Moving Shapes: A Multiplayer Game Based on Color Detection Running on Public Displays

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Abstract
Over the past few years the use of public displays has increased drastically, with the most common public displays being flat surface LED walls or projections on walls. Presently interactive public displays often make use of depth cameras. This paper introduces a cheaper variant that allows people to interact with the display and each other by using the color detection abilities of an ordinary webcam. As proof of concept a simple game was created that demonstrates how people are able to control and interact with photographed shapes via their own smartphones. Alternately a special hardware interface was built for users who do not own a smartphone. Contrary to ordinary games, this game works without points; instead, the leading user is awarded the ability to make decisions about game speed and is able to influence the audio through his movements.

Author Keywords
Public Displays; Interactive Installation; Game; Art; Mobile Devices; Camera Tracking; Physical Interface.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

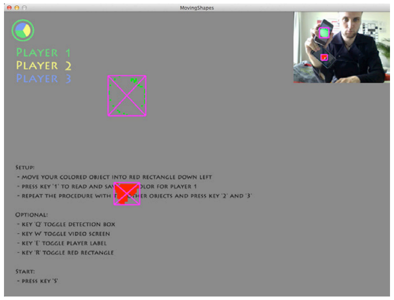

Figure 1. The Setup Screen allows different colors and shapes to be assigned to the players.

Introduction

It is no great secret that public displays have permeated our daily lives entirely. Interactive Public Displays are a special form of display, since they can deliver personalized information if the user is willing to interact with them. With regard to encouraging a user to interact with a foreign system a public screen is still a problem, as described by Brignull et al. [6].
This paper presents a different approach in which the user does not need to interact with a computer directly, but rather interacts with other people while the public display acts as a medium for the purpose of decreasing user inhibitions.

Related Work

Many different projects already deal with interactive public displays, so here we will give a basic overview as to how other researchers have chosen to manage user input. In most cases interactions can be accomplished with simple or multi touch on the display itself, as long as the display is not too far away, as described by Müller et al. [14]. Vogel et al. [17] additionally develops a touchless "reach gesture" to access information beyond other users by using infrared motion capturing of the hand and persons. When public displays are out of range and not physically reachable or when a touch is not wanted, the majority of projects have used a depth camera such as the "Microsoft Kinect" [1] as shown, for example, by Beyer et al. [4]. To interact at a certain distance mobile phones can be used to increase interactivity - e.g. by tagging NFC-tags to manipulate a public display as shown by Messna et al. [13]. A more precise interaction is introduced by Ballagas et al. [2] who show how to select objects using a point and shoot technique with phone camera tracking. Boring et al. [5] also uses the back camera of an iPhone for tracking various objects on a public display in order to drag them to different displays. This camera tracking is based on edge detection, which recognizes the white borders of displayed objects. Another technique is color-based detection; this is often used for face and skin detection – Vezhnevets et al. [16] – or even for locating people as Jabri et al. [9] show. The decision was made to also use mobile devices as a remote interaction tool. As already stated from Broll et al. [7] and Matthies [11] mobile devices have become an integral part of everyday life with the majority of people owning smartphones. To avoid high costs as well as complicated data processing and streaming, this project uses color detection via an ordinary webcam, which could be located, for example, underneath the public display. To make the users' devices identifiable the user takes a photo of a displayed object (that he will then control), which is detected and tracked while displayed on the screen of the mobile device.

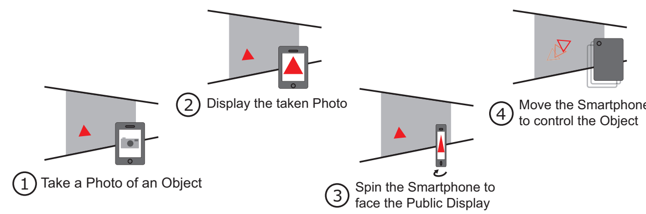

Figure 2. How to control a shape with a smartphone

The Game

Moving Shapes, understood as a Public Multiplayer Game, is an artistic approach to game design that attempts to reduce game play to its minimalist components while retaining basic game mechanics. Moving Shapes is an interactive screen-based

[1] MS Kinect: *http://www.microsoft.com/en-us/kinectforwindows/*

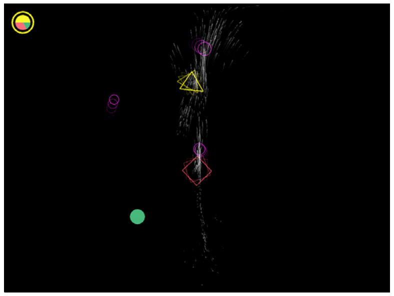

Figure 5. Game play: The scoreboard can be seen at top left, with the outer circle showing the leading Player. The green circle is inactive so it fills with color in order to be photographed by a smartphone, while users are manipulating the yellow triangle and red square.

installation in which multiple players can interact in a digital two-dimensional space on a public wall. In order to participate in the game, players photograph the object of their choice - one of three player avatars – and then move the avatar in the game space by moving the image on their smartphone within range of the game camera *(see figure 2)*. If the player does not have a smartphone *(see figure 3)*, he can alternately use a physical interface *(see figure 4)* to synchronically control the corresponding geometric shape on the screen. Self-moving, computer-generated circles can then be captured by the game avatars. The number of the objects that have been captured is shown by an arc diagram in the corner of the game space *(see figure 5).* The dominating player is able to influence the game speed and background music through his movements.

