The BIOdress: A Body-worn Interface for Environmental Embodiment

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Abstract

This paper discusses the development of a body-worn interface facilitating the communication between humans and their environment. It seeks to allow the wearer to understand the state of their natural environment through an extended state of embodiment. First, it discusses our motivation for sustainability and the need to change our anthropocentric attitude to a more holistic one that includes the natural environment. Then, it discusses how clothing can be seen as an immediate way of embodiment, and how computational technology and connection to the Internet of Things can contribute to the development of wearable interfaces, which expand our notion of the human body to include our natural environments. It then introduces the BIOdress, a body-worn interface facilitating interspecies communication with a goal to create an expanded network of embodiment. The overall objective is to encourage human empathy beyond the anthropocentric towards more sustainable development.

Author Keywords

Human-Environment Interface; Human-Plant Interaction; Wearables; Interspecies communication; Anthropocentrism; Sustainable design; the Internet of

Things; Technology-mediated embodiment; non-human agencies and interactions.

ACM Classification Keywords

H.5.1. [Information Interfaces and Presentation]: Multimedia Information Systems – *evaluation/methodology*

Introduction

Embodiment is usually something we associate with the human body: as humans, it is natural to think in this anthropocentric manner while difficult to imagine embodying the thoughts and feelings of other living creatures. With different modes of expression between humans, animals and plants, human empathy towards the non-anthropocentric is difficult to develop. This is reflected in our continual maltreatment of those we do not understand – from the destruction of our flora and fauna, to the contamination of our natural resources – resulting in what Eisenstein refers to as the ‘age of separation’ [2]. Thus it is possible to attribute our current environmental crisis to our state of human dis-embodiment from the natural environment.

The BIODress was thus born out of a desire to reconnect human bodies with their external environmental and expand our notion of embodiment to encourage more sustainable design. As a body-worn interface, it literally allows the wearer to connect to their external environments through their responsive clothing, mediating the relationship between humans and their natural world.

This paper will discuss how environmental embodiment, as supported by the BIODress, can help break down non-anthropocentric barriers. First, we will discuss

issues of sustainability and the need for non-anthropocentric thought. Then, we will explore the medium of wearable interfaces and how it can lend itself to the human embodiment of non-human elements. We discuss how advances in computational technology and the growing Internet of Things have contributed towards the development of the BIODress. Finally, we will discuss how such a body-worn interface can aid interspecies communication, environmental embodiment, and the development of a non-anthropocentric approach to sustainable design.

Anthropocentrism and sustainable design

Being human makes anthropocentric thought a natural disposition, as favoritism towards one’s own kin is a part of evolutionary selection, which has been observed across a wide array of species, from primates to insects and even microbes [12, 13, 15]. Thus it is natural that our decisions concerning development are driven by anthropocentric thought and focus on human need. Indeed, the definition of *sustainable development* currently accepted by most sectors of the design world is defined by the United Nations as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” and focuses primarily on human needs [3].

However, we must not forget that we are dependent on more than ourselves for our own survival and that our sustainability, social as well as ecological, is inevitably dependent on a sustainable natural world. Climate change is but one reminder: decreasing air, water and earth quality; the scarcity of energy resources; and the extinction of flora, fauna and other forms of life; is proving that our current, anthropocentric approach to development is unsustainable. Such environmental

degradation can be attributed to our anthropocentric perception of nature as a resource for the human species and the inability of humans to acknowledge the value and the right to existence of other species independently of their benefit to humans. Rather, true sustainable development must consider life holistically, coupling the human-made and natural systems, and taking into account the needs of plants and animals, not to mention the quality of air, water and earth in the design process.

While we acknowledge that we are inherently anthropocentric creatures, we also acknowledge our dependency and connection with other forms of life. In this paper, we challenge these current anthropocentric values and argue that the achievement of true sustainability requires a non-anthropocentric point of view. This requires the establishment of non-human-based values, involving a fundamental shift in human thinking from a model in which humans are our central concern, to one in which other living creatures are equally valued. While animal rights have received growing attention since the 1970s, we have been much slower to attend to the rights of plants, possibly due to our inability to understand them. However, as called for by Mancuso, we can no longer afford to ignore them, as much for our sake as their own [9].

We thus propose a non-anthropocentric approach to the field of design, in which humans are no longer the sole focus of the design outcomes. Using clothing as an effective medium of embodiment, we aim to increase human awareness of the wants and needs of other living creatures through interspecies communication and the encouragement of human empathy towards them.

