestrian tracking and data from on-screen logging.

The main contributions of this paper are:

- Novel evaluation of a spherical multi-touch display in a public setting.
- Comparison of two on-sphere touch interaction techniques, demonstrating a larger usable on-screen area and longer interaction times for Spin+Tilt interaction as compared to Spin Only.
- Technique for quantifying the Honey Pot Effect by analysing the times between interactions.
- Demonstration of unique interaction behaviours given the spherical shape of the display, including crowding behaviour and movement around the display during interaction.

BACKGROUND

Touch Interaction on Large Curved Displays

Since the first spherical display was presented at SIGGRAPH in 2002 [14], the usability and functionality of these displays has made significant advances. Modern spherical displays support high-resolution graphics, on-sphere multi-touch interaction, and screen sizes varying from 600mm to 2000mm[1].

In the first touch sensitive spherical display, Benko et al described how multi-touch interactions could be used on a spherical surface [4]. Benko et al analysed how traditional interaction techniques such as pinch and flick could be implemented on a sphere to manipulate discrete content. They also present new techniques to support collaboration on a sphere. For example, Benko et al describe the "Send to Dark Side" gesture where users can hold their palm down on content to send it to the opposite side of the display.

Bolton et al explored competitive and collaborative actions on a spherical display [7], developing different software based "peeking" techniques to support collaborative interaction. Their results show that users preferred to walk around the display to see shared content and that conversation over the top of the sphere was widely used, indicating that the physical attributes of the form factor may inherently support these kinds of collaborative actions.

Beyer et al completed a study that compared how people approached a cylindrical and flat display and how they oriented themselves towards the display in a lab setting [5]. The evaluation saw one user interact with the displays in a setting that was staged as part of an evaluation. Their results show that users walked longer distances when interacting with the cylindrical display but spent a longer time interacting at the flat display. Beyer et al also looked at how a cylindrical display with different framing techniques changed how people interacted with the display in a museum setting [6]. The results show that virtual framing on a frameless display changed user behaviour, influencing where users stood in front of the display.

Challenges with Public Displays

A major challenge to deploying public technologies is actually getting users to notice interactive elements and enticing them to approach. Previous work has described the Honey Pot Effect, where users are more likely to interact if other users are already doing so [8]. But how do you entice users in the first place? Walter et al completed a field study that explored how large displays could show passers-by how to interact with gestures using a variety of prompts [25]. Kukka et al looked at how different visual qualities such as colour versus grey scale and animated versus static content could either encourage or discourage passers-by to approach a touch sensitive display [13].

Memarovic et al describe five core challenges with designing and deploying public displays, ranging from low-level hardware issues to community interaction design [15]. The P-LAYERS framework proposed by Memarovic et al provides ways of mitigating these challenges throughout the design process. Memarovic et al also describe the need for public displays to satisfy the needs of both passive and active engagement in public spaces [16]. Whyte's seminal work on the social lives of small urban spaces describes the physical and social aspects of places that improve urban areas [26]. When designing public displays, it is important to evaluate how technology fits in a public space, satisfies the needs of that place, and supports place making.

Evaluating Displays in Public Spaces

Evaluating technology outside of the lab in real world public spaces has clear advantages but requires specific metrics and techniques [9]. Alt et al describe seven key research questions to guide the evaluation of public displays: audi-

[1] Spherical Displays by Pufferfish Ltd.
http://www.pufferfishdisplays.co.uk/
http://www.pufferfishdisplays.co.uk/

ence behaviour, user experience, user acceptance, user performance, display effectiveness, privacy, and social impact [2]. These questions can be approached through ethnography and interviewing, lab studies, field studies, and deployment-based research [2].

Some approaches evaluate public display success by looking at the wider space where installations are deployed. Fischer et al analysed the positions of spectators around a large interactive façade [11]. Fischer et al describe how the areas around the façade facilitate different types of spectating, such as gap spaces, comfort spaces, and potential interaction spaces. Although these results relate specifically to large façade interfaces, the analysis approach used by Fischer el al. could generalise to nearly any public display to better understand how people approach, crowd, and spectate around a display. Peltonen et al completed an intervention study on a public walkway with a touch sensitive display [19]. Their system, called the CityWall, supported multi-touch interaction with images. The CityWall evaluation used interaction logs and manual coding to evaluate the deployment.

Figure 2. A stylised map of the world was used to show where artists performing in the festival were from and was designed to match the branding of the festival.

There are few examples of curved displays being evaluated in public spaces. Although some work has been completed looking at cylindrical displays in public spaces [6, 29], there is significantly less research using spherical displays. To the author's knowledge, this paper presents the first evaluation of multi-touch interaction on a spherical surface in the wild. The study is based on a comparative evaluation deployed in a public setting without the presence of an experimenter [27]. The results provide novel insights into how touch should control continuous content on spherical surfaces and how these displays are used in public spaces.

