From Wearables to Soft-Wear: Developing Soft User Interfaces by Seamlessly Integrating Interactive Technology into Fashionable Apparel

Daniel Gilgen and T. Raune Frankjaer

Trier University of Applied Sciences, Department of Design,
Irminenfreihof 8, D-54290 Trier, Germany
gilgen@hochschule-trier.de, raune@frankjaer.de

Abstract. The development of electronic features for use in apparel has advanced rapidly in recent years, and applications in athletic wear have been particularly successful. However, 'Smart Fashion' has not yet been integrated into everyday garments. In this paper we propose a new approach to the design of interfaces in Smart Fashion, which we refer to as the Soft User Interface (SUI). The ways in which e-textiles physically convey information differs greatly from traditional ways in that information is communicated via graphical user interfaces on computers, smartphones or on WearComp devices. As a result of our research, we advocate the use of iconic and indexical signs for Smart Fashion as these are widely accessible and understood. As an extension to this new interface paradigm, we expect that the harvesting of biometric data, including bodily gestures, will significantly extend the possibilities of SUIs.

Keywords: Smart Fashion, applied semantics, gestural input, embedded electronics, physical computing, wearable networks, hybrid space, interactive technology, Soft User Interface, SUI.

1 Introduction

Interactive technologies have been successfully integrated into clothing in industries in which functionality is very important, such as sports, healthcare, security and safety. Nevertheless, this remains a niche market, and Smart Fashion is not yet common in everyday wear. Electronically augmented fashion is generally known as illuminated outfits that are reserved for stage performances or other special events. In this paper we discuss how Smart Fashion can be integrated into everyday clothing. We examine the concerns that need to be addressed and the design requirements that need to be met for seamless integration of interactive technologies into fashionable apparel.

A cooperative interdisciplinary design research project between the Department of Fashion and the Department of Intermedia Design at the Trier University of Applied Sciences constituted the basis for our investigations. This research, which focuses on psychological design aspects as well as on semiotic and aesthetic issues, commenced in 2011 and will be finalized by the end of 2014.

A. Marcus (Ed.): DUXU 2014, Part IV, LNCS 8520, pp. 253–260, 2014.

The application of new technologies to long-established products like clothing often meets with strong resistance as society has very strict pre-established conceptions about these everyday artifacts. Along with these cultural expectations come certain habits and behaviors that are very hard to challenge, as they are associated with objects for which the patterns of interaction are internalized at a very deep level. These patterns are established over many generations and are passed on during infancy. Thus, different types of clothing and clothing items are highly archetypical, often with concise perceptions and with high iconicity. These archetypes are independent of prevalent fashion trends and, in stark contrast to other technological developments, evolve slowly. There are generally three ways to approach established mental models in the field of new technology:

1.1. The technology can physically disappear into a known product, such as imperceptible embedded sensors that track personal biodata and transmit the data to a medical service. One example is the cancer-detecting bra developed by First Warning Systems [1, 2].

1.2. A novel product category can be designed that is not associated with any preconceptions. The Nike FuelBand, Jawbone's UP and FitBit are examples of this type of product [3, 4, 5]. One could argue that these devices are similar to wristwatches or bracelets; however, the integrated functionality provides a novel experience, so these technologies may be perceived as original and different.

1.3. A known product can be extended using interactive technology. The Sporty Supaheroe Jacket for bicyclists by Utope is a good example of this. The primary function of a jacket is to protect against adverse weather conditions, and the Supaheroe Jacket extends this function by providing increased visibility and the ability to communicate the cyclist's intentions to others using the road [6].

This paper focuses on the third category i.e. applications in the field of smart wearable textiles, which we define as Soft User Interfaces (SUIs). We position SUIs as a subcategory of Wearables. But distinct from WearComp, such as augmented glass technologies, smart watches and digital wristbands, so-called fourth screens rely on text- and image-based communication.

