Human-Material Interaction for Expression, Performance, and Remembering

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Fig. 1. We show three projects through which we explore Human-Material Interactions. a) Soft Logic; b) Corsetto; c) Teleabsence-Phonebooth

CCS Concepts: • **Human-centered computing → Interaction design theory, concepts and paradigms**; **HCI theory, concepts and models**.

Additional Key Words and Phrases: human material interaction, radical atoms, soft interfaces, wearables

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1 INTRODUCTION

Our research team at the Tangible Media Group is invested in a vision for the future of Human-Material Interaction, in which all digital information has a physical manifestation. Humans have evolved a heightened ability to sense and manipulate the physical world, yet the GUI based on intangible pixels takes little advantage of this capacity. Our vision

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for tangible media builds upon our natural dexterity by embodying digital information in physical space. By exploring the intersection of contemporary human-computer interaction research with an emphasis on tangible affordances, we are continuing to re-envision the potential future of human-computer relations. Over the past quarter century, through a series of Tangible Bits and Radical Atoms projects, we have been pursuing Human-Material Interaction (HMI) as a new model of HCI for the post-pixel era. The aim of this "Body x Materials" workshop resonates with our vision of HMI.

We would like to contribute to the workshop by introducing the three categories of "Body x Materials":

- Human-Material Expression: Creative Environments
- Human-Material Performance: Wearable Responsive Materials
- Human-Material Transcendence: Beyond Life

2 HUMAN-MATERIAL EXPRESSION: CREATIVE ENVIRONMENTS

Toolkits and environments for designers and artists will benefit from new material-enabled body-based multi-sensory experiences. In the past thirty years, we developed different systems that simulated but also allowed creators to explore new ways to build things through their bodily interaction with actuated environments, with different levels of materiality depending on the current evolution of technologies.

2.1 Illuminating Clay

Illuminating Clay is a system for the real-time computational analysis of physical landscape models. Users manipulate a malleable landscape model while the topography of the model is captured in real-time by a laser-scanning device. This interface allows users to explore and analyze free-form spatial models. Using this platform we explore the domain of landscape design, where the relationship between form and computational simulations is of particular relevance. Landscape models are constructed using ductile clay support. Three-dimensional geometry is captured in real-time using a laser scanner. From this information simulations such as shadow casting, land erosion, visibility, and traveling time are calculated. Finally, the results are projected back onto the clay model.

2.2 Physical Telepresence

Physical Telepresence [3] is based on shared workspaces with the ability to capture and remotely render the shapes of people and objects. In this project, we describe the concept of shape transmission and propose interaction techniques to manipulate remote physical objects and physical renderings of shared digital content. We investigate how the representation of the user's body parts can be altered to amplify their capabilities for teleoperation and describe our finding of building and testing prototype physical telepresence workspaces including the interaction between bodies and actuated surfaces.

2.3 Soft Logic

Soft Logic is an ongoing project that investigates the relationship between textile structures and active material systems (Figure 2). Developed in the pre-ceramic age, the principles of textiles have remained unchanged, surviving the mechanization of the craft with the introduction of power machinery; textiles, in both their linguistic origins and their later influence on the development of computation, are synonymous with our first notions of technology. Through the strategic use of fiber actuators and the self-organizing tendencies of different fabric systems, this project presents a methodology that once again brings craft to the forefront of human-computer/human-material interaction.

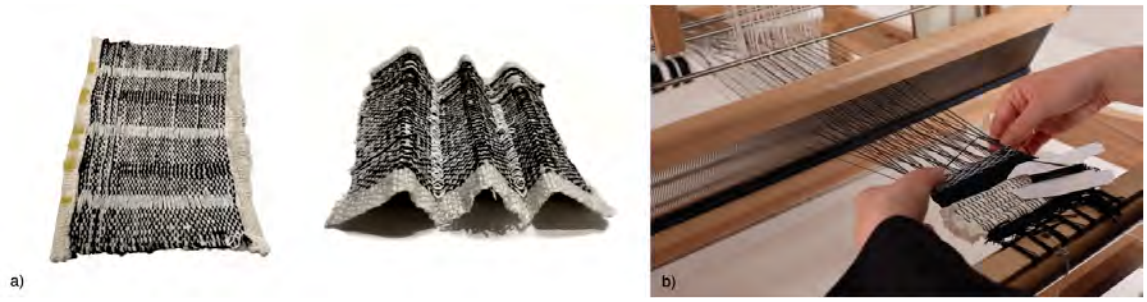

Fig. 2. Soft Logic;(a) Image of a passive and active textile sample that created a folded form in its actuated state, (b) process image of weaving a sample on a 16-harness loom.

