

Distributed Liveness: Understanding How New Technologies Transform Performance Experiences

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ABSTRACT

We identify emerging phenomena of *distributed liveness*, involving new relationships among performers, audiences, and technology. Liveness is a recent, technology-based construct, which refers to experiencing an event in real-time with the possibility for shared social realities. Distributed liveness entails multiple forms of physical, spatial, and social co-presence between performers and audiences across physical and virtual spaces. We interviewed expert performers about how they experience liveness in physically co-present and distributed settings. Findings show that distributed performances and technology need to support flexible social co-presence and new methods for sensing subtle audience responses and conveying engagement abstractly.

Author Keywords

Distributed performance, liveness, audience engagement

ACM Classification Keywords

J.5 Computer Applications: Arts and Humanities

INTRODUCTION

We investigate how performers' experiences of liveness are transformed by technology in distributed performance, where performers and audiences are not all present in the same physical space. By *liveness*, we mean experiencing an event in real-time with the potential for shared social realities among participants [8]. The concept of 'live' performance emerged in the 1930s with the introduction of radio as a way to distinguish from broadcasts of recorded performances [1]. Initially, live performances involved only physically co-present performers and audiences. The Internet and social media advanced new forms of online liveness in which performers and audiences are socially co-present, but not physically [8].

We observe that as technologies for representing performance evolve, notions of live and recorded evolve with them. It becomes important to investigate the impact of this co-evolution on both performers and audiences. Prior HCI researchers

have focused on audience experiences [2, 3, 6, 14]. We instead focus on performers and how they experience liveness.

This investigation examines traditional forms of performance: theater, dance, and music. To broaden exposure, live art performances have begun using technologies for distributing across the world [13, 18]. A resident of a small town in the UK can listen to the Metropolitan Opera from home or attend an expensive production by the National Theatre in London at the local theater. One might think that this was enabled by television, but television is one-way. The goal of distributed performance is to join performers and audiences in a shared sensory experience through bi-directional connections.

Emerging from our investigation, we identify the phenomena of *distributed liveness*, involving new relationships among performers, audience, and technologies that have the potential to transform live experiences. Distributed liveness encompasses various forms of physical, spatial, and social co-presence. For example, in *Can You See Me Now?*, physically and socially co-present performers run through city streets, chasing online players who are spatially and socially co-present in a virtual game space [3]. Distributed liveness is supported by hybrid spaces [4], which connect the physical and virtual to create shared experiences.

We conducted a qualitative investigation of performance artist experiences. We interviewed artists experienced in both physically co-present and distributed settings. Through data analysis, we discovered four themes: challenges in social co-presence, performer attention to distributed liveness, sensing engagement through subtle feedback, and representations of audiences. Findings motivate implications for design of hybrid spaces that promote distributed liveness for performers.

This paper begins by connecting related work. Next, we present our qualitative methodology, followed by a discussion of findings, and implications for design.

RELATED WORK

Prior work has developed several methods for sensing and visualizing audience engagement. Emphasis has been on physically co-present performances. Distributed performances are now using teleconferencing systems and interactive technologies to enable bi-directional signals among spaces. HCI researchers are investigating audience experiences in these emerging forms of performance and technology. In this paper, we focus on performers' experiences and needs for distributed liveness.

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Audience Engagement

Latulipe et al. defined audience engagement in terms of affective states of arousal (sleep-activated) and valence (positive-negative) [12]. They used galvanic skin response (GSR) sensors to measure individual's arousal while watching videos of dance performances. Wang et al. used a hybrid method that combines GSR data and survey responses for determining the audience engagement during a play [19]. Mobile devices have been used to collect audience feedback, in the form of likes and dislikes [17] and comments and responses to questions [6]. Corness et al. used interviews to provoke audiences to re-live a performance and measure their empathy towards performers [7]. Teevan et al. visualized audience engagement using graphics, in which circles changed colors based on engagement [17]. Alternatively, Cerratto-Pargman et al. displayed text messages from the audience on a large display behind the actors [6].

Performance and Technology

Theaters are exploring new ways to use broadcast and teleconferencing technology in live performance. The UK's National Theatre successfully broadcasts live performances of plays onto cinema screens around the world [13]. However, this is still one-way communication. Miracle Theatre recently used the Vconnect platform (teleconference system) to perform the play *The Tempest* between two locations, where both actors and audiences were distributed [20]. Teleconferencing systems provide visual and auditory audience feedback, but our investigation found that this is often not enough for performers to form connections with remote audiences.

