Chapter 12
Designing for Smart Clothes and Wearables—User Experience Design Perspective

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Abstract Due to the recent years' advances in prototyping techniques, flexible electronics, and component miniaturization, research has emerged to explore novel concepts and functionalities for wearable computing. So far, the attention has been mostly toward technical rather than user experience studies, seeking to illustrate novel and proof-of-concept-level functional prototypes. In this chapter, wearable computing is approached from the user experience (UX) design point of view. The principles of UX design are discussed with respect to the area of designing smart clothes and accessories, and three examples of concept designs, focusing on young athletes, a solar powered coat design, and a smart handbag design, are presented.

12.1 Introduction

The past decade has witnessed giant steps in the area of computing technologies, and waves of digitalization and everyday mobile technology use have spread over urban societies. We currently carry around computing gadgets, such as mobile phones and tablets, and new form factors are emerging to the mass market. In particular, in the health and wellness domain, various physical activity trackers have already been adopted by large user groups, e.g., in the form of bracelets and armbands. The world is substantially moving toward wearable computing. Although the technologies in today's wearable products are mostly still in the form of gadgets or standalone objects, the designs are getting lighter, more aesthetic and more closely integrated to the clothing and human body. Also in research, wearable computing is emerging from being a technology-dominated field toward the fields of user experience design, industrial design, and textile design.

In this chapter, user experience (UX) design aspects are considered in respect to wearable computing design, especially smart clothes. With smart clothes, we mean objects of *wearable computing, which integrate technology and intelligence in a way that the form factor design follows the one of a clothing design*. Smart clothes provide

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S. Schneegass and O. Amft (eds.), *Smart Textiles*,
Human–Computer Interaction Series, DOI 10.1007/978-3-319-50124-6_12

new possibilities for the design of tangible user interfaces, aesthetics, and rich user experiences. In addition, smart clothes offer potential for developing concepts that link with, e.g., sustainability, energy efficiency, and recycled material, providing an interesting playground to design for underexplored angles of wearable computing. In the following sections, we take an overview to UX research and human–computer interaction (HCI) research on topics of interest for smart clothes and wearable computing. We then present three design cases on our smart clothes design research.

12.2 User Experience Design and Research for Wearable Computing

12.2.1 User Experience and Ubiquitous Computing

User experience research is linked with the wider field of user centric design (UCD), which puts the target users in the center of the design process by involving them throughout the design process. Typically, a UCD process starts from end-user research through interviews and observations in the field and is followed by a concept design phase where users are involved, e.g., through participatory design sessions. Toward the end of the design process, an evaluation of design prototypes is made with user tests, and the designs are iterated according to their results. User experience research is a relatively young field, which has developed to its own track from a basis of usability research, taking a broader view in evaluating and designing interactive products. Although a single definition for UX concepts and theory is challenging to find [1], it is generally agreed that UX goes beyond the instrumental values and utilitarian aspects [2]. Hassenzahl defines user experience (UX) as *'a momentary, primarily evaluative feeling (good–bad) while interacting with a product or service'* [3].

Whereas traditional usability research has focused on investigating interaction performance, error rates, and ergonomics and has used measurable and quantifiable factors in evaluation processes, UX research emphasizes the importance of subjective, emotional, and aesthetic aspects related to the interaction with products and services. User experience is defined as consisting of both utilitarian and hedonic aspects [4]. The utilitarian side typically dominates in the overall motivation for application design; however, in constructing the user interface, hedonic aspects are important to consider in order to create pleasurable and engaging experiences. Hedonic aspects can also relate to different values that are represented through the design, and which the target user can relate with. In contrast to conventional graphical user interfaces, when smart clothing and wearables are considered, tangible factors such as material selections and physical form become an important part of the user experience design. They can affect both utilitarian and hedonic sides of the user experience design, e.g., through usability and comfort.

Wearable computing is part of the larger domain of ubiquitous computing. In ubiquitous computing, the computers and sensor systems are considered to be integrated to our everyday environments, blurring the borderline between physical and digital worlds. The field has largely be driven by Mark Weiser's vision [5], which presents how computers will disappear in the periphery of human attention, leaving the environments calm and serene. Smart clothes easily integrate with this vision, as they can truly hide the technology within the garments we wear every day.

