The Viscous Display: A Transient Adaptive Interface for Collective Play in Public Space

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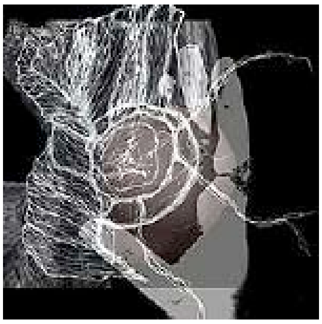

Figure 1: Conceptual Drawing

Figure 2: Viscous Display Prototype

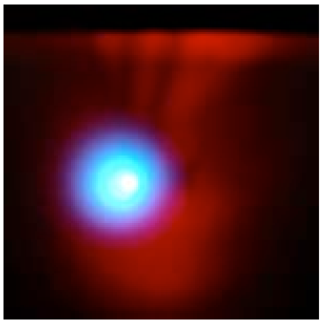

Figure 3: Display Graphic

Abstract

The Viscous Display explores the exchange of social information through transient public interfaces. Shaped by principles of 'underground public art', the Viscous Display is conceived as a novel mobile communication medium, where messages can be shared in public spaces. Inspired by biological learning systems; the Viscous Display learns sensorial information that form along traces of a participant's touch and maps this information onto a flexible display. Because it is made up of inexpensive materials, the Viscous Display is also a disposable artifact that may be collected in public spaces. It combines multi-modal sensing, learning algorithms, and a pliable silicone display.

Keywords: Interpersonal communication, tangible user interface, transient, mobile device, wireless, real-time graphics, learning algorithm, social networks, 'underground public art'.

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1 Introduction: Social Histories

In *The Production of Space,* Henri Lefebvre describes space as a social phenomenon where history accounts for the "interrelationships of spaces and their links with social practice"[8]. He argues that the production of space is grounded in inherent conditions, where traces of social existence are forever creating our histories and our perception of space.

Traditional conceptions of 'public space' have often suggested open spaces that are structured around central nodes, monuments and events. As our physical environments become increasingly permeated with sensorially provocative forms of technology, our perception of location and presence within space becomes coupled with momentary attachments. Can 'public space' include less structured, communication spaces? Can public spaces have transient meanings?

This paper proposes an investigation into the development of the Viscous Display; a mobile geolocational communication tool embedded with simplistic intelligence. The Viscous Display explores the exchange of social information through transient adaptive public interfaces. Shaped by principles of so-called 'underground public art', the Viscous Display is conceived as a novel communication medium, where symbolic graphic messages can be shared in public spaces. Similar to stickers that are left in public spaces and pheromones that are left by ants in colonies, the Viscous Display is designed as a mobile artifact that is meant to enable participants to pick them up and place them in various locations. The significance of the Viscous Display's mobility is that it promotes greater personal expression and authorship in the public realm. As a consequence, digital information/artifacts can also be left around public spaces via the Viscous Display for people to stumble upon.

Current location-based systems do not provide an approach that accounts for social behavior and how interactions are collectively experienced. The Viscous Display promotes a location-based activity where several interactive public displays relay symbolic color information depending on the interacting participants' actions/reactions. The Display system also acts as a reactive storage device that can both react to other Displays (in the form of simplistic color information) and can download symbolic color information to be retrieved with a mobile/GPS system.

What sort of activity is generated when information can find you on the street? What are the issues of 'public space' and 'privacy' that emerge from this? How might they impact our behaviors in public space and affect our sense of location, identity, and community?

We are especially interested in the collaborative aspects of this experience; in finding how this collaborative experience, where each individual's actions/reactions contributes to the whole, generates activity and empathy between familiar and unfamiliar participants. This paper will present an example scenario, describe our experience in one experimental demonstration using the Viscous Display system, and include an analysis of the design of the mobile device and its expressive graphic qualities. This work contributes to a vision for changing spatial metaphors in public space. It is important in that it presents a novel mode for dynamic expression and collective communication.

2 Related Work

This system is not the first to explore ideas of group interaction with mobile devices. There is a recent history of ad hoc activities forming around mobile communications, and an even longer history of improvised activities forming around public spaces. Within this historical context, we hope to contribute to the provocative dialogue that is part of a burgeoning area of study of mobile communication in urban environments.

