Ambient Environments for Emotional Physical Communication

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ABSTRACT
This paper extends our understanding of existing physical and gestural interfaces and presents a potential design space in affective computing using human movement as a form of emotionally expressive interaction across physical distances. We discuss a conceptual design in which emotive, non-verbal modes of social collaboration can facilitate remote communication over networked intelligent environments. Exploring this idea for such an interaction can help us consider future contexts in facilitating more expressive and communicative human-human interaction.

Categories and Subject Descriptors
H.5.2 [Information Interfaces and Presentation]: User Interfaces – haptic i/o, input devices and strategies, interaction styles, theory and methods, user-centered design.

General Terms
Design, Human Factors

Keywords
Ambient intelligence, communication, emotion, physical movement, tangible interfaces, user experience

1. INTRODUCTION
Emotional design and tangible interaction are compelling forms of enhancing user engagement. The combination of these modes of interaction can create a new dimension of human experience when physical movement in space or the manipulation of objects triggers emotions within an individual. By seamlessly integrating expressive tangible interaction techniques with ambient intelligence, that is, by creating environments that are sensitive and responsive to human gestures, meaningful experiences can be constructed.

Motivated by our study of the research and findings conducted by Lee et al. [10], the aim of this paper is to extend our existing understanding of movement and tangible interfaces to the potential design space in affective computing using human movement as a form of emotionally expressive interaction across physical distances. We draw upon background theory and existing frameworks for exploring the possible relationship between emotional design, tangible interfaces, and ambient intelligence in our own conceptual design. We propose the concept of involving emotive, non-verbal modes of social collaboration for facilitating remote communication over networked intelligent environments. This concept, while preliminary, contributes further possibilities and considerations for future contexts of affecting computing to facilitate more expressive and communicative human-human interaction.

We begin by briefly introducing the various areas of interaction design relating with our research. Next we provide theoretical background of the frameworks and research involving movement and emotion. We then seek a concept to synthesize these two forms of interaction within a coupled network environment and discuss the considerations, limitations, and context of use of such a design. We conclude with a discussion of the future role in which ambient environments for emotional physical communication facilitate more expressive and communicative human-human interaction.

1.1 Theoretical Background
The following section outlines previous background and research information in the areas of emotional design, physical and tangible interfaces, and ambient intelligence.

1.1.1. Emotional Design
Emotion is a fundamental aspect of what makes us human; it shapes our cognition, perception, memory, and learning and it colours our past, present, and future experiences [1][2]. Emotional value is important in design for enhancing user experience as Donald Norman [13] explains: “Our attachment is really not to the thing, it is to the relationship, to the meanings and feelings the thing represents.”

Emotional design then, provides an aesthetic interaction that engages users on an emotional, meaningful, and psychological level [8]. Whereas affective computing focuses on the system recognizing and adjusting to what it believes the user is feeling, emotional design focuses on the emotional experience [6]. Previous research and work in this area include an affective alarm clock [8] that creates an emotional relationship between object and user, for example.
1.1.2. Physical and Tangible Interfaces

Human movement is often spurred by intention and motivation within people. Tangible user interfaces (TUIs) allow users to interact with digital information by sensing and manipulating physical environments through objects, surfaces, and spaces. They focus on natural physicality and sense of touch rather than traditional graphics-based interfaces as touching and feeling provide a greater understanding and meaning of our environment [3]. Many examples of TUIs can be found in existing entertainment systems that respond to human gesture and movement. As much as these interactive systems sense human movement and gestures, they do not employ these rich communicative gestures to stimulate emotional meaning in the interaction.

1.1.3. Ambient Intelligence

Ambient intelligence refers to socially-aware environments that seamlessly integrate technology into objects and environments [15]. Ambient intelligence enhances social interaction and behaviour in an environment by learning and adapting to the user’s context of use in daily rituals and everyday life. Nack et al. [11] developed affective pillows that adapted the environment according to the mood sensed from the user or transformed themselves to provide functionality for supporting a current task. By understanding how people inhabit their environment and being able to infer intention and adapt to contexts and patterns of behaviour, a meaningful interactive experience be created.

2. THEORIES OF EMOTION AND MOVEMENT

In order to understand the relationship between emotion and physical movement, we examined several research studies that formulated framework models in the area of emotional interaction through physical movement and human movement and emotion in interaction.