Clothing as an interface for embodiment

Clothing can be seen as the ultimate physical manifestation of design for embodiment: when worn on our bodies, it literally embodies us. While playing an important role in our bodily protection from the elements, in contemporary society, it is just as important as a way of communicating human identity, cultural belonging and one's social standing. In this sense, clothing acts as an extension and expression of the self and communicates a wide array of meanings, encompassing not just identity, gender and political and social standing but also temporary mood and attitude, as well as the moral and aesthetic standards of both the individual and society. Fashion garments can thus be viewed as an extreme embodiment of anthropocentrism and are not generally associated with advancing neither social nor ecological sustainability. However, given the influence fashion can have over human behavior, it is possible to use clothing as a vehicle for facilitating human-environment relationships.

Wearable technological interfaces

Much has changed concerning the notion of wearable interfaces since the head-mounted device introduced by Steve Mann in 1996 [10]. In a more integrated manner, recent advances in technology - such as light emitting diodes (LED), optical and thermochromic fibres, pressure pads, mechanical actuators and shape memory alloys - have led to the evolution of 'smart fashion' where the clothing itself becomes a fully-functional, portable and wearable display. When combined with the Internet of Things (IoT), a plethora of new possibilities emerge. Using sensors, it is possible to connect to the network of bio-signals underlying the natural world. Then, by utilising the garment as an

Figure 1: BIODress prototype showing both human and plant participants.

Figure 2: Plant sensing station, measuring air-quality, particle levels and the bio-electric signals emitted by the plant.

interface for their communication, it is possible to express this information. By facilitating communication from plant to environment to human, we can begin to expand traditional anthropocentric thinking to encompass the natural environment.

Related bio-technological design work

Experiments surrounding e-textiles has grown considerably over the past two decades. Distinctly thermochromic ink experiments with e-textiles and conductive thread by Maggie Orth since the late 80s, illustrate the temporal nature of using this medium. Shape-shifting explorations through the Skorpions range of clothing produced by Berzowska et al. of xslabs in 2007, showcase opportunities to interact in unexpected ways with the clothes we wear. Notably, the *whisper* research project of 2003 provided an exploration of strategies and techniques of embodiment. The group, led by Thecla Shiphorst, sought “methods of embodiment that extend through the body, softening the edges between our selves and each other” [17]: this includes somatic practices, or first-person methodologies. Through the *whisper* project Shiphorst et al., sought to develop an “experience model” to use the feedback mechanisms in order to create an interaction model, wearable garment design and body-to-body network protocol [17]. In all, the *whisper* project provided a context through which participants could exchange physiological data between themselves and their garments - thus creating networked participation.

The search to give plants a voice through bio-signal-driven art dates back to the nineteen seventies and pioneering artists such as John Lifton and Richard Loewenberg who translated their electric signals into

sonic output in works such as *The Secret Life of Plants*, 1976 [8]. Since then, the attempt to connect plants to humans through environmental monitoring and its artistic representation has taken a number of forms, from interactive soundscapes to plant mimicry for robotic applications. Of them, wearable technology can be seen as perhaps the most embodied attempt to promote interspecies communication through the immediacy of clothing. One notable example is the *Wearable Forest Clothing System*, which transmits real-time bio-acoustic signals from a Japanese forest [6] to clothing, promoting human-computer-biosphere interaction. It expresses the soundscape through the garment using paper-thin speakers and visualizes them through an array of LEDs. Of course, there are many more biological interactions happening which are more difficult to observe, including bio-electric signals, pollution and particulate levels. We will explore these interactions and their alternative forms of expression through the BIODress.

The BIODress: a body-worn interface for environmental embodiment

The BIODress is a body-worn interface, which communicates environmental data. By linking the human wearer to an element of their natural environment, it allows us to better understand its quantitative state. In particular, the user is linked to a specific plant, which is able to sense its surrounding environmental quality on a more subtle level (see Figure 1). Environmental sensors are attached to the plant, forming a ‘plant sensing station’ (see Figure 2) which enables the BIODress to read what the plant is ‘sensing’ on a quantitative level. Design and technology then allow us to articulate this state qualitatively in three different ways, as shown in Figure 3:

Figure 4.1: BIODress prototype in its neutral state, displaying green and brown colouring indicating fresh air-quality.