Smartphone as control input

In order to control an object, the user must capture its image with their smartphone camera. Once the picture is displayed on the smartphone screen and held in front of the game camera, it can be tracked via color and game play can begin.

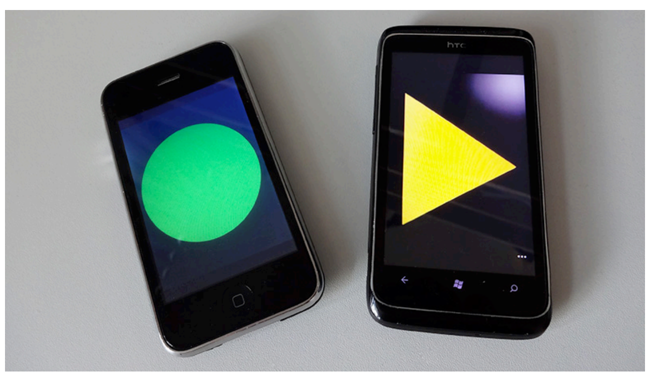

Figure 3. Captured Images of Game Avatars

Custom Physical User Interfaces as alternative input

Alternatively, the user can choose a physical interface, consisting of a geometric form (circle, triangle or rectangle) attached to a stick. The game pieces are made of Plexiglas integrated with colored cardstock and illuminated glow sticks. The glow sticks can be easily replaced by pushing the upper plate to the side.

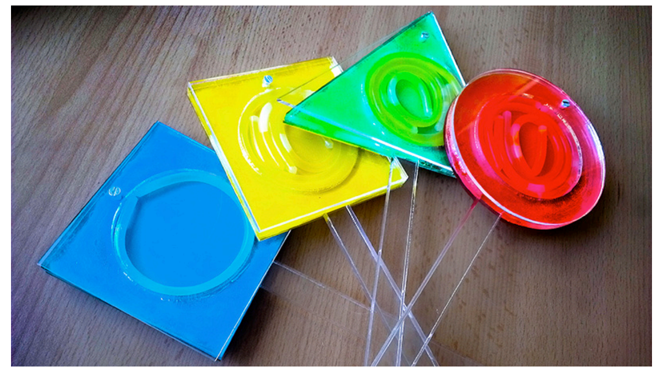

Figure 4. Physical User Interfaces: Laser-cut Plexiglas with glow sticks

Interaction & Game Mechanic

The user holds his smartphone displaying the photographed object, or the physical interface of his choice, parallel to the public display. The player's movements are translated synchronously to the movements of the projected image, i.e. a green triangle on the screen will move in the same direction as the green triangle on the player's smartphone. The actual physical movements of people are transferred into a digital, two-dimensional world. In this digital world, players capture quick-moving computer-generated objects (purple) flying through the game space by intercepting them with their chosen game avatar. A pie-diagram in the upper left-hand corner

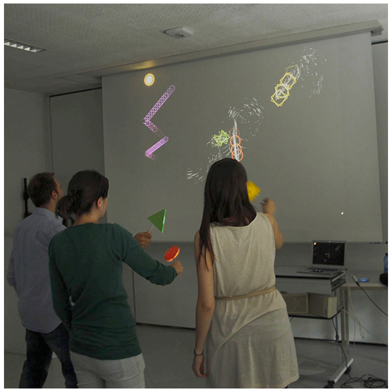

Figure 6. Three players interact concurrently while the participants fluently changed.

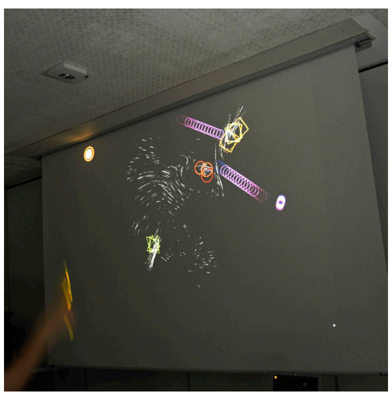

Figure 7. The 2D game field was projected onto a retractable screen in a busy corridor as a test environment.

provides players with an indication of their current standing. We consciously renounce the use of a classic point system, even if it encourages user engagement as recent findings show from Mekler et al. [12]. The dominating player is indicated by the color of the circle surrounding the pie-diagram.