GLOBALFESTIVAL: A SPHERICAL INFORMATION DISPLAY

The GlobalFestival application is a spherical information display that was deployed over four days in a concert venue during an international music festival. The application included a visualisation of a stylized globe, as shown in Figure 2, where artists performing in the festival were pinned in their hometowns around the world. When users tapped the pin, a pop-up box would appear with information about the artist and their appearance in the festival, as shown in Figure 3. The box could be closed with a button marked "x" or would close automatically after 30 seconds. Users could also move the globe by dragging the entire visualisation. When the globe was moved, any open pop-up boxes would reorient themselves so that the boxes always remained upright. The display was developed in collaboration with the festival and used the festival's branding and graphical look and feel to incorporate itself into the setting.

Figure 3. Users could touch an artist's name on the map and a pop-up with information about the artist would appear.

Comparative Evaluation: Spin+Tilt and Spin Only

The deployment used two versions of the GlobalFestival application with slightly different touch control techniques to compare how these different techniques would influence use of the display. These techniques were drawn from the prevailing metaphors currently in use in commercial applications of spherical information displays in order to better understand empirically how these two interaction metaphors are used in an in the wild context.

The first application used a "Spin Only" approach, mimicking the properties of a physical globe. Given the globe visualisation of the sphere, this physical metaphor was used to help users' understanding of how to control the sphere and browse its content. For the Spin Only application, users could only move the globe in the horizontal direction, similar to how they would interact with a physical globe. The map appeared with the North Pole at the top centre of the display. The globe spun on the axis perpendicular to the ground so that spinning left and right could be completed with touches in either direction.

The "Tilt+Spin" version of the application was designed to exploit the capabilities of a spherical display. Because the display is not limited by physical properties that a traditional globe would be, this version of the application supported touch control both vertically and horizontally. For the Tilt+Spin application, users could move the globe in any direction. To prevent the globe visualisation from entering an unusable state, for example being upside-down or in another unfamiliar orientation, the tilt movement was restricted. The map could be tilted a maximum of 35º away from the North Pole axis. The map would also reorient itself to the default position (North Pole at the top centre of the display) after 10 seconds without any input.

The comparative evaluation was completed by deploying the two versions of the application on alternating days of the four day trail, resulting in each version of the application running for two days. Spin+Tilt was the first condition to run.

Touch Me: Capturing Curiosity of Passers-by

Enticing users to approach a display is a known issue in developing successful displays. The GlobalFestival application included an idle state that was designed to attract users to the display. The prompt appeared whenever the display was in an idle state, i.e. after 20 seconds without any touch input. The prompt displayed the text "Touch Me, I'm Interactive" and showed images of artists appearing in the festival, as shown in Figure 4. These graphics scrolled around the display continuously until a touch event occurred.

Figure 4. In order to attract passers-by to the display, the application had an idle state that would scroll the words "Touch Me I'm Interactive" and images of performers from the festival around the display.

This prompt was adapted for multi-touch spherical displays based on the results presented by Walter et al [25]. Their work proposes successful prompts for teaching passers-by how to interact with a flat gesture-based display. For the GlobalFestival application, we used two key aspects of those prompts to design a spherical invitation to interact. First, we used the temporal division technique, where the prompt to interact uses the entire screen area for a defined period of time. This technique was shown to successfully engage 47% of users to perform the correct gesture in Walter et al's previous work [25]. This was optimized for a multi-touch display since we could clearly define an idle state to advertise the display's capabilities over the entire screen. Secondly, we used the technique of "communicating manipulation only" to show passers-by what was possible without clearly communicating the effects [25]. This resulted in the ambiguous and playful phrase "Touch Me" as the large text prompt on the display.

Concert Venue: Deployment Setting

The deployment was completed at a large concert venue that comprises of a main auditorium that can accommodate over 2,400 seated guests and six additional smaller venues ranging from 40 to 500 seated capacity. The display was situated in the centre of an alcove between the two main auditorium entrances, shown in Figure 5. The alcove was across from a small café and between two of the venue bars.

The display was staged without an experimenter present in order to provide the most natural and undisturbed experience as possible [27]. Beyond the simple prompts described above, no further guidance or support was given during interaction. Signs were placed around the display with University of Glasgow branding and notification of video recording around the display.