Several significant antecedents to these locational activities exist in works at the MIT Media Laboratory, Media Lab Europe, PLAY Research Studio, and Proboscis. Works such as *M-Views* and *Texting Glances*, create authoring tools that use visual metaphors to generate a narrative activity in spaces. Instead of competing with opponents as in the Botfighters or other hunting games, *Texting Glances* enables the participant to use her/his mobile hand-held to author and collect visual and textual stories onto a fixed screen in a public space [15]. Similarly, *M-Views* enables participants to create, edit and share videographed stories along a physical path [3]. Rozier's [12] *An Augmented Reality System of Linked Audio* places audio into a space using GPS (global position system). This project uses a centralized database of information, where the distributed tangible interface components act as a 'digital pointer' metaphor and objects point to centralized digital data rather than actually storing the data. Centralization simplifies the implementation of these schemes, but it is important to note that there are significant social and artistic ramifications in distribution of information in centralized systems. Proboscis' *Urban Tapestries Project* engages the virtual realm by allowing users to annotate their own virtual city and proposes to enable wireless access to 'threads' that link locational information with social threads [11]. And Finally, *Sonic City*, a project by the PLAY Research Studio, "enables people to create music by walking through a city" [10]. *Sonic City* translates the participant's sensor information into MIDI signals that are mapped onto a laptop.

While the Viscous Display is informed by and carry's some of the traits of its antecedents, in that it: 1). Attempts to enable authorship in public space, 2). Translates sensor information into a symbolic (although visual) form, 3). Links social information within a locational space. Yet the Viscous Display also contains several nuances in that it proposes to create a reactive environment with collective activities. Because the Viscous Display is meant to be left in public space, it enables people to leave digital traces in the public landscape that may, in turn, locate other participant's as they pass by. The *Viscous Display* aims to create landscapes that are charged with the traces and stories of others that have inhabited the same space.

3 Background: Collective Activity

The coupling of symbolic signals with group activity has precedence in the ethology of collective intelligence through a broad spectrum of species that spans from the behavior of ant organisms to that of humans.

In 1810, in his book about ant behavior, naturalist Pierre Huber argues that the social behavior of ants resembles the social play of other species of animals and that if we could see them as creatures rather than as machines, we might attribute emotional behavior these organisms [1]. Charles Darwin, in 1870, went on to compare these seemingly abstract organisms with that of man and made significant connections between social behaviors and collective activity. In 1911, William Wheeler further examined insect colonies and defined the ability of the hive to accomplish tasks that no individual ant or bee is intelligent enough to do on its own as "emergent properties" of a "superorganism" [12].

In *Emergence* (2001*)*, media and cultural critic Steven Johnson composes an analysis comparing organisms of ants with that of cities that continues where naturalists such as Pierre Huber, Charles Darwin and entomologists such as William Wheeler left off. Johnson describes how an ant organisms' ability for pattern detection allows metainformation to circulate through the colony mind; he argues that while "compared to human languages, ant communication can seem crude, typically possessing only ten or twenty signs, ants don't need an extensive vocabulary and are incapable of syntactical formulations, [instead] they rely heavily on patterns in the semiochemicals they detect" [7]. Johnson compares this interaction between a 'superorganism' of ants with that of strangers in urban public space where "neighborhoods of individuals solve problems without any of those individuals realizing it"[6].

Figure 4: As the Viscous Display captures a more stable sensor data mapping, the color display becomes more stable and coherent

4 Implementation: Environmental Traces

When used in public spaces, the Viscous Display can become a tactile transmitter of social histories: a publicly retrievable dialogue, engaging users across an informational space to relay and retrieve symbolic messages of another's experience.

We have developed Viscous Displays that are embedded with learning algorithms which learn sensing information forming along the traces of a participant's touch. Abstracted visual and sensing information are taken from her/his environment and mapped onto this flexible, viscous display. The malleable, sticky quality of the Viscous Display enables participants to attach it to many objects in the environment.

As the user samples biometric information with an attached sensor ball, the Viscous Display's dynamically responsive, fabric-like interface unfolds visually represented messages. After an initial training process, stable signals develop from unpredictable environments due to the adaptive and temporal behavior of the computational system. The evolving characteristic of these embedded learning algorithms enables the transmission of complex environmental messages to this fairly simple computational device.

5 Physical Design

The LED based display is made of a copper mesh and flexible silicone encasement to enable sensing, folding, and manipulation of this malleable display. Small surface mount LEDs are woven into a copper mesh to create a full-colored diffuse display. Sensorial information is captured by heart rate sensors and FSRs (Force Sensor Resistors) that are placed inside a silicone spherical object, and woven via flexible wires to the center of one side of the display.

6 Computational Design

The training procedure is facilitated by an atomic gesture analysis algorithm, based on a neural gas model [4] that measures collective sensing information that is sampled from the participant. The algorithmic processes perpetually receive sensing data, learn biometric paths, and adapt to the sensorial information offered by the user. We assert that, in designing such a device, the principles of adaptive systems are central to the problem: we seek devices that change, devices that remember (change back), and devices that couple timescales (interaction, recall and termination).

This algorithm is based upon a robust associative learning algorithm, the neural gas model, modified to be more appropriate for learning and responding to time series input. It can learn distributions and mappings with little prior knowledge of the content of an input (heart rate, pressure) space.

