Wearable Forest Clothing System: Beyond Human-Computer Interaction

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ABSTRACT

Wearable Forest **is a garment that bioacoustically interacts with distant wildlife in a remote forest through a networked remote-controlled speaker and microphone. It expresses the unique bioacoustic beauty of nature and allows users to interact with a forest in real time through a network to acoustically experience a distant forest soundscape, thus merging humans and nature without great environmental impact. This novel interactive sound system can create a sense of unity between users and a remote soundscape, enabling users to feel a sense of belonging to nature even in the midst of a city. This paper describes the theory of interaction between the Human and the Biosphere through the design process of the Wearable Forest concept.**

Introduction: Contradictive Link Between Human Beings and Nature

Wearable Forest, shown in Figure 1, is a clothing system that bioacoustically interacts with distant wildlife in a remote forest through a networked remote-controlled speaker and microphone as shown in Figure 2 [1, 2]. It is based on the concept of human-computer biosphere interaction (HCBI) [3], described in Figure 3. It aims to express the unique bioacoustic beauty of nature and allow users to interact with a forest in real time through a network and acoustically experience a distant forest soundscape, thus merging human beings and nature without great environmental impact.

Figure 1. ***Wearable Forest Local System for Human-Computer-Biosphere Interaction*****. Non-verbal communication beyond the physical and inter-species barriers. © 2008 Hiroki Kobayashi, Ryoko Ueoka, Michitaka Hirose. Photo Masaharu Hatta.**

Our relationship with nature is constantly evolving to maintain human civilization. And yet, nature is being destroyed in the process of urbanization. The environmental movement, which promotes conservation areas for preservation purposes, has ironically increased the demand for tourism in these areas and thus accelerated the speed of environmental destruction [4]. Nevertheless, a sense of connection with nature is indispensable for emotional balance. Japanese Zen Buddhism, for example, encourages deep meditation in order to achieve a sense of being at one with nature [5]. The sounds of birdsong, buzzing insects, gently swaying leaves, and the trickling of water in a forest can imprint the beauty of nature in our memory.

In previous studies, the authors developed a networked bioacoustic streaming and recording system by which environmental sounds in a sub-tropical forest on Iriomote Island, Japan, moving water in a pond in Tokyo, aqua-music instruments in a Japanese garden in Kyoto, and a street in Mumbai, India are continuously streamed in real time by networked microphones [6, 7]. The authors also developed a human-wildlife bioacoustic interaction system for efficient remote monitoring of wildlife that introduces the concept of HCBI [8]. This system, Wearable Forest, presents the possibility of a new relationship: non-verbal interaction with nature in daily life through the telepresence of different species.

HCBI Concept Overview

Wearable Forest is based on the concept of HCBI, described in Figure 3, presented as an extension of human-computer interaction (HCI) [9] and human-computer-pet interaction (HCPI) [10]. The field of computer-supported cooperative work (CSCW) is based on such computer-interaction paradigms to support specific activities. For instance, we exchange our ideas, thoughts, theories, and messages by encoding them into transferable words, communicating them through computer systems, and decoding them. However, in our daily lives, we implicitly exchange and share a great deal of additional non-verbal information, such as the presence and mood of others, to maintain our social relationships [11].

Figure 2. ***Wearable Forest Remote System for Human-Computer-Biosphere Interaction.*** **Networked audio I/O system placed in an uninhabited subtropical forest on Iriomote Island, Japan (24°20'N, 123°55'E). © 2008 Hiroki Kobayashi.**

The consideration of implicit (background) information opens up new possibilities for interaction through non-linguistic, wearable forms and non-verbal, remote communication among different species. Wearable computing enables us to express ourselves through fashion in order to develop human-to-human communication [12, 13, 14]. HCPI, as described in Figure 3, is a novel type of physical interaction paradigm that proposes to create symbiosis between humans and pets through a computer and the internet as a new form of media. Botanicalls was developed to provide a new way for plants and people to interact in order to develop better, longer-lasting relationships that go beyond physical and genetic distance [15]. Thus, computer systems become a medium to express telepresence among different species in the biosphere through their non-linguistic expression as perceived and understood by individuals, violating the rules of linguistic science [16].

