Demonstrations of Expressive Softwear and Ambient Media

Sha Xin Wei[1], Yoichiro Serita[2], Jill Fantauzza[1], Steven Dow[2], Giovanni Iachello[2], Vincent Fiano[2], Joey Berzowska[3], Yvonne Caravia[1], Delphine Nain[2], Wolfgang Reitberger[1], Julien Fistre[4]

[1]School of Literature, Communication, and Culture / GVU Center
Georgia Institute of Technology
xinwei@lcc.gatech.edu, {gtg760j, gtg937i, gtg711j}@mail.gatech.edu

[2]College of Computing/GVU Center
Georgia Institute of Technology
{seri, steven, giac, ynniv, delfin}@cc.gatech.edu,
[4]gtg918b@ece.gatech.edu

[3] Faculty of Fine Arts
Concordia University
Montreal, Canada
joey@berzowska.com

ABSTRACT

We set the context for three demonstrations by describing the Topological Media Lab's research agenda. We next describe three concrete applications that bundle together some of our responsive ambient media and augmented clothing instruments in illustrative scenarios.

The first set of scenarios involves performers wearing expressive clothing instruments walking through a conference or exhibition hall. They act according to heuristics drawn from a phenomenological study of greeting dynamics, the social dynamics of engagement and disengagement in public spaces. We use our study of these dynamics to guide our design of expressive clothing using wireless sensors, conductive fabrics and on-the-body circuit logic.

By walking into different spaces prepared with ambient responsive media, we see how some gestures and instruments take on new expressive and social value. These scenarios are studies toward next generation TGarden responsive play spaces [25] based on gesturally parameterized media and body-based or fabric-based expressive technologies.

Keywords

Softwear, augmented clothing, media choreography, real-time media, responsive environments, TGarden, phenomenology of performance.

CONTEXT

The Topological Media Lab is established to study gesture, agency and materiality from both phenomenological and computational perspectives. This motivates an investigation of human embodied experience in solo and social situations, and technologies that can be developed for enlivening or playful applications.

The focus on clothing is part of a general approach to wearable computing that pays attention to the naturalized affordances and the social conditioning that fabrics, furniture and physical architecture already provide to our everyday interaction. We exploit the fusion of physical material and computational media and rely on expert craft from music, fashion, and industrial design in order to make a new class of personal and collective expressive media.

TML'S RESEARCH HEURISTICS

Perhaps the most salient notion and leitmotiv for our research is continuity. Continuous physics in time and media space provides natural affordances which sustain intuitive learning and development of virtuosity in the form of tacit "muscle memory." Continuous models allow *nuance* which provides different expressive opportunities than those selected from a relatively small, discrete set of options. Continuous models also sustain *improvisation*. Rather than disallow or halt on unanticipated user input, our dynamical sound models will always work. However, we leave the *quality* and the *musical meaning* of the sound to the user. We use semantically shallow machine models.

We do "materials science" as opposed to object-centered industrial design. Our work is oriented to the design and prototyping not of new devices but of new species of augmented physical media and gestural topologies. We distribute computational processes into the environment as an augmented physics rather than information tasks located in files, applications and "personal devices."

APPLICATIONS AND DEMONSTRATIONS

We are pursuing these ideas in several lines of work: (1) softwear: clothing augmented with conductive fabrics, wireless sensing and image-bearing materials or lights for expressive purposes; (2) gesture-tracking and mathematical mapping of gesture data to time-based media; (3) physics-based real-time synthesis of video; (4) analogous sound synthesis; (5) media choreography based on statistical physics.

We demonstrate new applications that showcase elements of recent work. Although we describe them as separate elements, the point is that by walking from an unprepared place to a space prepared with our responsive media systems, the same performers in the same instrumented clothing acquire new social valence. Their interactions with co-located less-instrumented or non-instrumented people also take on different effects as we vary the locus of their interaction.