In contrast, SUIs are "embedded computing worn on the body, made of soft and flexible materials, and, being devoid of screens, exclusively rely on non-verbal communication as a mean of interaction." SUIs must be aligned with established attitudes towards clothing and must be simple and intuitive to use. This can be achieved by reducing the symbolic representations in the interface design [7].

2 Nonverbal Communication

With WearComp, as with any screen-based communication, the focus is on text, image and auditory interactions. Thus, although the extent and importance of nonverbal interactions in interpersonal communication is widely recognized, nonverbal

communication has not been integrated into human-computer interfaces in Smart Fashion. Between 70–90% of all inter-human communication takes place through wordless clues, which are primarily used to establish and maintain interpersonal relationships [8, 9]. Understanding and applying these patterns of communication is paramount for the development of SUIs, as clothing provides a wide array of non-verbal communicative cues. There are many types of nonverbal communication, and artifactics, proxemics, chronemics, kinesics and haptics are particularly significant for the design of SUIs.

2.1 Artifactics

Artifactics denote the communication and non-verbal signaling that emerges from personal accessories, such as dress or fashion accessories. The choice of what to wear is an efficient means of communicating during social interactions: Clothing not only conveys a message, but it also directly manipulates and influences how we and others establish our identities. Clothing acts as an extension of oneself and can non-verbally communicate a wide array of meanings, including identity, mood and attitude. Identities that are communicated by dress are also influenced by technology and society-wide moral and aesthetic standards [10, 11].

The aesthetics of a garment are important cues for interpreting dress. These include the construction material and usage, manufacture (handmade vs. machine produced vs. high-tech), design and historical references (innovative vs. traditional) and syntax (use of colors, patterns and shapes).

When choosing what to wear, both conscious and unconscious decisions are made. The primary considerations are suitability: Is the clothing suitable for the situation (expected dress code, weather conditions and wearer's persona)? Is it physically suitable (consistent with one's personal style and body shape)? People generally take 10–30 minutes to dress in the morning, but sometimes they take up to an hour (both genders). There is a general unwillingness to complicate the process of dressing by adding the need to configure a dress electronically. In fact, over the last hundred years, clothing development has trended towards greater simplicity and towards clothing that is easier to put on and wear [12].

2.2 Proxemics

Proxemics describes the use of space and orientation within nonverbal communication. Proxemics differentiates between two kinds of space, territorial and personal, the latter being of particular interest in the development of SUIs. This space, termed the Personal Reaction Bubble, can be divided into four groups that are associated with differing distances depending on the situation and the people involved. Intimate distance is used for close encounters, such as embracing, touching, or whispering. Personal distance is used with close friends and family members. Social distance is used among acquaintances and is used in a workplace or school setting, where there is no physical contact. Public distance is used when strangers meet or for public meetings [13].

2.3 Chronemics

Chronemics are concerned with the use of time in the context of human communication interactions. Chronemics is the study of the interaction time that is associated with our formal and informal obligations. However, chronemics also include subjective and personal temporalities [15]. In the design of SUIs, chronemics offer a reliable and easily executable tool for control. For example, the duration of time that a wearer chooses to spend in a place or in proximity to a certain object or person generally reflects the wearer's interest in the person or object. Chronemics are mostly used in conjunction with proxemics. When applying these tools to the design of a SUI, provisions must be made for situations in which the time and body position is out of a wearer's control, such as riding an escalator or sitting in a doctor's waiting room.

2.4 Kinesics

Kinesics is the interpretation of non-verbal behavior as related to movement either of a particular part of the body or of the body as a whole. These include facial expressions, gestures and posture. Only a few gestures are universal, such as the shrug, the 'halt' gesture and pointing, with slight culturalvariations in the execution of the gesture [16]. Facial expressions, however, are to a large extent innate and are therefore often universal and easy to read [17].

