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THE DESIGN SPACE AND THE SHIFTING TRIGGER IN WEARABLE PRODUCT DEVELOPMENT.

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ABSTRACT

Maybe it is too early to conclude that wearable design needs a new paradigm which is radically different to desktop and mobile. But some findings are worth discussing from both our practices and observation of the recent industrial boom of wearable devices.

Following literature reviews, we categorize wearable design consideration as clusters of “T”, “H”, “F” & “I”. As the trigger for a new wearable product development, the selection of the entry point from different considerations could lead different design process and results. We examine recent trend of trigger shifting and the reasons behind it.

Keywords: Design paradigm; Design consideration; Wearable design.

INTRODUCTION

Today, wearable computing is largely considered to be an evolution of the smartphone. However, the real history of wearable computing as the general public know it goes back quite a bit further, well before the first smartphones. In early prototypes from research labs, such as MIT (Mann, 1997) and CMU (Smailagic, 2002)’s exploration in 1980s and 1990s, we find the roots of current wearable devices, such as portable PC, camera and sensors, even though most of them look bulky and obtrusive. Nether-the-less, until the recent hardware resurgence and crowdfunding, the acceptance and adoption of wearable devices is notably slower than most modern ICT technologies, such as cellphone and the Internet. The reason partly comes from technical

barriers, such as the challenges in building reliable and lightweight MEMS (Micro-Electro-Mechanical Systems) and batteries. Furthermore, the design complexity for a better wearable experience also need be realized thoroughly, which is even trickier than mobile or desktop artifacts.

THE DESIGN SPACE OF WEARABLE PRODUCT

It is not easy to launch a wearable product with a high-quality user experience, for both startups and big brands. On one hand, creating an innovative wearable product needs to apply expertise broadly cross HCI, electronics, kinesiology, and even biotechnology etc. On the other hand, the trade-offs between cross-disciplined factors are very difficult, mainly involving body interface, sensing technologies, form factor and interaction modality, especially in an agile conception stage.

From the matrix (Figure 1), it can be seen that the results of wearable design are quite varied even when based on similar settings and constraints. For example, if we explore the possibility of a head mounted input device, it could be see-thru glasses which use eye movement (EOG; electrooculogram signal), or a bigger helmet which has an adequate volume to carry an additional camera, display and more sensors, or maybe keep it is simpler like earbuds which measure the head’s movement (IMU; Inertial Measurement Unit signal), or even maybe a form like a hairpin is better fashion conscious wearers. Variables in wearable design are richer than smartphone and most 3C products, which leads to a more complex but wider design space.