While creating soft, shape-changing robotic systems, we investigate how the combination of these principles allows for material-enabled body-based experiences that re-situate our understanding of fabric at the scale of the object, the wearable, and the interior.

3 HUMAN-MATERIAL PERFORMANCE: WEARABLE RESPONSIVE MATERIALS

Within the Human-Computer Interaction (HCI) community, we have seen the adoption of novel actuated materials and interfaces for experiences pertaining to our tactile apparatus. Much progress has been made in devising experiences involving active materials for mediating interactions that interface our own bodies and that with others. To the design community, the functionality and aesthetics of the material is not measured solely in terms of what it looks like as it moves, but more importantly, what it feels like interacting with our skin, movements, and bodily engagements [2]. Our vision for wearable materials is to provide the experience of a second skin or muscle that interacts with our dexterous bodies, enriching physical interactions.

3.1 bioLogic

Our project, bioLogic [5], seeks a harmonious perspective, where biology and engineering approaches flow in synchrony by introducing natto cells (Figure 3a) as nanoactuators for designing transformable wearable materials that respond to changes in humidity of our bodies. The cells have been harvested in a bio lab, assembled by a micron-resolution bio-printing system, and transformed into responsive fashion, a "Second Skin" that self-transforms as a synthetic biological skin activated by living bacteria. This bio-skin reacts to body heat and sweat, causing flaps around heat zones to open and close, which in turn creates an ecosystem between the human body and the covering (Figure 3b).

Fig. 3. bioLogic: (a) SEM image of natto cells, (b) two dancers wearing custom designed cell-patterned second skin, (c) the dancer altering her choreography to amplify the response of cell-patterned flaps during the performance

We imagined a world where actuators and sensors can be grown rather than manufactured, being derived from nature rather than engineered in factories. In a bio lab, we harvested humidity and heat-sensitive bacteria and applied onto fabrics that were worn by expert dancers. Based on the wearer's sweat and heat maps, tiny vents on the fabric were designed to open or close by curling. We observed that the biological skin transformed slowly in response to the dancers' bodily movements as their body heat increased and perspired. Perhaps more intriguing, during the performance the dancers started altering their pre-composed choreography in response to the flaps behavior, demonstrating a unique moment of intimate correspondence between the dancer's body and the bacteria (Figure 3c).

3.2 Corsetto

When we listen to someone singing, it becomes a dynamic felt experience of a resonance of sorts between bodies. In particular, when professional vocalists listen to one-another, they resonate or vibe with the muscle movements of the singer. They feel the muscular movements, tensions and engagements of the singer through listening to the sound produced, interpreting what movements will have had to take place in order to create the singing. We saw an opportunity to learn and thrive off the richness of professional vocalists' aesthetic appreciation of listening and their ability to resonate with another singer. We wanted to create mediating technology that would let audience participants share more of such 'resonance' experiences, feeling the movements of the singing body unfolding in synchrony with the sounds heard.

Fig. 4. Corsetto garment; (a) front view demonstrating rib and abdominal modules; (b) side view demonstrating rib, abdominal, lower back modules; (c) back view demonstrating lower back and spinal modules; connected to FlowIO hardware stack.

Our project Corsetto [1] presents an upper body garment consisting of robotic materials, designed to perform a repertory of haptic gestures triggered by a singer's vocal expressions. Based on singing techniques from the classical opera tradition, we created a corset-style kinesthetic garment for transferring somatic reminiscent of vocal experience from an expert singer to a listener, leveraging the unique affordances of a 'wearable second-muscle' that is able to materially emulate and viscerally communicate the nuances of a singing body (Figure 4).

Our aim was to express some of the qualities and movements embedded in the singing body – the vocal gestures – translated into haptic gestures performed by actuated materials worn on the torso of the listening body. The gestures in the haptic materials we created thereby added a new aesthetic dimension to the experience of the performance. It became a voice of its own, sometimes resonating with sounds produced by the singer, sometimes adding an entirely different voice singing with, or against, the singer. This inter-subjective haptic voice fostered a novel form of inter-subjectivity between singer and audience: bridging inner and outer experiences in the listening body; traversing the subject-object divide; and adding novel ways of aesthetically experiencing and appreciating the other.