Ubiquitous computing is deeply rooted in its computer science and engineering background, and UX research aspects have so far played a nominal role. To illustrate this, for instance Dünser et al. report that for the mixed reality research papers in 1993–2007, only in 10% included any kind of user evaluation [6]. In a literature review assessing UbiComp-related research papers pre-2014, Väänänen-Vainio-Mattila et al. report that only a minor part of them included UX evaluation aspects, and even then, mostly applying a narrow selection of methods [7]. UX is still mostly considered from the utilitarian perspective, e.g., usability, and the hedonic qualities are often summarized under simplified categories, for instance with descriptions such as 'playful' or 'fun.' However, UX research has the potential for a much richer vocabulary, and closer exploration can offer more concrete feedback and ideas for designers.

12.2.2 Aesthetics and Materiality in Interaction Research

When designing tangible user interfaces, material qualities are an integral part of the holistic experience. Material qualities of physical objects have been thoroughly considered in areas such as art, industrial design, and mechanics, but research on the material's role in interactive systems has been somewhat sporadic, leaving much to explore. Tangible user interfaces (TUIs) can make use of the human senses in a richer and more multidimensional way than conventional digital user interfaces (UIs) [8]. Thus, it is valuable to explore the different qualities that are perceived and associated with different physical materials.

So far, the focus in the research on materiality qualities in HCI has mostly concentrated on proof-of-concept-level installations, where a certain material has been evaluated as part of the concept. For instance, interactive systems using water in the user interface have been studied. With water, user study participants have described that the cool water creates a pleasant sensation against the skin [9, 10], and spilling water has been reported to offer a more powerful UI feedback than simulated virtual feedback [11]. Aesthetics can also relate to the fragility and lifespan of the user interface, as with ephemeral UIs [12].

Systematic studies on materiality in HCI are so far scarce, with a few exceptions. On the methodological side, Jung and Stolterman have introduced the material probes method [13]. The method proposes a step-by-step procedure to gain information on different tangible materials in order to gain hands-on knowledge about user perceptions, and to help, e.g., industrial designers when designing interactive

systems, [13]. Häkkilä et al. present a study comparing user experiences when interacting with different natural materials [14]. The user experience findings on using natural material reflect the curiosity, aesthetics, and playful nature of the interaction, and they provoke many associations and memories.

12.2.3 Wearables UX

Wearable form factors for computing are becoming increasingly important. Wearable computing, as discussed here, includes clothing-type form factors, but also accessories such as handbags and jewelry, as well as smart watches and head-mounted displays (HMDs) [15]. In addition to clothing and accessories, also user interfaces on the skin offer interesting possibilities, of which Liu et al. provide a good overview [15]. When considering UX with wearables, we can see two main trends on which the design has focused—designing for utilitarian needs, or designing with aesthetics as a goal. Utility is heavily emphasized with so called functional clothing and when designing for accessibility and special user groups. Aesthetics is in a major role when jewelry-type form factors are considered or, e.g., when the target user group is trend or fashion conscious.

One of the areas where beauty is an inherent design goal is digital jewelry. Aesthetic design has to be a conscious goal or at least an important and integral part of the end results. Gadgets are progressing toward increasingly small form factors, such as rings. For instance, Ashbrook et al. have introduced Nenya interactive ring concept with aesthetic design [16]. Recently, end-user products have gained the maturity level to truly integrate biosensors to an aesthetic ring design. Oura ring, launched in 2015, supports physical activity and sleep rhythm monitoring with a jewelry-type design form factor [17]. Different bracelet-type gadgets have become popular especially among health and wellness monitoring, and FitBit and Polar Loop can be found on the wrist of many users. Pakanen et al. have investigated different tangible UI features and input mechanisms to a bracelet-type wearable, and propose different design solutions, which address visual and haptic aesthetics [18]. BuddyBeads is an interactive bracelet concept for social and emotional group connectivity between teenage girls [19]. Fortman et al. have charted design preferences for digital jewelry with an online survey and report that form factor, functionality, display, and interaction design were perceived as the most important factors in the design [20]. With a similar study on wearable wellness devices, Rantakari et al. report that functionality and form factor were seen as the most important design factors, compared, e.g., to context-awareness and sharing features [21].

