//

ESTABLISHING DESIGN KNOWLEDGE FOR EMERGING INTERACTION PLATFORMS

Hyowon Lee and Alan F. Smeaton
CLARITY: Centre for Sensor Web Technologies
Dublin City University, Ireland
hlee@computing.dcu.ie

ABSTRACT

While awaiting a variety of innovative interactive products and services to appear in the market in the near future such as interactive tabletops, interactive TVs, public multi-touch walls, and other embedded appliances, this paper calls for preparation for the arrival of such interactive platforms based on their interactivity. We advocate studying, understanding and establishing the foundation for interaction characteristics and affordances and design implications for these platforms which we know will soon emerge and penetrate our everyday lives. We review some of the archetypal interaction platform categories of the future and highlight the current status of the design knowledge-base accumulated to date and the current rate of growth for each of these. We use example designs illustrating design issues and considerations based on the authors' 12-year experience in pioneering novel applications in various forms and styles.

Keywords: Interaction Design, Design Knowledge, Interactive Devices

INTRODUCTION

When mobile computing devices started hitting the market in the late 1990s and early 2000s, there were a lot of hype, discussions and projections on technical implications and future usage scenarios. But at the same time, the *usability* of the actual products in the market – exemplified by PDAs (Personal Digital Assistants) with a desktop Graphical User Interface (GUI) style screen and stylus pen – was extremely poor and the interaction design community became increasingly uncomfortable with their inability to improve it. The field of Human-Computer Interaction (HCI) focusing on Mobile Interaction called it a "usability crisis," calling for remedies and prescriptions on improving poor mobile interaction usability. Due to this, many mobile interaction sessions in various HCI-related conferences at the time often started with the problem statement and a call for alternative interaction paradigms (e.g. Marcus et al. 1998, Kristoffersen & Ljungberg 1999, Longoria 2001). Various PDA products from major electronics companies appeared, promising "productivity on the go" but the purchase was more based on the appealing idea of mobile computing rather than the actual benefits, and after the novelty and excitement wore out, poorly crafted user interaction on the small screen resulted in disappointment, user frustration and eventual abandonment. Why was it so? And 10 years on, how has the situation changed?

One of the major culprits was to do with the maturing status of the interaction design knowledge, experience and skill set which had been tuned to desktop PCs at the time. More than 20 years of continuous efforts in improving usability propelled by market-driven usability engineering methods, growing "computer skills" and familiarisation with GUI by the general public, standardised windowing operations and widgets that have been refined to minute details – the interaction design community had a growing confidence in their ability to ensure the usability of the interaction of computing systems. However, a large portion of the accumulating design expertise and experiences assumed a particular interaction setting rather than generally applicable knowledge, i.e. a desktop PC with a large monitor, keyboard and mouse where a user is sitting in a comfortable office environment.

What we did not realise was the fact that what had been assumed as the “interaction with computers” (and the body of design knowledge that has been accumulating) would soon turn out to be that with only one of the many different types of interactions platforms. Much of the design knowledge that grew for one interaction platform (i.e. desktop PC) cannot be directly transferred to a different one which exhibits very different characteristics and affordances. Thus the menu bars, icons and widgets and in essence the overall interaction paradigm itself that were fine-tuned for the desktop PC simply didn’t work for mobile devices. Attempts to port the desktop PC styles and interaction strategies to the mobile device with a small screen, awkward input mechanism and expected distracting usage environment were doomed to failure. What worked so well on a large desktop monitor with a user giving full attention to it is no longer effective on a screen 1/20th of the size while walking on a busy street, requiring a fundamentally different interaction paradigm and strategy. Realising this took almost a decade, during which a long trial-and-error process continued witnessing a series of failed mobile products, false promises and user frustration. In hindsight, this is understandable as the desktop PC was the very first and only ubiquitous computing platform we ever had and thus it was difficult to extrapolate how very different platforms could be used alongside the desktop PC.

About a decade since the dawn of mobile computing products, now we seem to be doing much better: no more “porting desktop PC interaction to mobile” but more focus on the special affordances of mobile use; no more graphic-heavy interaction that requires constant user-attention but emphasis on simple, shallow and sub-second animated screen elements during the interaction; no more elaborate browsing and deep information structuring but more on intelligent filtering and concise summarisation; no more attempting to squeeze in a large amount of visual information on the screen but more on providing simple visual hints and guides to imply more information only when the user needs it; and with recent innovative mobile products such as the Apple iPhone and Android phones with novel modalities such as touch and shake, our understanding of what strategies work well will deepen and progress.

An important lesson from the mobile usability crisis is that when a new interaction device or platform comes with a great promise of revolutionising how we work and play, we need to focus on identifying the special characteristics and affordances of that particular platform then design its interaction accordingly, instead of trying to rely on our established wisdom for designing existing devices.

There is no doubt that a number of novel interaction platforms other than mobiles will start appearing in the market in the near future. Interactive tabletops, interactive TVs, public multi-touch walls and all sorts of embedded appliances are currently being researched and experimented with in technology laboratories around the world today. With the awareness of these upcoming novel interaction platforms, the interaction design community needs to be prepared in advance by studying these novel platforms’ special interaction characteristics and affordances and experimenting with possible applications accordingly, so as to avoid yet again a lengthy and expensive trial-and-error process as experienced with mobile platform products.