However, no matter how advanced the technologies are, these are human-centric interactions. We expect some perceivable feedback from others in response to our command before we end an interaction. On the contrary, in our daily lives, there are many non-human-centric interactions. The sounds of singing birds, buzzing insects, swaying leaves, and trickling water in a beautiful forest implicitly imprint the beauty of nature in our minds. When we are emotionally stressed, recalling the beauty of nature can help us recover a sense of well-being.

The crucial factor here is not the means of conveyance (words or language), but “something” hovering around, or an atmosphere that we cannot exactly identify. This interaction follows the teaching of Zen Buddhism, the Japanese love of nature. Zen is one of the products of the Chinese people, which was introduced into China in the first century AD after their contact with Indian teachings of Buddhism.

The authors propose HCBI, the concept of human-computer biosphere interaction, to extend the field of interaction from countable objects, pets, and plants to their auditory environment, which is an uncountable, complex, non-linguistic soundscape, something surrounding, much like Zen elements. In the HCBI vision, the sounds in a forest, or other natural environments, are integral to helping us feel one with nature. Thus, with HCBI, we listen to and feel the telepresence of the global ecological system, integrating all living beings and their relationships, including their interaction with the elements of the biosphere. With HCBI, we begin to interact with subjects beyond physical and inter-species barriers.

Interaction Design: From a Law of Acoustic Ecology

Natural communities contain a spectrum of life forms that interact with one another [17]. Many scientists agree with the statement that the essence of ecology is the study of interactions among species in their native habitats [18]. In particular, animal communities in tropical forests have extremely complex interactions involving vast numbers of species [19]. The natural sounds in a rainforest convincingly demonstrate the special relationships among the many insects, birds, mammals, and amphibians [20]. Several field recordings prove that when one creature stops vocalizing, another immediately joins the chorus [21]. Therefore, the animals interact bioacoustically with other animals according to the biological diversity of their habitat. We used bioacoustic information to develop the concept of human-computer biosphere interaction.

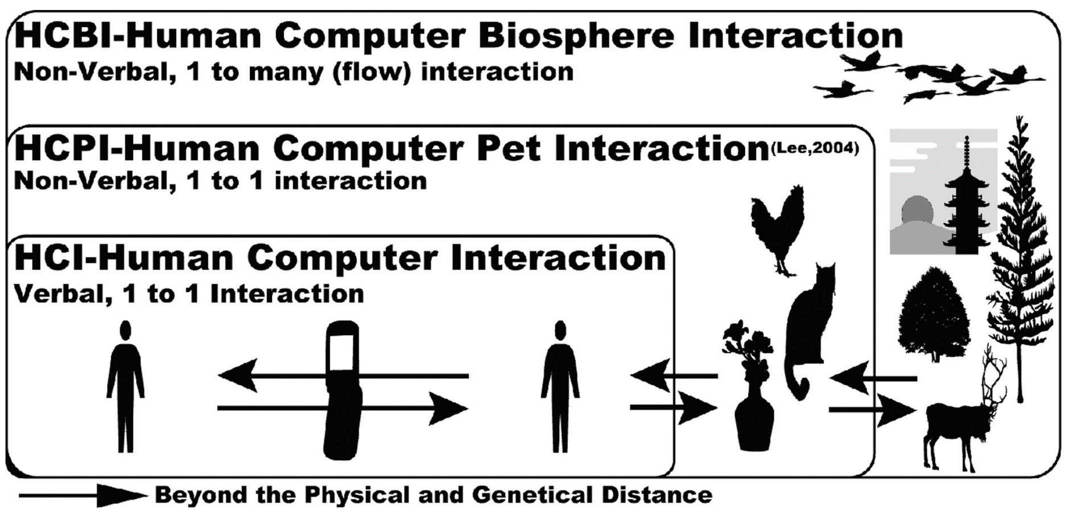

Figure 3. Human-computer-biosphere interaction (HCBI) concept, an extension of HCI and HCPI. © 2008 Hiroki Kobayashi, Ryoko Ueoka.

