Building with a Memory: Responsive Color Interventions

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ABSTRACT
Building with a Memory is a subtle responsive intervention that aims to provide cohesion and community awareness through the use of light and color. The installation delivers thought-provoking information by capturing, analyzing and rendering real-time and archived human activity in a workplace setting. The installation senses movement in the space through an IR camera and computer vision techniques. Two custom lighting fixtures and a video monitor render the aggregated movements. The visually simple aesthetic of the piece aims to balance active engagement and passive contribution, providing a rewarding experience for both occasional passersby and regular users of the space. This paper describes the motivations and contributions of the installation, together with insights gained from an informal evaluation and directions for future explorations.

Categories and Subject Descriptors
J.5 [**Computer Applications**]: Arts and Humanities – *fine arts.*

General Terms
Design, Human Factors.

Keywords
Memory, motion tracking, color feedback, ambient presence, distance communication.

1. INTRODUCTION
Building with a Memory proposes an interactive installation that represents activity history within a semi-public space through light and color visualization. We present a reflective artistic and architectural intervention for enhancing community awareness in a distributed workplace. Physically distant workspaces present recognized challenges in many organizations in terms of cohesion, knowledge transfer and community spirit [1]. Our response attempts to provide an aesthetic workplace intervention that provokes contemplation of group action. This reflective installation encourages consideration of aggregated activity over time using visually simple light and abstract visualizations designed to be mindful of individual privacy concerns.

Collaborating across distances, communicating effectively or locating resources are common organizational problems that have been tackled by diverse disciplines including designers, engineers, artists and computer scientists. Prior work in multimedia applications addresses the needs of geographically separated enterprises by providing novel computational communication techniques [3],[8]. Artists and designers have attempted to address similar issues through the development of mediated architectural spaces and installations that deal with institutional memory and communication across space [4],[7]. Our approach brings together both communications technology and design aesthetics to promote community cohesion through activity awareness. While prior work [2],[5] uses a similar interactive approach, we attempt to do so in a non-invasive, ambient fashion.

MM'10, October 25–29, 2010, Firenze, Italy.

Figure 1: A panoramic photograph of the primary *Building with a Memory* installation.

Building with a Memory, an installation in two parts, both provides a unique aesthetic visual experience and conveys patterns of social activity between separate physical locations. The installation uses computer vision algorithms to sense the level of activity within a defined public space and presents light and video feedback in response. People in the space observe their own movements in the form of variations in the hue and saturation of two physical "pixels", and an abstracted visual representation. Figure 1 depicts one physical installation of the piece situated in the lobby of a research organization. Networked variants of the installation depict activity both over time and across space by mirroring portions of the feedback between locations.

Conceptually, *Building with a Memory* seeks to reframe the mundane patterns of everyday activity as interactive art practice, where people's movements draw and redraw their presence emphasizing community activity. We aim to situate our work elegantly between the functionally informative and the visually engaging, where contemplation of organizational action and interaction can help provoke commentary, insight and cohesion.

2. PRIOR WORK
We draw on different related areas of inquiry to motivate and inform our approach. The problem of communicating over distances has been tackled by several relevant interactive media art works. Specifically within the context of the workplace, research on the representation and perception of ambient organizational presence and activity has produced novel interfaces

and installations generated by both academic and commercial interests. From a conceptual standpoint, the role of light and color in conveying meaning about human activity reveals a long historical record of traditional, digital and interactive artistic explorations that serve to both situate and direct our work.

2.1 Communication over Distance

Communicating between geographically separated related entities has been addressed by *Reflexion* [3], a teleconferencing tool developed to connect partner research labs in different continents. This installation, while supporting direct synchronous communication, does not reveal any sense of prior or continuous use between participants and presents several problems in terms of privacy and workplace interruptions. More informal communication between individuals or groups has been examined by *Remote Impact* [9] and *Mutsugoto* [4]. *Remote Impact* uses a large, soft pressure-sensitive screen as an interface for a boxing game while *Mutsugoto* supports long distance relationships by allowing distant couples to communicate through touch and light. These two projects present playful and aesthetically appealing interactions across distance. Our work seeks to build on these examples, combining rich visual and aesthetic feedback for exploring history of connected spaces.