Unfortunately, it is difficult to integrate facial expressions into smart fashion because using tracking technology on the face is both conspicuous and uncomfortable. To a lesser extent, this is also true for the use of gloves or fingerings to track hand gestures [18]. Therefore we assume that future e-textiles will have embedded sensors, such as gyroscopes, flex sensors and accelerometers, that will allow the tracking of gestures and posture. To some extent, these sensors can be fashioned by exploiting the properties of soft materials that are used in the manufacturing of garments [19]. Evaluating these data could be important for reading and interpreting nonverbal cues.

In addition to using preconscious bodily gestures to better interpret the user's intentions, certain conventions used in body gesture control could be developed. Such conventions are used in interactions with the multitouch surface of smartphones and tablets. There has been little research into using sign language for bodily interfacing. Existing research focuses on the use of camera-based tracking technology and does not use data directly from the body [20].

2.5 Haptics

Haptics are concerned with the significance of touch and the impressions received through touch. These include vibrations or motion, heat, cold and pressure. Vibration is most commonly used in mobile technologies to convey information unobtrusively. In Smart Fashion, haptic impressions are most commonly used to communicate presence [21]. Although of the utmost significance in the human perception of reality, haptics are not widely used in inter-human communication. In most cultures, the act of touching is used only as a gesture of recognition when meeting or departing or in

an intimate situation. Some cultures do not touch at all in public. Another aspect of touch in interfacing is the issue of hygiene, as for public touch-screen displays [22]. Therefore we have not integrated haptics into the SUI as a direct functionality between wearers. However, haptics do provide ample opportunities for recipient-based information mapping. Unfortunately, current technical possibilities are limited, so that impressions will be intrinsically symbolic in nature. However, it is possible that technical improvements in actuators, vibration motors and heating materials will meet the necessary requirements to convincingly communicate an iconical haptic input to the wearer.

3 Levels of Integration

Fashion is one of the oldest ways to express one's personal identity. People are generally willing to accept new fashions, yet new fashions are expected to be uncomplicated to wear and to require no significant learning. In our research, we found that in order to make technology an integral part of everyday clothing, we need to develop a greater awareness of the level of integration. Integration can be subdivided into four main elements that can serve as guidelines for integrating interactive technology into fashionable apparel.

3.1 Signal Level

Signals represent information in different ways, i.e. via symbolic, indexical and iconic representation. Indexical and iconic representation are preferable, as they are more in line with established perceptions and require little or no additional learning. Symbolically represented information is either based on socio-cultural conventions or has to be learned. Due to our ocularcentric perception, the visual signals and display level of the garments are a primary focus. Wearing illuminated apparel draws the observer's attention to the wearer, as the animated light patterns tend to distract from other (non-visual) information. Therefore light-emitting technologies have to be applied very carefully. A well-executed example of this is the electroluminescent fashion Alpha Lyrae by Vega Zaishi Wang. Wang applies the photonic material indirectly to create an ethereal and pleasant effect that does not directly confront the onlooker with an overpowering light source [23]. There are additional signals that can be conveyed through tactile and acoustic cues rather than through visual cues that are also important methods for conveying information. As we are continually aware of tactile impulses, without the need for focused attention, tactile cues have the potential to provide new kinds of wearable ambient displays [24].

3.2 Level of Interaction

Multitouch sensitive devices that have Natural User Interfaces (NUI) have gained popularity in the last 5 years and standards of operation such as swiping and pinching have been established [25, 26]. In fashion technology, comparable standards have yet

to be established, with a plethora of suggestions that range from zippers, hooks and velcro to touch-sensitive textile surfaces. As the level of interaction is closely related to the input possibilities, we questioned the ways in which the body, covered with textiles, can be used as an input device. We studied gesture and movement for their potential for intuitive affordances, analyzed the most common approaches and compared the advantages and drawbacks. Our investigations confirmed the expectations that body gestures are socially, culturally and individually determined symbols. However, we believe that with the use of NUIs, more gestures can become "intuitive" as the market becomes increasingly saturated.