In this paper, we review some of the emerging and upcoming interaction platform categories and the current status of our understanding for each of these categories, and by doing so, derive a wider view of design knowledge for the interactive devices that are with us today and that are coming in the near future. This is based on the authors’ extensive experience in designing for novel applications in a variety of interaction platforms over the past 12 years. In reviewing the design knowledge for each of the platform categories, specific examples as designed by the authors will be given to illustrate how the growing body of knowledge, especially when it is only beginning to shape, might be explored and experimented in practice. By summarising and highlighting the current status and rate of growth of interaction design knowledge for each of these interaction platform categories, we, as design community, will be in a much better position to positively and pragmatically contribute to shaping the new breed of interactive products and services, *before* they start appearing in the market.

EMERGING AND UPCOMING INTERACTION PLATFORMS

It would not be a false optimism to say that in near future we will be interacting with a variety of the novel interactive devices *more frequently than* with the desktop PC and mobiles in a typical day. With novel interaction modalities such as multi-touch, speech and gesture coupled with ever-improving hardware and processing power today, our future lifestyle may even be characterised as that of *continuous engagement with diverse interaction devices throughout the day.*

While one could envisage an endless variety of forms and shapes of possible interactive devices, there are a few archetypical categories of interaction platforms within which specific devices could fall, based on the general affordances that they exhibit. For example, mobile interaction is one of the recent and already ubiquitous interaction platforms collectively exhibiting generic characteristics and affordances, even though there are many different variations of mobile products in terms of their screen orientations, text input mechanisms, functionality, and overall size and weight of the devices. Categories of interaction platforms other than mobile and desktop PC are not yet ubiquitous but within the last decade or two, many technology laboratories have been researching and experimenting with these more novel platforms and with them the study of interaction design, with varying levels of collective knowledge, experience and skill sets are available for each today.

CURRENT STATUS OF INTERACTION DESIGN KNOWLEDGE

In this section we summarise the current knowledge-bases available for each of the archetypal interaction platforms. For those with relatively longer history (e.g. desktop PC) the knowledge base is quite substantial manifested in textbooks and portfolios/experiences by designers, whereas for those with shorter history (e.g. multi-touch wall) the knowledge base is scant and only starting to grow as more researchers study them.

DESKTOP PC INTERACTION

As mentioned earlier, much of the accumulated body of knowledge, procedures and skill sets in the HCI and Interaction Design field has mainly progressed with the desktop PC setting as its assumed interaction platform. We currently have a wealth of knowledge for this interaction design, encompassing a dozen well-known HCI textbooks, numerous design principles, heuristics and design guidelines, and endless resources on design tips and advice. Many members of the general public have also faced and experienced in one way or another some of the design issues for this platform, in designing home pages, in customising their blog and social networking sites, noticing desirable and undesirable features on other web services they have been encountering daily for many years. There are a well-researched and standardised set of screen interface widgets for desktop PC/Web such as buttons, tabs, scroll bars and drop-down boxes that we know work well as the result of a 2 decades-long incremental refinement process. While this rich amount of knowledge helps push better usability in PC/Web applications, it tends to hamper the usability of non-PC/Web applications because the knowledge and skill often *does not transfer to different interaction platforms* and yet designers try to leverage their existing skills to other platforms. How we think a system should be designed is also closely related to how we think it should be evaluated, reflecting the level of maturity and our understanding of interaction design knowledge. Desktop PC applications have been traditionally evaluated in a formal laboratory environment often with a quantitative style of inquiry, and such a lab setting could be considered not too different from its expected usage setting where a user will be sitting in front of a monitor with a keyboard and mouse under their hands.

Examples: *My Visual Diary* (Lee et al., 2008) is a web-based desktop application where a user of “Lifelogging” activity with a passive photo capture device such as a Microsoft SenseCam can review, search and browse tens of thousands of their Lifelog photos in a visually exploratory way. Having automatic content analysis techniques from computer vision and multimedia as its back-end, the designed interaction presents representative photo samples whereby a user's mouse-over action flips through other related photos while a colour-coded timeline strongly orients the user's photo navigation on temporal dimension. Using standard widget behaviours such as mouse-over, menu pop-ups and drilling down the hierarchy of information step by step, the design leverages users' familiarity of modern GUIs and invites the users to explore the provided visual screen space in-depth to support a novel activity (of reviewing Lifelog photos) in a conventional and understandable way.

With considerable amount of knowledge base and experience, innovative applications and services based on the desktop PC have been pouring out within last 7-8 years. Online video sharing and voting, pre-visiting an unfamiliar place with 3D street views, blogging and tweeting are some examples of new activities created with the familiar desktop PC in mind, in effect “innovative appropriations of existing technology.” (Lowgren & Stolterman, 2007, p113). There are a near-indefinite number of possibilities for creating novel and innovative desktop PC-based applications to enrich our lives, but it can be imagined that even more possibilities can be realised with more novel interaction platforms.

