CSIS Discussion Paper No. 118

Carrier Pigeon-like Sensing System:

Beyond Human-Red Forest Interactions

Hill Hiroki Kobayashi and Hiromi Kudo

Abstract

The Carrier Pigeon-like Sensing System (CPSS) is a future-present computing archetype that will enable the human race to observe inaccessible natural spaces, such as the contaminated forests around the Fukushima nuclear power plant. The system aims to elucidate the scientific knowledge underlying the self-repair mechanisms of contaminated natural areas and allows users to maintain a connection with forests in the absence of any human intervention for future societies. This novel sensing system can be used to create a sustainable balance between humans and animals to ensure that the self-repairing process of contaminated natural areas can be applied anywhere in the future. This paper describes the theoretical underpinnings of such a sensing system through designing a CPSS.

Introduction: Contradictive Link between Human Beings and the Red Forest

Carrier Pigeon-like Sensing system (CPSS) is a future-present archetype in network computing that will enable the human race to observe inaccessible and contaminated forests around the Fukushima nuclear power plant. The system employs wildlife-borne sensing devices which have animal-to-animal internet sharing capability and which can be used to expand the size of monitoring areas where electricity supply and information infrastructure is either limited or nonexistent. In so doing, information can be collected from remote areas cost effectively and safely. The system is based on the concept of Human-Computer-Biosphere Interaction shown in Figure 1. The primary aim of the system is to elucidate the self-repair mechanisms that arise in contaminated natural areas and to allow users to maintain a connection with the forest without human intervention in order to develop sustainable and remote future societies.

Our relationship with nature has changed constantly over the course of human civilization; however, despite these changes, the one constant has always been that nature is destroyed in the process of scientific advancement. After the nuclear accident at Chernobyl in 1986, the Soviet Union created a permanent exclusion zone in the forest surrounding the nuclear site (Red Forest). Despite the extremely high levels of radioactive contamination, animals returned after only 20 years. At the time of the accident, people had no means of investigating or remediating the natural system and could not obtain any "knowledge required for healthy living" as a result (**Alexakhin et al. 2006, Mycio, 2006**). After the accident at the Fukushima nuclear plant in Japan, foreign countries were the first to begin scientific investigations into the mechanisms involved in the remediation of contaminated area. If this situation continues, the ripple effect brought about by the "knowledge required for healthy living" will surely bypass the human race.

In previous study, the authors developed a networked bioacoustic streaming and recording system that continuously streamed, in real time, environmental sounds from an area of subtropical forest on Iriomote Island, moving water from a pond in Tokyo, water-powered musical instruments in a Japanese garden in Kyoto, and a street in Mumbai, India using a series of networked microphones (**Kobayashi et al. 2009**). The authors also introduced the concept of Human-Computer-Biosphere Interaction (HCBI) (**Kobayashi et al. 2009**) for creating a relationship with nature and HCBI clothing, called the wearable forest, which forges new relationships between humans and nature through a human-wildlife, wearable, interaction system that facilitates non-verbal interactions with nature in our daily life through the telepresence of different species. The system described in this study, the CPSS, presents the possibility to balance the apparent contradiction between/seemingly opposite forces of Human Beings and the Red Forest using the Fukushima Nuclear disaster on 11 March 2011 as an example. The Fukushima Nuclear disaster is the largest nuclear disaster since the Chernobyl disaster of 1986.

This paper presents our vision of a HCBI by introducing the concept, related work, a developed advanced interface, and related discussions. The paper is not only intended to propose a solution to a single problem, rather, it proposes a new view of HCBI-based designs and interfaces to support our future society using a multidisciplinary approach from the single problem

Background: A Matter of Survival on the Day

When the massive earthquake hit on 3.11, the author was in Tokyo lying in bed, a little tired after having worked through the night. The quake started as a weak vibration and a low frequency sound, but then became so powerful that it jolted him wide awake. He expected it to eventually stop as usual, but this time it was different. Everything slid off the table. Pans, plates, and utensils were clashing together and fell from the kitchen cabinet. A tall mirror, which hung on the wall, swayed and almost fell.

The shockwave shook the whole building from its foundation up. At that moment, the collapsed buildings of the 1995 Kobe earthquake flashed across his mind. He walked on his hands and knees and opened the front door to secure a means for evacuation. After he confirmed the safety of family members by cell phone he watched the events unfold on television.