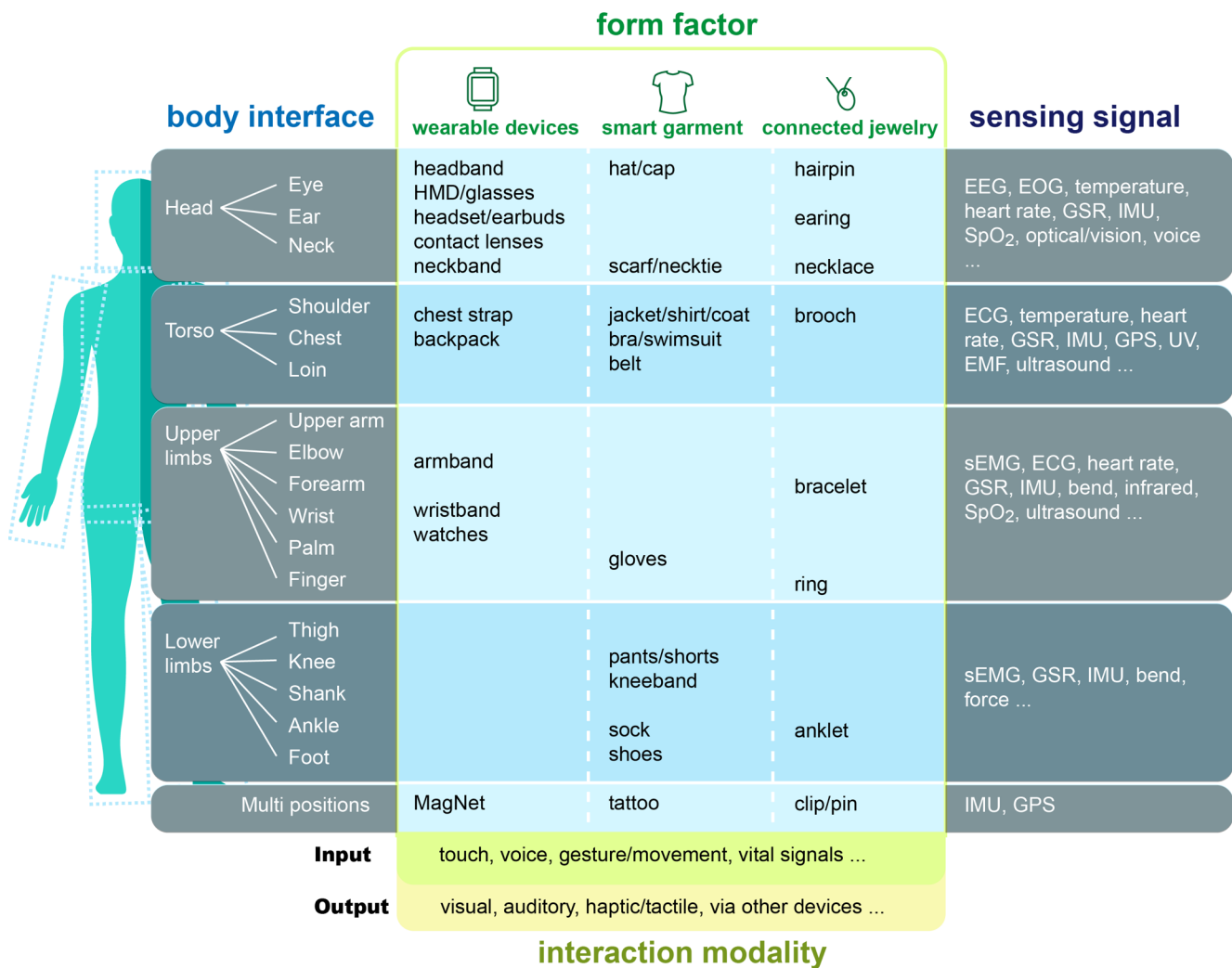


Figure 1. the design space of wearable product. (illustrated by authors)

The key issue in wearable design trade-off is that all resources are quite limited, from computing, power, body space, and human capabilities, to daily attention users would want to expend on it. In addition, this species of artifact is often too close to the human body for a long time, and the human body is naturally quite sensitive. So designers have to consider every feature carefully under multi-dimensional considerations (shown as Table 1). Let us now consider examples of these categories. No matter whether it is considered a constraint or an enabler, Technology factors cannot be neglected in wearable design. The miniaturization and application of technologies, from electronics, textile, material and mechanics, computer science, to biological and medical sciences, boost wearable products' functionality, availability and reliability tremendously. These Human factors were one of the

first “non-technical” factors respected by early researchers. Lin (2001) argued that many consumer products are not suitable for wearing because they interfere with normal activities. Similarly, Gemperle (1997) developed the concept wearability and relevant design guidelines to consider wearable computing from a human-centered perspective. As with human factors, Form factors have been considered as an element of some early research because it closely links with body comfort. However, academia and industry now prefer to regard form factors as an independent and important category beyond simply consideration of comfort. This change in thinking to realize the full meaning of form factors could be described as the move from “Computer that can be worn comfortably by user” to “A beautiful thing that people love to wear all time”.