Broadhurst describes how technology in performance creates tensions at the threshold between physical and virtual spaces [5]. She suggests "it is within these tension-filled spaces that opportunities arise for new experimental forms and practices." Benford et al. experiment with mixed reality performances in which physical and virtual spaces are combined with live performance and interactivity [3, 4]. Audience members become directly engaged as interactive participants. Connections between performers and audiences are supported through hybrid spaces. We investigate the experience of performers in traditional live performance contexts where the audience is a participant, but not necessarily an interactive one. Audiences in traditional live performance are becoming more interactive with new uses for mobile technologies, such as second screens as alternate views on a performance [2]. Our focus in this investigation is on performer experiences and how technologies can support or limit their engagement with audiences.

METHODOLOGY: INTERVIEWS

To construct an understanding of how performers sense audience engagement and the differences between physically co-present and distributed performances, we performed a qualitative investigation together with performance artists.

We conducted semi-structured interviews with eleven artists including five musicians, three actors, two dancers, and one director (Table 1). All of them are successful professionals, with training and careers in performance. Their levels of

experience with distributed performance varied. Participants were recruited from institutions already engaged in exploring creative intersections between art and technology.

Interviews were conducted via video chat, with the exception of one participant who was interviewed via e-mail. Interviews lasted from 30-60 minutes. Participants were asked about their experiences in sensing a live audience both in physically co-present and in distributed performance. Video and audio were recorded. Researchers took observational notes during interviews.

After each interview, researchers discussed observational notes. Potential interesting phenomena were identified. Interview questions were revised to help ask clearer, more specific questions directed at emerging phenomena.

Interviews were transcribed. Transcripts were broken down into units of meaning. Over 600 units were derived from the data. We performed open coding [16] on units to iteratively derive emergent themes. We initially developed over 20 codes. Codes were categorized into four themes presented in the following section.

FINDINGS AND DISCUSSIONS

Our analysis of interview data discovered several themes. First, how spaces are connected can prevent social interaction despite the intention of supporting social co-presence. Second, distributed liveness requires active attention from performers, in order to sense audience engagement. Third, performers sense engagement of physically co-present audiences through subtle physical cues that are lost in distributed settings. Fourth, abstract representations of audiences can be effective at conveying engagement to performers.

Challenges in Social Co-Presence

Performers experience problems connecting with distributed audiences when using technologies intended to support social interaction among performers and audiences, such as video and audio communication channels. Musicians, in particular, described how in physically co-present settings, they are able to socially interact with audience members during setup, sound check, between songs, and after the performance. However, they felt socially disconnected in distributed settings, despite video and audio channels supporting two-way communication with the audience.

M2: It makes a difference that fact the audience is there. It makes a difference that I'm aware that the audience is there, and I try to make sure that what I perform is something that I would like to hear, and I'm not just experimenting the whole time ... It's not the same as going to a venue. Talking to the people there. Making sure that the wires are well connected. Having people come in slowly and realizing, "Oh, shit! This is actually a real thing."

Being physically co-present supports performers developing social awareness about a space, even without paying close attention to what is going on in that space.

M1: When you are in the room, you're together in a space with the sound, the physical movement of the sound. You are

Table 1. List of participants, ID, performer type, gender, and expertise in performance and with distributed liveness. Performance expertise describes participants' experiences in the roles of performer and designer. All performance designers were also expert performers. Distributed liveness expertise is based on number of distributed performances where participant was involved, and the role that participant took in designing performances.

ID	Type	Sex	P. Expertise	Distributed Liveness Expertise
A1	Actor	F	Expert	<i>Novice.</i> Interactive theater piece with mobile video; some performers were not physically co-present with other performers and the audience.
A2	Actor	F	Expert	<i>Expert.</i> Combined theater and music pieces across two physical locations. Performers and audience in both locations.
A3	Actor	F	Expert	<i>Novice.</i> Instructional performance for planning a distributed theater performance; she was not physically co-present with audience.
D1	Dancer	F	Designer	<i>Expert.</i> Distributed performance designer. Art performances in which she was not physically co-present with other performers or the audience.
D2	Dancer	F	Expert	<i>None.</i>
M1	Musician	M	Expert	<i>Expert.</i> Many performances; various levels of physical, social, and spatial co-presence.
M2	Musician	M	Expert	<i>Novice.</i> Improvisational music performances; he was not physically co-present with other performers or audiences.
M3	Musician	M	Expert	<i>Novice.</i> Improvisational music performance; he was physically co-present with audience and several performers. Other performers were not physically co-present.
M4	Musician	M	Designer	<i>Expert.</i> Distributed performance designer; physically co-present with audience and several musicians. Other musicians were not physically co-present.
M5	Musician	M	Expert	<i>Novice.</i> Improv. music performances; not physically co-present with others.
R1	Director	M	Designer	<i>Novice.</i> Interactive theater piece with mobile video; some performers were not physically co-present with other performers and the audience.

in the same space as the musicians and the audience, so even if you are not necessarily paying attention to it, I think we must be aware of what's happening in that space.