2.2 Ambient Presence in the Workspace

Several installations experiment with the use of ambient presence in the workspace, integrating information about activity in digital realms into the physical world. This activity may be explicit, as in the progress displays of the *Panic Studios Status Board* [10], or implicit, as in *Pinwheel* [5], a system that renders network traffic as the rotating speed of a physical pinwheel. Other relevant research involves semi-public workspace displays that present abstract graphics meaningful only to insiders [11] or allow large-scale, shared interaction with virtual collections [9]. These projects exist within a distribution from pragmatically functional to deliberately abstract. We position our work towards the middle of this curve, whereby we seek to render real-time and collated activity data in a generally understandable, visually clean representation.

2.3 Color, light and motion

Our approach is influenced by the works of color field artists such as Mark Rothko, Hans Hofmann, Morris Louis, and Barnett Newman. These artists used visually simple formats, generally eliminating recognizable imagery in favor of abstraction and psychological use of color. Within the realm of lightworks, seminal pieces by James Turrell and Olafur Ericsson inspired us to more deeply conceive of light and space as powerfully expressive media. These two artists set the mood and enhance the emotional and visual impact of their work through mindful and provocative use of color.

In terms of digital or interactive approaches, we reference artists such as Camille Utterback, whose *Aurora Organ* and *Abundance* pieces render the history of a space in the form of an interactive experience. *Aurora Organ* engages movie theater patrons by depicting a history of interactions as sculptural bands of colored light. In *Abundance*, Utterback provides more literal traces of history, displaying the motion of groups and individuals through a public square as an animated projection on a public facade. In a related vein, *Motion Traces*, a project by Golan Levin [7], maps real-time movement through a public lobby space onto multicolor lighting and wall projections. Our piece aims to develop a color and visual language that is cognizant of this rich, diverse and highly influential art practice.

3. METHODS

The *Building with a Memory* project expands upon prior work of the authors, in which commercial colored light fixtures were used to alter the character of a space in response to the level of human activity. These preliminary explorations grew into our continuously evolving collaborative project. Currently, our efforts focus on the goals of analyzing and representing the history of human motion in a space and connecting multiple geographically distant environments. We began by constraining the work to pure light and color representations, working with the idea of architectural objects rather than light fixtures. From there, we considered how best to represent the mood and history of a space through the manipulation of light and color, attempting to capture a more nuanced representation of activity over time rather than simply a direct mapping of current activity to "mood." The idea of communication across distance entered the piece as we considered how to allow the installation to convey information about activity in multiple locations, both within a building and between different buildings. While the first instantiation of the *Building with a Memory* project existed in only one location, we have designed the project to support communication between distributed workspaces in the future. In order to accommodate the regular functions of the initial target location (a lobby reception in a research institution), the installation was designed to serve as an accent, rather than an overwhelming transformation of the space.

In the following subsections, we describe the major components of the *Building with a Memory* installation: the interactive lighting feedback and the video display feedback.

3.1 Building with a Memory Installation

The *Building with a Memory* project comprises sensing, analysis and feedback components. The installation includes two wall-mounted light panels and a wall-mounted 32" LCD monitor that augments the physical pixels with more in-depth information (see Figure 2).