Softwear: Augmented Clothing

Most of the applications for embedding digital devices in clothing have utilitarian design goals such as managing information, or locating or orienting the wearer. Entertainment applications are often oriented around controlling media devices or PDA's, and high-level semantics such as user identity [1, 7] or gesture recognition [28]. Our approach to softwear as *clothing* is informed by earlier work of Berzowska [2] and Orth [19].

We study the expressive uses of augmented clothing but at a more basic level of non-verbal body language, as indicated in the provisional diagram (Fig. 1). The key point is that we are not encoding classes of gesture into our response logic but instead we are using such diagrams as *necessarily* incomplete heuristics to guide human performers.

Performers, i.e. experienced users of our "softwear" instrumented garments will walk through the floor of the public space performing in two modes: (1) as human social probes into the social dynamics of greetings, and (2) as performers generating sound textures based on gestural interactions with their environment. We follow the performance research approach of Grotowski and Sponge [10, 25] that identifies the actor with the spectator. Therefore we evaluate our technology from the first person point of view. To emphasize this perspective, we call the users of our technologies "players" or "performers" (However, our players do not play games, nor do they act in a theatrical manner.) We exhibit fabric-based controllers for expressive gestural control of light and sound on the body. Our softwear instruments must first and foremost be comfortable and aesthetically plausible as clothing or jewelry. Instead of starting with devices, we start with social practices of body ornamentation and corporeal play: solo, parallel, or collective play.

Using switching logic from movements of the body itself and integrating circuits of conductive fiber with light emitting or image bearing material, we push toward the limit of minimal on-the-body processing logic but maximal expressivity and response. In our approach, every contact closure can be thought of and exploited as a sensor. (Fig. 1)

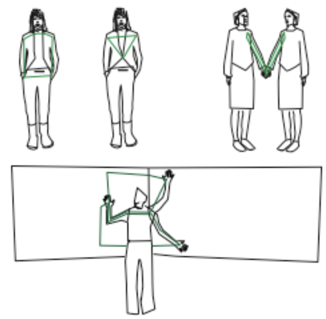

Fig. 1. Solo, group and environmental contact circuits.

Demonstration A: Greeting Dynamics (Fantauzza, Berzowska, Dow, Iachello, Sha)

Performers wearing expressive clothing instruments walk through a conference or exhibition hall. They act according to heuristics drawn from a *provisional* phenomenological schema of greeting dynamics, the social dynamics of engagement and disengagement in public spaces built from a glance, nod, handshake, embrace, parting wave, backward glance. Our demonstration explores how people express themselves to one another as they approach friends, acquaintances and strangers via the medium of their modes of greeting. In particular, we are interested in how people might use their augmented clothing as expressive, gestural instruments in such social dynamics. (Fig. 2)

Fig. 2. Instrumented, augmented greeting.

In addition to instrumented clothing, we are making gestural play objects as conversation totems that can be shared as people greet and interact. The shared object shown in the accompanying video is a small pillow fitted with a TinyOS mote transmitting a stream of accelerometer data. The small pillow is a placeholder for the real-time sound synthesis instruments that we have built in Max/MSP. It suggests how a physics-based synthesis model allows the performer to intuitively develop and nuance her personal continuous sound signature without any buttons, menus, commands or scripts. Our study of these embedded dynamical physics systems guides our design of expressive clothing using wireless sensors, conductive fabrics and on-the-body circuit logic.

Whereas this first demonstration studies the uses of softwear as intersubjective technology, of course we can also make softwear more explicitly designed for solo expressive performance.

Demonstration B: Expressive Softwear Instruments Using Gestural Sound: (Sha, Serita, Dow, Iachello, Fistre, Fantauzza)

Many of experimental gestural electronic instruments cited directly or indirectly in the Introduction have been built for the unique habits and expertises of individual professional performers. A more theatrical example is Die Audio Gruppe [16]. Our approach is to make gestural instruments whose response characteristics support the long-term evolution of everyday and accidental gestures into progressively more virtuosic or symbolically charged gesture.