Interruptions to cellular networks and power blackouts began soon after the quake, and for a time he lost all means of communication. It was a real "Dialog in the Dark" outside after sundown. All of the factories and stores suspended their activities as night fell, even dogs on the streets seemed to sense the unusual atmosphere and did not bark. Police officers were standing in the middle of intersections, directing traffic with hand signals illuminated by the headlights of fire trucks. People crossing the intersection offered "thanks" to the officers and many walked home in silence.

The cashiers and staff at the grocery store used flashlights to assist customers with purchases. A small radio behind the casher broadcast the voice of the Japanese Emperor who was comforting the entire nation in the dark. It seemed like the last day of World War II, which the author had only read about in history books, in that he had never seen such warm interactions among ordinary citizens. Outside the store, when he looked up at the night sky, stars were shining more brightly, more brightly than he had ever seen them shine in Tokyo before. However, elsewhere the situation was devastating.

At the time of the Fukushima Nuclear disaster, people in Japan had no means of investigating the damage. As a result, they were unable to acquire "the knowledge required for healthy living”. Only foreign countries were able to start investigating the earthquake immediately after the accident at the Fukushima nuclear plants; they were then followed by

Japanese officials as time progressed. If such a situation were to continue into the future, the ripple effect brought about “knowledge required for healthy living” would certainly bypass by the human race. It is therefore important that we prepare the necessary logistics and the research in order to prepare fort such events in a sustainable future society.

Problem Statements

Ecological monitoring of wild animals involves the analysis of information related to target animals, such as data related to their location and prey preferences in actual environments, as well as data related to meteorological conditions. Using ubiquitous and wearable technologies, it is generally considered likely that species inhabiting environments near urban areas (human settlements) can be monitored effectively given the relatively close proximity of these environments to urban areas and the availability of electric power, information infrastructures and information systems such as those associated with cellular phones (**Ueoka 2001, Lee et al. 2006**).

However, in more remote areas, such as in the contaminated home ranges of wild animals, the availability of electric power and information infrastructure required for monitoring wild animals is either limited or nonexistent. This is primarily because it is typically not economically viable to install such infrastructure-based services in areas such as wildlife refuges where the number of potential users is low.

Furthermore, in areas where there are no infrastructure networks, predicting the behaviors of species with extensive home ranges (on the scale of several kilometers) is difficult. Although field surveys of such species are conducted periodically, monitoring target species in hot and humid forests or in radioactive environments can impose a considerable burden on the observer. It was therefore necessary to develop methods and techniques for maximizing monitoring performance while using the fewest possible resources.

HCBI Concept Overview

The CPSS is based on the HCBI concept described in Figure 1, and which is an extension of human-computer interaction (HCI) (**Kobayashi. 2010)** and human-computer-pet interaction (HCPI) (**Lee et al. 2006**). In 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 in space through computer systems, and then 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, in order to maintain our social relationships (**Itoh et al. 2002**).

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 devices enables us to extend our spatial interactions and to develop human-to-human communication beyond physical distance **(Lisa 2004, Seymour 2008, Ueoka et al 2009**). HCPI, as described in Figure 1, is a novel type of physical interaction paradigm that proposes the creation of a symbiosis between humans and pets through computers and over 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 (**Bray. 2006**). Thus, computer systems become a medium through which a telepresence can be expressed among different species in the biosphere through non-linguistic means that are perceived and understood by individuals, violating the rules of linguistic science (**Alex. 2001**).

However, irrespective of how advanced the technologies are, these are spatial interactions. We expect some feedback from others before we issue the command to end an interaction. On the contrary, there are many temporal interactions in our daily lives. The sounds of singing birds, buzzing insects, swaying leaves, and trickling water in a forest implicitly imprint the presence of space in our minds. When we are away from a forest, recalling the memory of a forest takes us back to the same place. The crucial factor here is not the means of conveyance (words or language), but the "something" that hovers around; an atmosphere that we cannot identify exactly but that lasts beyond generations. This interaction follows the theory of natural selection proposed by Charles Darwin. The theory of evolution, which has become one of the fundamental cornerstones of science, was introduced to readers in his book on the origin of species that he wrote after visiting the Galápagos Islands (**Darwin. 1859**).