3.3 Level of Connectivity

There are many different input options, from the wearer's biometric data as captured by sensors integrated into the clothing, to information from remote locations or interactants. Accordingly, the level of connectivity can vary greatly. It begins in the personal sphere of social interactions between two people and extends to group interactions. However, when remotely extending beyond peer-to-peer (P2P) communication, the need arises for an additional control mechanism to distinguish among remote interactants.

3.4 Level of Privacy

Generally there are two main approaches to privacy in Smart Fashion. First, the signals and signs that are displayed can be completely visible but only be understandable to the wearer due the arbitrary nature of symbolic representation. Alternatively, the signals can be invisible or imperceptible except to the wearer [27].

However, as SUIs aim to extend the function of fashion as a public display, the wearer makes a decision about privacy when choosing to wear a certain garment. If the wearer feels outgoing and communicative, a brighter and more expressive garment can be chosen. If the wearer is in a more introspective mood, more unobtrusive designs can be favored. This user-controlled approach to privacy is in line with current practices for dressing.

4 Discussion and Conclusion / Further Work

Clothing constitutes one of our main cultural assets and is deeply rooted in human history. These traditions influence both clothing design and our perception of clothing. For interactive technology to become a truly integral part of our culture, these preconditions have to be acknowledged and respected. Only a few of the examples that we studied reflect these aspects fully or even partially. Often it is the technical elements that need to be improved substantially for the interactive garments to truly become suitable for every day wear. For example, two important practical considerations are the garment’s power supply and washability.

In our analysis of representative examples of Smart Fashion we deduced that apart from the technical specifications, the design of the interface itself is of paramount importance for the acceptance of Smart Fashion. We identified the following parameters that should to be applied to the development of what we describe as the SUI:

The SUI is a subcategory of Wearables, which, in contrast to WearComp, is a physically embedded interface with a textile or other flexible material that can be worn comfortably on the body as the main substrate. The SUI has no screens and is in direct contact with the user. The operation of the SUI relies on biometric and contextually relevant data in conjunction with the nonverbal communication cues of the wearer and other interactants.

An SUI must be as easy to use as any other everyday garment, and the interface should not requiring any additional configuration or training. Consequently, the focus must be on indexical and iconic representations within the user interface. As part of enhanced apparel, an SUI can extend and amplify social interactions on a variety of levels, including interactions with distant environments as well as with interactants. However, when incorporating multiple remote connections, the issue of distinguishability arises. We anticipate the areas of application of this technology to be predominantly in inter-personal communication, although it will introduce novel methods of interaction with surrounding architectural space or to remote locations [28]. Therefore, one challenge in the development of SUIs is for the interfaces to remain understandable to interactants in a larger network. We think that haptics have great potential for information mapping when the technical issues are resolved.

We believe that the application of context-relevant data, and sensor-based data harvesting and evaluation of nonverbal communication cues in particular, has the potential to create a new paradigm for the design of SUIs. To accomplish this, it is necessary to establish the positioning and movement of the body (kinesics) in conjunction with distance (proxemics) and time (chronemics) with regard to a given location. The ensuing seamless integration into everyday apparel should result in a soft human-computer interface.

References

1. Streitz, N., Nixon, P.: The Disappearing Computer. Communications of the ACM 48(3), 33–35 (2005)
2. First Warning Systems, Inc., http://www.firstwarningsystems.com/
3. Nike+ FuelBand SE Activity Tracker & Fitness Monitor, http://www.nike.com/us/en_us/c/nikeplus-fuelband (accessed November 20, 2013)
4. UP by AliphCom dba Jawbone, https://jawbone.com/up/ (accessed January 12, 2014)
5. Flex by fitbit, https://www.fitbit.com/ (accessed March 4, 2014)
6. Sporty Supaheroe jacket for bicyclists by Utope, http://www.utope.eu/sporty-supaheroe_jacket01.html (accessed November 20, 2013)
7. Frankjaer, T.R., Gilgen, D.: Wearable Networks, Creating Hybrid Spaces with Soft Circuits. In: Marcus, A. (ed.) DUXU 2014, Part II. LNCS, vol. 8518, pp. 435–445. Springer, Heidelberg (2014)