Performers want to socially interact with audience members, but the technology does not always facilitate such interactions with distributed audiences. Providing two-way communication does not insure that performers and audiences will experience remote participants as live. In one example, actors in Korea talked to an audience in New York via live video, but audience members failed to recognize the actors' liveness.

A2: I thought it would have been really great to react and talk to the audience, because I wasn't even sure if they were aware of us being in Korea. I got feedback from New York afterwards, and they said some of the audience members were actually confused. When they were informed later that we were actually in Korea performing at 6 in the morning, they were like, "Oh my god! That was Korea." Some of the people weren't aware of us being in Korea and doing telepresence. They thought that was just a video clip of something. Although, we talked in it with them.

While performers described the importance of social interactions in the moments before and after a performance, the amount of interaction with the audience during the performance varied by performer and context. Several of the musicians and actors expressed concern about certain audience reactions that they believed could harmfully affect the performance, such as audience members ignoring the performance and talking to each other. The participants wanted flexible control in distributed settings over the kinds and amount of audience response transmitted to them.

M3: It's nice to have that constant connection with the venue. In terms of visual feedback, I would always like to have it there in some form. The form could change in little ways that

the data was being displayed. ... I would always like something there, so that I might not have to be looking at it all the time, but if you were just to glance across at the screen you could quickly see how things were with the audience.

Audience feedback is delayed due to technological limitations. This disrupts continuity of feedback loops, creating cyclic periods of performing and watching. A participant performs an action that requires a response, and then must wait to observe reactions from the audience or another performer.

D1: Because there is always a slight delay, there's always an element of I do it and I watch. So, there's a little bit of that tiny time segment of what is performance. Do and watch. You know in that sense that we are witnessing each other as well as engaging with each other.

Performer Attention to Distributed Liveness

The lack of physical co-presence in distributed performances challenges performers' abilities to be attentive to remote audience engagement. A performer must adapt how she directs her attention towards audiences in other spaces. The common approach for connecting spaces is to provide video or audio streams of the other spaces. These connections filter what a performer is able to perceive about an audience, providing a limited, focused representations of a space. Performers must actively direct visual attention at a display with a video stream. Each connected space is often represented by an individual display, requiring performers to divide their attention among several different displays. As a result, participants expressed favoring auditory feedback more than visual in past distributed performances.

A2: More audio than video. Because of the nature of the telepresence, it is really hard to focus on different screens at the same time. So, I can only focus on the other performer or on the other location.

When physically co-present with others, performers will build connections with those around them (e.g., technicians in a studio or performers in the same space). The shared physical space and the directed attention of those observing creates a localized performance within the larger hybrid space.

D1: *The audience changes, because even when you are doing a remote performance, the reality is that you do have an audience. You have people in the lab, and you can't help but connect with the people that you are with ...*

Thus, the model of distributed liveness consists of smaller, localized performances that are combined to constitute a whole, connecting spaces, performers, and audiences.

Sensing Engagement through Subtle Feedback

Participants reported using sensory feedback involving vision, hearing, and kinesthesia to sense audience engagement in physically co-present settings. Much of the feedback described involved subtle physical responses from the audiences reflecting changes in emotional state or engagement, such as facial expressions, tightening of muscles, or a shared energy. In particular, dancers and actors described this physical feedback as kinesthesia or proprioception, sensing through the positioning of body parts and movement. When an audience is engaged, the performers and audience are physically synchronized (e.g. sharing similar respiratory patterns).

D1: *If I do something that has constant inhales, [inhales deeply several times] and I keep doing this; the way human beings are designed is that we mimic, so the audience will start doing that. When you are doing extreme things on the stage that involve breath or risk taking, you can feel the audience's kinesthetic engagement with you; and that is a powerful thing. That really makes you feel connected.*

Performers want to feel the audience's presence and engagement. The audience's physical presence gives energy to the performers, creating a unique live experience for all.

D2: *When there are a lot of people gathered around you, of course, there is an energy. That's a natural energy of human beings being together as a collective, which is an experience that we don't have very often.*

Participants primarily experienced audience presence in distributed performance through cameras and microphones, used to capture views and sounds of the audience and stream those to the performer. Participants reported problems with this approach for conveying the subtle feedback of human expression and engagement of distributed audiences.