2.1 Emotional Interaction through Physical Movement

The research conducted by Lee et al. [10] explores the impact of using physical movement to enhance the emotional value and expression of a product. Lee et. al studied Kepes and Moholy’s classification of formal components of movement, which are as follows: rhythm is the interval of time between a motion and the next motion, beat refers to the rhythmic flow or pace, sequence describes time-based events that relates to both rhythm and beat, and direction is generated from sequential movement in space.

Besides studying movement, Lee et al. also acquired an understanding of the classification and characteristics of emotion. In order to develop a relationship between emotion and movement, they used a multidimensional categorization based on psychologist Russell’s Circumplex Model of Affect, which organizes emotion on the two axes of pleasantness and activation. Activation relates to the speed and volume of movement, while pleasantness relates to smooth or jerky movement. They developed the Emotion-Movement relation framework based on two elements of emotion and three elements of movement: velocity refers to rhythm and beat, smoothness as sequence and uneven rhythm, and openness as direction and volume.

This research conducted by Lee et al. focused on the physical movement of products to increase emotional experience; however, limiting this application of movement to inanimate objects also limits the potential for greater expressivity that can be enabled by our own bodies. A more interesting and compelling application of the Emotion-Movement relation framework, thus, would be to extend it to organic human movement, gesture and expression to activate an emotional interaction with objects, spaces, and environments.

2.2 Human Movement and Emotion in Interaction

Human movement is an emotionally expressive form of communication. Thus, it would be natural to employ physical human movement within an affective system to augment emotion during an interaction. Existing research exploring emotional interaction driven by human motion includes studies that have further analyzed the Circumplex Model of Affect to apply to movement of the human body and systems that support and build social relationships.

Fagerberg et al. [6] studied various theories of emotion and movements and designed a language of emotional expressions using a combination of shape (changing forms of the body in space), effort (space, weight, time, and space) and valence (pleasure and displeasure) for affective interaction.

Engaging interactive systems have been developed that engage users in emotional communication with others by responding to physical gestures. Gustbowl [16] and Buddy Beads [9] support affective remote communication and strengthen relationships through natural manipulation of everyday objects. Although these examples demonstrate the use of human gestures and motion to facilitate personal communication, they do not actually recognize and interpret movement into emotion and respond accordingly. Therefore, we aim to investigate the idea of using movement and gesture as an expression of emotion for social interaction.

3. DESIGNING FOR EXPRESSIVE COMMUNICATION IN AMBIENT ENVIRONMENTS

Ambient environments have been designed for a user experience rather than focusing on tasks as exemplified in an atmospheric room controlled with an expressive tangible interface [14]. Nonetheless, there still lacks emotional tangible interfaces in our everyday environments. With this shift from “technology use” to “technology presence” [14], ambient intelligence can naturally be used to support free-form expressive human movement as a mode of interaction integrated in our daily context.

We thus propose a preliminary concept of a coupled ambient environment network that can sense people’s physical movement in space and interpret their movement as emotions based on Faberg’s emotion-movement framework. For example, sadness involves movement that is slow and directed downwards, while angry movement is fast, sudden, and forceful with tension in the body [17]. The perceived emotion is then used as communication input from the sender’s environment to that of his/her loved one by affecting the receiver’s physical environment through change of lighting, colours, music and projected images.
Changes to the receiving environment would be reflective of the mood and actions of the sender. An emotional and collaborative connection can be established when the receiver acts on the perceived emotions by conducting responding movement that in turn affects the sender’s own environment (figure 1). Physical distance is therefore bridged between the participants and creates an aesthetic interactive experience using alternate means of personal communication that takes into consideration their physical states, actions, and environment. In this section we examine universal gestures, context of use, natural user interface, and emotional awareness as mechanisms for expressive communication across physical distances.

![Figure 1. Interaction sequence of emotional environments.](image)

### 3.1 Universal Gestures

In order to properly translate emotion from physical movement and expressions, the system must recognize and interpret these gestures from a commonly used set. This can be achieved through performance data collection by using video and audio recordings of movements and facial expressions.

Cross-cultural studies have shown that many facial expressions are universal and biologically based rather than culturally based [4], but what can be said about bodily expression? Weerdesteijn et al. [17] conducted experiments with kindergarten children in the Netherlands, where researchers verbally described an emotion and played appropriate music to have the children physically express that emotion. The various expressions of emotion shared similar characteristics among the different children. An interesting extension of the study then would be to conduct the experiment with participants of different cultures and backgrounds.