The author proposes that, much like elements of natural selection, the concept of HCBI can be extended to spatial interactions from countable objects, such as pets and plants in space, to their temporal environment, which is an uncountable, complex, non-linguistic, something beyond generation. In the HCBI framework, the sounds of a forest or other natural environments are all information cues that help us to understand natural selection. Thus, through HCBI, we can experience the wonderment of the global ecological system, with all living beings and their relationships, including their interactions with the elements of the biosphere. With HCBI, we begin to interact with inaccessible ecological natural systems beyond space and time.

HCBI System Design: From a Law of Animal Behavior

Natural communities contain a wide spectrum of life forms that interact with each other, and it is generally agreed that the essence of ecology is the study of ecological interactions among species in animal communities (**Begon et al. 1996**). In particular, animal communities in tropical forests have extremely complex interactions involving numerous species (**Ricklefs et al. 1993, Leigh et al. 1996)**. Indeed, the structure of natural sounds in rainforests convincingly demonstrates the magnitude of the extraordinary relationships that exist among the many insects, birds, mammals and amphibians that inhabit these environments. If one creature starts vocalizing, others often immediately join the chorus (**Bernie. 1987**). These spatial-temporal interactions between animals vary depending on the biological diversity of the natural habitat that has arisen as a result of natural selection.

To establish CPSS, an HCBI interface artificially creates a virtual acoustical field to acquire a homing reaction. It is modeled on three kinds of natural interaction: interspecies predator-prey relationships, intraspecies communication, and mixed-reality intraspecies communication.

First, a predator hunts for prey in its native habitat as shown at the top of Figure 2; the predator uses bioacoustic information as a cue for detecting the existence of its natural prey in the surrounding area. A scarcity of prey in a specific habitat can indicate the absence of specialized predators as a result of natural selection.

Secondly, intraspecies communication is considered to be a chorus produced by a group of the same species in Figure 2 (middle), and is similar to the Packet Internet Grouper (PING) command of the Internet Control Message Protocol between two computers (**Muuss. 1984**). A single individual, the caller, starts calling other individuals to confirm their presence. The other members of the species then recognize the call and report their existence to the caller. This is also as a result of natural selection.

Third, a species can conduct intraspecific communication in mixed reality. The bottom of Figure 2 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 is controlled by a remote-controlled PC over the internet. The real frogs answer the initial call and report their existence. This is a new synthesis of natural selection and cybernetics.

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. Thus, such human-biosphere interactions through computer systems can breach spatial-temporal barriers.

This study presented here used bio-acoustical information to develop a spatial-temporal interaction model, and proposes a novel cybernetic interface using mobile technology for CPSS in scientific applications.

CPSS: From a Law of Homing Pigeons

Human communities employ a wide spectrum of technologies that interact with nature. It is generally agreed that one of the most ancient forms of information communication technology involves the use of carrier pigeons; a homing pigeon that can carry messages and then to find its way home over extremely long distances. In the United States, the 1800 km-long Pigeon Race (sport of releasing specially trained racing pigeons, which then return to their homes over a carefully measured distance.) is the longest pigeons in the world (**Walcott. 1996**). In the field of computer network engineering, D. Waitzman announced a proposal to carry Internet Protocol (IP) traffic by birds such as homing pigeons (RFC 1149) on 1 April 1990 (**Waitzman. 1990**). Even though this was an April Fools' joke, several experiments proved that the method was effective.

However, only homing pigeons are capable to perform such the task specific activity. Other animals are not reported yet. In sum, to be able to monitor the contaminated home ranges of other wild animals, where the availability of electric power and information infrastructure required for monitoring wild animals is either limited or nonexistent, it is a necessary to design a CPSS. In doing so, we are able to observe inaccessible natural spaces, such as the contaminated forests around the Fukushima nuclear power plant. To date, infrastructural limitations have meant that the following two methods are typically used to monitor wildlife.

For example, a long-range sensor approach, such as a telemetry system that employs signals from a radio transmitter attached to a target animal and a receiver is then used to estimate the location of the animal. Using the long-range sensor approach, observers use a portable receiver to estimate the current location of a target animal by measuring the strength and direction of radio signals transmitted from animals that have been fitted with radio collars. Although numerous species have been observed using this method, the geographical characteristics of an animal's environment can have a marked impact on the reception of the transmitted radio signals. In addition, using this technique requires considerable experience and skill on behalf of the observer.