Figure 4.2: BIODress prototype detecting air toxicity, and subsequently displaying a red / magenta colouring to warn of danger.

Figure 3: The BIODress' response to 3 particulars

- Thermochromic dyes allow the garment to change colour according to the particulate levels detected in the air. The BIODress appears green and brown when the air is clean (see Figure 4.1). However, when pollutants are detected, red and magenta colouring is visible (Figure 4.2). The dyes are activated through heating up of embroidered conductive thread (i).
- Actuators expand and contract pleats situated on the shoulders of the BIODress, so that they appear to 'breathe', in response to the air quality. Faster breathing equates to poorer air quality, to the point of exhaustion (ii).
- The fabric leaves attached to the garment are fashioned using a shape memory alloy, which allows the leaves to move synergistically with the plants internal energy, measured by an EMG sensor (iii).

The BIODress thus acts as a responsive interface for qualitatively communicating the quantitative data measured by the plant sensing station. When worn by the human participant, the result is an embodied relationship between the wearer of the BIODress, and the plant to which he or she is connected. The impact works on a number of levels. As a wearer, one is able to embody the state of the plant and its surrounding environment. As an observer, this information is broadcast to the public domain (Figure 5.1).

Part of a growing environmental network

Beyond the singular BIODress prototype, which allows one wearer to interact with an allocated plant, we are currently expanding the network of connected plants and humans with the creation of more plant sensing stations. The first iteration of the BIODress project will consist of two identical stations and two interfaces. This means that two BIODress wearers will be able to communicate with each other and exchange data-sources (see Figure 5.2). In the next iteration, several plant stations and interfaces will be created and situated in different parts of the world. The idea is that environmental data from different locations can be shared by BIODress wearers from their native environments (see Figure 5.3).

Initially, the functionality of plant stations will be the same. However, as the project moves forward, more sophisticated sensors will be integrated, such as is currently being developed by the PLEASSED project [11]. The objective is to employ plants as biosensors of existing organic wireless sensor networks and integrate them both into natural environments, such as forests, as well as artificial ones, like city parks.

Figure 5.1: BIODress wearer broadcasting the state of the natural environment into the human sphere.

Figure 5.2: Two BIODress wearers entering close proximity and exchanging data-sources.

Figure 5.3: The BIODress wearers now broadcast environmental data into their native environment.

Not unlike the “living behavioural kinetic sculptures” developed by Joanna Berzowska and team at XSLABS, the primary distinction for BIODress is the input of sensor data from the surrounding environment. While Skorpions kinect garments by Berzowska et al. [1] are imagined as parasites, the BIODress is imagined as a communicative mediator between garment wearer and the external natural environment. The garment acts as

communicator, translator and reactor to the surrounding landscape. Building on the work of Berzowska et al. [1], it is evident that opportunities exist for artists and designers to further explore traditional garment as a soft interface, data conveyor and communication medium.

The beauty of the Skorpions range is the reference to the role of clothing as a reflection of our lack of control over our garments and our digital technologies. Skorpions seek to impose constraints on the body, while the BIODress seeks to reflect the conditions of the surrounding environment. By combining the explorations of shape-changing materials as seen in Skorpions by Berzowska et al. [1], through to the e-textile experiments with thermochromic paints and conductive thread by Orth [14], we seek to create a complex and layered interaction that embodies the wearer in a sense of shifting states. From transient and subtle shifts in colour, through to physical and kinectic reactions through shape shifts, this myriad of reactions defines BIODress as an embodied analogy, translating otherwise intangible and difficult to qualify environmental data.

Future Work

In the future, the project aims to create an entire collection of body-worn environmental interfaces. While the BIODress wearable will maintain the same functionality, the individual garments will differ in their method of expression according to their context. Stations and interfaces will connect to *the cloud* to enable the communication and so become part of the Internet of Things. Data received and displayed on an interface can thus come from different parts of the world. For example, a garment situated in Europe may

display environmental data coming from South America or Australia.

An additional interactional layer thus emerges between wearers of the interface, allowing a reciprocal exchange of environmental information. This exchange is to be triggered by proximity, subsequently leading to an interchange of interface identity. For example, when an interface displaying data coming from Africa and an interface receiving data from Asia are physically collocated, they will transfer their data-sources and thereby expand the network. Upon disengagement, the new identity remains with the particular interface until another wearer displaying data from somewhere else, is encountered.