Fashion-related wearable computing has gained attention during past few years, but it has been pointed out that research in this area is still taking its baby steps [22]. The need for fashion orientated software and hardware design will rise, but it is yet to be seen how the devices will vary in their expressions [23]. Currently, most of the concepts and research are heavily exploratory in nature. Juhlin et al. have presented an explorative study on different material qualities in the context of fashion, fabric,

and shape-change [23]. Examples of fashion show-type wearables include a robotic Spider Dress [24] and the Twitter Dress [25]. Here, the former is based on sensors and actuators, whereas the latter displays twitter feeds embedded to the dress surface. Colley et al. have presented several concepts for a handbag with an integrated public display, and investigated, e.g., adapting the outlook of the handbag to match the user's clothes [26]. The user study showed positive responses on the smart handbag concept, but, not surprisingly, highlighted that privacy aspects are important, as the display content is very visible and public.

Eyeglasses-type wearable computing has gained lots of attention since the project Google Glass [27]. Interest on Google Glass project has been demonstrated, e.g., in the invited keynotes given by Thad Starner [28] and Mark Billinghurst [29], both pioneering researchers in the area. Prior art on head-mounted displays (HMDs) has focused mostly on utilitarian use cases. Early work has considered areas such as architecture and construction sites [30, 31], helping fear of flying [32], or with Parkinson's disease [33]. Recently, the use of HMDs has been demonstrated as part of experiential UIs, for gaining experiences such as surprise and thrill. The Oculus Rift HMD has been demonstrated, e.g., for experiencing a simulation of flying as a bird in the sky [34], or how it is to ski on a physical skiing slope but with a view to virtual reality [35]. Also different directions to the aesthetics and visual style of eyeglasses-type wearables have been explored [36].

Research around smart watch form factor has started to bloom due the launch of several commercially available smart watches that function as an extension or replacement for smart phones. So far, the focus of the research has been on investigating suitable input mechanisms to interact with the smart watch, proposing different techniques from mechanical tilting and clicking [37], eye tracking [38] to deformation of the skin under the watch [39]. It their study, Schirra and Bentley have reported that users stated that the appearance of the smart watch had impacted on their purchasing decision. They desired a model that had a subdued design and could pass as a normal watch [40].

Clothes-type wearable computing has addressed both the utilitarian and hedonic sides of user experience design. Hedonic experiences are demonstrated, e.g., with fashion-related wearables, as mentioned before. Multisensory feedback has been harnessed for communication purposes, and an example of emotional communication is the Hug Shirt, which is used to send hugs over a distance [41]. Utilitarian aspects are addressed especially with wellness-related smart clothes concepts, such as in detecting joint movements [42], or movements of an unborn baby with sensors integrated to maternity clothes [43]. Also safety-related domains and target users such as firefighters [44] provide a high-utilitarian emphasis for wearables design.

12.2.4 Positioning Statement

In the following, three examples of designing smart clothes or wearables are presented. These examples represent different ways on how user experience research

has been integrated to the concepting and design process. The examples have been conducted in the research team led by the author during 2015. Although all these examples can be regarded as falling into the area of UX design and user centric design, the presented research cases represent somewhat different design processes and methods. Thus, they can provide tools and inspiration for other researchers and practitioners working in the area of smart clothes and wearables design.

The cases introduced in the following include three different types of form factor concepts for wearable computing. Case I presents a design concept where sensor technology is attached to wearable sports gear as removable stickers; Case II addresses a concept and design that integrates the technology as part of the clothing (a jacket) itself; and Case III demonstrates a smart accessory design. It is to be noted that this chapter focuses on the process and methods used, not on presenting the content-related findings of the user studies.

12.3 Case I—Ice-Hockey Youth

12.3.1 Context and Motivation

The first concept introduced in this chapter relates to health and wellness technologies. Tomorrow's health-related systems and services will increasingly take advantage of a myriad of different sensor systems, which can track our physical activity and everyday life. Today, sensor technologies have achieved a sufficient level of technical feasibility, miniaturization, and cost efficiency as to be able to be easily integrated into various types of everyday objects. This enables an omnipresent tracking of our activities, which consequently provides an overview of our lifestyle. The role of technology in monitoring our everyday activities, physical exercise, and overall lifestyle is promising, but requires yet more research and development work both for the technical aspects as well as for design.