To establish non-verbal interaction between different species, an HCBI interface artificially creates a virtual acoustical field to acquire feedback from remote wildlife. It is modeled on three kinds of natural interaction: interspecies predator-prey relationships, intraspecies communication, and mixed-reality intraspecies communication. First, a predator hunts prey in its native habitat as shown at the top of Figure 4. Bioacoustic information is one of the signals employed by predators to detect the existence of prey in the surrounding area. A scarcity of prey in the habitat indicates the absence of predators. Secondly, intraspecies communication is considered to be a chorus produced by a group of the same species in Figure 4 (middle), rather like the Packet Internet Grouper (PING) command of the Internet Control Message Protocol between two computers [22]. A single individual, the caller, starts calling other individuals to confirm their presence. The other members of the species then randomly respond to the call and report their existence to the caller. Third, a species can conduct intraspecific communication in mixed reality.

The bottom of Figure 4 shows a user playing back a pre-recorded sound of an initial call from an acoustic speaker; the speaker is placed in the natural environment and controlled by a remote-controlled PC over the internet. The real frogs answer the initial call and report their existence. The initial call (the virtual call played by the speaker) can deceive the real frogs into believing that it was made by a real frog in the vicinity. This human-biosphere interaction through computer systems can breach the physical and inter-species barriers.

Wearable Forest System: Description and Discussion

Wearable Forest consists of a local audio-visual interactive clothing system as shown in Figure 1 and an audio I/O system placed in a remote forest as shown in Figure 2. The remote and local systems perform remote interaction with non-human creatures.