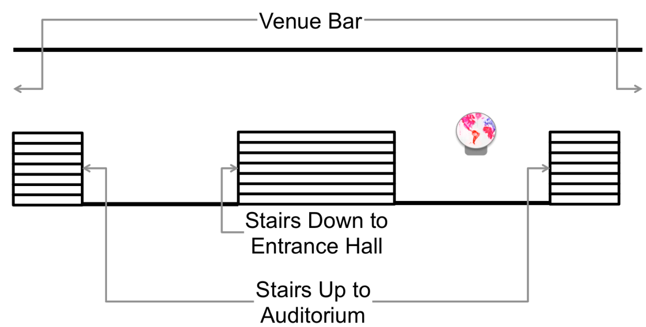

Figure 5. The display was situated in the centre of an alcove between the two main auditorium entrances.

PufferSphere® and Deployment Hardware

The deployment was completed using a commercially available interactive spherical display[2]. The display is constructed of rigid plastic with a diameter of 600mm, standing off the ground at a height of 1475mm tall. Thus, the majority of users can see other users over the top of the display but also have an area of more personal screen space in front of them. The screen is rear-projected from a single projector using a fish-eye lens situated at the base of the display. The resolution of the projector visible on the sphere is 1600x1600 pixels. The projector and all other internal elements are encased in a metal surround. Applications for the spherical display produce output in the azimuthal projection that falls naturally onto the sphere's inside surface creating a seamless spherical projection.

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[2] PufferSphere® M by Pufferfish Ltd.
http://www.pufferfishdisplays.co.uk/products/puffersphere-m/

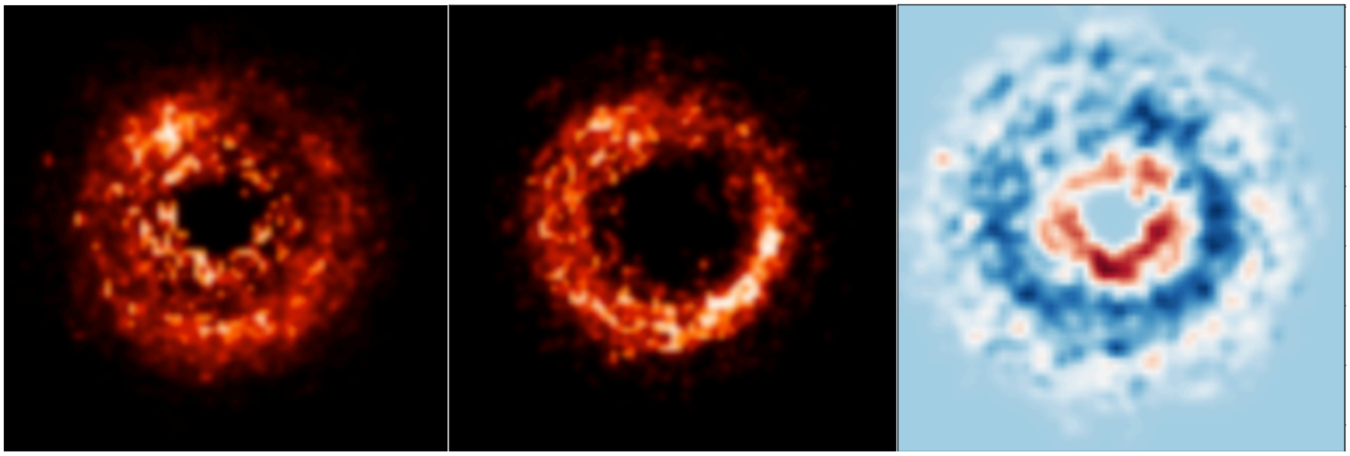

Figure 6. Heatmap visualisations of Spin+Tilt (left), Spin Only (centre), and the log ratio of these two maps (right).

The display supports multi-touch interaction using an array of infrared LEDs at its base. A camera captures input with fish-eye lens located at the base of the spherical screen and next to the projector lens. The camera images are used to track touches using blob detection at a 24 frames per second. The detected blobs are communicated using the TUIO protocol [12]. Video data of the deployment space was captured using a CCTV style camera with a resolution of 640x480, recording video at 5 frames per second. The camera was mounted 9 meters above the display.

RESULTS

The results are based on overhead video data and on-screen logging of touch events. This includes 21 hours of video data with 382 interacting users, 3,808 unique touches, and 2,318 pedestrian trails. The analysis was completed using manual qualitative analysis of video data, automatically generated pedestrian maps [28], and statistical analysis of on-screen touch logs. Unique touch events are analyses as a series of touch points generated while the finger is in continuous contact with the display

The Benefit of Tilting: Touch on the Vertical Axis

From touch logs gathered during the deployment, the results demonstrate that Spin+Tilt led to more of the display area being used and longer touch interactions being performed. These differences can be observed by comparing the vertical/latitudinal axis for all touch points. Figure 7 shows a histogram of these touch points along the latitudinal axis, where 0º is the equator. The histogram for Spin+Tilt shows a broader fitted curve (standard deviation 29.59º) that favours the upper half of the sphere (mean of 5.36º above the equator). The histogram for Spin Only shows a narrow fitted curve (standard deviation of 19.09º) that falls almost directly on the equator (mean of 0.13º below the equator).