Conclusions

Sustainable development requires non-anthropocentric environmental empathy, and embodiment of the environmental condition is a way of encouraging this. By utilizing the wearable interface as a manifestation of embodiment, we attempt to develop a sense of environmental empathy. By placing us in the shoes of a plant, the BIODress can be seen as an extension of our capacity of empathy beyond the anthropocentric.

Positioned as a hybrid between artistic exploration and discursive expressive design practice, the BIODress connects the emerging IoT to the “earth’s natural internet” [16] or “wood-wide web” [4] of mycelium-enabled inter-plant communication. It reveals the blindness of the anthropocene era, by enabling its participants to visualize, understand and thus participate in an interconnected world inclusive of all inhabitants and elements of this planet. This flow of actants, i.e. reciprocal exchange between actors [5, 7]

within the IoT, enables an effective recombination of nature and technology, and in doing so facilitates a human emotional response necessary to the development of empathy inclusive of our natural environment.

The exchange of environmental data across countries and continents furthermore establishes an intercultural connectedness and awareness, by making the environment of distant others an immediate and perceivable concern. For example, the plight of draught-stricken areas or the pollution of megacities is usually experienced by the rest of the world outside these areas via the detached imagery of traditional screen-based media. The BIODress, however, would allow a wearer to feel these foreign environmental conditions directly on one’s own body, bringing distant realities into areas of real, tangible perception. Thus over time and on a larger scale, the BIODress could contribute to worldwide understanding and empathy through embodiment.

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Video

https://www.dropbox.com/s/ugmkegbmm88iavr/BIODress_final_text_sound.mp4?dl=0

References

1. Berzowska, J., Mainstone, D., Bromley, M., Coelho, M., Gauthier, D., Raymond, F., Boxer, V. 2007. Skorpions: Kinetic electric garments. *Proceedings of the 9th International Conference on Ubiquitous Computing* (2007)
2. Eisenstein, C., 2007. *The Ascent of Humanity*, Panentheia Press.
3. Harlem, B.G. and others. 1987. Our common future. *United Nations World Commission on Environment and Development (WCED)*, Rio de Janeiro.
4. Helgason, T. et al. 1998. Ploughing up the wood-wide web? *Nature*. 394, 6692 (1998), 431–431.
5. Khong, L. 2003. Actants and enframing: Heidegger and Latour on technology. *Studies in History and Philosophy of Science Part A*. 34, 4 (2003), 693–704.
6. Kobayashi, H. et al. 2009. Wearable Forest clothing System: Beyond Human-computer interaction, in *Leonardo*, 42, 4, (2009), 300–306
7. Latour, B. 1990. Technology is society made durable. *The Sociological Review*. 38, S1 (1990), 103–131.
8. Lowenberg, R. 1976 *The Secret Life of Plants*. Retrieved May 22, 2015 from: http://greenmuseum.org/content/work_index/mg_id-613__prev_size-0__artist_id-94__work_id-149.html.
9. Mancuso, S., & Viola, A. 2015. *Brilliant Green: The Surprising History and Science of Plant Intelligence*. Island Press.
10. Mann, S. 1996. "Smart clothing": wearable multimedia computing and "personal imaging" to restore the technological balance between people and their environments. *ACM Multimedia* (1996), 163–174.
11. Manzella, V. et al. 2013. Plants as sensing devices: the PLEASED experience. *Proceedings of the 11th ACM Conference on Embedded Networked Sensor Systems* (2013), 76.
12. Mehdiabadi, N.J. et al. 2006. Social evolution: kin preference in a social microbe. *Nature*. 442, 7105 (2006), 881–882.
13. Morin, P.A. et al. 1994. Kin selection, social structure, gene flow, and the evolution of chimpanzees. *Science*. 265, 5176 (1994), 1193–1201.
14. Orth, M. 2013. On the Short Life of Color-Change Textiles. Blog post on Words about Art + Technology + Sustainability. Retrieved December 16, 2015 from: http://www.maggieorth.com/Short_Life.html
15. Queller, D.C. and Strassmann, J.E. 1998. Kin selection and social insects. *Bioscience*. (1998), 165–175.
16. Stamets, P. 2011. *Mycelium Running: How Mushrooms Can Help Save the World*. Ten Speed Press.
17. Schiphorts, T. 2005. Soft, softer, softly: whispering between the lines. In *aRt+D: Research and Development in Art*, V2_Publishing, NAI Publishers (2005), pp.167–175.