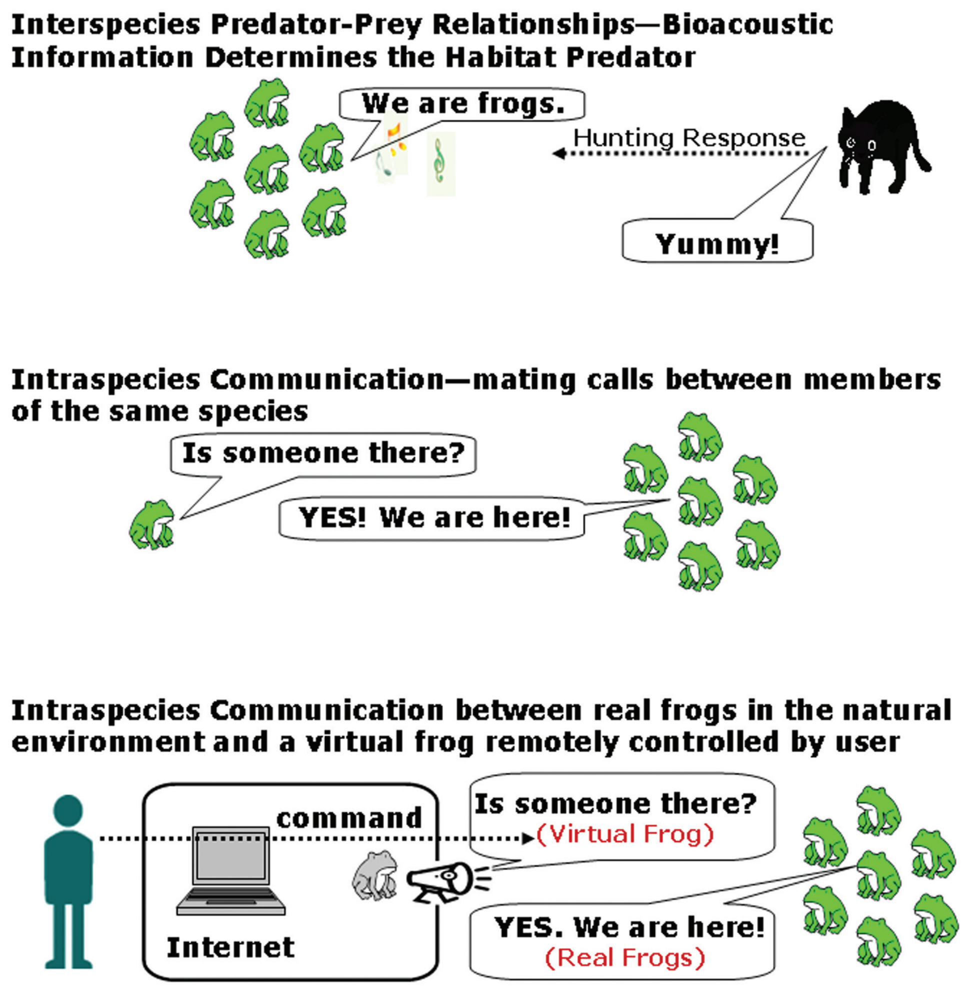

Figure 4. Interspecies predator-prey relationship (top), intraspecies communication (middle), and intraspecies communication in a mixed reality (bottom). © 2008 Hiroki Kobayashi.

The remote system, consisting of weather-resistant microphones and speakers, is placed in an uninhabited subtropical forest on Iriomote Island in Japan (24°20'N, 123°55'E). The songs of small birds, the trickling of a stream, and the sounds of insects moving about in the forest represent the diversity of organisms on the island. The audio I/O system continuously captures and transfers the live soundscape to a local system over the internet. The local clothing system consists of two paper-thin speakers embroidered on the fronts of both shoulders, a matrix array of 256 white-colored light-emitting diodes (LEDs) sewn with conductive thread, and sleeve-shaped textile sensors woven with thin wires. An embedded CPU system receives the live soundscape data from the remote forest wirelessly, immediately quantizes the bioacoustic activity of wildlife from the data, and visualizes the result as a luminescent pattern through the LED array.

To visualize and illuminate the bioacoustic activity contained in the remote forest soundscape as clothing fashion in real time, we proposed a bio-activity index (BAI) to convert this activity into numerical data using the internet [23]. BAI uses active contour models to quantify the bioacoustic activity of the calculated area into the shape of the visualized bioacoustic patterns of the live soundscape data [24]. Higher levels of bioacoustic activity are conveyed as larger LED patterns.

