TagURIt: A Proximity-based Game of Tag Using Lumalive e-Textile Displays

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CHI 2011, May 7–12, 2011, Vancouver, BC, Canada.
ACM 978-1-4503-0268-5/11/05.

Abstract
We present an electronic game of tag that uses proximity sensing and Lumalive displays on garments. In our game of tag, each player physically represents a location-tagged Universal Resource Indicator (URI). The URIs, one chaser and two target players, wear touch-sensitive Lumalive display shirts. The goal of the game is for the chaser to capture a token displayed on one of the Lumalive shirts, by pressing a touch sensor located on the shirt. When the chaser is in close proximity to the token player, the token jumps to the shirt of the second closest player, making this children's game more challenging for adult players. Our system demonstrates the use of interactive e-textile displays to remove the technological barrier between contact and proximity in the real world, and the seamless representation of gaming information from the virtual world in that real world.

Keywords
E-textiles, Wearable Computing, Philips Lumalive.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Design, Human Factors.

Introduction

E-textiles potentially provide a great medium for social interactions in a public setting. Wearable computing provides a platform for conveying emotions, exchanging information, displaying information, and for role-playing games. With this in mind, we developed a game of tag to demonstrate the use of wearable computing for displaying and exchanging information in a social environment. In this paper, we present TagURIt, a dynamical game of tag in which players physically represent a Universal Resource Indicator (URI) tagged with real-time location information (see Figure 1). Each player in this game wears a high resolution Lumalive textile display embedded in a shirt. The display is powered by a small wearable Bluetooth Arduino computer that has a number of sensors allowing the TagURIt system to track how close the player is to a chaser (the person who is "it"), as well as when the player is touched by the chaser. At the beginning of the game, one player is randomly chosen as the chaser by the system, while the others are designated targets. As the TagURIt system keeps track of the relative distances between chaser and the target URIs, it displays a tag token on the Lumalive display of the target that is second closest to the chaser. When the chaser comes closest to this target player, the token jumps to the Lumalive display on the shirt of the now second closest player, making this a much more challenging game for the chaser. Tag tokens have different points associated with them, which vary through time. TagURIt thus augments the traditional game of tag with new strategies that more realistically represent a manhunt scenario, making for a more interesting game for adults to play in social settings.

Figure 1. Participants playing the TagURIt game.

Social Gaming

People enjoy playing multi-user games because it is a social activity that is shared by a group of individuals. Engaging in a social game is an exciting opportunity to get to know other people because it is free from the usual cognitive barriers that prevent us both from approaching people and from unveiling ourselves in a non-game environment [10].

While the introduction of online social gaming has allowed users to play against one another without being limited by their geographical location, natural interactions such as behavioral engagement, proximity and touch are not preserved over networks. In recent years, physical proximity-based games have emerged that make use of some correlate between player location in the real world, as tracked by a cellular phone, and the virtual game world [2,4,5,6,7,14]. E.g., Falk [5] studies playful misconduct in social games, by allowing cellular phone owners to tag surrounding owners. In Pirates! [7], users use PDAs to explore their physical environment to fulfill their missions and interact with other players. Pirates! uses proximity sensing and a projection of the game world onto the physical world to conserve the social interaction. Another approach to social gaming is using a more immersive environment where people interact only in a 3D virtual world, e.g., in the MIND-WARPING gaming system [16]. However, none of these games incorporate displays directly integrated into the world of the players, making the virtual game play disjoint from the physical game play, be it on a mobile phone or on semi-immersive screens.

Human Pacman [3] was one of the first games to allow for physical contact in the real world to represent virtual contact in the game world. It also directly integrated display into the users' environment. In this game, humans physically role-played the characters of the Pacman and Ghosts. During game play, the Pacman player devoured the virtual target by tapping on the physical target's shoulder. Also, to obtain a virtual "magic" cookie, the Pacman player had to physically pick up a treasure box with an embedded Bluetooth device. To allow the real and virtual worlds to fuse, however, the Human Pacman system required an augmented reality goggle to be worn by the chaser. We were interested in exploring how we could remove the technological barrier between contact and proximity in the real world, and the seamless representation of gaming information from the virtual world in that real world, through the use of e-textile displays.