M4: *The artist-audience relation becomes even more pronounced. Which is unfortunate, because you want to think of the internet as very egalitarian, democratic. But when you put it in that context, only the local audience is so specialized. You really feel that difference even more so. Yes, it is harder to tell whether or not they are actually engaged. It's difficult to know if people are smiling. A smile is a difficult thing to capture, even with a good camera. Particularly, when people are moving, and they don't want to be on camera themselves. Those little differences in peoples' faces. The look of excitement. Very hard to communicate that through a screen. Those*

are things that are really missing for a performer. They just can't get those subtleties of human expression.

In traditional stage performances, such as theater, opera, and ballet, the absence of sound can be an indicator of audience engagement. During intense moments, a performer expects the audience to be on the edge of their seats silently engaged. If the performer hears the audience rustling, it could be an indication that audience members are disinterested.

D1: *Silence can also be an incredible indicator. [The audience] retracts in a way. That's also really powerful. You feel they give you the space to go deeper into your moment, which might sound like a contradiction. That they kind of recede and you feel even more alone or quiet and silent, but in a way it connects you even more.*

Representations of Audiences

Distributed liveness is supported by providing representations of audiences to remote performers. In one context, improvisational musicians performed together in a distributed live event where movement of audience members, sensed by a camera, was translated into abstract graphic scores for the performers. As the score changed, so did the music they produced. The abstract visual representation was interpreted by the performers not only as a musical score, but also a form of visual feedback about audience engagement. Increased movement in the graphic score, indicated a highly mobile audience, with people coming and going and not particularly engaged with the performance. Slow movements indicated an audience that was standing still and watching the performance.

M3: *As the room sort of filled up and emptied out, then the density of the score would change. You couldn't literally see that it was people that you were looking at. You see it more as sort of shapes moving. Which is very interesting to play to, as a performer's perspective, because for one it gives you a gauge on how many people you are actually playing to. You can tell how many people are in the room at any one given time. And two, it sort of gauges how people are responding, reacting to what is going on. I sort of had it in my head that if people were standing still, if there wasn't a lot of motion happening, generally that would sort of mean that the audience was engaged and concentrated on listening to what we were playing as opposed necessarily to if there was a lot of motion people moving around, coming in and out, the opposite.*

The graphic score was combined with a microphone feed of the audience space. Sensory feedback loops between performers and the audience emerged. Audience members movement provided visual feedback to performers, and resulting musical changes in the musicians' performances fed back to the audience. Indirect spatial co-presence emerged through abstract representations in a virtual space.

IMPLICATIONS FOR DESIGN

We present implications for the design of new performance environments to support distributed liveness. Designing hybrid spaces that give performers flexible, directed control over social interactions with audiences will improve experiences of liveness. The physical separation of spaces in distributed

liveness requires new methods for sensing subtle visual, auditory, and kinesthetic reactions from distributed audiences, and conveying that feedback abstractly to performers.

Design Hybrid Spaces for Flexible Social Co-Presence

Distributed performances bring together performers and audiences across different spaces, both physical (e.g. theaters) and virtual (e.g. YouTube streams). Design for distributed liveness creates hybrid spaces [4] that mix the physical and virtual. Physical spaces situate performers, audience members, and objects. Virtual spaces are comprised of representations of people and their engagement.

We need to design hybrid spaces to effectively support social co-presence in distributed performances. The technology used to connect spaces impacts how performers and audiences form connections with each other. Despite the provision of visual and auditory channels, meant to convey social cues, performers reported difficulty socially interacting with distributed audiences. Without rich social interaction, performers expressed feelings of isolation, along with confusion for audiences about the liveness of the performance.

Several participants wanted ways to engage in direct social interaction with distributed audiences. One way that this is presently supported is text chat. Examples of hybrid spaces that effectively support social co-presence through text chat can be found in the virtual game spaces of *Can You See Me Now?* [3] and live streaming environment of Twitch [10]. In performance art contexts, reading text chat during the performance would be difficult for many of our participants. Yet in these contexts, technology should still support performers interacting with audiences before, during intermissions, and after the performance. For example, performers should be able to view audience text chat, toggle on video and audio feeds, and talk to audiences directly, addressing questions, chatting about the performance, as well as see and hear how other performers are engaging specific audiences.

Sense Subtle Feedback, Convey Abstractly

Performers identified the importance of sensing audience engagement through subtle visual, auditory, and kinesthetic feedback. The physical separations and clear boundaries effected by video screens and speakers make prior teleconferencing systems inadequate for conveying this feedback.