The non-parametric Mann-Whitney test was completed to determine the statistical significance of the variance between these two conditions on the longitudinal axis. The test results show that there is a statistically significant different between Spin+Tilt and Spin Only, with a p-value <0.0001. This demonstrates that the Spin+Tilt condition resulted in a significantly larger area of the screen being used during interaction, specifically expanding the useable area above the equator. This can be seen clearly in the heat map visualisations shown in Figure 5.

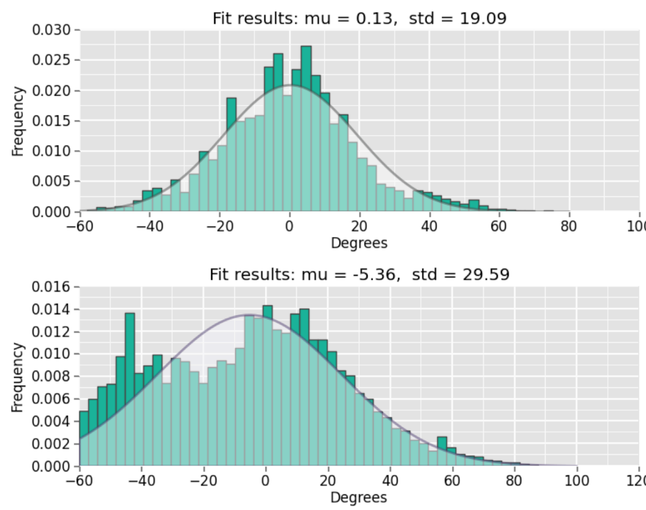

Figure 7. Histogram of touch point frequency along the vertical/longitudinal axis for Spin Only (top) and Spin+Tilt (bottom). The equator sits at 0º.

Heat map visualisations show the areas where touch interaction occurred during both conditions. Figure 6 shows a visualisation of Spin+Tilt, Spin Only, and the difference of these maps (visualised as the log ratio of the two conditions). These visualisations are presented in an azimuthal projection, where the top of the display (North Pole) appears in the centre of the visualisation and the bottom of the display (South Pole) appears on the outer edges. These maps demonstrate how the areas above the equator had increased touch interaction for the Spin+Tilt version of the application. The log ratio map (Figure 6, right) shows these areas of non-overlap in red.

Interacting Users at the Sphere

Figure 8 shows the average interaction times for users at the display in both conditions. The interaction time was calculated using manual notation of the video, where each interaction begins when the user first touches the display and ends when the user turns away from the display. Only users who physically touched the display are included for a total of 382 users. For Spin Only, the average interaction length was 31 seconds with a standard deviation of 47 seconds. For Spin+Tilt, the average interaction length was 46 seconds with a standard deviation of 57 seconds. The boxplot in Figure 8 shows the series of outliers for longer interaction sessions that skew the data. To compare these conditions, we completed the non-parametric Mann-Whitney test to compare interaction times. The results show that users spent significantly longer interacting with the Spin+Tilt than with the Spin Only version, with a Z-value of 2.44, a p-value < 0.01, and effect size of r = 0.2.

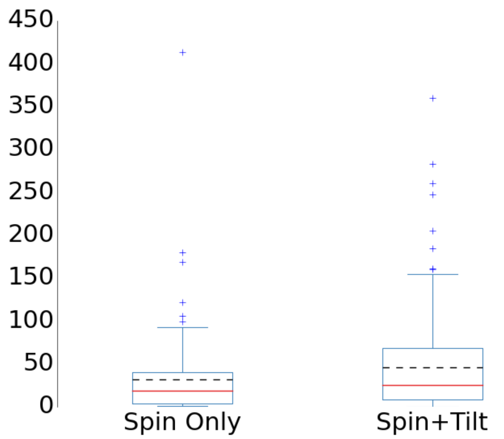

Figure 8. Boxplot for interaction times for Spin+Tilt and Spin Only conditions. Times are given in seconds.

Users also performed more touch interactions in the Spin+Tilt condition as compared to Spin Only. Users in the Spin+Tilt condition completed an average of 12 unique touch events while users in Spin Only completed an average of 7. The unique touch events were also longer for users of Spin+Tilt, with an average touch length of 512 milliseconds as compared to just 316 milliseconds for Spin Only. This means that not only did users spend a longer time interacting with the Spin+Tilt application, they also performed more touches with a longer touch length.