Fabric Computing and E-Textile Displays

In the mid 90s, researchers began to investigate the augmentation of garments with electronics. Zimmerman [15] developed a wireless communications system, PAN (Personal Area Networks), which allowed for electronic devices located on or near the human body to exchange digital information through near-field electrostatic coupling. Orth et al. [9] stated that fabric is soft to touch, strong, and flexible – allowing for the creation of computing devices that are both malleable and durable. Berzowska [1] developed a display material called Electric Plaid that allowed for a more high-resolution and flexible fabric display. It used conductive yarns that when heated, changed the color of thermo-chromic ink sewn onto the fabric. While this process is slow, it did allow for preset high-resolution patterns to appear and be altered dynamically on a garment.

More recently, Philips developed the Lumalive display [12] as a 14 x 14 pixel matrix of multicolored light emitting diodes (LEDs) that are woven into a flexible fabric with padding resembling a lightweight white pillow. Lumalive displays are designed to be worn under a shirt. When worn, the display emits light through the shirt's surface, providing one of the first flexible electronic displays for garments that are of sufficient quality to show images, logos, text, and animations. The Philips Lumalive display is designed primarily for use in advertising. As such, the Lumalive display is not interactive – that is, the display is typically worn by models to display promotional material. The most current implementation of the Lumalive (Lumalive Event Gear MC) features a small battery-powered control unit that is worn in the belt of the t-shirt. Images are pre-loaded onto the control unit using Lumalive software. By wearing an additional belt with a wireless receiver, the playlists on the control unit can be controlled using a remote control.

Figure. 2(a). The *goomba* token, which is worth 10 bonus points.

Figure. 2(b). The *boo* token, which is worth 20 bonus points.

Although considerable work has been done in the area of wearable computing, currently there are no interactive garments available that allow for a display of sufficient resolution to display symbolic or graphic information at any level of realism within a game. Additionally, current high-resolution electronic garments are unable to detect and respond to its proximity to another electronic garment.

TagURIt: A Proximity Based Tag Game with Lumalive Displays

In order to address both the issue of merging virtual and physical game worlds, and developing more interactivity into wearable e-textile displays, we developed an electronic version the game of Tag. Tag is chasing other players in an attempt to tag or touch them (usually with their hands).

In our modified version of the game of tag, a chaser (the player who is "it"), is required to obtain a token from one of the two individuals (players) who are wearing interactive and proximity sensing Lumalive shirts (see Figure 1). In order to obtain one of the tokens (see Figure 2 for an example of a token), the chaser needs to press on one of the touch sensors on his/her shirt. The token can jump back and forth between the two players based on the proximity of the player to the chaser – that is, when the chaser gets closest to the target player (who has the token displayed on his/her shirt), this token will jump to a player who is the next furthest away from the chaser.

The game ends when the chaser touches one of the touch sensors on the player with the token. Two different Super Mario Brothers themed tokens can be captured: a goomba and a boo (see Figure 2). We programmed the boo to appear less frequently than the goomba on the Lumalive display of a target. Obtaining the boo results in 20 bonus points for the chaser, 10 for the target while obtaining the goomba results in 10 bonus points for the chaser, and 20 for the target.

Additionally, as an incentive for the target players to try to hold onto their token longer (that is, to prevent it from jumping to the other player in the game), the longer the target player holds onto the token, the more points he/she accumulates for him/herself. The target's score is incremented by 1 point for each second he/she has possession of the token. The inverse happens for the chaser: he/she starts out with 150 points, with one point subtracted for every two seconds. While targets can theoretically collect 300 points in a 5 minute game, the token is likely to distribute these points evenly between two targets, putting each at an average of 150 points after 5 minutes.