Visual & Auditory Effects

The entire game consists only of geometric shapes: circles, triangles, and quadrilaterals. Optical effects provide all the necessary action. The game objects turn permanently on their own axes and pull a tail behind them for as long as they are controlled. Additionally, particles are emitted during movements for increased optical effect. If the game object is not actively being controlled it fills with color, ready to be photographed. For auditory effect the leading player is able to influence the frequency of the background music with his movements on the coordination system.

Implementation

The game was implemented through an Open Source Java-Framework: Processing by Ben Fry and Casey Reas [8]. This decision lightened the workload considerably as many libraries (e.g. video processing, sound, etc.) already existed. Interface tracking was accomplished using a laptop-integrated webcam with color tracking. In order to mimic the brightness of smartphone screens, glow sticks were integral to the physical interfaces to minimize tracking fails. A sample code for tracking by John Wang [18] was of significant help. By means of a Gaussian function, selected colors were smoothed and a threshold was defined. The mean Euclidean distance to the edges of the tracked object defines the center point of the object shown on the display. Stepping closer to the display does not have an effect on the avatars' positions, but only on the range the users have to move their arms. Further visual effect is provided by an advanced particle system by Memo Akten's MSA Fluid [1]. Along with this is a soundtrack developed by Holy Konni [10], which is influenceable through a frequency filter.

Informal User Evaluation

There are many ways of trying to evaluate user experience, as described by Vermeeren et al. [15], but there are still many questions left concerning games - Bernhaupt et al. [3].

The user study we conducted in an attempt to measure user experience followed a very different approach based on the idea of "brainstorm paradox/inverse" technique, which is a mix of a qualitative and quantitative evaluation. We could not find any other researchers doing such an inverse evaluation, but we believe that this way more realistic results could be gathered.

A one-session user study with 11 participants was conducted, where three users where able to play at the same time. The participants' ages were between 21 and 39, consisting of 5 males and 6 females.

The users were asked to give a statement (in the form of a single word) on how they experienced the game and its interaction. We collected 7 different statements – as in many user studies, they were only positive evaluations rather than critical ones. To figure out whether the users actually enjoyed the game or not, we inverted every statement and asked the users to anonymously (except for gender identification) rate the inverted statements on a 5-point scale, where 5 is rated the highest. So rating "boring" with 5 means that there is nothing more boring than this game. Afterward we collected all ratings and calculated the average.

Opposite evaluation	male (5)	female (6)
boring (exited)	1.8	1.33
realistic (crazy)	1	1
drab (colorful)	1.6	1.33
serious (funny)	1	1
discouraging (thrilling)	1.2	2
uninspired (creative)	2.8	2.5
unpleasant (enjoyable)	3	1.5

Table 1. shows the results of the inverse evaluation.

In this short study we found that our male subjects rated the game as significantly more boring than female subjects. Conversely, female subjects generally rated the game as more enjoyable. However to classify a gender specific effect, a greater user study would have to be conducted. Our observations also showed that even if the game had a higher grade of graphic abstraction (basic shapes instead of pictures of spaceships, aliens, etc.), the game mechanics would be instantly recognizable and self-explanatory to the user. The fast moving purple circles are intuitively identified as targets without giving the user any hints. When users were trying to catch the same target, the users' arms sometimes bumped against each other. Users would then immediately apologize to one another during the game, which often led to further discussion about their experience afterwards. Some users did not try intensively to be the leading player; instead they seemed to enjoy just controlling their object and creating visual effects by the particle system.

Conclusion

Camera tracking is not a new concept and remains an active research field of computer graphics. For example, it is also used for tracking construction errors in the production of microchips and circuit boards. In this project it is used for a very different field of application. With it we solved the question of how to provide the user with a unique identification that could be tracked on a 2D axis. By taking a photo of a colored shape with a smartphone and tracking it with an ordinary webcam, our requirements were met efficiently and cheaply. Low- to mid-resolution cameras work poorly at distances over 5 meters, thus the ideal game-play distance is within this field of distance. Color irritations, such as when players wear a color similar to that of the game avatars do exist, but only when the color is very bright and the environment is well illuminated. Thus color tracking with normal webcams is problematic at high brightness levels and requires a darkened environment. Even if depth cameras are more reliable, we cannot say which type of tracking is more efficient for simple 2D tracking. As a recommendation for future research, a study on the accuracy and error rate of color tracking in multiple environmental brightness levels would be beneficial. We find that this type of interaction - taking a photo of an object on a wall and being able to manipulate it in the real world on a public display - is an interesting approach to game play. The mechanics of our game also deviate from standard concepts: we refrain from awarding players points, but rather allow the dominating user the power to influence game constrains such as speed as well as audio. We hope to inspire other researchers and developers to also use simple, cheap and effective technology to activate a sense of play in their users. Furthermore we introduced an inverse evaluation technique to gain more realistic qualitative feedback, which could also be very beneficial for evaluating user experience.

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