This extended interaction time can also be seen in the display's "uptime," the measure of time where the display is being used. For Spin+Tilt, the uptime is 12% as compared to 9% for Spin Only.

Measuring the Honey Pot Effect

Previous research has identified the Honey Pot Effect [8], which has been quantified by Müller et al [18] based on changes in conversion rates of passers-by. Here, we present a novel method for quantifying the Honey Pot Effect that extends previous work by analysing the space between interactions.

The Honey Pot effect can be quantified by analysing the times between new users approaching the display when the display is idle versus when the display already has at least one interacting user. Only users that physically touched the display are included in this data.

In this deployment's Spin+Tilt condition, the average time for a user to approach the display when idle was 55 seconds. This decreases dramatically to 3 seconds when the display is already in use. For the Spin Only condition, these values are 74 seconds when no users are at the display and 4 seconds when the display is in use. The values for all four days are shown in Figure 9.

Figure 8 bottom shows a clear increase in the number of additional passers-by that approach the display when there are already others using the display, approaching soon after (<10 seconds) others start using the display. The histogram also visualises how turn-taking at the display means users often approach the display shortly after others have left. Figure 8 top shows that is some cases the idle time of the display is very short (<10 seconds). However, this figure also shows that interaction trails off and idle times become much longer if there are no users at the display for more than 30 seconds.

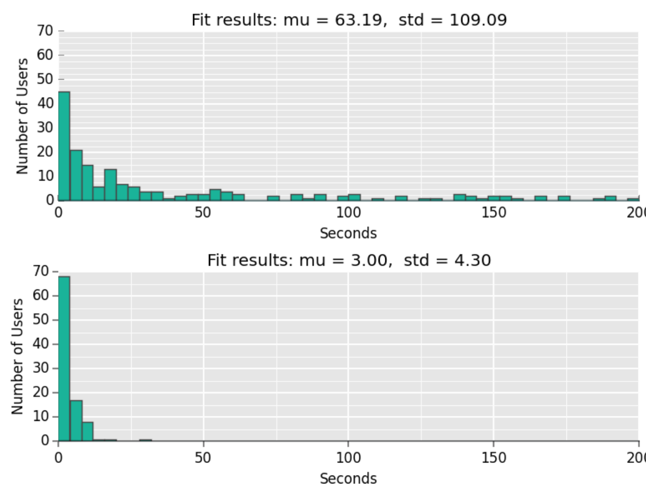

Figure 9. Times between users approaching the display when there are no users currently at the display (top) and when there are already users at the display (bottom).

Pedestrian Tracking

In order to gain a wider understanding of how users approach the sphere, we completed an analysis of pedestrian traffic around the display [28]. The pedestrian tracker was validated using the procedure described in [28] using 3 randomly selected 5-minute clips. Manual behavioural maps for these clips were compared with the automatic results from the pedestrian tracker. The validation shows that the pedestrian tracking software successfully captures 64% of passers-by and can accurately identify 72% of passers-by as interacting users. These values are in line with validation results described by Williamson et al [28]. This performance is acceptable for understanding pedestrian behaviour and drawing general conclusions from the data.

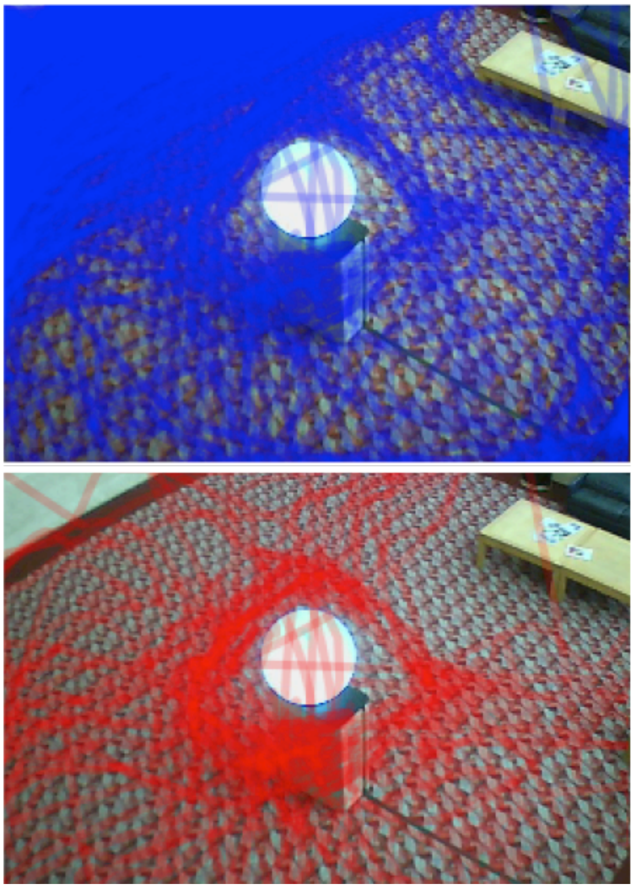

Figure 10. Automatically generated behavioural maps show flows of traffic around the display. Top: All passers-by are visualized for one day of data in the Spin Only condition. Bottom: Interacting users are isolated from the above data set.