In addition, the total mass of a transmitter system that can comfortably be borne by an animal is limited to 2% or less of the animal's body weight. Consequently, large animals like elephants can wear systems weighing up to 100 kg and mid-sized animals (e.g., the size of a small cow) can bear loads of up to 6 kg. As a result, there has been considerable interest in research and development of ubiquitous sensor systems for monitoring large- and medium-sized terrestrial mammals, including systems based on wireless LAN (**Juang et al. 2002, Thorstensen et al. 2004**), ZigBee (**Nadimi et al. 2008**), infrared sensors (**Kobayashi et al. 2006**), motion control using actuators (**Wark 2007**), virtual fencing with GPS-based electric stimuli (**Bishop et al. 2007**), and so forth. However, small mammals and birds are usually only capable of carrying loads of ≤75 g or ≤30 g, respectively (Figure 5.4), which limits the range over which such systems can be applied. Furthermore, in the case of wild animals, it is not usually possible to recapture a collared animal every two or three years for battery replacement (e.g. GPS-based studies for elucidating the migration routes of migratory birds; **Argos System 2007**).

To achieve these aims, an outdoor, remote, acoustic information acquisition devices have been constructed and deployed (**Kobayashi. 2010**). Other methods have also been employed to detect living organisms; for example, a musical instrument called a Theremin that utilizes indoor capacitance has been used to register the presence of laboratory rat, and problems associated with this method were clarified (Skeldon et al. 1998).

Beyond Human-Red Forest Interaction: Discussion

After the nuclear accident at Chernobyl in 1986, the Soviet Union created a permanent exclusion zone (CEZ) in the forest surrounding the nuclear site (known as the Red Forest after the disaster because the trees turned red when they died). Despite being the worst nuclear disaster to date, the event had a positive impact on the biota in the CEZ. Specifically, the recovery observed in the biota of the CEZ due to the cessation human activities has been dramatic (e.g. due to the termination of agricultural and industrial activities and the accompanying environmental pollution in the most affected area). As a result, the populations of many plants and animals have increased and the CEZ now supports many species that were previously rarely seen (**Alexakhin et al. 2006, Mycio. 2006**).

In the nuclear accident at Fukushima in 2011, the Japanese Government also established a temporary exclusion zone in the surrounding area. Despite the extremely high levels of contamination, people are scheduled to return home. As the number of repatriation activities has increased, so has the amount of agricultural and industrial activity. The increase in the anthropogenic activities has, in turn, had a negative effect on the biota in the forest surrounding the nuclear site (CEZ). These activities increased markedly when the news media reported on the full extent of the environmental damage to the area. The reports prompted an increase in restoration-type activities, which in turn increased local repatriation activities, which together increased the negative impacts of both types of human activities on the biota in the CEA. Only foreign countries started investigating the effect of the disaster on the biota of the region immediately after the accident; the surveys by Japanese officials occurred gradually over time. If this slow approach continues to be adopted, then the ripple effect associated with "knowledge required for healthy living" will surely pass us by. Furthermore, as the cost of measures against contamination by radioactive materials increases throughout the world (7 trillion yen in 2030*).it is important to be able to monitor the contaminated area. (* BP Energy Outlook 2030: January 2011

We have a more than 10 years of research and development experience with "*CPSS*" initiatives. The system has integrated the efforts of researchers with computers and the ecosystem (Figure 3), and can be applied to investigate ecosystems in remote and permanently restricted areas. (i.e. areas that are either too remote to be serviced by traditional communications infrastructure or that that have geographic attributes (e.g. terrain and vegetation cover) that make monitoring difficult)

Our past achievements include:

- Conducting regional surveys of subtropical rain forest using a remotely operated sensor attached to endangered species and that enabled us to observe, probe and control behavior.
- To predict climate change, we developed methods to "see and hear" the amount of long-term growth in mountainous rainforests.
- Assistance with environmental investigations into domestic and foreign cities, oceans, polar regions and contributions of environmental educational material to the government and educators.
- We Developed methods to assess damage of the agricultural and forestry areas.
- We will acquire world leading knowledge related to radioactive contamination resulting from the Fukushima nuclear accident by "*CPSS*". Based upon the assessments by agriculture and forestry workers in that area, combined with specialists from around the world, we will finally gain "the knowledge required for healthy living". We will then releasing the obtained data to the public in real time.