Integrating wellness technologies into clothing and other wearable gear is an intuitive step following on from the carrying of sensors as separate gadgets, e.g., step counters and mobile phones. In particular, with sports, integrating sensors and tracking technologies in clothes allow them to be taken effortlessly with the user when doing exercise, and avoiding additional loose items that can hinder the performance or get tangled with other objects.

Whereas wearable form factors offer good possibilities for data collection, they are typically limited in their interaction interface. Many wellness gadgets already function together with a smart phone app, which provides the user interface to access the information. Since mobile phones have become a generic tool for their communication and user interface (UI) functionalities, they have been widely adopted also when developing new technology or service concepts. This approach, i.e., a combination of wearable tracking technologies and a mobile app providing the user interface, was found to be suitable also in this case.

12.3.2 The Concept

The wearables concept is targeted to young ice-hockey players, and it introduces attachable tags that collect the player's activity data during training sessions. The work has been described in more detail in [45]. The player is equipped with several tags that can be attached to ice-hockey gear to collect data on movements and collisions during the activity. The data is then transmitted to a smart phone, where it is processed and viewed after the ice-hockey training or game, see Fig. 12.1. In the concept design, the target was to utilize printed electronics for manufacturing the tags, enabling low-cost mass production for the end product.

The collected data and individual user's mobile app were part of a larger service concept. In the concept design, the data from the training session would be collected from each player, enabling the coach to see the overall picture of the team, as well as comparisons between team members. Also, each player would get a visualization of their own performance in respect to the whole team, handled in an anonymous way. Moreover, the concept design included the idea of enabling the addition of other 3rd party service providers, e.g., a personal trainer or a doctor, modularly to the application, and to share data with or receive recommendations from them.

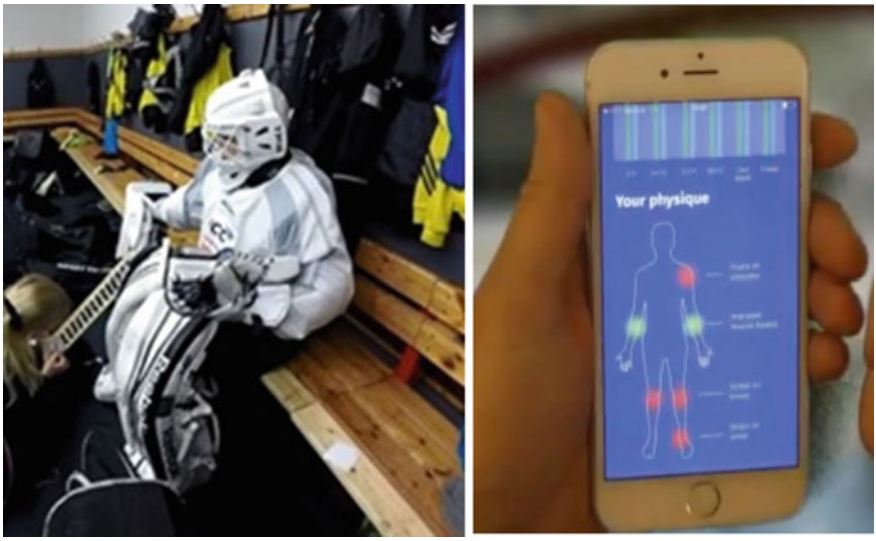

Fig. 12.1 Concept of using wearable tags and mobile app to collect data from ice-hockey training

Fig. 12.2 Examples of brainstorming tasks in concepting workshops—creating a big picture of stakeholders and brainstorming with a mobile app prototype as a stimulus

12.3.3 Design Process

The overall design process of the holistic concept consisted of the following main steps:

- Concepting workshops,
- Concept design, with first mobile app mock-ups,
- Creating a video presenting the key use cases,
- Wearable prototype and mobile app demos (simulated), and
- Concept evaluation in the field.