These results can be used to quantify the conversion rates of passers-by to interacting users. Over the four days of the deployment, 9% of passers-by approached and touched the display. The pedestrian tracking results also describe how pedestrian traffic flowed through the deployment setting and how users approached the display. Figure 10 shows the behavioural maps from one day of the Spin Only condition. Figure 10, top, clearly shows that the majority of passers by walk along the alcove without stopping, showing a clear density of walking in this area. When the interacting users are isolated, Figure 10, bottom, shows the behavioural map for interacting users. Although the majority of users approach from the top and left edges of the frame, interaction is distributed evenly around the sphere. Figure 6 verifies this, illustrating that were touches distributed relatively evenly around the display.

Social Interaction on the Sphere

Qualitative analysis of the video data demonstrates some common behaviours observed around the spherical display. The video was analysed manually in a three step process. First, the entire video dataset was analysed by tagging any interesting behaviours that were observed around the display. Then, these tags were then organised and grouped into a generalised set. Finally, the entire video dataset was reanalysed with the refined tag set, which informed the results presented below.

Users frequently shuffle around the display, taking small steps as a group to move clockwise or anti-clockwise around the display. Sometimes, this action was performed in response to spectators standing at the edge of the interaction space, but it was also completed when no one else was around. When there are spectators standing near the display, this shuffling may act as a signal to make room for or invite spectators to interact with the display. This may also be completed to see more of the display without disturbing other's viewing angles. When there are not spectators standing near the display, this action may be performed to test the seamlessness of the display and check that content on the other side of the display is not missed. Both of these actions benefit from the continuous content on the display that creates a different experience when viewed from different positions. Because there is no intrinsically defined front or centre of the display, different views offer different elements to see and interact with.

The most common way of crowding around the display is to stand in a semi-circle around one side of the display, with users orienting their bodies towards each other. Often, groups of up to four users will crowd around one side of the display rather than spreading out around the entire display. As mentioned above, the continuous content of the display means that users will only see shared content if they crowd around the display on one side. While some users did interact across from each other while gesturing and talking over the top of the display, the GlobalFestival application was more commonly used while crowding around one side of the display for a shared perspective.

Some users tapped the display as they went past without slowing down or continuing to interact. This may be a way for passers-by to "test" the display and check that it is touch-sensitive while minimising risk of social embarrassment. If a passer-by walks past the display without slowing to wait for a reaction, they minimise their risk of looking foolish if there is no reaction. However, if the display responds they can still choose to stop and interact.

Users often touch the display then immediately stand back from the display while watching the effects of their touch. The GlobalFestival application did not involve visuals or animations the expanded beyond a small viewing area, so stepping back from the display for a wider viewing angle would not give any obvious advantage. This action seems to be performed mostly for spectators as a way to com-