In the engineering domain, many well-known examples are mimetic of conventional, classical music performance. [15]. Informed by work, for example, at IRCAM but especially associated with STEIM, we are designing sound instruments as idiomatically matched sets of fabric substrates, sensors, statistics and synthesis methods that lie in the intersection between everyday gestures in clothing and musical gesture.

We exhibit prototype instruments that mix composed and natural sound based on ambient movement or ordinary gesture. As one moves, one is surrounded by a corona of physical sounds " generated" immediately at the speed of matter. We fuse such physical sounds with synthetically generated sound parameterized by the swing and movement of the body so that ordinary movements are imbued with extraordinary effect. (Fig. 3)

The performative goal is to study how to bootstrap the performer's consciousness of the sounds by such estranging techniques (estranging is a surprising and undefined word here) to scaffold the improvisation of intentional, symbolic, even theatrical gesture from unintentional gesture. This is a performance research question rather than an engineering question whose study yields insights for designing sound interaction.

Gesturally controlled electronic musical instruments date back to the beginning of the electronics era (see extensive histories such as [13]) .

Our preliminary steps are informed by extensive and expert experience with the community of electronic music performance [25, 31, 32].

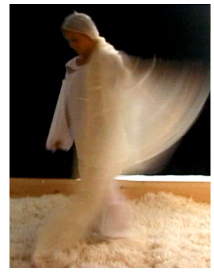

Fig. 3. Gesture mapping to sound and video.

The motto for our approach is "gesture tracking, not gesture recognition." In other words we do not attempt to build models based on a discrete**,** finite and parsimonious taxonomy of gesture. Instead of deep analysis our goal is to perform real-time reduction of sensor data and map it with lowest possible latency to media texture synthesis to provide rich, tangible, and causal feedback to the human.

Other gesture research is mainly predicated on linguistic categories, such as lexicon, syntax and grammar. McNeill [17] explicitly scopes gesture to those movements that are correlated with speech utterances.

However, given the increasing power of portable processors, sophisticated sub-semantic, non-classifying analysis has begun to be exploited (e.g. [30]). We take this approach systematically.

Interaction Scenario

In all cases, performers wearing softwear instruments will interact with other humans in a public common space. But when they pass through a space that has been sensitized with tracking cameras or receivers for the sensors tracking their gesture, then we see that their actions made in response to their social context take on other qualities due to the media that is generated in response to their movement. This prompts us to build responsive media spaces using our media choreography system.

Ambient Media

After Krueger's pioneering work [14] with video, classical VR systems glue inhabitants' attention to a screen, or a display device and leave the body behind. Augmented reality games like Blast Theory's *Can You See Me Now* put some players into the physical city environment, but still pin players' attention to (mobile) screens [4].

Re-projection onto the surrounding walls and bodies of the inhabitants themselves marks an important return to embodied social, play, but mediated by distributed and tangible computation.

The Influencing Machine [12] is a useful contrasting example of a responsive system. The Influencing Machine sketches doodles apparently in loose reaction to slips of colored paper that participants feed it. Like our work, their installation is also not based on explicit language. In fact it is designed ostensibly along "affective" lines. It is interesting to note how published interviews with the participants reveal that they objectify the Influencing Machine as an independent affective agency. They spend more effort puzzling out this machine's behavior than in playing with one another.

In our design, we aim to sustain environments where the inhabitants attend to one another rather than a display. How can we build play environments that reward repeated visits and ad hoc social activity? How can we build environments whose appeal does not become exhausted as soon as the player figures out a set of tasks or facts? We are building responsive media spaces that are *not* predicated on rule-based game logic, puzzle solving or exchange economies [3], but rather on improvisatory yet disciplined behavior. We are interested in building play environments that offer the sort of embodied challenge and pleasure afforded by swimming or by working clay.