The concepting workshops held consisted of a multidisciplinary group of participants from industry and academia, brainstorming around concepts related to digital health services. During these workshops, different methods derived from the service design were applied to facilitate the discussion and ideation process. Examples of co-creation methods used in the concepting workshops are illustrated in Fig. 12.2. As an outcome, the workshops resulted in creation of a persona, a stakeholder map, a day-in-the-life story, and service chain descriptions of different health and wellness-related services that could potentially be joined with the key concept. The developed persona, Niklas, was a 13-year-old ice-hockey player, and the application and service concepts were developed with him as a target user.

A wearables concept, including an industrial design for attachable sensors and an interactive prototype of a mobile app, was developed through several sketching and prototyping phases. Figure 12.3 (left) illustrates early hand drawn sketches, which were further developed and printed to product-looking sensor stickers (Fig. 12.3, right). These could be attached to the ice-hockey gear and clothes. The final concept is illustrated in Fig. 12.1.

In order to evaluate the concepts, an evaluation workshop was organized with a team of 13-year-old ice-hockey players. The test and feedback session with the young athletes was made in the field, i.e., at an ice skating rink, during a standard training session. The evaluation session lasted approximately 2.5 hours. In the beginning of

Fig. 12.3 Designing wearable tags: sketches and printed mock-ups

the training session, researchers explained the concept to the players, and attached, or helped to attach, the simulated sensor stickers to their training gear. The boys wore the stickers through the whole training time on ice, after which the mobile phone application concept was discussed together with the wearables concept and form factor.

12.3.4 Discussion on User Experience Perspective

Case I has presented a wearables concept where the technology is attached to the wearable gear as removable stickers, taking ice hockey as a domain for the design case. The aim for this concept was that a modular design would allow greater freedom for the user (or a coach) to decide optimal and interesting body areas to be monitored, and tailor personal tracking solutions.

In this concept, we paid attention to both utilitarian and hedonic aspects in the user experience design. The aim was to create a concept with utilitarian value and a useful use case, and the service itself promoted healthy lifestyle, personal training, and sports. Hedonic aspects were considered especially through the polished designs of the prototypes, and the tags were designed to be professional and aesthetic looking, as well as easy to use.

The use of persona creation as a method in the design process has gained controversial discussion [46], but despite this, it still remains a commonly used method. In our case, the persona functioned both as a communication tool as well as an aid for designers. In particular, when making visual designs, sketching and illustrating

descriptions of the concept, a selected, defined target user persona was important to have in order to create a unified vision and presentation of the concept. The role of the persona was important also when communicating the concept within the interdisciplinary project. As is usual with this type of project, several workshops with people with various different backgrounds and roles were included in the process, and a persona provided a consistent and illustrative tool when referring to the concept design.

12.4 Case II—Solar Cell Coat

12.4.1 Context and Motivation

The second case presented in this chapter considers clothing-type wearable computing and introduces a coat-like garment. Clothes integrated computing components represent one of the typical approaches to wearable computing. They have also become more easy to construct and prototype with available toolkits, e.g., Arduino microcontrollers, and gained more public attention through Google Project Jacquard [47]. The concept presented in the following sections features a flexible solar cell integrated to a coat and is motivated by trends for sustainable design and energy harvesting. The aim of the concept design was to produce a design vision, which communicates to a large audience a sustainable approach for wearable computing design. The concept and prototype was targeted to a design exhibition, which set high standards for its overall appearance. Thus, a polished design clearly articulating the design vision was more important than the technical functionality of the prototype.

12.4.2 The Concept

The concept *Solar Shirt* is a coat-like design garment, presented in Fig. 12.4. The garment includes solar cells as an integral part of the design—hence the concept name, *Solar Shirt.* The Solar Shirt uses felt as the main material, and the clothing design approach applies arctic design—matching the design style to that of the arctic nature and environment. The use of natural materials (over manmade fibers) gives warmth and softness to the design and aligns with the ecology focused values of the concept.