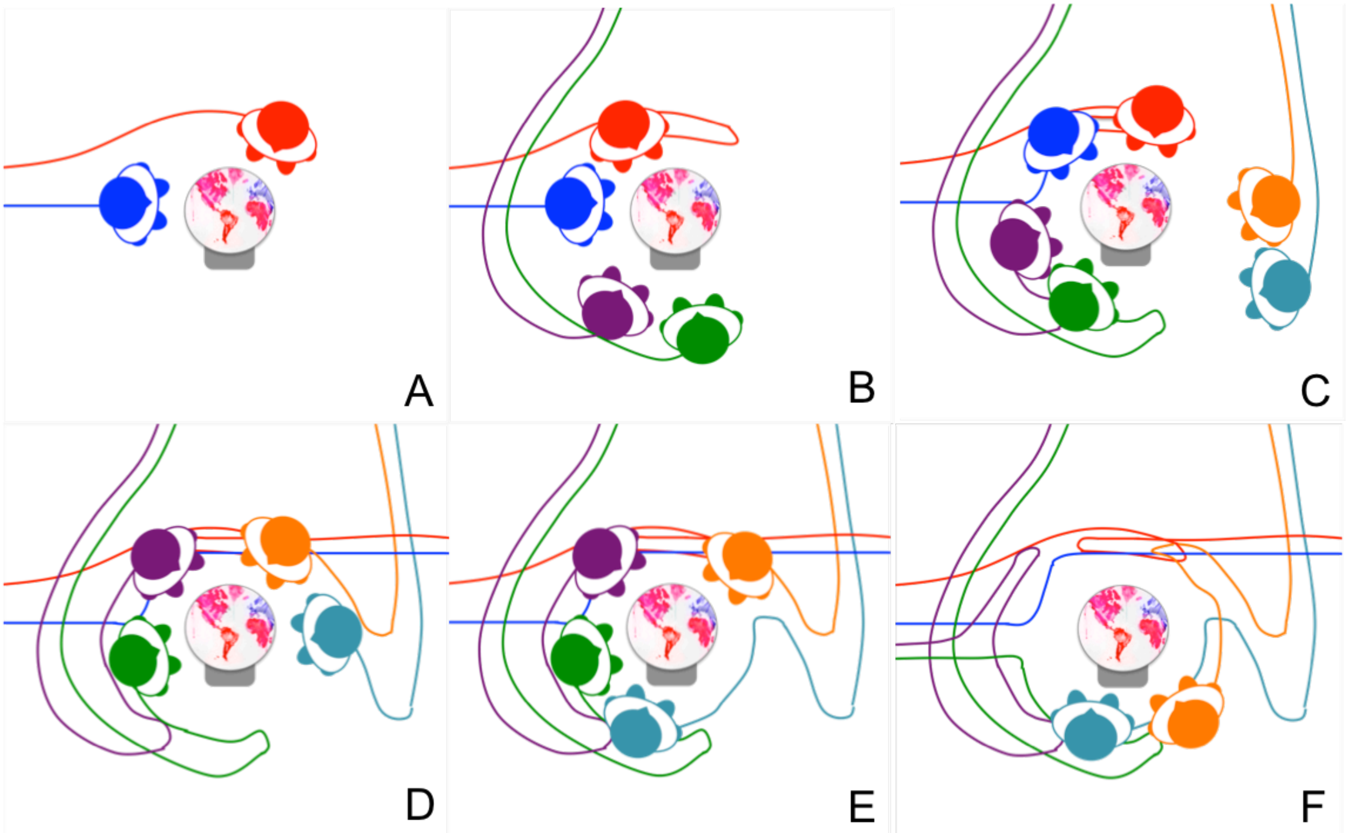

Figure 11. A detailed case study of a 1 minute segment of data demonstrates how groups interact at the display. Textual descriptions for each frame in this diagram are given in Figure 11.

municate that the user is still learning to use the display. Such an action may be another way of mitigating social inhibition by physically distancing one's self from the display should it not respond in the way expected.

Case Study: Typical Interaction at the Sphere

Detailed analysis of one interaction session provides an in-depth look at how groups used the spherical display during a 60 second segment of the video data. The clip was selected based on the qualitative analysis previously presented.

Figure 10 shows the progression of a typical interaction session captured during the deployment, with detailed textual descriptions given in Figure 11. In summary, this interaction session involved three groups of two users that approached the display at different points throughout the segment. These groups showcased some of the behaviours commonly observed around the display. For example, groups one and two crowded together into a semi-circle around one side of the display. The groups approached at different times and did not appear to know each other, yet they still crowded together into one group.

All three groups shuffled around the display at some point during their interaction. This occurred for the first time at 13 seconds into the segment in response to the arrival of additional users. The first two groups began by shuffling anti-clockwise, but then changed to shuffle clockwise around the display. Once the third group of users began interacting with the display, they once again shuffled together to form a semi-circle around one side of the display. When the second group left the display, the third group moved back together at one side of the display.

The third group began their approach to the display by standing back and spectating before interacting. This seemed to prompt the first group to leave, giving the third group an opportunity to interact at the display. Because spectating users were often visible to interacting users (as opposed to a flat display where spectators may be standing behind users) turn-taking on a spherical display can be informed by a wider range of social signals. Waiting users can stand directly in the line of sight of users, and can even take control by dragging content away from others.