MOBILE INTERACTION

Interaction design for mobiles brings in very different and contrasting issues compared to that for desktop PC because (i) the display area is usually much smaller, (ii) the input mechanism is more limited, and (iii) distraction during use is expected. Without factoring in these issues and designing accordingly, the resultant design will not be successful in terms of usability. Because the interaction characteristics between desktop PC and mobile are in such contrast, it has been very noticeable how the desktop interaction designer's existing knowledge becomes a hindrance to successful mobile interaction design. After almost a decade of trial-and-error with early PDAs and mobile phones, we now have one textbook on mobile interaction design (Jones & Marsden, 2006) and a few industry experience-oriented books, journal titles such as the International Journal of Mobile Human Computer Interaction (IJMHCI), conference series such as the International Conference on Human Computer Interaction with Mobile Devices and Services (MobileHCI), a sizeable amount of design guidelines and recent successful commercial exploitation such as Apple iPhone. The iPhone success will sharply increase mobile design knowledge as researchers and practitioners retrospectively work on analysing the match between the design solutions incorporated in the device and the resulting usability seen from customer response and feedback. Evaluating mobile interfaces also raises distinctive issues due to its indoor or outdoor mobile context, and observing a user on the move is physically and technically challenging. The increasing adoption of ethnographic methods with interviews and/or self-reporting such as diaries in a longitudinal setting for mobile interaction evaluation (e.g. Palen & Salzman 2002, Van House et al. 2005, Liu et al. 2010) indicates the usefulness of such techniques, and work on characterising alternative study methodologies for mobile HCI is also found (Hagen et al., 2005).

Examples: In order to reduce the interaction burden from the user by giving more back-end intelligence to the system, our early *mobile Físchlár-News* (Gurrin et al., 2004) used as its main feature the automatic recommendation of recent news stories from daily broadcast TV news using a collaborative filtering technique. Without having to intensively search by typing in or to intensively browse by sequentially selecting a day/month/year, the user is simply presented with a short list of news stories that the system determined to be of most interest to him/her at the time of access. While this particular design approach may be a little extreme in shifting the burden off the user onto the system, it illustrates one possible mechanism towards ideal mobile interaction where an elaborate user action sequence is minimised and instead relies more on back-end processing to filter, select and summarise so that the front-end user interaction will be minimal. As another example, our mobile personal photo manager *MediAssist* (O'Hare et al., 2005) used usage context information such as time of the day and the location of access in order to infer and select a small set of photos the user is most likely want to view at this time in this location. Context-awareness is one very effective way to reduce the user interaction burden in a mobile interaction situation.

TABLETOP INTERACTION

Interactive tables are not yet common today, but research and development has been going on for years and considering the ubiquity of physical tables we use as everyday furniture, there is great potential for such an interaction platform in our future day-to-day living in places like waiting rooms, restaurants and coffee shops, hotel lobbies, etc. Designing for tabletops brings in a very distinctive set of design issues, again quite different from those for either desktops or mobiles, in particular: (i) task allocation or division of labour amongst the users around the table needs to be designed in, (ii) a level of workspace awareness amongst the users needs to be decided so as to facilitate how much individual users should be aware of what other users around the table are doing, and (iii) coordination and conflict resolution policy needs to be designed in so as to provide a smooth collaborative environment amongst users around the table. Without explicitly factoring in these issues and designing for the application, a tabletop interface cannot support multi-user collaborative interaction successfully. Currently we have no design textbook specifically for tabletop interaction, but a few design guidelines have been suggested (e.g. Scott et al., 2003) backed by a number of empirical table studies that identified people's behaviour on the table, such as territoriality (Scott et al., 2004), implicit partitioning of table (Tse et al., 2004), social impact of the orientation of documents on the table (Kruger et al., 2003), conforming to social protocols (Morris et al., 2004), and modality between gesture and speech during table use (Tse et al., 2007). Much of the earlier work on groupware (e.g. Grudin 1994, Gutwin & Greenberg 1999, and Pinelle et al. 2003) can also be applied when we regard the tabletop interaction as a co-located groupware environment, adding to the tabletop interaction design knowledge. We have yet to see more commercial outlets such as Microsoft Surface, and as with mobile interaction, more uptake of such commercial products will sharply increase the interaction design knowledge for the platform, in a way serving the real-world market as the large-scale field test. Evaluating tabletop interaction is not well understood yet as the interaction *amongst* the users around the table as well as *with* the table becomes an influential factor in the overall success or failure of the interaction. Thus taking into account the personality compatibility amongst the users around the table (McGivney et al., 2008) could be one way to evaluate the tabletop interaction.

Examples: Our *collaborative search table* (Smeaton et al., 2007) is designed to support 2-3 people around an interactive table to search for video clips together. In order to maximise the workspace awareness amongst the users, the designed interaction is deliberately based heavily on physical arm movements in the action of placing a video clip from one location to another. By making all action trigger mechanism as 'action spots' around the table, a user has to drag an object to one of the spots (e.g. 'delete this video' spot or 'play this video' spot) in order to see its intended effect. While constantly requiring dragging objects from one side of the table to another is not particularly efficient in terms of ergonomics and individual productivity, such a physical manipulation (e.g. arm movement) instead of symbolic manipulation (e.g. menu pop-up and selecting an item on it) naturally increases the awareness of what each person is doing at the table. An evaluation of the table with 16 people revealed that this increased awareness resulted not only in smoother and less error-prone interaction amongst the users but also in better search activity performance compared to a table with individual efficiency-enhanced features. Another aspect we investigated in the evaluation shows that a higher level of personality compatibility between the users around the table resulted in reduced overall performance in the task at hand, although more experiments with a greater number of different personality types would make this finding more conclusive. A well thought-out trade-off between facilitating such awareness mechanisms and supporting individual performance level is the unique consideration which was completely unnecessary in the desktop PC or mobile interaction design era.

