Beyond-screen Interface for Interactive Television

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Background The electronic device trend of "being smart" has revolutionized personal hand-held devices, leading to the emergence of smart phones and tablet PCs. The trend has now spread to home entertainment media, resulting in the emergence of interactive TVs (ITVs). The information systems of interactive television are becoming increasingly interactive and complex, and the information is often presented in a highly distracting and inconvenient manner with insufficient display space. In this study, we developed a Beyond-Screen Interface (BSI) wherein the display system extends the physical space of the graphical user interface (GUI) in ITVs using projectors.

Methods We implemented the BSI prototype by devising a projector and TV set and compared the usability and quality of user experience of BSI with those of ITV user interfaces of conventional styles. For the evaluation, not only the overall usability but also the hedonic/pragmatic quality of user experience and the degree of lean-back experience were measured with subject scale. Observation and user interview were followed to obtain user feedback and insights.

Results and Conclusion Our user evaluation implies that BSI can provide a novel experience for using interactive functions in ITV while maintaining user engagement with TV contents like a traditional TV. The extended display system also evoked a wow response. Such positive user experiences of display extension can facilitate the access to various applications and complex information in an ITV viewing context.

Keywords Interactive television, augmented visual interface, peripheral projection

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1. Introduction

Since the emergence of internet connected television, television has become more interactive. It has even become possible to use various applications with interactive television (ITV) just like with a smart phone or personal computer (PC). ITV now provides more diverse functions than ever and demands enhanced content navigation support (Chorianopoulos, 2006). This differentiates the user experience (UX) of ITV from that of traditional TV. Thus it needs specialized user interface (UI) suitable for both traditional TV viewing context and new experience to use diverse applications on ITV. The on-screen interface (OSI), the UI style for conventional TV, is considered inadequate for ITV where the presentation of complex information is required, because increased amount of graphical elements on the TV screen can interrupt viewer engagement (Cruickshank et al., 2007). In contrast with conventional TV, furthermore, ITV requires more frequent transitions of visual information on the screen because viewers have to navigate menus often in order to switch to and use other functions of ITV. This makes the viewer get lost while navigating menu unless the complicated menu presents on fullscreen. Thus, ITV needs a new visual interface that is suitable for displaying complex information.

The user interface (UI) of a personal computer may be an option since it is specialized to handle multiple tasks which ITV provides, such as navigating menus while maintaining the previous task. However, PC-styled UIs that consist of windows, menus, icons, and a pointer (WIMP) have been considered inappropriate. Compared to computers, TV is a ten-foot medium where the screen has little screen real estate and thus, cannot present complex information on the screen with a PC-styled UI. Also, it is generally considered that TV is characteristically a "lean-back" medium that carries a sense of passivity involved in the common cultural habit of watching TV, while the computer and Internet is a "lean-forward" medium (Dewdney & Ride, 2006). Therefore, task-oriented UIs, such as those used by PCs in a living room environment, require considerable

effort to control the UI, which may impair the ITV user experience (UX).

To overcome irritation related to the ITV user experience and to simplify the UI on an ITV screen, researchers have tried to remove graphical user interface (GUI) elements from the TV screen and place them on a second screen such as a PDA or mobile phone. Cruickshank et al. (2007) and Robertson et al. (1996) tried to remove peripheral information on the TV screen and put it on mobile devices so that the user can focus on the TV screen as well as directly interacting with peripheral information and the interface from the mobile device. Those trials were evaluated as successful in delivering a more immersive ITV-viewing experience, as well as provide rich and interactive functions such as social viewing in an easy way. However, it is questionable as to whether or not providing an enhanced ITV viewing experience via a second screen interface (SSI) is possible, especially in a living room context where there are multiple TV viewers. Viewers might lose the context of the content because they have to look at the TV set and a personal device via a secondary screen. The user with the remote control might be able to see additional information on the second screen but the other viewers might fail to understand what is happening on the TV.