This motivates a key technical goal: the construction of responsive systems based on gesture-*tracking* rather than gesture-recognition. This radically shortens the computational path between human gesture and media response. But if we allow a continuous open set of possible gestures as input, however reduced, the question remains how to provide aesthetically interesting, experientially rich, yet legible media responses.

The TGarden environment [25] that inspired our work is designed with rich physicalistic response models that sustain embodied, non-verbal intuition and progressively more virtuosic performance. The field-based models sustain collective as well as solo input and response with equal ease.

By shifting the focus of our design from devices to processes, we demonstrate how ambient responsive media can enhance both decoupled and coordinated forms of playful social interaction in semi-public spaces.

Our design philosophy has two roots: experimental theater transplanted to everyday social space, and theories of public space ranging from urban planners [20, 33] to playground designers [11]. R. Oldenburg calls for a class of so-called "third spaces," occupying a social region between the private, domestic spaces and the vanished informal public spaces of classical socio-political theory. These are spaces within which an easier version of friendship and congeniality results from casual and informal affiliation in "temporary worlds dedicated to the performance of an act apart." [18]

Demonstration C: Social Membrane (Serita, Fiano, Reitberger, Varma, Smoak)

How can we induce a bit more of a socially playful ambience in a dead space such as a conference hotel lobby? Although it is practically impossible in an exhibition setting to avoid spectacle with projected sound or light, we can insert our responsive video into non-standard geometry or materials.

We suspend (*pace* T. Erickson [8]) a translucent ribbon onto which we project processed live video that transforms the fabric into a magic membrane. The membrane is suspended in the middle of public space where people will naturally walk on either side of it. People will see a smoothly varying in time and space transformations of people on the other side of the membrane. (Fig. 4) The effects will depend on movement, but will react additionally to passersby who happen to be wearing our softwear augmented clothing.

The challenge will be to tune the dynamic effects so that they remain legible and interesting over the characteristic time that a passerby is likely to be near the membrane, the affect induces play but not puzzle-solving. Sculpturally, the membrane should appear to have a continuous gradient across its width between zero effect (transparency) and full effect. Also it should take about 3-4 seconds for a person walking at normal speed in that public setting to clear the width of the inserted membrane.

Fig. 4. Two players tracked in video, tugging at spring projected onto common fabric.

Above all the membrane should have a social Bernoulli effect that will tend to draw people on the opposite sides to one another. The same effects that transform the other person's image should also make people feel some of the safety of a playful mask. The goal is to allow people to gently and playfully transform their view of the other in a common space with partially re-synthesized graphics.

Artistic Interest and Craft

We do not try to project the spectator's attention into an avatar as in most virtual or some augmented reality systems. Instead, we focus performer-spectator's attention in the same space as all the co-located inhabitants. Moreover, rather than mesmerizing the user with media "objects" projected onto billboards, we try to sustain human-human play, using responsive media such as calligraphic, gesture/location-driven video as the medium of shared expression. In this way, we keep the attention of the human inhabitants on one another rather than having them forget each other distracted by a "spectacular" object [6].

By calligraphic video we mean video synthesized by physicalistic models that can be continuously transformed by continuous gesture much as a calligrapher brushes ink onto silk. Calligraphic video as a particular species of time-based media is part of our research into the preconditions for sense-making in live performance. [10, 5].

ARCHITECTURE

For high quality real-time media synthesis we need to track gesture with sufficiently high data resolution, high sample rate, low end-to-end latency between the gesture and the media effect. We summarize our architecture, which is partly based on TinyOS and Max / Macintosh OS X, and refer to [24, 25] for details.

Our current strategy is to do the minimum on-the-body processing needed to beam sensor data out to fixed computers on which aesthetically and socially plausible and rich effects can be synthesized. We have modified the TinyOS environment on CrossBow Technologies Mica and Rene boards to provide time series data of sufficient resolution and sample frequency to measure continuous gesture using a wide variety of sensory modalities. This platform allows us to piggy-back on the miniaturization curve of the Smart Dust initiative [13], and preserves the possibility of relatively easily migrating some low level statistical filtering and processing to the body. Practically this frees us to design augmented clothing where the form factors compare favorably with jewelry and body ornaments, while at the same time retaining the power of the TGarden media choreography and synthesis apparatus. (Some details of our custom work are reported in [24].)