INTERACTIVE TV

Today's digital technology and network connectivity have great potential for leveraging the ubiquity and familiarity of TV sets at home. Designing for interactive TV again branches dramatically from either of the aforementioned platforms because (i) interaction with a TV is typically a “lean-back” experience as opposed to lean-forward, where the user’s physical attitude and mental mindset is relaxed and lazy, (ii) the input device is a remote control, and (iii) there is a varying degree of viewer's level of attention (e.g. focused movie watching vs. half-engaged evening news watching while having dinner vs. TV turned on while doing something completely different). Others characterised the interactive TV design as that for quick decisions, a short attention span, a hand-held remote control, and instant gratification (Jensen, 2005). Again, without understanding these issues and explicitly factoring into design, we cannot design a usable interactive TV (iTV) application. The R&D history of iTV is relatively long with many examples of commercial trials and failures, but very little “actionable” or “ready-to-use” design knowledge is available today. With no standardised or agreed-upon TV screen widgets for iTV (remote control-based widgets have very different affordances from keyboard /mouse-based widgets) and no exemplary commercial success today, the interaction design aspect of iTV will need a lot more HCI research input. A small number of currently available design guidelines come from different sources, including an account from the developer’s experience in a broadcasting company (Gawlinkski, 2003), compiled after conducting focused usability testing (Ahonen et al., 2008), from a corporate perspective (BBC, 2005), and from a literature review (Lu, 2005). References to most of these guidelines can be found in Ahonen et al. (2008) and Kunert et al. (2007). Re-invigoration of the R&D scene in interactive TV is only happening now with efforts to bring in the social network phenomenon to the TV environment, and we are just starting to see some tangible design guidelines and heuristics (e.g. Ahonen et al. 2008 and Geerts & De Grooff 2009). In addition, evaluating a lean-back interaction such as interactive TV requires different approaches to a conventional usability evaluation (Pemberton & Griffiths 2003, Chorianopoulos & Spilnellis 2004) and a structured evaluation framework for TV interaction that accommodates affective issues has been proposed (Chorianopoulos & Spilnellis 2006), but remains theoretical and requires more empirical backup.

Examples: One way to enhance our TV experience at home is to increase the level of interactivity with TV by providing more content-related or social networking-related features. A big challenge in doing so is the potential interaction complexity (e.g. more buttons on the remote, more clutter on the TV screen, etc.) as the “lean-back” mindset of the user demands a very simplistic, easily-understandable and care-free operation. Our *Interactive Multimedia TV* (Lee et al., 2008b) incorporates a number of advanced multimedia functionalities such as searching for similar shots/scenes as is currently being broadcast, viewing a visual summary of the programmes and monitoring the number of current viewers of a channel and chatting with remote TV viewers. By using a few colour buttons and the up/down/left/right arrow buttons on a conventional remote control, a user invokes various features while watching a broadcast programme. An invoked feature appears as a slided-in semi-transparent panel overlaid on top of the broadcast screen, supporting both those wishing to continue to watch the current broadcast and those wishing to use interactive features. Further levels of advanced features appear when the viewer repeatedly presses the same button, cycling through 2-4 levels of functionality layers adopting a “spiral” approach. Requiring only the use of arrow buttons during interaction allows the viewer’s eyes to be comfortably fixated on the TV screen rather than having to look down at the remote control to choose a button to press. The combined result of these design considerations is a TV with highly sophisticated and advanced multimedia functionalities accessible in a deceptively simple use of a conventional remote control.

INTERACTIVE WALL

Large public display walls with multi-user touch capability will become a common public interaction platform in the future, to be seen on the streets, in shopping malls and town squares, and generally those public places with many people around. Designing for such a device is yet another challenge because we currently do not have much knowledge or experience of it and yet it exhibits very different and distinctive characteristics to what we are currently familiar with. For example, in a scenario where a few pedestrians walk up to an interactive wall and interact with it at the same time, the display size is probably too wide for each user's field of vision, raising an interesting visualisation problem between focal and peripheral vision of the user; having multiple users standing near the wall raises a group behaviour issue, private/public data usage issue as well as other co-located collaboration issues as in the tabletop interaction. Defining and characterising this category of interaction and suggesting some consequent design implications has been done early on (Dempski & Harvey, 2005) but a lot more follow-up research is required. A multi-touch wall is still a very rare interaction platform today, but experimental public deployments such as the CityWall in the city centre of Helsinki and its user studies (Peltonen et al. 2008 and Jacucci et al. 2010) are starting to happen, and no doubt more knowledge and guidelines for such a medium will start becoming available for designers. Evaluating such a platform will require perspectives from social science or perhaps urban studies in addition to the conventional usability engineering perspective.