Due to significant social and artistic ramifications, we have chosen to design a system that communicates along a distributed network rather than one that uses a centralized database of information.

7 Example Scenario

In an example scenario, a pedestrian might notice a Viscous Display attached to a public bench. This person knows about the Viscous Display because her friends mentioned playing with one of them. She walks over to the Viscous Display, touches and slightly shifts the attached ball. Colors on the low-resolution display begin to change. Because her heart rate was fast and she was pressing the sensor ball firmly, the colors become more blue and yellow and they move in a diagonal pattern. Her sensorial/color trace affects several nearby Viscous Displays; their colors become slightly more green and more vibrant as a result of this greater change in one Viscous Display.

Another person is walking in the area and his PDA 's alarm sounds because it contains program that searches for the Viscous Display's tag. He downloads the Viscous Display's color information and, in case it has been moved and doesn't have a correct locational awareness, he also uploads

GPS locational information to the Display. The color and pattern information give a simplistic indication of the mood of people who have been walking through this area, how they have interacted with the Display (shapes of patterns), and how recently the interactions occurred (through intensity of color). He notices that the colors and patterns are quickly changing from green to red and purple. This means that several people are interacting with the *Display* and have very different sensor information (e.g.: green/fast diagonals = fast pulse rate and purple/circles= slow shaking). He decides not to touch the *Viscous Display*s sensor ball.

Now that the Display has an awareness of its location it can relay its locational information in addition to its color information for anyone who is searching for the *Viscous Display*.

8 Evaluation

For our first experimental performance, we sought to evaluate the success or failure of the Viscous Display by focusing on the qualities of the physical design and the interaction design. A goal in this initial evaluation process was to gain an understanding of the patterns of use and play within particular contexts to further inform the design of the *Viscous Display*. Based upon our observations of patterns of use and play, we will investigate possibilities for future designs of location-based systems that can support emerging applications and modes for personal expression.

Our initial implementation included two participants working together and one display that was attached to an urban park bench. It is important to note that both participants were informed of the study before they interacted with the display. The first participant interacted with the display by first detaching it from the bench and then attempting to manipulate it. As soon as the participant grabbed the sensor ball, the display lit up and began to rapidly change color. The second participant became involved by also grabbing the sensor ball and trying to move it in the same direction as the shifting graphic. The display began to rapidly shift through several low resolution colors until the Display could capture a steady set of heart pulses and then it shifted between reds, blues and purples to finally become more stable on a red display with a blue circular pattern. Afterwards, we asked the participants about their experience with the Viscous Display with a short questionnaire.

In our initial implementation with these two participants, we found that the physical and computational design (using adaptive algorithms) enabled some exploration and storage of information in the Viscous Display. While there are long-term benefits that this embedded learning has over statically defined mappings, we also found that embedded learning also provides a number of user interface problems that need to be addressed for greater robustness within the computational system. These problems have provided specific constraints towards the design of our system.

The first problem involved a gap in the timing between the sensor data and the time it took the first participant to train the device. To manage these constraints, we will design learning algorithms that can have their learning rates modulated by an external source. By tying an estimation of current sensor data to the rate at which our device learns, we can build a system that adapts to the repeated sensor information that are characteristic of training, but responds with little adaptation to the occasional interaction designed to recall what was previously there.

The second problem was of participants being unsure if they had succeeded in actually embedding information into the device. While the graphical resolution became more uniform as the sensor data became more stable, one of the participants was not aware of this interaction. We are addressing this problem by using a learning algorithm that can provide feedback as to how well stabilized a recall is. Specifically, we will display on the device an environment around the recalled sensor/color information. If this environment is smooth and uniform, then a user can know that the input process has been successful; however, if this display consists of a number of different colors that change incoherently, then the user can tell that their training of the device must continue. The training should typically take less than one minute.

The final problem that the participants faced was in finding stored information. We propose a solution based again on the coherence of the color display. By using graphical coherence as a feedback device, users can "go in search" of stored sensor patterns using the stability and the coherence of the color response to guide their search.

9 Conclusion

We plan to continue this work with a forthcoming qualitative analysis by documenting 30 user interactions with video recordings (for later review) to understand how people interact with the Viscous Display system in a semi-public space, to determine how successfully multiple systems act together, and to identify what sorts of activities emerge. We will generate two scenarios to cover a wider range of situations. Within these scenarios, we will specify how the users interact within the specific context to provide examples of use and to contribute to the testing of the overall design. These scenarios will serve as a 'walkthrough' of the system, where the various emergent interactions between the user and the system and with other people will become more defined with user testing. For the walkthroughs, it will be significant to understand the intended users beforehand why they may use the system. It will also be important to know the users' experience with computational devices.

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