After determining a universally shared set of bodily movements representing emotion, we can subsequently employ Fagerberg’s framework of mapping shape, effort and valence to an emotion.

### 3.2 Context of Use

In real-world interactions humans socialize through verbal, non-verbal, and collaborative means. Non-verbal communication is an efficient way of unintentionally conveying powerful messages about our inner emotional state. Sometimes facial expression and gestures serve as more effective means of expression than words because language is inherently limited by cultural context [18]. However, over long-distances we are constrained to verbal or text-based technological modes and we subsequently lose the intimacy and spontaneous personal expression that are fundamental to fulfilling social interactions. Thus our expressive ambient environment promotes collaboration, sharing, and social interaction between friends and family as a means of maintaining close connections over distances.

Environment interfaces can be affected both synchronously and asynchronously. Synchronous communication occurs in real-time, where one action is immediately reflected in the connected space. In the case where only one person is present, communicated signals are not expressed until the receiver enters his/her room afterwards. Signals sent between the users would be subjectively interpreted by the users based on their shared vernacular and culture. This form of haptic and non-verbal communication can provide the participants a sense of togetherness while triggering positive emotions during the interaction, resulting in a potential for transforming the dynamics of long-distance relationships or empowering lonely hospital patients.

### 3.3 Natural User Interface

Ubiquitous computing techniques of integrating technology into everyday artifacts and environments permit participants to inhabit and move naturally around their space. Sensing technologies would be employed to detect user presence and recognize various types of physical expressivity, such as the shape of body movements, rhythm, and valence. Cameras and motion sensors are required to detect and capture all the movements and gestures of the actor. Floor pressure sensors are useful for sensing the effort and force exerted in a movement that otherwise would not be recognized by motion sensors. Wireless networking enables the two connected rooms to communicate and affect each other.

Smart artifacts and surfaces seamlessly integrate within the participant’s environment insofar as it permits the creation and personalization of the space and atmosphere. Visual displays such as image projection on walls, lighting and colour schemes based on colour theory and associations with mood [7], as well as audio devices playing music or sound would react and activate based on the emotion sensed from the sender’s remote environment. Resulting audio may be selected based on the measured relationship between emotion and musical data [12]. Further considerations may also include cross-cultural differences in the receiver’s perception of visualizations and environmental contextual changes.

### 3.4 Emotional Awareness

Creating an emotionally sensitive environment requires certain design considerations. Not only does the system need to be able to recognize human expressivity and movement, it must also be able to understand and interpret what the person wants to express. This includes being able to account for individual differences, personal style, and creativity as well as allowing for freedom of improvisation. One powerful potential is the ability for the system to learn an individual’s style and their change in emotional expression over time and adjust its recognition and responses based on established patterns. Another important aspect is having the system understand a user’s current context and adjust accordingly to his behaviour. For example, when the user is sleeping or working he would not want to be disturbed by incoming ambient signals and would rather prefer to maintain privacy within his own space.
4. CONCLUSION AND FUTURE APPLICATIONS

In this paper we examined the theories of emotion and movement and the resulting research implications of emotion-movement relation frameworks that analyze and map properties of movement to an emotional expression. By synthesizing these two forms of human expression, we can establish more engaging and meaningful social interactions. Ambient environments offer a physical, tangible and natural way in which people can go about their daily tasks and rituals; however, the lack of emotional quality does not lend itself to enjoyable or sociable interactions.

We therefore proposed the concept of a system of emotionally intelligent environments that combines the two areas of physical and affective computing and engages users’ movements to support emotional communication, social awareness and physical collaboration over long distances. This aesthetic interaction focuses on supporting human behaviour and creating meaning through interaction rather than on simply usability or ergonomics. We shall then observe our everyday activities transforming from conventional human-computer interaction models to those of human-human and human-environment interaction.

By exploring this new design sphere we can consider future contexts in facilitating more intimate human-human interaction. Future application possibilities include addressing patient isolation within hospitals or nursing homes in order to not only connect them to the outside world, but to provide a comfortable and enjoyable habitable environment. An emotionally-coded room could also help autistic people, who are unable to process implicit emotional cues and require explicit information [5], to easily interpret emotional states via altered objects, sounds and ambience. And finally, people facing with language communication barriers such as speech disorders would have a communication outlet through which to freely express themselves.

5. REFERENCES