Examples: Most modern desktop PC software features a very similar “menu” system where a bar at the top of a window shows menu items such as “File”, “Edit”, “Help” and when one of these is selected with a mouse cursor, a sub-menu list appears below from which further one sub-menu item can be selected. This style of accessing a variety of functionality through a menu widget has been studied and refined for a long time and now its level of usability is agreed to be good – when a new application is designed, adopting this menu style will do a good job whatever its application area might be, as long as the application is for a desktop PC with keyboard and mouse. Similarly, we can envisage this kind of “generic” menu style suitable for a large public multi-touch wall. What would such a menu look like? Our *Multi-touch menu system* (Wang et al., 2010) separates all provided functionalities into two groups: “global menu” items that affect everybody using the wall when triggered, and “local menu” items that only affect a user who needs it. Thus a global menu has a set of buttons on a floating panel on the lower part of the wall display, and any user can drag the menu onto his/her proximity and trigger a function – by having a single set of shared menu options floating about, people’s awareness of somebody using this menu is enhanced, thus reducing the possible surprise that influences their use of the wall. A local menu only appears when a user touches an object to be manipulated on the wall, and after using the menu, it disappears. Featuring these two different sets of menus, we designed a simple object drawing application where multiple people can approach and make shapes in different colours and transparencies. Multiple users’ actions are smoothly coordinated due to their awareness of globally-impacting functions when any of them intends to use, while at the same time discretely conducting their own private tasks with their local menu. Designing for a public multi-touch wall application requires consideration on how one user’s action might influence others and the balance of effects between discrete and public actions.

EMBEDDED APPLIANCES

Apart from the interaction platforms mentioned so far, we envisage many other hidden or embedded appliances that we will be interacting with on a daily basis in the near future. Information signage on a corridor, touch displays on a refrigerator door, wearables and other sensor-based appliances are examples of such platforms that will enrich our lives with the power of digital technologies. Due to the different characteristics of different appliances it will not make sense to try to draw design guidelines for embedded appliances as a whole, but we as the interaction design community needs to understand the special characteristics of each of these devices, experiment and draw new knowledge accordingly, and make them available for future designers of that particular type of appliances. For example, an energy-monitoring In-Home Display (IHD) is a good example of a special interaction device that will become commonplace soon. Meant to be on for 24/7, such a display should always display useful information on the screen without a user having to approach and interact with it to get information ("main menu" type of non-informational or administrative screen, thus, is to be avoided, unlike a mobile device where main menu is most likely a useful starting point of interaction). We currently have very little accumulated design knowledge for such devices but as more experimental and innovative applications appear in the market, more details of what works and what doesn't will emerge and the know-how start accumulating.

Examples: Our *Home energy monitor* (Doherty et al., 2010) is a touch-screen device that sits in the kitchen or living room in a household and displays real-time and historic electricity usage continuously in order to help the home users be more aware of their own energy usage and consequently to motivate them to reduce needless energy consumption. Because it is meant to be on day and night giving information quietly, the background of the screen is dark (black and dark grey) while the foreground information is in bright yellow and orange, similar to the way the digits on a bedside clock radio are displayed. Having a bright background as most desktop PC applications and websites are currently designed, would only brighten the room or blind a user's eyes at night time. The initial screen shows a graphical representation of electricity consumption by hour with estimated spending in a monetary currency where the house is located. A user can drill down to minutely breakdown of a particular hour, or move up to a daily/weekly/monthly view with the hourly view as the starting point. Cycling through different views with the initial view as an hourly view, the "main menu" that only shows administrative buttons was removed. Thus a home user just passing by or sitting from a distance can turn his/her head or glance over to see the useful data readings without having to approach and engage in the interaction.

Gesture, touch and voice are some of the interaction modalities that could further enhance interaction with the above platforms and we expect some of the weaknesses of device characteristics would be compensated for by incorporating these modalities. For example, we envisage that an accelerometer-enhanced TV remote control similar to the Nintendo Wii-mote will start appearing to support more intuitive and richer experiences with interactive TV in the future. Completely controller-free gesture interaction with gesture recognition as used in the Xbox Kinect will enhance the naturalness of interaction in certain usage situations (e.g. action games or other socially-oriented entertainment). Voice recognition will also complement many of the otherwise awkward input mechanisms of mobile devices. We also expect that advances in context-awareness/augmentation will help shape interaction design of the future (Canny, 2006), and that various hybrid interaction devices will appear that exhibit not typical characteristics of an interaction platform as summarised in this paper but mix some characteristics from multiple platforms. For example, Apple iPad is a mobile device but with much larger display area than a typical mobile device thus removing some of the limitations of implied usage characteristics. Using a device such as an iPad as a TV remote control would add to another novel mix of interaction characteristics, requiring yet more re-thinking of the specific affordances and their design implications for such a setting.