Human beings seem incapable of peacefully coexisting with nature and the often expressed desire for sustainable relations between man and the environment sometimes appears to be an unobtainable future dream. It sometimes seems that the best way to solve all of the world's environmental problems would be to destroy all civilizations. In ancient times, interactions between nature and human societies were significantly less frequent due to cultural and mythological reasons. Before human beings became capable of leveling mountains with heavy construction vehicles, humanity and nature were physically separated but spiritually and emotionally connected. Japanese farmers prayed to gods in seasonal festivals for the weather conditions needed to ensure successful crop production and the general population was taught to respect the gods that resided in and protected the mountains. Because of this, wild animals and their habitats in the mountains were left undisturbed for the most part and Japan's history and culture evolved in benevolent interaction between nature and humanity. Indeed, society and even business activities paid respect to the traditions and cultural aspects of nature until the human development process known as "Scientific Advancements" began spreading. With the advent of advanced technologies, human society created a paradox in its relationship with the Red-Forest in Fukushima, Japan.

Acknowledgements

Part of this work was supported by Japan Society for the Promotion of Science (JSPS) KAKENHI (Grant No. 09J08994 and 24800010) and Japan Science and Technology Agency (JST) Adaptable & Seamless Technology Transfer Program Through Target-driven R&D, (Grant No. AS242Z03455K).

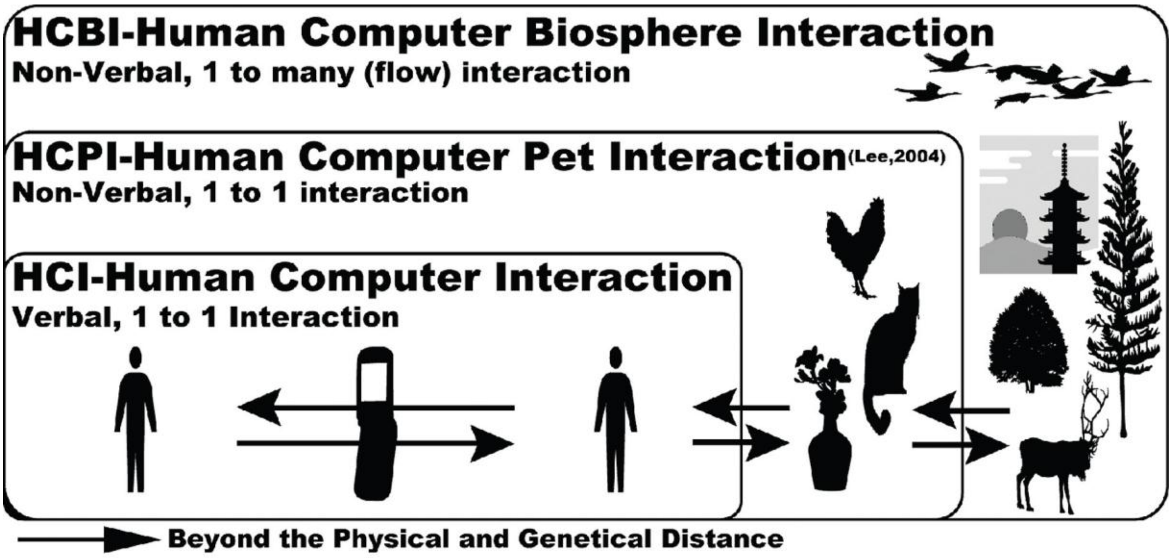

Figure 1. Human-computer-biosphere interaction (HCBI) concept; an extension of HCI and HCPI © 2008 Hiroki Kobayashi and Ryoko Ueoka.