The concept illustrates the possibilities of using energy harvesting as part of the design and envisions how wearable computers could be designed in a manner such that they actually produce the energy they use, rather than consuming energy from external sources. The solar cells are manufactured with printed electronics technology and come in flexible and thin format. In addition, the coat includes a similarly flexible electrochromic display. The functionality of the concept is designed

Fig. 12.4 Solar Shirt wearable computing design concept—final prototype

around environmental sensors. The coat includes sensors that detect the ambient noise level, and the pattern shown on the coat's display changes when a threshold noise value is exceeded. The final prototype of the design concept is presented in Fig. 12.4. The Solar Shirt was presented as part of the Kaiku exhibition at Ventura Lambrate, during Milan Design Week 2016.

12.4.3 Design Process

In this case, the concept design began with a design brief, which defined the target of creating an outdoor coat-type wearable computing concept employing solar cells as part of the design. In this first phase, several different concept designs were created at a sketching level, and the work was conducted in groups of 4–5 design students. The starting point of the work was to explore the design possibilities from the clothing and

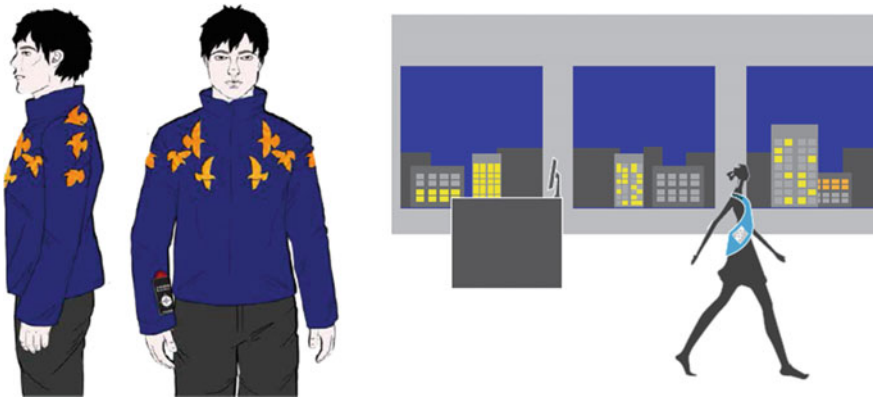

Fig. 12.5 Sketches on different concepts illustrating outdoors coat-type garments with solar cells

industrial design concept point of view, and, differing from the other two design cases presented in this chapter, end users were not involved in the design process. The first concepts designs were illustrated through sketches and use scenarios were drawn. Figure 12.5 illustrates this phase in the design process. Figure 12.5—left illustrates an early sketch of the concept with alternative design of coat-integrated solar cell modules. This visual design was soon abandoned when refining the style of the concept, and also because of the unavailability of the required technology.

Figure 12.5—right presents an early draft of the concept that was selected for further development. The picture presents a use scenario, where the garment is worn in a city environment, and the integrated sensors collect environmental data from the user's surroundings. The form factor of the garment is beginning to take shape, i.e., an asymmetric design that goes over one shoulder across the user's chest. This concept was then developed further into a physical prototype (see Fig. 12.6). Figure 12.6 presents two early constructions, where the shape of the garment and the material selections are tested on a human size mannequin. The prototype was developed in phases by iterating the design, the cut lines, and materials used. The final prototype was constructed using a clothing design process and equipment, and the finalized prototype is presented in Fig. 12.4.

12.4.4 User Experience Perspective

In this wearables concept, the utilitarian aspects were included mostly in the design aim—the target was to concept an outdoors coat-type wearable computing garment, which utilizes solar cells. The utility factors came from the use of energy harvesting technology, the functionality of the concept, and from the wearing comfort that would affect to the usability of the garment. Hedonic design aspects came from the

Fig. 12.6 Shaping the early wearables prototype with a mannequin: early shaping of the form factor (*left*) and an already mature prototype of the concept (*right*)

aesthetics of the design and through the material selections, which were chosen to associate with luxury, sustainability, and comfort.

With this design case, the design process prioritized clothing design over engineering and technology implementation. Thus, the prototype was designed according to the principals and practices of clothing design. Altogether, the *Solar Shirt* concept focused on creating a polished final design piece and in communicating the design vision, creating an example on how energy harvesting garments could look in the future.