We need to develop new techniques for sensing and conveying audience engagement. Physiological sensors, such as those for GSR, respiration rate, electromyography, provide means for measuring audiences' and performers' bodily responses. Participants described forming connections with the audience and other performers through similar bodily experience, such as shared breathing patterns, heart rates, or muscle tension. Physiological sensors have been previously shown as effective measures of audience engagement [12, 19].

While invasive sensing technologies are suitable for experimentation, deployment in the wild requires non-invasive techniques that address privacy concerns. New commercial devices for health and fitness, such as Apple Watch¹ and Fit-

¹<http://www.apple.com/watch>

bit², provide personal sensing of physiological data, such as heart rate and body movement. These sensing technologies can be combined with mobile applications that operate only in local areas. This would enable audience members to opt-in to collection of anonymous sensor data in commercial performance venues, such as theaters, to participate in distributed liveness. This approach enables performance venues, such as theaters broadcasting the Met Opera, to serve as distributed liveness venues. Standards and compliance certification for how-to collect such data and guarantee privacy would ameliorate, but not eliminate, privacy issues.

We advocate representations that convey subtle sensory feedback. Some musicians we interviewed had experience performing in response to abstract representations of distributed audiences. They found these representations helpful for perceiving audience engagement. Abstract representations avoid overwhelming attention. They are ambiguous and allow performers to form their own interpretations. Gaver et al. point out that “ambiguity can be frustrating, to be sure. But it can also be intriguing, mysterious, and delightful. By impelling people to interpret situations for themselves, it encourages them to start grappling conceptually with systems and their contexts, and thus to establish deeper and more personal relations with the meanings offered by those systems” [9].

Representing kinesthetic feedback requires using physical devices beyond screens and speakers. For example, heart rate data could be represented with a pulsating arm band that expands and contracts to mimic beats of the heart. This representation is a form of wearable *kinetic garment*, containing mechanical components, such as actuators, that move in response to physiological data [15]. Such garments will pronounce kinesthetic engagement in new ways to performers, as compared to traditional physically co-present settings. Devices, such as TVs and headphones, which convey visual and auditory feedback, reproduce light and sound waves for our eyes and ears, as if physically co-present where original stimulus was produced. Devices for kinesthetic feedback produce a new sensation that seeks to mimic the original stimulus, but it is not the same. Performers will have to train their kinesthetic senses to interpret feedback from these devices. Conversely, remote audience members can wear kinetic garments, creating bi-directional kinesthetic feedback loops.

CONCLUSION

We coined the term *distributed liveness*, to refer to an emerging aspect of computer-supported collaborative performance with broad impact on creative human experiences. The Internet provides means to connect performers with audiences from around the world. Yet, this technological connection often fails to provide a shared sensory experience. Performers and audiences are physically and often temporally separated. Performers become unaware of remote audience experiences. We contextualized this historically, noting that liveness is a socio-technical construct, nearing a century in age.

We conducted interviews to understand performer experiences of liveness in different settings. Analysis of our find-

²<http://www.fitbit.com>

ings contribute implications for design of distributed liveness environments. Hybrid spaces for distributed performances need to support flexible social co-presence, enabling performers to switch among levels of social interaction at different moments in a performance. We need to develop new ways to sense subtle physical cues of audience engagement, and communicate audience response without overloading attention.

As an emergent arena of phenomena, distributed liveness provides avenues for exploration of diverse, new forms of computer supported collaborative work and play. In addition to the performing arts and games, we envision designing new classroom environments for distributed liveness, in which virtual spaces connect classrooms of students at multiple institutions, as well as students at home, in shared learning experiences. Abstract representations of aggregated sensory data from remote participants, in concert with live streaming, will enable teachers to sense remote student engagement and address gaps in student attention.

A result of the seams inherent in experiences of distributed liveness is that we must co-design performance and technology, because the tandem fundamentally prescribes participant experiences. Seamful design strategies, in which performance is composed while taking into account limitations, such as delay, is one part of this. Another is to build representations that holistically combine sensory feeds, using a strategy such as information composition [11].

Co-designed approaches to distributed liveness have the potential to transform the nature of performance events, connecting participants physically, spatially, temporally, and socially in new ways. As technology changes performance, so performance must change, creating new hybrid forms [5]. Performers will need to broaden their skills, learning to interact with new technologies and engage in new types of performance. Likewise, writers and directors will need to account for the characteristics of seams and the situated technologies that produce them. We look forward to new hybrid spaces and works that engage collaboration through distributed liveness to achieve compelling, participatory forms of performance.

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