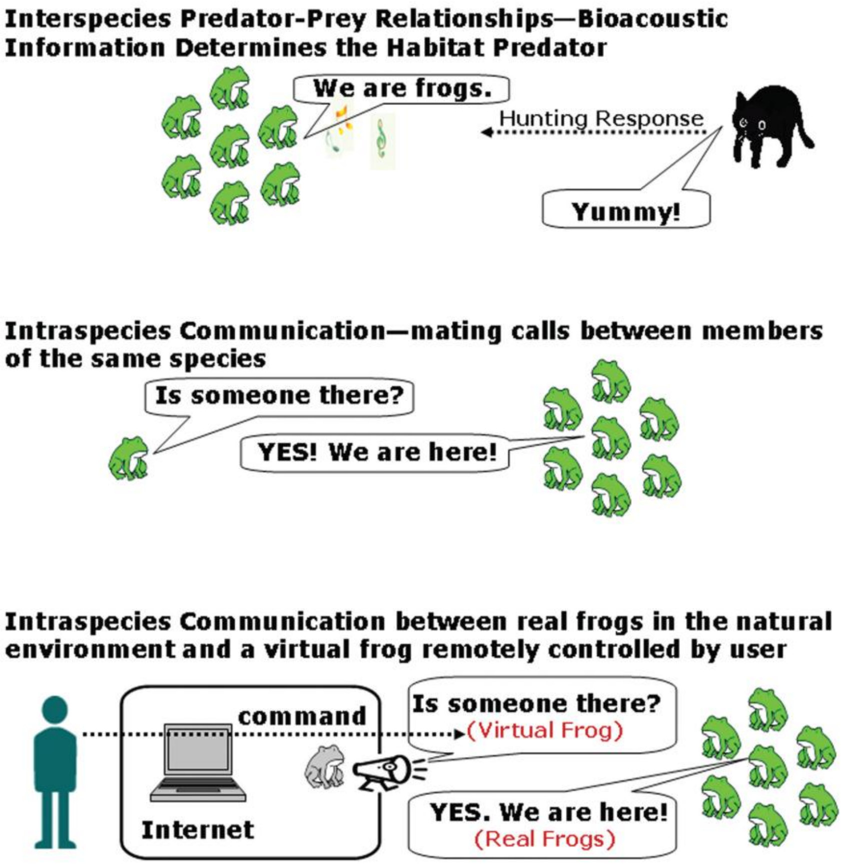

Figure 2. Interspecies predator-prey relationship (top), intraspecies communication (middle), and intraspecies communication in a mixed reality (bottom). © 2008 Hiroki Kobayashi.

Figure 3. Conceptual image of the Carrier Pigeonic Sensing System
http://www.switched.com/2009/09/11/pigeon-beats-isp-in-60-mile-race-to-deliver-data/

References

Alex M. Andrew. 2001. *THE ROBOT IN THE GARDEN: TELEROBOTICS AND TELEPISTEMOLOGY IN THE AGE OF THE INTERNET* edited by Ken Goldberg, MIT Press

Alexakhin, R.; Anspaugh, L.; Balonov, M.; Batandjieva, B.; Besnus, F.; Biesold, H.; Bogdevich, I.; Byron, D.; Carr, Z.; Deville-Cavelin, G.; Ferris, I.; Fesenko, S.; Gentner, N.; Golikov, V.; Gora, A.; Hendry, J.; Hinton, T.; Howard, B.; Kashparov, V.; Kirchner, G.; LaGuardia, T.; Linsley, G.; Louvat, D.; Moberg, L.; Napier, B.; Prister, B.; Proskura, M.; Reisenweaver, D.; Schmieman, E.; Shaw, G.; Shestopalov, V.; Smith, J.; Strand, P.; Tsaturov, Y.; Vojtsekhovich, O.; Woodhead, D.. (2006) Environmental consequences of the Chernobyl accident and their remediation: Twenty years of experience. Vienna, International Atomic Energy Agency, 166pp.

Begon, M., Harper, J.L. And Townsend, C.R., (1996): Ecology: Individuals, populations Andcommunities (3rd ed.).- Oxford: Blackwell Science.

Bernie L. Krause., 1987. "Bioacoustics, Habitat Ambience in Ecological Balance," Whole Earth Review, #57, Winter,

Bishop-Hurley, G. J., Swain, D. L., Anderson, D. M., Sikka, P., Crossman, C., And Corke, P. 2007. Virtual fencing applications: Implementing And testing an automated cattle control system. Comput. Electron. Agric. 56, 1 (Mar. 2007), 14-22. DOI= http://dx.doi.org/10.1016/j.compag.2006.12.003

Bray, H., Faludi, R., Hartman, K., And London, K. 2006. Botanicalls: The plants have your number, http://www.botanicalls.com/

Darwin, Charles. 1859, On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life (Full image view 1st ed.), London: John Murray, pp. 502, retrieved 2011-03-01

Itoh, Y., Miyajima, A., And Watanabe, T. 2002. 'TSUNAGARI' communication: fostering a feeling of connection between family members. In CHI '02 Extended Abstracts on Human Factors in Computing