Now we have built a wireless sensor platform based on Crossbow's TinyOS boards. This allows us to explore shifting the locus of computation in a graded and principled way between the body, multiple bodies, and the room.

Currently, our TinyOS platform is smaller but more general than our LINUX platform since it can read and transmit data from photocell, accelerometer, magnetometer and custom sensors such as, in our case, customized bend and pressure sensors. However, its sample frequency is limited to about 30 Hz / channel.

Our customized TinyOS platform gives us an interesting domain of intermediate data rate time series to analyze. We cannot directly apply many of the DSP techniques for speech and audio feature extraction because to accumulate enough sensor samples the time window becomes too long, yielding sluggish response. But we can rely on some basic principles to do interesting analysis. For example we can usefully track steps and beats for onsets and energy. (This contrasts with musical input analysis methods that require much more data at higher, audio rates. [21])

The rest of the system is based on the Max real-time media control system with instruments written in MSP sound synthesis, and Jitter video graphics synthesis, communicating via OSC on Ethernet. (Fig. 5)

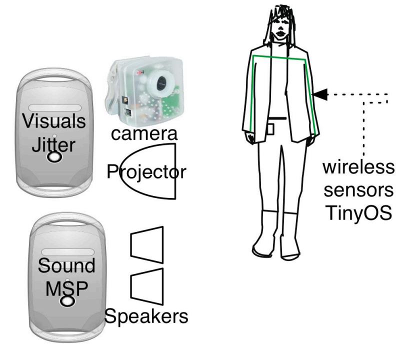

Fig. 5. Architecture comprises clothing; sensing: TinyOS, IR camera; logic and physical synthesis in OSC network: Max, MSP, Jitter; projectors, speakers.

Technical Comment on Lattice Computation

Our research aims to achieve a much greater degree of expressivity and tangibility in time-based visual, audio, and now fabric media. In the video domain, we use lattice methods as a powerful way to harness models that already simulate tangible natural phenomena. Such models possess the shallow semantics we desire based on our heuristics for technologies of performance. A significant technical consequence is that such methods allow us to scale efficiently (nearly constant time-space) to accommodate multiple players.

ACKNOWLEDGEMENTS

We thank members of the Topological Media Lab, and in particular Harry Smoak, Ravi Varma and Kevin Stamper for assisting with the experimental construction, and Junko Tsumuji and Shridhar Reddy for documentation. Tazama St. Julien helped adapt the TinyOS platform. Erik Conrad and Jehan Moghazy worked on the prior version of the TGarden. Pegah Zamani contributed to the design seminar.

We thank Intel Research Berkeley and the Graphics, Visualization and Usability Center for providing the initial set of TinyOS wireless computers. And we thank the Rockefeller Foundation and the Daniel Langlois Foundation for Art, Science and Technology for supporting part of this research.

This work is inspired by creative collaborations with Sponge, FoAM, STEIM, and alumni of the Banff Centre for the Arts.

REFERENCES

1. Aoki, H., and Matsushita, S. Balloon tag: (in)visible marker which tells who's who. *Fourth International Symposium on Wearable Computers* (ISCW'00), 77-86.
2. Berzowska, J. Electronic Fashion: the Future of Wearable Technology.