12.5 Case III—Smart Handbag

12.5.1 Context and Motivation

The third concept presented in this chapter addresses the design of a wearable public display, which are still rare in the area of wearable computing, although some examples do exist. For instance, using wearable public displays to visualize social media feeds is done in [25, 48]. Mauriello et al. have integrated displays into runners' shirts at sporting events [49], and Puikkonen et al. [50] tested a Tic-Tac-Toe T-shirt which integrated the game on the front side of a t-shirt by using single-colored LEDs. In our research, we were interested in exploring the user perceptions of a public display

integrated to a personal item, which the user carries around in their everyday life context.

The design cases also investigate an underexplored form factor in the area of wearable computing—the handbag. Handbags are interesting objects as they combine the functionality of carrying important items, with a fashion and appearance conscious form factor. They are at the same time very visible, but still personal and intimate objects.

12.5.2 The Concept

The research on interactive handbag employing a public display included three different concepts: using the display, (A) to match the handbag to the user's outfit and context, (B) as a see-through interface to the handbag content, and (C) as an information display. The concepts are described in more detail in [26].

Concept A, i.e., matching the handbag to the color of the wearer's shoes or jacket, focuses on aesthetics and fashion design. It considers handbag as a part of a larger outfit, and the context-awareness and adaptive display content are used for hedonic purposes. This approach also enables a chameleon effect, which further explores the idea of matching the handbag to other surfaces on which it is placed on or against to. An illustration of the polished concept design is presented in Fig. 12.7.

In design concept B, the handbag surface was composed of a display creating a see-through illusion to the contents of the bag. In the study presented in [26], different visualization techniques from full color images to X-ray style were explored. In addition, the concept included the ability to interact with the items in the bag through the bag's surface display and to show the brand of a perfume bottle contained within.

The smart handbag concept C employed the handbag's surface as a public information display. The smart handbag provides possibilities for its wearer to interact

Fig. 12.7 Design concept of a smart handbag adapting its colors to the user's outfit

socially, in public, in a more ad hoc way than is possible with traditional printed designs. For example, the user may select a personal motto or statement to be displayed on their handbag.

12.5.3 Design and Research Process

The research process for the smart handbag concept included iterative prototype design, the development of several concepts, testing them in a user study, and finally creating a 3D modeled, polished industrial design of a selected concept (concept A, illustrated in Fig. 12.7). The user study was conducted with two early prototypes, which were constructed as interactive, responsive artifacts by using off-the-shelf technology.

The prototype design consisted of several parts. Two off-the-shelf handbags were modified by cutting and sewing to fit a tablet in and to attach a mock-up camera lens on one side of the bag, see Fig. 12.8. Graphics design for the displayed items was made, and several different visualization techniques were used. The concept was evaluated in a user study with the wizard-of-Oz method, and for that, a mobile phone application was implemented to enable a hidden human operator could control the content that was shown on the handbag.

In the user study, it was important to collect feedback not only of the concepts themselves, but also about how it was perceived in use. As the prototype relied on wizard-of-Oz techniques and was not mature enough to be tested completely in-the-wild or in a long-term study, it was decided that the study would include tasks that would expose the user to public situations. During the approximately 1-hour study session, the user was asked to walk through a university campus cafeteria with the interactive handbag. This task, although short, provoked many comments and reactions from study participants and increased the validity of the feedback.

Fig. 12.8 The interactive handbag prototypes used in the user study. The study task to match the handbag pattern and *color* to the clothes is conducted

12.5.4 User Experience Perspective

The research conducted to concept an interactive handbag resulted in several concepts, which emphasize different user experience design aspects. Matching the handbag's outlook to the clothes or environment clearly appeals to the hedonic side of UX, as it seeks to offer an aesthetic and personalized design solution. Using the attached display as a see-through surface to the handbag content or as an information display focused on utilitarian needs as design drivers. With these concepts, the functionality needs careful UI design that takes into account privacy aspects. Thus, addressing the aesthetics and hedonic values is a less risk-prone and easier design approach.

12.6 Discussion and Conclusions

This chapter has addressed the user experience design perspective on wearable computing and has introduced three different wearable computing design concepts from the user experience design point of view. Wearable computing design, when the term design is understood in a similar way as in smart phones and other mobile technologies, is still taking its early steps. The push for wearable computing has so far been coming from the technology side, demonstrating engineering and computing solutions. However, when the technology matures and the concepts begin to aim for commercial markets rather than being research demos, the pressure to create appealing industrial and user experience design grows.