ROLE OF GENERAL DESIGN KNOWLEDGE AND DESIGN ABILITY

On top of the specialised design knowledge for various platforms described throughout this paper, there is a body of interaction design knowledge that is commonly applicable regardless of platform. Those design principles and guidelines that are cleaned up with any embedded assumptions on a particular platform will become available as high-level principles, patterns and guidelines across the platforms that interaction designers can learn, practice, then customise for a specific platform (this latter act subsequently adding further to the specialised platform knowledge). Along with the design knowledge discussed in this paper, other less-understood but clearly influential design abilities will continue to serve as the key factor for successful design, e.g. the ability to innovate across disciplines

(Norman, 2008), a skill to quickly derive an initial solution then move between problem and solution space (Cross, 2006), dealing with different levels of abstraction at the same time (Cross, 2006; Lawson, 2006), juggling between conflicting guidelines by prioritising, developing sound judgments in the creative design process (Wolf et al., 2006), and also particularly relevant in the context of creating novel applications in the absence of well-defined user needs and requirements, the ability to work in ill-defined problem situations (Cross, 2006). These design abilities become even more crucial in developing novel interactive applications especially with emerging platforms due to the lack of established usage, requirements and prior examples from which a development process could conventionally benefit.

The design knowledge as summarised in this paper are domain- or activity-independent thus can be regarded as the part of "solution space" in terms of the problem-solution spectrum of knowledge required for designing an application. This means that we can readily use this type of knowledge without fully understanding where the system will be used and in what activity/task context. Moreover, unlike the technology and technical understanding that make up the other part of solution space, the design knowledge embodies the our understanding of human users' inherent physical and cognitive capabilities and limitations contributing to the overall user-centredness in designing an application, not in the sense of fitting the designed artefact to the end-users' particular activity/task requirements but in the sense of ensuring a clear base usability of how to interact with various elements of the application.

It is difficult to try to design an application when there are no existing needs or activities for it. Many of the interaction platforms mentioned in this paper currently have no application areas, user needs or user base to ascertain any realistic usage requirements from. Designing an application using one of these novel platforms means that we are trying to discover new needs or to create new activities by first coming up with tools to support them. Once a specific activity area that an interactive application can support is discovered or created, then we can commence a variety of requirements and usability engineering techniques and processes to incrementally refine and make a better fit to that activity for the users over time. Many of the currently existing HCI tools and methods are excellent in addressing and supporting this incremental refinement process based on obtaining user feedback through opinions and behaviour observation.

CONCLUSION

Mobile computing devices with nifty, well-crafted touch-screen interfaces, location-awareness and accelerometers are big in the market today, and accordingly a lot of public interest, resources and research efforts are focused on tapping on this potential. Keynote speeches in HCI-related conferences today often talk about the mobile revolution and how it progressed over the past 10 years, and this particular category of interaction devices will continue to be refined, new ways of usages identified, empirical studies conducted to pin down some of the uncertain design factors, gradually bringing our interaction with mobile platforms more efficient and pleasant to use over time.

However, considering the mobiles as the only (or one of the two, along with desktop PC platform) major interaction platform we will ever have is a short-sighted view. Certainly efforts should be put into increasing mobile design knowledge to make today's users happy, but putting efforts into preparing for emerging interaction platforms will be an investment for tomorrow's users. Just as mobile computing became ubiquitous within last 10 years when we had thought the desktop PC computing was equal to the "interaction with computers", we will most likely start seeing some 3rd major interaction platforms start to become ubiquitous in the near future. Whether an interactive tabletop or interactive display in the kitchen wall at home or large multi-touch wall display on the streets, we should not just wait around until that time comes. There are plenty of studies we can already work on, before any of these novel interaction platforms start joining the mainstream interaction along with desktop PCs and mobiles, in order to start accumulating the knowledge and skill set required to design usable interaction strategies for their applications.

This paper attempts to establish a wider view of interactive computing products in which the desktop PC and mobiles, the two currently dominant interaction platforms, are only two of many other very different types of interaction that are to come into our lives in the near future. With this wider view, truly general interaction design knowledge is separated from platform-specific design knowledge, and the knowledge base for each grows separately. We can envision a future where designing a computing application starts with determining which of the various interaction platforms would most suit the activities and tasks it is to support, then commencing the design accordingly.

The argument presented in this paper is the result of the authors' self-reflection and discussion on the experiences in actually designing a series of novel applications in different platforms over the years. In doing so, we started with identifying the major design decisions made for each of our projects, qualitatively analysed how much of it came from the existing body of design knowledge and how much from inventing new schemes then developing them throughout the projects, then ended up grouping them by the categories of interaction platforms. We then checked how a new, future application could be perceived by linking a selection of back-end technologies with a particular interaction platform and a new usage scenario.

Having a wider understanding of the diversity of a growing body of interaction design knowledge for different platforms gives us a vantage point where various usage scenarios and technological tools can be experimentally coupled/tested, helping envision our future use of interactive technologies in a more comprehensive, unified and cost-effective way. We believe it is imperative to recognise the upcoming interaction platforms, and to turn the act of accumulating design knowledge for them as a streamlined and well-prepared process so that the designers, when they apply their creativity and solution-oriented approach to such problems, have a good basis to start with. Engaging a lengthy trial-and-error routine whenever a novel device hits the market is not a necessary step in the evolution cycle of an interactive product design.

ACKNOWLEDGEMENT

This work is supported by Science Foundation Ireland under grant 07/CE/I1147 and Dublin City University Research Fellowship scheme.

REFERENCES

Ahonen, A., Turkki, L., Saarijarv, M., Lahti, M. and Virtanen, T. (2008) Guidelines for designing easy-to-use interactive TV services: experiences from the ArviD Programme. In *Interactive Digital TV: Technologies and Applications*, IGI Publishing, pages 207–223.