| Categories | | Examples for heuristic evaluation |
|---------------------|--------------------------|--|
| Technology factors | Sensor | Is the contact surface enough for reliable data sensing? |
| | Indicator | How can user receive tangible feedback based on specific input? |
| | Power | Could it be always on during a typical usage cycle until next charging? |
| | Robustness & resilience | Can it be washed, dried, dropped, and treated like everyday objects? |
| | Containment | Does it have an adequate volume to allow the insertion of electronics, batteries and other components? |
| | Others | What kinds of alternative connection are provided for data transfer and service access? |
| Human factors | Placement | Is this body area suitable with a similar size in the entire population? |
| | Human movement | Can the free movement be supported during all kinds of wearing? |
| | Accessibility | Is it physically easy to access in all kinds of context by all people? |
| | Perception | Does the operation require too accurate, fast or complex to achieve? |
| | Others | Do user difference be considered thoroughly, such as gender, age, left/right prefer, low-literacies and disables? |
| Form factors | Aesthetics | Is it appealing, fashionable and cool? |
| | Socio-culture acceptance | Does it wear like a nerd, or offend someone? |
| | Fixing to body | Which one is better, wrap a shape around the portion or using single-point fixing, such as clips or straps? |
| | CMF | Is it possible to apply new materials and textile, different colors, and finishing technique? |
| | Others | Can it be produced by assembly line, garment factory or craft workshop? and the challenges in sourcing and supply chain. |
| Interaction factors | Modality | Which input and output channels are applied to achieve human device dialogue? |
| | UI model | What kind of UI structure and metaphor want to be built by interaction mapping? |
| | Usability | Is it easy to use without too much effort? |
| | Application | Do the functionality match the way of interaction, especially in its ultimate use case? |
| | Others | Is it flexible to interact with a body centered/around space? |

Table 1. a brief list of wearable design considerations (adapted from Gemperle, 1997; Lin, 2001; Motti, 2014; Canina, 2014)

From the mouse for a desktop computer, to touch for smartphone, and maybe even gesture and voice in wearable devices, Interaction factors always play a key role for computing artifacts. Reviewing wearable computing projects at Carnegie Mellon in the early years, Smailagic et al. (2002) identified the exploration of user interface models and input/output modalities as essential as an essential part of design in addition to other factors. Baber (2001) discussed different types of human computer dialogue to demonstrate how wearable computers require fundamental revision of the way in which we traditionally consider human-computer interaction such as the WIMP (windows, icons, menus, pointer) metaphor. Contrasted to conventional HCI, new types of interacting with computers include domain specific control, minimal dialogue, and multimodal HCI, which could inspire designers to explore alternative concepts.

CASE: WATCHME

WatchMe is a smart watch project incubated by a startup team from Media Lab, Hunan University, in collaboration with partners to launch a small-scale

product. Three versions have been iteratively designed and developed since 2012. The team explored different considerations to drive this “learning by doing” process. The 1st version (the left in Figure 2) launched in 2013 with some technical advantages, included a better refresh rate e-ink display than its competitors, BLE (Bluetooth Low Energy), applications in smartphone and longer battery life than competitors. But the market gave the team a lesson - it did not meet market expectation. The 2nd (middle) version launched in 2014, which came from an industrial design driven process. Benchmarking with more competitors at that time, the feedback of this version was better, especially in terms of its appearance. But like other watches, touching on such small screen became the key experience bottleneck that seriously frustrated users after interacting for a while. So the team started next round of design exploration on tangible gesture interaction by fusing available in-device sensors, such as infrared, light and PPG sensor (the right of Figure 2). Currently, development is still in progress of the features and interaction before product launch.



Figure 2. the smart watch WatchMe. (illustrated by authors)

THE SHIFTING TRIGGER IN WEARABLE PRODUCT DEVELOPMENT

Maybe it is too early to conclude that wearable design needs a new paradigm which is radically different to desktop and mobile. But some findings are worth discussing from both our practices and observation of the recent industrial boom of wearable devices.

Just like the typical new product development (NPD) process, product definition is a key milestone between wearable conception and detailed development. All above considerations (“T”, “H”, “F”, “I” in Figure 3) influence product’s features, such as size, weight, usage, I/O interface and BOM (bill of materials) cost. During the design process, it is always hard to prioritize clearly which factor is more important than others. Synergetic effects between different factors are common. Bodine et al.(2003) examined the link between the functionality and the comfort of wearable artifacts. Jacob et al. (2014) discuss how fashion design can inspire wearable computing, for example designing for intimacy and privacy in smart garments.