Systems (Minneapolis, Minnesota, USA, April 20 - 25, 2002). CHI '02. ACM, New York, NY, 810-811. DOI= http://doi.acm.org/10.1145/506443.506609

Juang, P., Oki, H., Wang, Y., Martonosi, M., Peh, L. S., And Rubenstein, D. 2002. Energy-efficient computing for wildlife tracking: design tradeoffs And early experiences with ZebraNet. In Proceedings of the 10th international Conference on Architectural Support For Programming Languages And Operating Systems (San Jose, California, October 05 - 09, 2002). ASPLOS-X. ACM, New York, NY, 96-107. DOI= http://doi.acm.org/10.1145/605397.605408

Kobayashi, H., Ueoka, R., And Hirose, M. (2009). Human computer biosphere interaction: towards a sustainable society. In Proceedings of the 27th international Conference Extended Abstracts on Human Factors in Computing Systems (Boston, MA, USA, April 04 - 09, 2009). CHI '09. ACM, New York, NY, 2509-2518. DOI= http://doi.acm.org/10.1145/1520340.1520355

Kobayashi, H. (2010). Basic Research in Human-Computer-Biosphere Interaction. PhD Thesis, The University of Tokyo.

Kobayashi, H., Kawasaki, Y., AND Watanabe, S. 2006. Development of a Networked Remote Sensing Embedded System for Bio-acoustical Evaluation. Proceedings of 4th Joint Meeting of the Acoustical Society of America And Acoustical Society of Japan. Hawaii, U.S.A.

Lee, P., Cheok, D., James, S., Debra, L., Jie, W., Chuang, W., And Farbiz, F. (2006). A mobile pet wearable computer And mixed reality system for human–poultry interaction through the internet. Personal Ubiquitous Comput. 10, 5 (Jul. 2006), 301-317. DOI= http://dx.doi.org/10.1007/s00779-005-0051-6

Lisa Stead, et al., "The Emotional Wardrobe, (2004)." Personal and Ubiquitous Computing, Vol 8, No. 3-4, 282-290.

Mary Mycio, (2006).Wormwood Forest: A Natural History of Chernobyl. Homburg-Joseph Henry Press.

Muuss, J. M. 1984. Packet InterNet Grouper http://ftp.arl.mil/~mike/ping.html

Nadimi, E. S., Søgaard, H. T., Bak, T., And Oudshoorn, F. W. 2008. ZigBee-based wireless sensor networks for monitoring animal presence And pasture time in a strip of new grass. Comput. Electron. Agric. 61, 2 (May. 2008), 79-87. DOI= http://dx.doi.org/10.1016/j.compag.2007.09.010

Seymour, S. 2008 Fashionable Technology: the Intersection of Design, Fashion, Science, And Technology. 1. Springer Publishing Company, Incorporated.

Thorstensen, B., Syversen, T., BjØRNVOLD, A.T, AND Walseth, T. 2004. Electronic shepherd - a low-cost, low-bAndwidth, wireless network system. Proceedings of the 2nd International Conference on Mobile Systems, Applications, And Services MobiSys, Boston, Massachusetts.

Ueoka. R. (2001). "Mutual Interaction System between human-pet through network technology" (in Japanese) Interaction between human And companion animal 3rd, Letter from Companion Animal Information And Research Center, 2001

Ueoka, R., Kobayashi, H., And Hirose, M. 2009. SoundTag: RFID Based Wearable Computer Play Tool for Children. InProceedings of the 4th international Conference on E-Learning And Games: Learning By Playing. Game-Based Education System Design And Development (Banff, Alberta, Canada, August 09 -

11, 2009). M. Chang, R. Kuo, Kinshuk, G. Chen, And M. Hirose, Eds. Lecture Notes In Computer Science, vol. 5670. Springer-Verlag, Berlin, Heidelberg, 108-108. DOI= http://dx.doi.org/10.1007/978-3-642-03364-3_13

Walcott, C. 1996. Pigeon homing: Observations, experiments and confusions. J. exp. Biol. 199:21-27

Waitzman, D. 1990. A Standard for the Transmission of IP Datagrams on Avian Carriers. http://tools.ietf.org/rfc/rfc1149.txt

Argos System 2007. Preserving Europe's ospreys,: http://www.argos-system.org/html/information/news/news8_en.html