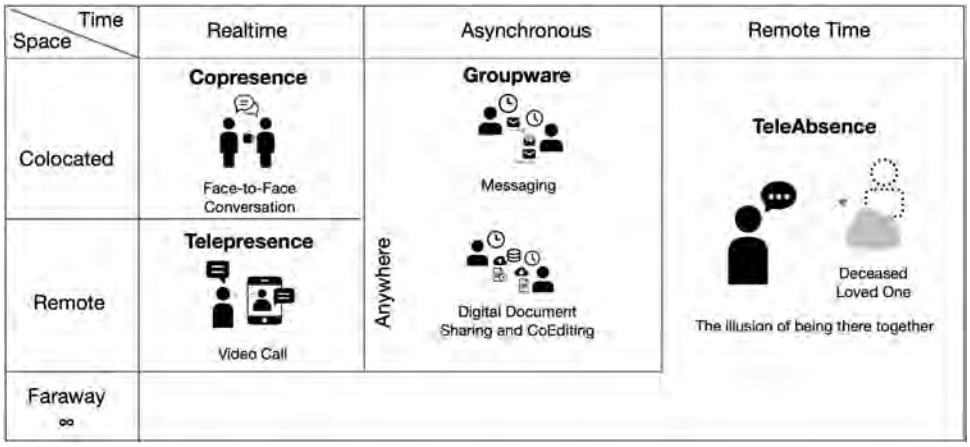

Fig. 5. Teleabsence; Different modalities to be together even beyond existence

4 HUMAN-MATERIAL TRANSCENDENCE: HCI BEYOND LIFE

The desire to feel connected and to communicate with ancestors is a universal part of the human experience, but during the COVID-19 pandemic, civilization became increasingly distanced from those who have fallen ill. The idea of Teleabsence is a counter concept to Telepresence: to create communication channels with those no longer with us to soothe the pain of bereavement. Teleabsence is designed around tangible objects, such as old typewriters, telephones, brushes, and pianos that were once touched and marked by the hand of a loved one.

4.1 TeleabsencePhonebooth

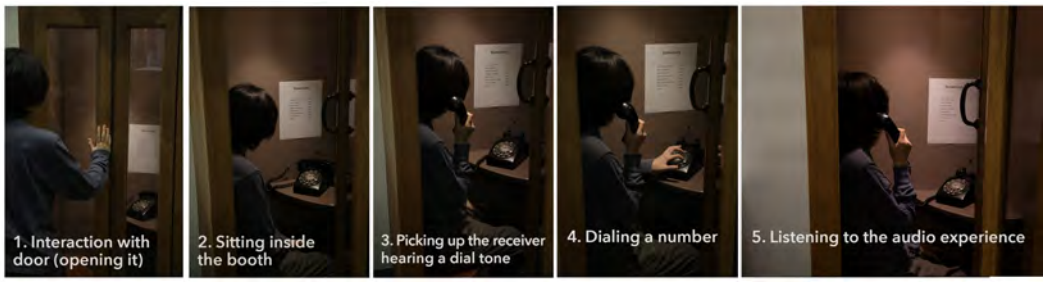

Fig. 6. TeleabsencePhoneBooth: (1) Interaction with door, (2) Sitting inside the Booth, (3) Picking up the receiver hearing a dial tone, (4) Dialing a number, (5) Listening to the audio Experience

Our project, TeleabsencePhoneBooth, is inspired by the "Wind Phone" in Japan, a disconnected telephone booth where visitors can hold one-way conversations with deceased loved ones. Developed using an existing phone booth produced by American Telephone and Telegraph Company in 1965, our project explores spatial audio, virtual reality, and tangible interfaces to allow anyone to revisit personal stories while they immerse themselves in a meaningful interaction. The TeleabsencePhoneBooth focuses specifically on creating a phone-booth-based platform to support

the creation of teleabsence experiences. In this project, visitors of the phone booth can make a phone call to feel the presence of their deceased loved ones and bring back vivid memories.