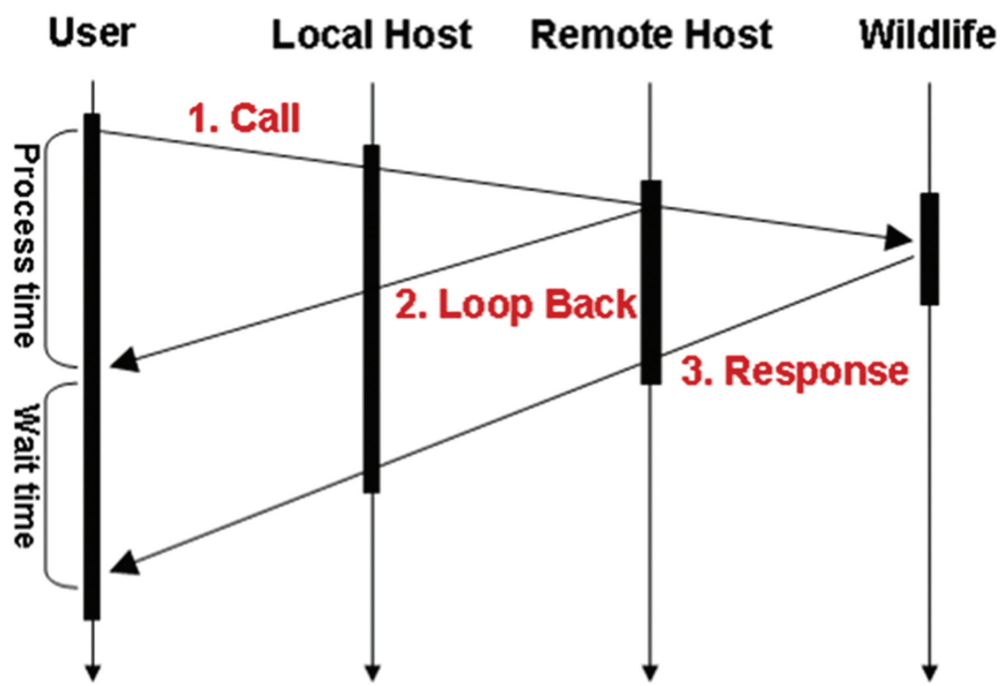

Figure 5: Diagram of non-verbal interaction between user and wildlife. © 2008 Hiroki Kobayashi, Ryoko Ueoka.

To interact with wildlife, users can touch the textile sensors, which transfer the user-selected, pre-recorded sounds of wildlife from the garment to the speakers in the forest on the remote island. This bioacoustic loop, which transfers live sounds bi-directionally from the remote and local sites, gives the user the opportunity to interact with wildlife. For example, in a relatively quiet period after a brief rain shower in the subtropical forest, the users at their urban location can play back the croaking of frogs through the remote speaker; in response, actual frogs might start croaking. If an appropriate sound is played back at an appropriate time, the actual wildlife might respond to the initial call. In this chorus-like experience, intraspecies communication in mixed reality between the user and the frogs could then possibly give the users a sense of belonging to nature in an experience similar to the peak experience in music therapy, which is triggered by choral singing [25].

First, the user can send an initial pre-recorded animal call to the remote host through the local host as shown in Figure 5. The pre-recorded calls of the Elegant Scopes Owl (*Otus Elegans*) and the Ruddy Kingfisher (*Halcyon coromanda*) are used to initiate the interaction with wildlife in the forest. Both species actually live in the forest. The Elegant Scopes Owl is nocturnal. The remote host receives the call, plays back the call from the speaker in the forest, and performs a loopback operation. If the wildlife is present in the forest, it listens to the call. The loopback call at the remote host occurs because the playback sound from the speaker is captured and transferred to the user by the remote host. When the users receive the loopback call from the forest, they recognize that the initial call did actually travel through the forest environment. The users wait for sounds that indicate that the wildlife is actually responding.

The system was exhibited and evaluated over five days during SIGGRAPH 2008 in Los Angeles, USA, and over six days during ACM Multimedia 2008 and Science World British Colombia in Vancouver, Canada. During the first exhibition, the "out of synchronization" problem was confirmed [26]. Visitors were unable to identify a specific sound from other sounds on the audio live feed from the remote forest. This resulted in users' inability to recognize the potential auditory response from the wildlife, even if the response had occurred to the user in the distant forest. Therefore, even if no response is transferred from the wildlife after the loopback call of the initial call, other acoustical activities in the forest can be perceived as believable responses, such as the sounds of birdsong, buzzing insects, gently swaying leaves, and a tree falling. Those sounds indicate the non-linguistic telepresence of entities in the forest. From a psychological aspect, participants who experienced *Wearable Forest* in the ACM Multimedia 2008 art exhibition described "a sense of oneness" with the remote forest. They rated the episode on a number of scales indicating characteristics of transcendence [27], such as sense of union and timelessness. The result indicates that the *Wearable Forest* HCBI interface is able to create a sense of oneness between human beings and wildlife beyond physical and genetic distance.

Conclusions

The HCBI paradigm defines a new conceptual approach to establishing communication between humans and natural environments through the use of computer-based media in order to create a sense of unity. We believe that the fundamental work outlined through the Wearable Forest project will create new possibilities for relationships among humans, computers, and the biosphere.

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