In this context, we propose that a peripheral display located close to the TV presents visual information in the same way as a personalized second screen, while maintaining the continuity and engagement of the experience. Utilizing the spatial environment behind the TV set as a peripheral display may be a feasible option, compared to deploying multiple TV sets or a larger TV set for peripheral display. Ambilight, the LED array around the TV display bezel, is an example of how to exploit the wall behind a TV set as a peripheral display in order to augment the mood of viewing contents by projecting light onto the wall. A projector may be a solution for displaying more complex information as compared to Ambilight. IllumiRoom (Jones et al., 2013) showed the possibility of displaying more interactive and complex information on the surrounding wall in order to increase the immersive experience by augmenting the living room environment with peripheral projection while maintaining the user focus on the TV display. Beyond the augmentation of the

content viewing experience that Ambilight and IllumiRoom revealed, we assumed that there are further possibilities of peripheral projection to maintain a TV viewing experience and even to handle such with peripheral tasks. Indeed, projectors have been utilized as a peripheral display to augment the personal working environment (Kane et al., 2009; Ziola, Kellar, & Inkpen, 2007) or a group meeting context (Rekimoto & Saitoh, 1999) where PCs or laptops are present. Since using a projector as a peripheral display may be beneficial for more intuitive control and multi-tasking, these benefits may be valid for ITVs in similar settings.

2. Beyond-screen Interface

Regarding the expected benefits of using a projector that previous studies showed, we assumed that giving different visual importance and qualities varying with the type of its information by using a projector and TV display may help the user to control their attention on presented information, and thus, they can maintain a "lean-back" experience and handle the menu navigation and multiple tasks in a less obtrusive way. We present a Beyond-screen interface (BSI; Figure. 1), which is a display system that consists of a TV screen as the primary display (foreground screen) and projectors as the peripheral display (background screen) that augments primary display. Expanding the display area of the TV using the BSI concept has the following advantages:

• Space-multiplexed UI: by increasing the screen area, it becomes possible to present different kinds of visual information simultaneously. Peripheral information can be moved from the primary display so the visual content of the display remains uninterrupted. This helps users to view peripheral information on the background screen without missing visual contents on foreground screen.

• Two distinctive GUI layers: the images on the foreground and background screens have distinctive visual qualities. This helps people to be less confused or lost when they view complex visual information using ITV.

Figure 1 The two GUI layer of Beyond-screen interface:
(1) foreground screen and (2) background screen (projected area)

Based on these key features, we propose three different types of GUIs (Figure 2). "Application menu" is used for basic menu navigation and it separates the menu GUI from the primary display. The application menu is located on the left side of the TV since the UI layout, which has a navigational menu on the left and the body contents on the right, is one of the most common styles of screen interface and many people are accustomed with it. The "widget menu" contains application widgets that show real-time information without launching the applications. Users can check peripheral information by calling out the widget menu while they are viewing a TV program. The widget menu is located on the top of the TV display to tell it apart from the navigational menu, such as the application menu and history menu. The "history menu" shows recently used application lists so users can go back to previously used applications directly.

Figure 2 Variations of BSI:
(1) application menu for navigating applications, (2) widget menu, and (3) history menu for presenting recently used applications and their contents

3. The Prototype

In the prototype, a single projector was used on the side of viewer instead of multiple projectors behind the TV set. The interface prototype consisted of a touch-based input device, a TV set, a projector, and a PC that integrates all the other components. The system software was built using Flash ActionScript 3. We selected a touchscreen as the input device because various input techniques such as cursor pointing, finger gesture inputs, and text entry could be achieved using a single device. The prototype input device was implemented using a smartphone (Samsung-Google SHW-M420S: Galaxy Nexus) and a button switch planted underneath the smartphone to enable click input accompanied with tactile feedback (Figure 3). The basic input technique used by the prototype was the same as the touchpad on a laptop, i.e., pointing and clicking. The only new technique was sweeping three fingers to call up menus on the background screen (Figure 4).