BBC. (2005) *Designing for Interactive Television v1.0*, BBCi and Interactive TV Programmes. British Broadcasting Corporation, 2005.

Canny, J. (2006) The future of human-computer interaction. *ACM Queue*, 4(6), pages 24–32.

Chorianopoulos K. and Spilnellis, D. (2004) Affective usability evaluation for an interactive music television channel. *Computers in Entertainment*, 2(3).

Chorianopoulos K. and Spilnellis, D. (2006) User interface evaluation of interactive TV: a media studies perspective. *Universal Access in the Information Society*, 5(2), pages 209–218.

Cross, N. (2006) *Designerly Ways of Knowing*. Birkhauser, Basel, Switzerland.

Dempski, K. and Harvey, B.L. (2005) Touchable interactive walls: opportunities and challenges. *IFIP 4th International Conference on Entertainment Computing*, Sanda, Japan, 19-21 September 2005. Springer Lecture Notes in Computer Science, 3711, 192-202.

Doherty, A., Qiu, Z., Foley, C., Lee, H, Gurrin, C. and Smeaton, A.F. (2010) Green multimedia: informing people of their carbon footprint through two simple sensors. In *ACM Multimedia 2010 - Proceedings of the International Conference on Multimedia*, Florence, Italy, 25-29 October 2010, pages 441-250.

Gawlinski, M. (2003) *Interactive Television Production*. Chapter 5: Usability and Design. Focal Press, Oxford, U.K., 2003.

Geerts, D. and De Grooff, D. (2009) Supporting the social uses of television: sociability heuristics for social TV. In *CHI'09 – ACM International Conference on Human Factors in Computing Systems*, Boston, MA, 4-9 April 2009, pages 595–604.

Grudin, J. (1994) Groupware and social dynamics: eight challenges for developers. *Communications of the ACM,* 37(1), pages 92-105.

Gutwin, C. and Greenberg, S. (1999) The effects of workspace awareness support on the usability of real-time distributed groupware. *ACM Transactions on Computer-Human Interaction*, 6(3), pages 243-281.

Gurrin, C., Smeaton, A.F., Lee, H., McDonald, K., Murphy, N., O'Connor, N. and Marlow, S. (2004) Mobile access to the Físchlár-News archive. In *Mobile HCI 2003 International Workshop,* 8 September 2003, Udine, Italy. ISBN 978-3-540-21003-0

Hagen, P., Robertson, T., Kan, M. and Sadler, K. (2005) Emerging research methods for understanding mobile technology use. In *OZCHI'05 – Proceedings of the 17th Australia Conference on Computer-Human Interaction*, Canberra, Australia, 21-25 November 2005, pages 1–10.

Jacucci, G., Morrison, A., Richard, G., Kleimola, J., Peltonen, P., Parisi, L. and Laitinen, T. (2010) Worlds of information: designing for engagement at a public multi-touch display. In *CHI 2010 - Proceedings of the 28th International Conference on Human Factors in Computing Systems*, Atlanta, GA, 10-15 April 2010, pages 2267-2276.

Jensen, J. (2005) Interactive television: new genres, new format, new content. In *IE 2005 - Proceedings of the 2nd Australasian Conference on Interactive Entertainment*, Sydney, Australia, 23-25 November 2005, pages 89-96.

Jones M. and Marsden, G. (2006) *Mobile interaction design*. John Wiley & Sons.

Kristoffersen, S. and Ljungberg, F. (1999) "Making place" to make IT work: empirical explorations of HCI for mobile CSCW. In *GROUP 1999 - Proceedings of the international ACM SIGGROUP Conference on Supporting Group Work*, Phoenix, AZ, 14-17 November 1999, pages 276-285.

Kruger, R., Carpendale, S., Scott, S.D., and Greenberg, S. (2003) How people use orientation on tables: comprehension, coordination and communication. In *GROUP'03 – Proceedings of the International ACM SIGGROUP Conference on Supporting Group Work*, Sanibel Island, FL, 9-12 November 2003, pages 369–378.

Kunert, T., Kromker, H. and Kuhhirt, U. (2007) Navigation design guidelines for interactive television applications. In *EuroITV 2007 - Proceedings of the 5th European Interactive Television Conference*, Amsterdam, The Netherlands, 24-25 May 2007, pages 7-23.

Lawson, B. (2006) How designers think: the design process demystified (4th Ed). Architectural Press.

Lee, H., Smeaton, A.F., O'Connor, N.E., Jones, G.F., Blighe, M., Byrne, D., Doherty, A. and Gurrin, C. (2008a) Constructing a SenseCam visual diary as a media process. *Multimedia Systems Journal*, 14(6), pages 341–349.

Lee, H., Ferguson, P., Gurrin, C., Smeaton, A.F., O'Connor, N.E., and Park, H. (2008b) Balancing the power of multimedia information retrieval and usability in designing interactive TV. In *UXTV '08 - Proceedings of the International Conference on Designing Interactive User Experiences for TV and Video*, Mountain View, CA, 22-24 October 2008, pages 105–114.

Liu, N., Liu, Y. and Wang, X. (2010) Data logging plus e-diary: towards an online evaluation approach of mobile service field trial. In *MobileHCI 2010 - Proceedings of the 12th International Conference on Human Computer Interaction with Mobile Devices and Services*, Lisbon, Portugal, 7-10 September 2010, pages 287-290.