Wearable design is always iterated in a “T-H-F-I” consideration cycle. As a trigger, it is important to select a good entry point (from T, H, F or I) to start conception work that would lead different design process and results. The trigger is shifting in last years. In the early explorations, wearable projects usually start with “T” factors (technical enabling), like the first batch of smart watches and HMDs.

Typically these consider appearance after core R&D because of high limitation and uncertainty in “T” factors. In reviewing design history, this kind of design strategy is common in the early stage of creating a new species of artifacts, from automotive, telephone to computer. But sooner or later many wearable projects change their strategy to start with a better look and feel first. That is why plenty of watches and wristbands emerged recently with various forms but similar functions. And some of them make their success on “F” factors. This is reasonable if comparing to a typical new technology adoption process, and technical solutions become more and more reliable and low-cost. At this point, as a newcomer, companies need non-technical features to attract different user segments and cultivate a mass market. The most important factor is that this new artifact needs to find its proper place. So it has to be trial and error with the effort from all players. In the recent wearable wave, the trigger shifting from “T” to “F” is very fast compared the similar stage in former adoption of computing devices like PC or cellphone. It is partly because wearable items conventionally just play a fashionable element in daily life. And also this time the industry should thank the contribution of social innovation and crowdfunding.

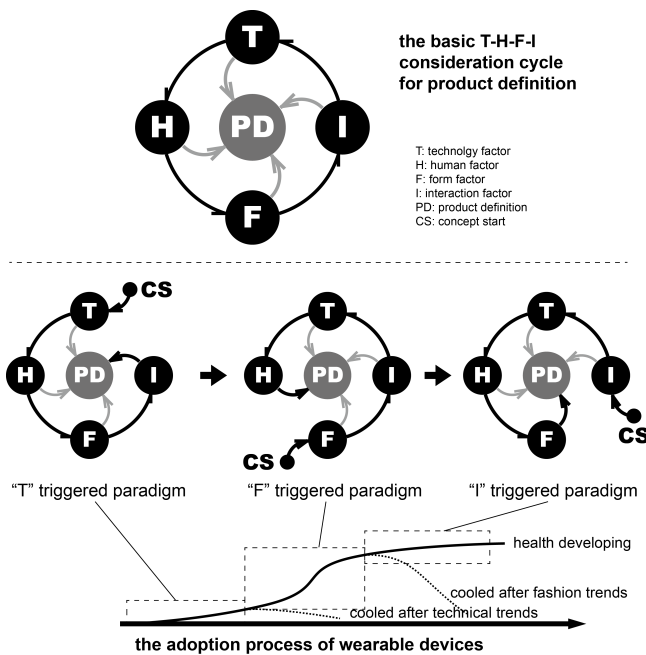


Figure 3. The shifting of design paradigm. (illustrated by authors)

However, after attracting customer to purchase, “F” factors only have marginal effect in daily use. Only its application and functionality could retain a user permanently. “I” factors then become an important entry point. Albrecht Schmidt (2015) argue the relationship between HCI research and new interaction technologies could be following or leading. But from industries cases, “I” factors are the fundamental design considerations for almost all mainstream computing devices, and it should be no exception for wearable. Just as Schmidt discussed, the potential for new opportunities in HCI enabled through new technologies is massive and has not yet been fully explored even though technologies have already hit the market. That is why recent wearable startups increasingly appreciate HCI research and interaction design. The wearable design paradigm is shifting to “I” triggered. It is sometimes described as the reinvention process of pre-defined artifacts with relevant technologies, much like the iPhone in relation to smartphones in general. Maybe the wearable industry still needs to wait a few years to create its “I” triggered miracle (maybe not even the recent Apple Watch!). Only after this stage, the new species of artifact could root itself firmly in the mass market and people’s life.

CONCLUSION

Just like Doug Engelbart could not realize the full meaning for people’s life in next decades when he developed mouse in 1960s, all new technologies will take a while for us to figure out the best manner of interaction as well as the standardization that removes one source of potential confusion (Norman, 2010). Both wearable artifacts and their design paradigms are still in the early development stage, so the evolution and the shifting of design paradigm will be highly dynamic in next few years. And, importantly, it is worthwhile for us to study it continually so that we understand the design space in which we live and work.

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