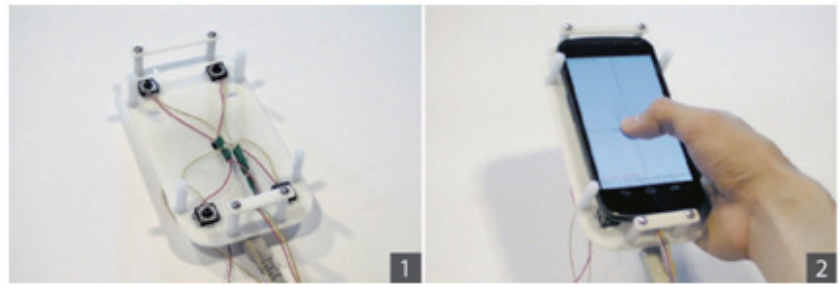

Figure 3 Input device of the prototype:
(1) button switches for click input and (2) integrated input device

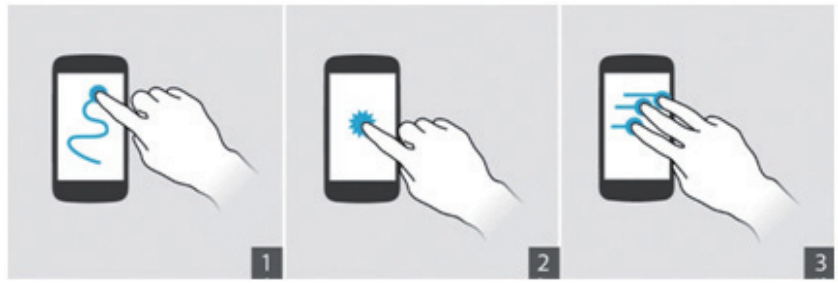

Figure 4 Input interaction techniques:
(1) one-finger pointing, (2) clicking, and (3) three-finger sweeping

4. User Evaluation

To figure out whether BSI can not only maintain the immersive viewing experience but also provide sufficient usability for new functions of ITV such as multitasking and complex menu navigation, we conducted both quantitative and qualitative user test. A within-subject user test is conducted to assess the perceived usability and affective quality of the BSI. Subjective rating scales for quantitative comparisons, which included a system usability scale (SUS; Brooke, 1996) and AttrakDiff (Hassenzahl, 2004), were used to measure the difference in the perceived usability and UX qualities with the BSI and an OSI. This quantitative evaluation was followed by interviews for a qualitative comparison. We prepared prototypes of the BSI and an OSI (Figure 5) for the evaluation. The OSI prototype had the same GUI components as the BSI but they

were displayed on the TV set screen. In addition, a lo-fi prototype of SSI that presented dummy images of the GUI on a smartphone screen was prepared to facilitate a qualitative comparison between the two interfaces and the SSI, which was made using the Wizard of Oz method.

Sixteen university students were recruited for the user evaluation. The participants were aged from 21 to 35 years old with an average of 25.31 years, and they were comprised of seven male and nine female participants. As Pemberton and Griffiths (2003) suggested, a pair of users who already know each other participated during the evaluation to generate an ordinary TV viewing context and help the participants "think-aloud." The participants were asked to use one of two prototypes and rated subjective scales for it. Then they were asked to use the other prototype and repeat the evaluation. To prevent order effect, each of the pairs experienced BSI and OSI in a different order.

During the test session, the participants used four demo applications, including broadcast programs, a web browser, Facebook, and YouTube, as well as three menus: application menu, widget menu, and history menu. Participants were asked to use the prototype arbitrarily after doing a series of tasks: (1) to navigate a web browser application by using the application menu and searching for a drama episode while they were watching a drama; (2) to check out social news by using the widget menu and launching Facebook to see more detailed news while viewing broadcast programs; and (3) to continue to watch a broadcast program when they were using other applications. At the end of evaluation, the participants discussed issues of prepared UI prototypes.