Longoria, R. (2001) Designing mobile applications: challenges, methodologies, and lessons learned. In *HCI International 2001 - Proceedings of the Human-Computer Interaction International Conference*, New Orleans, LA, 5-10 August 2001.

Lowgren, J. and Stolterman, E. (2007) *Thoughtful interaction design: a design perspective on information technology*. MIT Press, Cambridge, MA.

Lu, K. (2005) *Interaction design principles for interactive television*. Chapter 5: Principles of interaction design for iTV (M.Sc dissertation). Georgia Institute of Technology, Atlanta, GA.

Marcus, A., Ferrante, J., Kinnunen, T., Kuutti, K. and Sparre, E. (1998) Baby faces: user-interface design for small displays. In *CHI'98 - Proceedings of the International ACM Conference on Human Factors in Computing Systems*, Los Angeles, CA, 18-23 April 1998, pages 96-97.

McGivney, S., Smeaton, A.F. and Lee, H. (2008) The effect of personality on collaborative task performance and interaction. In *CollaborateCom'08 - 4th International Conference on Collaborative Computing*, Orlando, FL, 13-16 November 2008.

Morris, M.R., Ryall, K., Shen, C., Forlines, C. and Vernier, F. (2004) Beyond "social protocols": multi-user coordination policies for co-located groupware. In *CSCW'04 – ACM Conference on Computer Supported Cooperative Work*, Chicago, IL, 6-10 November 2004, pages 262–265.

Norman, D.A. (2008) *The design of future things*. Basic Books, New York, NY.

O'Hare, N., Gurrin, C., Lee, H., Murphy, N., Smeaton, A.F. and Jones, G. (2005) My digital photos: where and when? In: *ACM Multimedia 2005 - 13th ACM International Conference on Multimedia*, Singapore, 6-12 November 2005.

Palen, L. and Salzman, M. (2002) Beyond the handset: designing for wireless communications usability. *ACM Transactions on Computer-Human Interaction*, 9(2), pages 125–151.

Peltonen, P., Kurvinen, E., Salovaara, A., Jacucci, G., Ilmonen, T., Evans, J., Oulasvirta, A. and Saarikko, P. (2008) It's mine, don't touch!: interactions at a large multi-touch display in a city centre. In *CHI 2008 – Proceedings of the ACM International Conference on Human Factors in Computing Systems*, Florence, Italy, 5-10 April 2008, pages 1285–1294.

Pemberton, L. and Griffiths. R. (2003) Usability evaluation techniques for interactive television. In *HCI International 2003 – 10th International Conference on Human-Computer Interaction*, Crete, Greece, 22-27 June 2003.

Pinelle, D., Gutwin, C. and Greenberg, S. (2003) Task analysis for groupware usability evaluation: Modeling shared-workspace tasks with the mechanics of collaboration. *ACM Transactions on Computer-Human Interaction*, 10(4), pages 281-311.

Scott, S.D, Grant, K.D. and Mandryk, R.L. (2003) System guidelines for co-located, collaborative work on a tabletop display. In *ECSCW'03 – 8th European Conference on Computer-Supported Cooperative Work*, Helsinki, Finland, 14-18 September 2003, pages 159-178.

Scott, S.D., Sheelagh, M., Carpendale, T. and Inkpen, K.M. (2004) Territoriality in collaborative tabletop workspaces. In *CSCW'04 - ACM Conference on Computer Supported Cooperative Work*, Chicago, IL, 6-10 November 2004, pages 294–303.

Smeaton, A.F., Lee, H., Foley, C. and McGivney, S. (2007) Collaborative video searching on a tabletop. *Multimedia Systems Journal*, 12(4), pages 375–391.

Tse, E., Histon, J., Scott, S.D. and Greenberg, S. (2004) Avoiding interference: how people use spatial separation and partitioning in SDG workspaces. In *CSCW'04 – ACM Conference on Computer Supported Cooperative Work*, Chicago, IL, 6-10 November 2004, pages 252–261.

Tse, E., Shen, C., Greenberg, S. and Forlines, C. (2007) How pairs interact over a multimodal digital table. In *CHI'07 – ACM International Conference on Human Factors in Computing Systems*, San Jose, CA, 28 April – 3 May 2007, pages 215–218.

Van House, N., Davis, M., Ames, M., Finn, M. and Viswanathan, V. (2005) The uses of personal networked digital imaging: an empirical study of cameraphone photos and sharing. In *CHI'05 – ACM International Conference on Human Factors in Computing Systems*, Portland, Oregon, 2-7 April 2005, pages 1853–1856.

Wang, C. and Lee, H. and Smeaton, A.F. (2010) Designing interaction for a multi-touch wall. In: *iHCI 2010 - 4th Irish Human Computer Interaction Conference*, Dublin, Ireland, 2-3 September 2010. ISBN 1872327885.

Wolf, T.V., Rode, J.A., Sussman, J. and Kellogg, W.A. (2006) Dispelling "design" as the black art of CHI. In *CHI'06 – ACM International Conference on Human Factors in Computing Systems*, Montreal, Canada, 22-27 April 2006, pages 521–530.