As technologies become more mature and prototyping tools easier to use and more widely adopted, the ability to produce high-fidelity prototypes grows. With more mature prototypes, the chances to employ wearable technologies in real life increase, and evaluating concepts in-the-wild with users becomes easier. When the basic technology works reliably, one can pay more attention to other aspects of the prototype. This means that the design aspects become more prominent in the research. It becomes more relevant to investigate the user perceptions in a holistic manner and to find solutions on how to introduce the technology to larger audiences. With ever smaller components, the ability to integrate technologies invisibly to garments and accessories grows and design restrictions become less of a concern. With declining energy consumption, battery charging demands become less, and the use of wearable computing more flexible.

The presented example concepts illustrate three different approaches to wearable computing—solutions where the technology is attached and integrated to the wearable garments or gear (Case I and II, respectively), and designing a wearable accessory (Case III). As the technical implementation and manufacturing are becoming easier, there will be great growth potential for products and business in this area. In the future, the role of designers and technologists working in the wearable technology and smart textiles area can make a difference in the everyday lives of wide

audiences. Although the topic is currently at the beginning of its era in terms of commercial applications, it will become mainstream tomorrow.

The examples presented in this chapter place different emphasis on the design processes as well as in user experience design. When the use cases were tested and different features of the concept were evaluated, we utilized wizard-of-Oz techniques in order to achieve an illusion of a seemingly better technical maturity level for the prototypes. This was done with Cases I and III, where the design process included the concept evaluation with target users. In Case II, with *Solar Shirt* concept, the aim was to communicate a design vision that integrated solar cells as part of the visual design of a wearable item to a wide audience. Here, special attention was paid to get the visual design, material selections, and overall appearance to ensure the final garment appeared polished. This affected the user experience design, which was driven toward luxurious and aesthetic factors.

It is hoped that the examples presented in this chapter provide inspiration for the user experience design work in the domain of smart clothing and wearables. The presented case studies can be used as examples of design processes where each has a different emphasis and reflects different aspects of user experience design.

12.7 Summary

User experience (UX) design considers both utilitarian and hedonic aspects of the design. Functionality and selected use cases largely define the priority and balance of utilitarian and hedonic UX design. Utilitarian aspects are addressed especially through usability and accessibility aspects. Polished designs and material selections affect largely to the hedonic side of the user experience with the prototypes.

This chapter has presented three examples of designing smart clothes and wearables. The examples address different form factors and domains of use, namely ice-hockey gear with sensors attached (Concept 1), a coat-integrating solar cells for energy harvesting (Concept 2), and a smart handbag with an integrated display (Concept 3). These concepts have been designed and evaluated with different methodological approaches and emphasis in the design process. The user experience design goals have an effect on what steps are emphasized in the design process and how polished the final prototypes are. To gain more reliable assessment of the user experience design, the concepts and prototypes should be evaluated with users in the real life use context. With smart clothes and wearables, for instance the wearability and social acceptability can be better assessed in-the-wild. The design process examples presented in this chapter seek to provide hands-on background information and inspiration for researchers and practitioners working on user experience design of smart clothes and wearables.

Acknowledgements The work presented in this chapter has involved several students, designers, and researchers working under the author's supervision. For the Case I, ice-hockey gear, I want to thank Mira Alhonsuo, Lasse Virtanen, and Juho Rantakari. For Case II, the solar cell coat design,

I want to acknowledge students in my interaction design course in winter 2016, Paula Roinesalo for her design of the final prototype and Anu Kylmänen for the supervision from the clothing design perspective. For the interactive handbag concept, I wish to acknowledge Lasse Virtanen for the concept visualization; Ashley Colley for the technical implementation; and Minna Pakanen, Saara Koskinen, Kirsi Mikkonen, and Tuomas Lappalainen for the user study. This research has been supported by a grant from Tekes—the Finnish Funding Agency for Innovation as part of 'The Naked Approach—Nordic perspective to gadget-free hyperconnected environments' programme.

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