Figure 5 The interface prototype for OSI, (1) BSI (2), and SSI (3)

5. Results and Discussion

5.1. Overall usability and user experience

The overall usability ratings of the two interface prototypes were measured using SUS. The SUS score for BSI (mean = 75.63, SD = 11.95) was higher than OSI (mean = 69.69, SD = 13.66), but the difference was not statistically significant for T-test. AttrakDiff was used to compare the UX attributes. Similar to the SUS results, the pragmatic quality ratings of the two interface prototypes did not differ significantly. However, the hedonic quality of the BSI was higher (mean = 1.45 on a scale ranging from -2 to 2, SD = 0.62) than the OSI (mean = 0.11, SD = 0.87). The difference in the hedonic quality was statistically significant ($t(15) = -6.28$, $p < 0.05$) (see Figure 6). The overall attractiveness of the BSI (mean = 1.76, SD = 0.58) was also significantly higher than the OSI (mean = 0.63, SD = 0.83) ($t(15) = -4.90$, $p < 0.05$). Thus, the BSI provided more entertaining UX for ITV user context where users view broadcast contents as well as use wide range of functions.

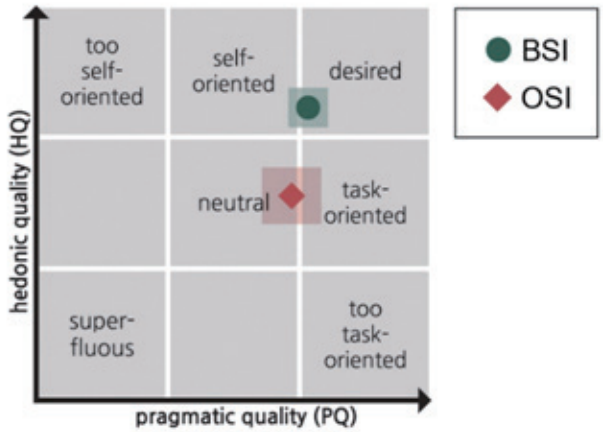

Figure 6 Hedonic quality (HQ) and pragmatic quality (PQ) matrix for two interface prototypes

5.2. "Lean-back" experience

Regarding the experience of viewing on a traditional TV, we considered the "lean-back" experience as one that does not lose user engagement in the content on television, but one that allows users to interact with the TV with less stress and a relaxed atmosphere. The quality of the "lean-back" experience is measured by the degree of the engagement with the TV content and the degree of relaxation while using the UI. To evaluate the quality of the "lean-back" experience of BSI and OSI, the participants were asked to rate their level of engagement and relaxation using a seven-point rating scale (Figure 7). The degree of engagement was significantly different for the two interfaces ($t(15) = -2.97$, $p < 0.05$) and the BSI was considered to be more engaging (mean = 5.60, SD = 1.35). However, the degree of relaxation did not differ significantly. The participants said that using projector as a peripheral display in a TV viewing context was novel but unfamiliar, which may have affected their relaxation. Furthermore, more than half of the participants had no previous experience to use various and complex functions on TV, so using ITV itself might be considered less relaxing than traditional TV.