The intimacy of a phone booth cultivates a space where personal storytelling can be evoked through the interactions of the visitor. A modified antique black telephone with a rotary dial input is installed inside the TeleabsencePhoneBooth. Picking up the receiver, the visitor hears a dial tone. By selecting a soundscape associated with memories, visitors are invited to enter a liminal zone, where the presence of a loved person or place is evoked by the user's selection of ambient media which surrounds the visitor through immersive audio and interactive virtual reality.

For the current iteration, we have focused on four core environments, each grounded in distinct universal themes. 1) Domestic Memories; 2) Natural Environments; 3) Transportation; 4) Departures. The subtle haptic qualities of sound around the visitor transports the visitor, as the bumps they feel on a train ride or the vibratory sensation from fireworks or thunder feel real, full, and ambient.

4.2 Newell/SimonSpace

Fig. 7. Newell/SimonSpace Installation View, From Left to Right: Image of Apple IIGS desktop interface, Detail view of interactive archive application, Commodore Pet Computer and Oscilloscopes

Teleabsence has largely explored frameworks for enabling individuals to connect with personal connections beyond the constraints of life. The mixed reality installation Newell/SimonSpace questioned how we can access and enter the mental spaces of those that we admire or know from a collective and cultural perspective.

Newell/SimonSpace incorporated both computer-generated and analog interactive experiences in a large-scale mixed-reality environment, to engage visitors with the history of artificial intelligence. A type of "augmented reality archive", the environment was inspired by the architecture of the offices of notable scientists Allen Newell and Herbert Simon, often considered the "fathers of artificial intelligence". A collage of period-specific computing environments- stretching from the 1960s to the 1980s- the space was embedded with augmented reality and gesture-controlled interactive applications. This multimedia research environment provided a rich and engaging way for visitors to learn about the origins of artificial intelligence, by "embodying" the original researcher's point of view, while interacting with their research through interactive augmented reality.

5 CONCLUSION

In anticipation of the future of mediated interactions between bodies and materials, we are passionate about exploring this new frontier, not only through the objects we touch and grasp, but in the materials we wear and how they are woven into how we live. What new computational affordances do these wearable materials enable? How will responsive and active matter transform performances and choreographic environments? And in a world with these new approaches to human/material interactions, what kind of new tools will designers and creators have at their disposal?

Human-Material Interaction not only redefines what HCI, Interaction Design, or the Performing Arts have been independently exploring in the last century, but also defines a new space for expressiveness which enables radically new experiences, extending human agency to a realm "beyond the body". Philosopher Maurice Merleau-Ponty [4] wrote that "our body is not in space like things; it inhabits or haunts space. It applies itself to space like a hand to an instrument." Material enabled body-based multi-sensory experiences are the flesh of these spectral hauntings, connecting our bodies in exciting new ways, in the here and now, and into the future as it emerges before us.

6 AUTHOR BIOS

Prof. Hiroshi Ishii is the Jerome B. Wiesner Professor of Media Arts and Sciences at the MIT Media Laboratory. After joining the Media Lab in October 1995, he founded the Tangible Media Group to make digital tangible by giving physical form to digital information and computation. He pursues his visions of Tangible Bits (1997) and Radical Atoms (2012) that transcend the Painted Bits of GUIs (Graphical User Interfaces) as a dominant paradigm of HCI (Human-Computer Interaction).

Ozgun Kilic Afsar is a Graduate Research Assistant at the Tangible Media Group at MIT Media Lab. Her research focuses on engineering integrated soft robotic fibers and textiles that correspond to the dexterity of human biomechanics. These active textile systems feature multimodal haptic feedback to kinesthetically support skill acquisition and transfer in creative movement practices.

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Jack Forman is a Ph.D. student at the MIT Media Lab, in the Tangible Media Group and Center for Bits and Atoms. Jack's vision is to make tangible artifacts embedded seamlessly with responsive behavior, through the development of programmable materials and ways to fabricate them.

Sarah Nicita is a Research Assistant at the Tangible Media Group at the MIT Media Lab and a Master's candidate at the Harvard Graduate School of Design. Her practice focuses on active textile architectures, human perception, and soft robotics. Her work is guided by how the material condition of textiles may be leveraged to augment the relationship between body and space.

D. Pillis is a Graduate Research Assistant at the Tangible Media Group at the MIT Media Lab and a specialist in performance capture, mixed reality, and interactive computer graphics. Their work lies at the intersection of queer media archaeology, tangible media, and experimental animation.

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