   http://www.berzowska.com/lectures/e-fashion.html

3. Bjork, S., Holopainen, J., Ljungstrand, P., and Akesson, K.P. Designing ubiquitous computing games -- a report from a workshop exploring ubiquitous computing entertainment. *Personal and Ubiquitous Computing*, *6*, 5-6, (2002), 443-458, Springer-Verlag, 2002.
4. Blast Theory. *Can You See Me Now?* http://www.blasttheory.co.uk/v2/game.html
5. Brooks, P. *The Empty Space*. Touchstone Books, Reprint edition. 1995.
6. Debord, G. *Society of Spectacle*. Zone Books. 1995.
7. Eaves, D. et al. NEW NOMADS, an exploration of Wearable Electronics by Philips, 2000.
8. T. Erickson and W.A. Kellogg. Social Translucence: An Approach to Designing Systems that Support Social Processes. *ACM Transactions on Computer-Human Interaction* , 7(1):59-83, March, 2000.
9. f0.am, txOom Responsive Space. 2002.

   http://f0.am/txoom/.
10. Grotowski, J., *Towards a Poor Theater*, Simon & Schuster, 1970.
11. Hendricks, B. *Designing for Play*, Aldershot, UK and Burlington, VT: Ashgate. 2001.
12. Hook, K., Sengers, P., and Andersson, G. Sense and sensibility: evaluation and interactive art, *Proceedings CHI'2003, Computer Human Interaction*. 2003.
13. Kahn, J. M., Katz, R. H., and Pister, K. S. J. . “Emerging Challenges: Mobile Networking for 'Smart Dust', *Journal of Communications and Networks*, Vol. 2, No. 3, September 2000.
14. Krueger, M. *Artificial Reality 2* (2nd Edition), Addison-Wesley Pub Co. 1991.
15. Machover, T., Hyperinstruments project, MIT Media Lab. http://www.media.mit.edu/hyperins/projects.html
16. Maubrey, B. Die Audio Gruppe. http://home.snafu.de/maubrey/
17. McNeill, D. *Hand and Mind: What Gestures Reveal About Thought*. University of Chicago Press, 1995.
18. Oldenburg, R. *The Great Good Place*. Marlowe & Company, 1999.
19. Orth, M., Ph.D. Thesis, MIT Media Lab, 2001.
20. PPS, Project for Public Spaces, http://pps.org
21. Puckette, M.S., Apel, T., and Zicarelli, D.D. Real-time audio analysis tools for Pd and MSP. ICMC 1998.
22. Reddy, M. J. The conduit metaphor. *in Metaphor and Thought*, ed. A. Ortony, Cambridge Univ Press; 2nd edition. 1993, pp. 164-201.
23. Richards, T. At Work with Grotowski on Physical Actions. London: Routledge. 1995.
24. Sha, X.W., Iachello, G., Dow, S., Serita, Y., St. Julien, T., and Fistre, J. Continuous sensing of gesture for control of audio-visual media. ISWC 2003 Proceedings.
25. Sha, X.W., Visell, Y., and MacIntyre, B. Media choreography using dynamics on simplicial complexes. GVU Technical Report, Georgia Tech., 2003.
26. Sonami. L. Lady’s Glove,

    http://www.sonami.net/lady_glove2.htm
27. Sponge. TGarden, TG2001.

    http://sponge.org/projects/m3_tg_intro.html.
28. Starner, T., Weavr, J., and Pentland, A. A wearable computer based american sign language recognizer , ISWC 1997, pp. 130-137.
29. Topological Media Lab. Georgia Institute of Technology. Ubicomp video.

    http://www.gvu.gatech.edu/people/sha.xinwei/topo logicalmedia/tgarden/video/gvu/TML_ubicomp.mov
30. Van Laerhoven, K. and Cakmakci, O., What shall we teach our pants? *Fourth International Symposium on Wearable Computers* (ISCW'00), 77-86.
31. Vasulka, S and W. Steina and Woody Vasulka: Instrumental video. Langlois Foundation Archives. http://www.fondation-langlois.org/e/collection/vasulka/archives/intro.html
32. Wanderley, M. Trends in Gestural Control of Music, IRCAM,- Centre Pompidou, 2000.
33. Whyte, W.H., *The Social Life of Small Urban Spaces*. Project for Public Spaces, Inc., 2001.