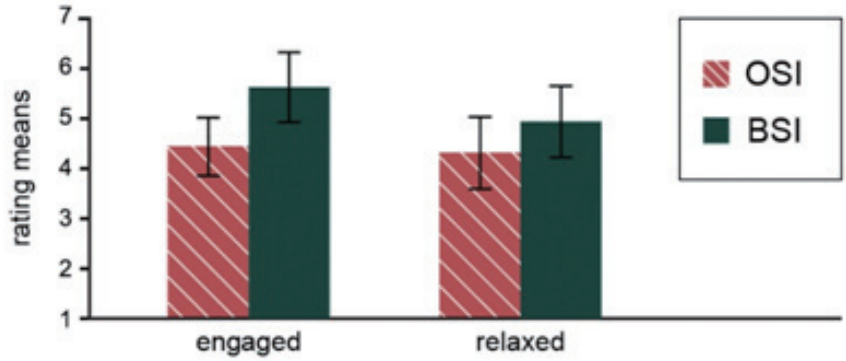

Figure 7 The degree of engagement and relaxation

5.3. User reaction and feedback

In general, the participants said that the BSI was very attractive and suitable for the ITV user context such as viewing immersive content and using other applications at the same time. Placing the background screen behind the TV set was novel and unfamiliar, but all participants could see the potential of BSI for augmenting the ITV viewing experience and context.

(1) Two distinctive GUI layers

A distinction was noted between the visual qualities of displayed images, which affected the ease of use. Participants said that "when using the 'history menu' or program browsing, it is really easy to navigate menus because the foreground screen acts as a magnifier of the whole map, the secondary screen (participant no. 13; P13)." The physical distinction between the two screens also affected the ease of use: "the rectangular frame of the foreground screen placed a virtual 'grid' on background screen, which helped me to remember and understand where the menus were located (P14)".

(2) Unobtrusive representation of visual information

The participants considered that the BSI was very effective for checking interactive information or as a pop-up alarm without interrupting the TV viewing experience. They stated that the "peripheral information pops up gently from the edge of the primary display without any distraction but sufficient to capture the attention, which was user-friendly (P3)."

The visual distinction between the foreground and background screens was considered to be another factor that facilitated a more unobtrusive representation. Most participants addressed that the display of interactive information on the background screen felt less obtrusive than OSI and it was more noticeable than the SSI, even if the interactive information on the background display changed dynamically.

(3) Immersive television-viewing experience

All participants considered that maintaining the video content as a full screen was the most important issue affecting the ITV UX compared with other media such as a PC or mobile phone. The BSI was considered to improve the engagement experience by maintaining a full screen. The participants said that "compared with the BSI, I was very irritated while using the OSI prototype because it was like seeing a person in front of me turning on a phone in theatre (P1)."

(4) Multiple viewers

With multiple viewers, we found that the person who did not have a remote control could participate more in controlling the TV with the BSI prototype than the OSI or SSI prototype. The participants said that "compared with the SSI, the BSI showed the task process on the background screen so I could understand what happened on the foreground screen when another person controlled the TV (P1, P2)," and "the person who had the remote controls had control of the TV viewing event. With BSI, however, TV viewing was considered to be 'more democratic' because people who did not have the remote control could see the overall control process and peripheral information (P7)."

5.4. Limitations

The test was conducted within one hour per a pair of participants. One hour was considered short to learn and get accustomed to UI prototypes. Therefore, it may affect to experiment result especially for perceived usability and UX. The user test was conducted under the lab environment where is different from living room. The participants probably had different affective quality comparing to under actual usage environment.

5.5. Possibilities

The participants appreciated that the BSI had the potential to provide functions that a PC or smart phone UI could not, such as the seamless integration of broadcast programs and other applications. Related to this issue, they suggested a function that enables a screenshot of a TV program to be shared via SNS. Separation between channel browsing and channel viewing was also possible with BSI, which was expected to be beneficial for multiple viewers. The participants proposed to browse TV program utilizing background screen without distracting other viewers' focused attention. In a similar manner, the participants proposed pinning broadcast programs on a "clipboard" using the background screen, to check multiple channels while they were watching the foreground screen.

6. Conclusion

We proposed a BSI for ITV and examined the features of display extension in BSI enhanced the ITV viewing experience based on a user evaluation. We found that the extension of the display area to the background wall and the visual distinction between the foreground and background screens can increase user engagement while viewing TV. The extended display system also evoked a wow response because it provided a more attractive and hedonic experience. We expect that this positive user experience of display extension will facilitate various applications and complex information to be accessed easily in ITV viewing context.

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