Suggesting Research Directions for the User Experience in the Connected Age

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ABSTRACT

With the rise of IoT, we are about to experience radical changes in the way we live and work. The growth of consumer IoT market, however, is reported to be slower than was originally expected. Analysts report that relentless realities caused by a premature user experience (UX) such as the use of unfamiliar techy terms, lack of empathic understandings of user needs, or lack of interoperability are among the worst barriers of consumer adoption. This is why UX is now considered crucial to the success of IoT business. The goal of this study is to address some UX challenges in the upcoming connected age and to suggest the desirable research directions. A systematic review and meta-analysis study was conducted to obtain the background data. This study is expected to ignite constructive discussions on how to make the IoT world more people-friendly.

Keywords: User Experience, Connected, Internet of Things, Industry 4.0, ESK-JES Joint Session

1. Introduction

We are now entering a connected, multi-device age. Prompted by the prevalence of connected products, we are experiencing radical changes in the way we interact with the world. For instance, thanks to connected products, people can now consume contents across multiple devices all day long. They own multiple products (e.g., smartphones, tablets, speakers, etc.), put them in a number of places (e.g., home, office, car, etc.) or carry them around everywhere. Because they want to use them together to accomplish their goals, they expect the products to work in harmony, so that they can always stay connected whenever and wherever they are.

To make the multi-device age to blossom, user experience (UX) designers in the consumer electronics industry had to struggle with a challenging mission of making devices connectable first. They collaborated with the engineers to resolve the technical difficulties of connectivity functions and to devise easier methods to connect and share files from one device to another.

In pursuit of appropriate business models for the device connectivity, a new paradigm called Internet of Things (IoT) emerged. Considering the potential benefits of IoT applicable to a variety of domains (CBInsights, 2016), it was convincing enough that IoT would be the next wave of disruptive changes to redefine the landscape of the global industry and market. The growth of consumer IoT market, however, is reported to be much slower than we initially expected (Farley, 2016). Analysts point out that the use of unfamiliar techy terms, the lack of empathic understandings of user needs, and the lack of interoperability are among the worst barriers of consumer adoption (Accenture, 2016). People still do not understand exactly what IoT means when they are asked. People are not sure if it can help them solve the real problems they struggle with every day. Moreover, unlike the scenarios, the relentless reality is that many connected devices cannot still talk to one another and each device comes with its own app, which can be confusing.

Lack of user adoption caused by premature UX is a reflection of the importance of UX to the success of IoT business. Disappointed at the lukewarm response from the consumer market, some IoT companies are turning their business focus to Industrial IoT (IIoT, aka Industry 4.0) with more emphasis on public, enterprise or industrial applications. Since the end-users of IIoT are also consumers, they will encounter the same market responses without taking UX concerns seriously.

The goal of this study is to address the UX challenges in the upcoming connected age and suggest the desirable research directions for UX professionals to confront the challenges more effectively.
2. Method

The authors investigated how many and what kind of studies have been conducted so far regarding the connected experience issues through a systematic literature review and meta-analysis study. Google Scholar service was useful in searching for academic publications related to the topics of interest. Especially the My Library function was helpful for saving and exporting the search results into other formats such as Microsoft Excel and Endnote files for further analyses. Our research hypotheses include:

1. The landscape of UX practices has changed in accordance with the maturity of connectedness over time.
2. Considering the speed of changes, conferences has delivered more practices than journals.
3. The distribution of publications varies by the topics of interest.

We started the search trials with the three high level keywords defined along the continuum of the maturity of connectedness, namely, Connected, IoT, and IIoT UX. During the process of iteratively refining the search queries by reviewing search results, we came up with a group of keywords that are associate with the three high-level keywords. The keywords were then classified into a taxonomy of domains for connected experience by applying card sorting and affinity diagrams as shown in Table 1.

Table 1. Domain keywords related to connected experience

| Domain Category | Sub-category                          |
|-----------------|----------------------------------------|
| Connected UX    | Connectivity functions                 |
|                 | Connected devices                      |
|                 | Multi-device experience                |
| IoT UX          | Smart devices and objects              |
|                 | Smart home                             |
|                 | Service and solution                   |
|                 | Ecosystem and business model           |
|                 | Intelligence                           |
| IIoT UX         | Various consumer applications          |
|                 | Various industrial applications        |

The scope of publication sources examined were international journals, conferences, or books related to human factors, ergonomics, and human-computer interaction, usability, or UX accessible at Google Scholar. Since only a few results were found for the IIoT UX keyword, additional search was conducted with other sources of publications outside the pre-specified area.

3. Results

A total of 699 publications were found as a result of literature survey.

3.1 Years of publications

Shown in Figure 1 is the annual number of publications related to the three topics of our interest.

![Figure 1. Annual numbers of papers published](image)

The earliest study related to connected experience was published in 1998, which was a study by Russel and Weiser (1998) presented at the ACM CHI Conference. Early studies, published during the period of 1998 through 2007 or so, were mostly related to enabling connectedness. Studies related to IoT and IIoT UX started to appear in 2008 and 2014, respectively (Leichtenstern and Andre, 2008; Gorecky, et al., 2014). The number of UX studies related to IoT and IIoT is increasing exponentially, while the growth in the number of studies on Connectivity UX seems to be slowing down.