Depending on which touch sensor is pressed to obtain the token, the chaser may receive a bonus multiplier to allow him/her to achieve a 300 point score as well. If the chaser presses on one of the shoulder touch sensors to capture the token, the chaser receives no bonus. Since the lower arm touch sensor is harder to reach (as the players can protect that area), pressing on an arm touch sensor allows the chaser to receive a 2x multiplication of his/her points. Each game lasts for 5 minutes, or until the chaser captures a token, whichever comes first.

Touch Sensing

In our implementation of an interactive Lumalive shirt, we used conductive fabric (pure copper polyester

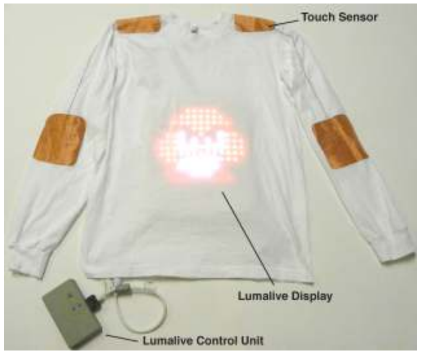

Figure. 3. Interactive Lumalive shirt with touch sensors: front (top) and back (bottom).

taffeta) patches to create touch sensors (see Figure 3). The patches of conductive material were connected together using conductive thread. The conductive thread is wired to a Phidget capacitive touch sensor [11] and connected to a Bluetooth Arduino through i*CATch [8], which is a bus-based wearable computing framework (see Figure 4). When the chaser touches the conductive fabric patches, this prompts the Bluetooth Arduino to send a signal to a control for the Lumalive display that updates the display with a final score.

Location Tracking

The shirts keep track of position through either a local or global positioning system (LPS or GPS). Our LPS system allows users to maintain relative location within a building or room. When a room is augmented with an in-ceiling computer vision system, the URI of each player is embedded in the shirt as a reacTIVision fiducial marker [13], allowing the system to read where each player is relative to each other through an overhead camera. We have also developed a radio frequency (RF) received signal strength (RSSI) based solution that allows tracking of relative distances between players. In outdoors location, the system relies on mobile GPS to track the location of URIs, augmented with RF positioning to enhance spatial accuracy of the game.

Conclusions

In this paper, we presented an implementation of an interactive Lumalive shirt that allows for proximity sensing. This technology was demonstrated using a modified game of tag in which the goal of the game is for the person who is "it" (the chaser) to capture a token. The token is obtained by pressing on a touch sensor of the player who has the token displayed on

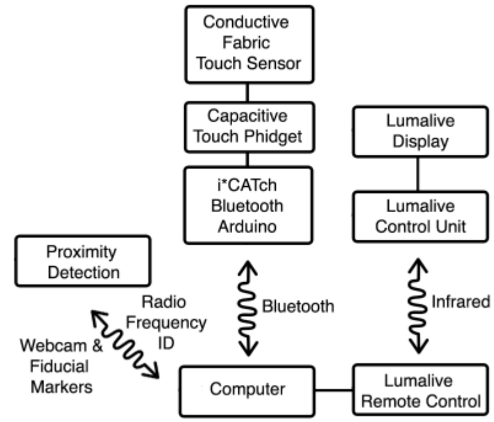

Figure 4. System Architecture of the TagURIt system.

his/her shirt. Our proximity-based game of tag with Lumalive displays is social activity that is built on mobility, physical actions, and the real world as a playground. While this game only lists one chaser and two additional players, the game can be expanded to include more chasers and players for a more immersive and engaging experience. We believe that our game of tag is a novel experience in the new hybrid field of physical, social, mobile gaming, and e-textiles that is built on ubiquitous computing and networking technology.

Acknowledgements

We thank Andreas Hollatz for his advice and work on the touch sensor hardware. This work was funded by the Ontario Research Fund and by an NSERC Strategic Project Grant. We thank Autodesk Research and *fuseproject* for their support.

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