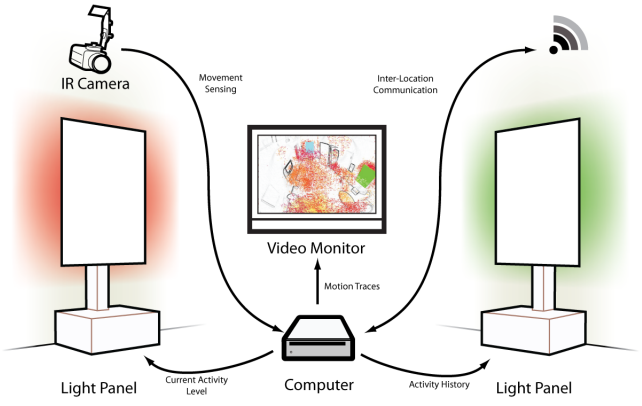

Figure 2: Installation schema and information flow

Each panel functions as a single physical pixel, using red, green, and blue colored incandescent lights to wash the wall around them with color. The lights are shielded from view behind a 2'w x 3'h white panel. Each light panel is driven by an off-the-shelf DMX dimmer pack. A CCTV camera captures video for motion analysis.

Figure 3: Details of the backside of the panels and color responses.

3.1.1 Interactive Lights

The lights (as shown in Figure 3) react immediately to motion in and out of the space. As someone enters the lobby, they are greeted with a burst of green color from both light panels. When exiting the space, the lights display a burst of red color. This immediate feedback informs visitors that the system detects and responds to their activity.

The green/red color convention was deliberately chosen as it corresponds to the culturally specific (US) convention of red exit signs and green "go"/entrance signs, appropriate given the US location of the initial installation. This mapping can be easily adapted to support different local understandings.

When not reacting to real-time entrances and exits, the panels display the history of overall activity in the space currently and over time. One light panel uses a "thermometer" metaphor to display the current level of activity in the space – high activity results in red-hued light; during periods of low activity, colors trend towards the blues. The system calculates the color of this panel in HSL space, varying hue between the two extremes while holding saturation and luminance fixed. Activity is scaled from zero (no activity) to one (the highest level of activity sensed since system startup). The second light panel fades through the history of activity in the last hour, using a palette of colors that corresponds to those used in the visual display, as discussed below. For each segment of time, the saturation of the color displayed corresponds to the quantity of activity at that time. These lights provide both a visually pleasing and constantly changing architectural element for the one-time visitor and a cogent representation of the level of activity in the space over time for participants familiar with the system.

3.1.2 Visual Display

The display reveals motion traces of the last hour overlaid on an abstract representation of the space. Scaled and filtered optical flow vectors are aggregated on this image to render spatial activity over time. In order to maintain privacy of individuals passing through the space, we used the motion vectors as a non-identifiable activity aggregate instead of a more literal representation such as live video. The display shows the most recent motion in violet. Over an hour, the traces fade through red, orange, yellow, green, blue, and then eventually fade away entirely, providing a sense of history. We selected this color palette to emphasize recent activity with dominant, warm, saturated tones, fading to cooler tints with age. In order to provide cohesion between lights and visuals, the light panels are contextualized on screen by replicating the location and state of the physical lights. Figure 4 shows a typical display during a period of medium activity.

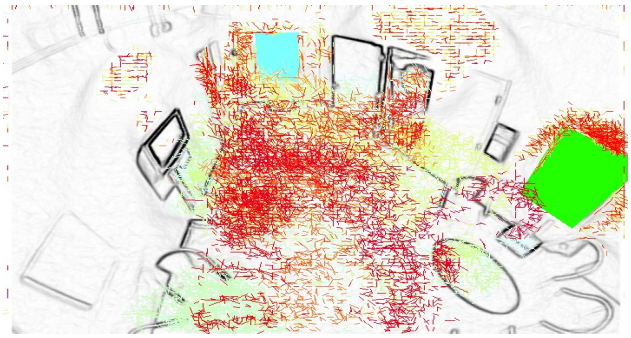

Figure 4: Video Monitor display depicting Activity over Time

4. RESULTS

The work was showcased at the opening reception of an annual gathering of artists, researchers and practitioners representing music technology, human-computer interaction, multimedia arts, and cognitive science. This 3-day workshop entitled "*Beyond the Instrument Metaphor: New Paradigms for Interactive Media*" was hosted by the School of Arts, Media and Engineering at Arizona State University. Figure 1 shows a panoramic image of the installation space at this venue. Approximately 75 people interacted with the installation while passing through the venue's lobby space on opening night. The installation also operated throughout the 3-day workshop, and it has been maintained in the space since, where members of the research community who regularly use the space continue to engage with it. Due to the opening reception being limited to one building, the distributed communication aspect was not present in this particular showcase. We are currently setting up a second version of the installation in one of our other buildings, as discussed in the future work section.