3.2 Sources of publications

The surveyed publications were found from 212 sources including proceedings, journals, and books. Summarized in Table 2 is the list of top ten sources. The CHI conference was the most popular to constitute 25% of total number of
studies surveyed, followed by Mobile HCI (8%) and INTERACT (6%); and only two journals, IJHCI and HCI were included in the top 10 list. Out of 51 sources with two or more publications, most popular type was conferences (36), followed by journals (9) and books (6).

Table 2. Top 10 sources of publications

| Publication Source                                                                 | Number of Publications (%) |
|-----------------------------------------------------------------------------------|----------------------------|
| Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI)     | 172 (25%)                  |
| Proceedings of the international conference on Human-Computer Interaction with Mobile Devices and Services (Mobile HCI) | 55 (8%)                    |
| International Conference on Human-Computer Interaction (INTERACT)                | 42 (6%)                    |
| International Conference on Universal Access in Human-Computer Interaction        | 28 (4%)                    |
| Proceedings of the Nordic Conference on Human-Computer Interaction                | 23 (3%)                    |
| International Journal of Human-Computer Interaction                             | 22 (3%)                    |
| Human-Computer Interaction                                                       | 21 (3%)                    |
| HCI International                                                                 | 18 (3%)                    |
| Proceedings of the Human Factors and Ergonomics Society Annual Meeting            | 14 (2%)                    |
| Proceedings of the International BCS Human Computer Interaction Conference       | 11 (2%)                    |

3.3 Topics of publications

To investigate the trends of the topics published, the taxonomy of domain keywords shown in Table 1 was used as the meta-analysis framework to classify the surveyed publications. As shown in Figure 2, publications related to Connected UX constitutes 64% of total publications.

Shown in Figure 3 and Table 3 is the distribution of studies related to the topics versus years of publication. Before 2008, studies related to Connected UX showed a slow and steady upward trend. The number of studies related to the design of new connected devices notably increased from 2009. The number of publications on the multi-device experiences has recently increased.

Studies on IoT UX marked a steep rise since 2013, mostly concerned with new services and solutions. A rise in the number of IoT UX studies concerned mainly with various industry applications is just starting.

4. Discussion and Suggestions

To reflect on our own experience of practicing connected experience, it makes sense that the concept of connectedness
has evolved and matured over time as the data shows. At first, when companies just started incorporating connected technologies in their products, the importance of connectivity itself was over-highlighted. Then the focus of efforts moved to designing new connected devices (e.g., a connected TV) and most of recent efforts are concerned with designing a better multi-device experience. With the rise of IoT, the growth in the number of studies related to Connected UX category seems slowing down. Nevertheless, more research efforts are still needed for a harmonious multi-device experience, that is, a group of connected devices with different functions owned by a person working in perfect harmony, often despite differences in platforms or manufacturers.

UX practitioners involved in developing IoT products and services often complain the lack of relevant and groundable research results applicable to their own problems of interest. More efforts are needed on all the topics related to IoT UX, which are crucial to making IoT more people-friendly, regardless of the application areas. A service or solution functions as a wrapper to hide all the complicated device-layer transactions, business ecosystem enables richer service experiences, a concrete business model makes the ecosystem sustainable, and the intelligence powered by big data captures user intention and personalizes the service. Note that since the end-users of IIoT solutions are also consumers, most findings related to IoT UX are also applicable to IIoT UX. Collaborative efforts between industry and academia are suggested to compile the first version of international standards, principles, and guidelines on IoT UX to be applicable to a variety of industrial domains.

Note also that only a small number of studies on IIoT UX were available from publication sources related to HF&E area. It means that the UX professionals’ interests have been focused mostly on consumer issues so far. More attention and interest to smart factory or other industrial or enterprise applications is suggested to UX professionals worldwide.

5. Conclusion

The purpose of this study is to suggest the research directions required to confront the user experience challenges of the upcoming Connected Age effectively. Findings from a systematic literature review and meta-analysis study have been adduced in combination with the reflections from their own practices of design and evaluation of connected experiences in drawing some suggestions.

The social and economic changes triggered by IoT and Industry 4.0 are expected to be much bigger and, worse yet, speedier than its predecessors. It will influence how people interact with the world; what the jobs of the future look like (World Economic Forum, 2016); corporate metabolism such the structure, process, or value system (DeMers, 2017); and the overall industrial and economic structure (Ferber, 2013). Central to the changes, however, is the people. In order to exhibit the potential power of IoT and to urge the growth of consumer market, it is most important to understand what people want and offer them a well-prepared, smart, delightful, and mature experience optimized to help them accomplish their goals.

UX professionals often exert themselves to tow the entire company’s decision uphill, preaching the importance of the people-centeredness in a product development process wherein the interests of various parties, such as design, development, marketing, or production, collide. In preparation for the connected age, their role is to be highlighted further. This study is expected to ignite open and constructive discussions on what we need to do to make the IoT world more people-friendly.

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