8. Hogan, K., Stubbs, R.: Can't get Through 8 Barriers to Communication. Pelican Publishing Company (2003)
9. Argyle, M., Salter, V., Nicholson, H., Williams, M., Burgess, P.: The Communication of Inferior and Superior Attitudes by Verbal and Non-verbal Signals. British Journal of Social and Clinical Psychology 9, 222–231 (1970)
10. Stone, G.: Appearance of the self. In: Human Behavior and Social Processes: An Interactionist Approach, pp. 86–118. Houghton Miffilin, New York (1962)
11. Roach-Higgins, M.E., Eicher, J.B.: Dress and identity. Clothing and Textiles Research Journal 10(4), 1–8 (1992)
12. Christine Frederick, C.: How long does it take your wife to dress? American Weekly (January 14, 1917)
13. Hall, E.T.: The Hidden Dimension. Anchor Books. Random House, Inc. (1990)
14. Bruneau, T.: Chronemics. In: Encyclopedia of Communication Theory. SAGE Publications, Inc., Littlejohn S.W (2009)
15. Doherty-Sneddon, G.: Children's Unspoken Language. Jessica Kingsley Publishers (2003)
16. Knapp, M.L., Hall, J.A., Horgan, T.G.: Nonverbal communication in human interaction. Cengage Learning (2012)
17. Sign Language Ring, http://www.red-dot.sg/en/online-exhibition/concept/?code=1033&y=2013&c=16&a=0 (accessed November 20, 2013)
18. Fraser, G.A., Raab, S.: Posture monitoring system. U.S. Patent 4, 730, 625 (1988)
19. Fox, M., Polancic, A.: Conventions of Control: A Catalog of Gestures for Remotely Interacting With Dynamic Architectural Space. In: Proceedings of the 32nd Annual Conference of the Association for Computer Aided Design in Architecture (ACADIA), San Francisco, pp. 429–438 (2012)
20. Cohen, C.J., et al.: Gesture-controlled interfaces for self-service machines and other applications. U.S. Patent No. 7460690 (2008)
21. Keng Soon Teh, J., et al.: Huggy Pajama: A mobile parent and child hugging communication system. In: Proceedings of the 7th International Conference on Interaction Design and Children, pp. 250–257. ACM, Chicago (2008)
22. Dix, A., et al.: Physicality and Spatiality: Touching private and public displays. In: Workshop on Designing Multi-touch Interaction Techniques for Coupled Public and Private Displays, Napels, p. 8 (2008)
23. Alpha Lyrae by Vega Zaishi Wang, http://www.vegawang.com/ (accessed November 20, 2013)
24. Wisneski, C.A.: The design of personal ambient displays. Diss. Massachusetts Institute of Technology (1999), http://dspace.mit.edu/handle/1721.1/
25. Buxton, B.: Multi-Touch Systems that I Have Known and Loved Microsoft Research. Original (January 12, 2007)
26. Wigdor, D., Wixon, D.: Brave NUI World: Designing Natural User Interfaces for Touch and Gesture. Morgan Kaufmann Publishers Inc., San Francisco (2011)
27. Fajardo, N., Andrew, V.M.: ExternalEyes: Evaluating the visual abstraction of human emotion on a public wearable display device. In: Proceedings of the 20th Australasian Conference on Computer-Human Interaction: Designing for Habitus and Habitat. ACM (2008)
28. Kobayashi, H., Ueoka, R., Hirose, M.: Wearable Forest-Feeling of Belonging to Nature. In: MM 2008, Vancouver, British Columbia, Canada, October 26–31, 2008. ACM (2010)