DISCUSSION

The deployment space in the concert hall during an international music festival offered a busy and positive setting for this evaluation. The space had regular patterns of traffic, where large flows of pedestrians attending concerts arrive and leave at the same time. Additionally, during intermissions concert attendees spent time near the display as a captive audience while waiting for the concert to resume. Both of these characteristics of the deployment setting may have increased the attractiveness of the display. The large num-

Time (Seconds)	Frame	Action
0		First two users approach the display from the left side of the frame.
3	A	First two users stand at one side if the display an arm's distance apart.
11		Second group of two approach the display from the top of the frame.
13	B	The first two users at the display stand closer together and the group as a whole moves anti-clockwise around the display.
20		The four users occupy this space in front of the display in a tightly packed group while they shuffle in a clockwise direction
27	C	Third group of two more users approach the display from the top of the frame but stand just over an arm's length back from the display and do not interact.
28		As the third group begin pointing at something on the display, the first group of two users begins to walk away, exiting at the right side of the frame.
31	D	The third group begins interacting with the display and the four remaining users shuffle towards each other.
36	E	The third group of users move around the display so that they are facing each other while they interact with the display.
40		The second group of users leave the display, exiting at the left side of the frame.
43	F	The third group of users move to stand together at one side of the display
60		The third group of users leaves the display, exiting at the left side of the frame.

Figure 12. Detailed textual description of the case study frames in Figure 10. Time values are given seconds, with actions associated to a particular frame noted in the second column.

bers and willingness of passers-by at such festivals make these settings popular for in the wild deployments [10, 23]. Additionally, our partnership with the music festival allowed us to integrate the GlobalFestival application seamlessly into the venue.

The two manipulation techniques showcased in the GlobalFestival application led to different results and experiences. For Spin+Tilt, users interacted with a larger area of the display for a longer time. Some of these differences may be attributable to increased usability and perceived responsiveness between the two conditions. During the Spin+Tilt condition, a touch in any direction would move the display. However, during the Spin Only condition only touches moving horizontally would move the display. The difference between continuous feedback (Spin+Tilt) and feedback only when "correct" gestures are performed (Spin Only) may have made Spin+Tilt easier to understand and interact with. The shorter interaction times observed during the Spin Only condition can be explained by users that approached the display, touched it briefly, and quickly walked away. This could be due to believing the surface was not touch sensitive or not understanding how to control the display. Even though Spin Only was designed to mimic a physical globe, a metaphor that would be familiar to the majority of passers-by, this condition was arguably less successful than Spin+Tilt. Usability issues arising from ergonomics and perceived ease of use at different points on the display remain an area of future work for spherical displays.

The relationship between the visibility of manipulations and the resulting effects has a clear influence on spectator experience [20] and social acceptance [17]. A spherical display has different affordances for visibility than flat displays, leading to different ways of interacting in this social setting. Firstly, not all of the display is ever fully visible, creating private or shared experiences based on physical perspective. Additionally, the GlobalFestival application did not specifically aim to make effects exaggerated or especially visible.

However, spectators watching from any angle of the display would be able to see that the map content was continuous. This form factor allows for content to be correctly oriented for a large number of users, supporting multiple simultaneous interactions around the display and addresses some issues of "users' territory" on the display and builds on traditional collaboration skills [22]. However, there are some issues with respect to control that are not addressed. Continuous content on a spherical display is analogous to a multi-side card rack. When one user rotates the card rack, someone looking at a card on the other side may lose sight of what they are looking at. Because such card racks are common in everyday life, people in general understand the social etiquette of using one. These rules also seemed to govern how users interacted with this display, being aware that pulling content toward one's self would pull it away from others at the display. This may be the reason for the shuffling behaviour observed during interaction, where users preferred to walk around the display rather than pull content towards themselves. This shuffling behaviour allows users to see more content on the display without disrupting the view of others. Exploring the dynamic between movable/immovable content and users' physical trajectories around the display is an area with many possibilities for future work.

The GlobalFestival application was a relatively simple information display. For this deployment, we used a globe interface that innately fits on a spherical surface. Given the novelty of the hardware used for this deployment, it was difficult to predict users' behaviour based on their expectations of what a spherical display could do. Further exposure to this technology and greater familiarity with the display could change how passers-by experienced both conditions. Building on these experiences, we believe that there are many opportunities to exploit a spherical surface for more complex and exciting applications. Applications with abstract graphics, gaming mechanics, or visualisation of non-linear data may go further to exploit the capabilities of this display. Exploring more complex and engaging interfaces promises for exciting opportunities in future work.

CONCLUSION

This paper presents a novel evaluation of a spherical information display in a public setting. The GlobalFestival application was deployed at a concert venue during an international festival over a four-day period. During the deployment, we completed a comparative evaluation of the application, evaluating the difference between Spin Only and Spin+Tilt interaction technique on the sphere. The results demonstrate that users of the Spin+Tilt display not only interacted over a larger area of the screen, they also interacted longer. The results also demonstrate a method for quantifying the Honey Pot effect, showing that the average time between users quantifies the dramatic differences between when the screen is idle as compared to when others are already at the display. Finally, the results describe some of the qualities of spherical displays with respect to where users crowd and how they accommodate new users to the display.

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