We observed a diversity of interactions with the piece and received insightful criticism. Many people understood the context of the panels/visualization and noticed that their actions were directly displayed on the screen by motion vectors. This motivated people to move around the space to create additional motion on the screen in order to add to the aggregated representation. Observers easily recognized the mapping of color to age of activity. It was also appreciated that the information about the activity and movement in the space was conveyed in an abstract way while maintaining individual anonymity, thereby avoiding a "Big Brother" feel. The understanding that the lights and visual display were part of the same installation was also clear and unambiguous. The prominence of color in the installation in the form of both light and the display provided a warm addition to the space.

These observations imply that the installation holds promise both to subtly augment the atmosphere of a space without distracting from its core function and also to provide useful information about the group activities of regular participants in the space.

5. DISCUSSION

This work provides a template for future attempts to integrate communication and awareness of aggregated activity into a shared visual representation. The initial exhibition received a positive response, as well as substantial feedback and ideas for future

iterations. Visitors appreciated the visual simplicity of the piece. However, we found some complications in conveying meaningful temporal data using only two color fields as "pixels".

Viewers expressed several concerns about the display: 1) the mapping of "activity age" to vector color was not obvious without annotation or some explanation. Viewers frequently thought that color, rather than line-length, represented intensity of activity. 2) Times of high physical activity produced dense visual screen clutter, with many overlapping vectors. 3) The video display tended to dominated viewers' attention, distracting from the light panels, which were comparatively dim and ambiguous. The light panels lacked a natural intuitive mapping of movement to color, instead requiring explanation of how the lights respond. Both the ambiguity of the display and light mappings imply that future iterations of the installation should ground color mappings in a more intuitive fashion.

For future artists working in similar spaces, our approach suggests several useful principles. First, light field or color-based output devices should add to the space (whether data-driven or not) without distracting from the normal use of the workplace. Mappings should be clear, immediate and concise. One of our major obstacles was the "flattening" of complex temporal data down to the activity of two color field "pixels". Second, the use of color in the installation was appreciated and provided a welcoming and energetic feel to the lobby space. It attracted the attention of viewers even if the higher level mappings between activity and color were missed.

6. FUTURE WORK

This work presents promising results in communicating the activity history of a semi-public space over time. Based on participant feedback and our own reflections and observations, we have outlined the following avenues of exploration.

First, we plan to study and improve the mappings of both the light-based and display-based feedback to enhance the aesthetic experience and the quality of information conveyed through the installation. We will map the alpha channel of the drawn vectors to the age of the activity the vector represents. We are considering mapping activity level to the wavelengths of visible light (e.g. low activity corresponding to violet; high activity to red). We must investigate clearer techniques to render the motion vectors in the display. One possibility is to utilize clustering analysis to determine the central mass of high activity areas. This approach requires further investigation, as it may not be feasible in real-time.

Second, we hope to expand the memory-based aspect of the piece to cover longer timescales. We are evaluating possible display-based visualizations of history. In one proposed version, we would display screenshots of the history every hour for the last six hours. We will explore other ways to show a prolonged history (maybe as long as an entire year) by graphing activity over time on a logarithmic scale.

Finally, the next iteration (currently under construction) will introduce a second, near-duplicate installation in another building, realizing the goal of inter-building communication. This second installation will use improved hardware such as individually addressable RGB LED light sources. This will give us the opportunity to orient one panel horizontally, creating a more natural mapping of space to time by manipulating individual LEDs to display points in history from left (oldest) to right (most recent). The other panel remains unchanged.

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