INTERACTION PLATFORM-ORIENTED PERSPECTIVE IN DESIGNING NOVEL APPLICATIONS

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The lack of HCI offerings in the invention of novel software applications and the bias of design knowledge towards desktop GUI make it difficult for us to design for novel scenarios and applications that leverage emerging computational technologies. These include new media platforms such as mobiles, interactive TV, tabletops and large multi-touch walls on which many of our future applications will operate. We argue that novel application design should come not from user-centred requirements engineering as in developing a conventional application, but from understanding the interaction characteristics of the new platforms. Ensuring general usability for a particular interaction platform without rigorously specifying envisaged usage contexts helps us to design an artifact that does not restrict the possible application contexts and yet is usable enough to help brainstorm its more exact place for future exploitation.

1. Introduction

Given the fast pace of research and development in variety of technology fields today, it is becoming increasingly important to quickly come up with new usage scenarios, novel applications and new ways of utilising these emerging technologies. Researchers in computational media technologies including Multimedia, Information Retrieval, Semantic Web and Sensor Web are developing many different kinds of potentially useful techniques and tools that, when properly applied and deployed, will change the way we work and play for the better, and make our life easier, more enjoyable and fulfilling.

The challenge is how we can exploit these technological developments into feasible scenarios and subsequently into usable applications. While the discipline of Human-Computer Interaction provides a crucial link between the technology and the end-users, its strong grounding on rigorous requirements elicitation and subsequent refinement mechanism by feeding back usage information does not lend itself well in supporting the initial invention stage or the “starting point” that actually triggers innovation that binds new technology to real world. Furthermore, most of the body of design principles, guidelines and experiences accumulated over the years in HCI tend to carry an assumption of a user interacting with a conventional Graphical User Interface operating on a desktop computer with keyboard and mouse in an office setting. This well-established evaluation methodology in HCI also focuses on measuring local, controllable, and relatively minutia elements for improvement within a given condition, promoting a creation of only what a current usability test can measure (Olsen, 2007) and thus is probably not suitable for evaluating explorative designs (Greenberg and Buxton, 2008). The consequence of all this is that available knowledge and methods might not exploit the full potential of developing technologies, failing to support radical, lifestyle-changing innovations but only incremental refinement of what is already there.

In this paper we argue that for the early stage of exploring possible exploitation of new technologies and subsequent invention of novel usage scenarios and applications, there is an *increasing amount of interaction platform-specific design knowledge* that we can leverage in the absence of the expected domain-specific knowledge or envisaged requirements. In our 10 years experience in designing innovative applications that incorporate novel computational tools from media technologies that have no precedence of use, we were able to develop feasible and usable solutions in this way given the inevitable lack of domain knowledge, requirements or use practice. This approach may be likened to a "build first then see if it does anything useful" approach except that the "build" stage strongly hinges on acknowledging a body of design knowledge specialised for the interaction platform being conceived. We show a number of novel applications we created over the years that, as generic as they are in terms of usage context, have strong usability for the particular interaction platform and serve as superb brainstorming artifacts for future applications.

2. Emerging media technologies: opening up the new possibilities

The general public is usually unaware of the variety of media technologies that are currently being researched in laboratories around the world. *Multimedia* technology focuses on developing ways to automatically index media contents (e.g. digital photos or video archives). For example, Sports Summarisation can automatically identify those most important moments in a sports video (e.g. a soccer match) to generate a 3-minute highlights; *Semantic Web* technology tries to automatically understand, aggregate and relate various pieces of data sources on the Web. Some of its experimental tools can digest huge amount of news stories from the Web to generate an interface template where automatically identified information objects (e.g. persons, organisations, geographic places, etc.) can be presented in a web of semantically-linked information space in a way that the current Web (manually established web of links among 'web pages') is unable to facilitate; *Sensor Web* technology investigates how a system could be designed to provide useful feedback to its users by capturing their physical states and the environment around them using a network of physical sensors such as heartbeat monitor, sensors embedded in clothing and wireless environmental sensors, bringing the power of computing into our physical world. For example, a network of sensors embedded in our clothing can monitor our calorie intake (from food) and calorie expenditure (from body movement) throughout the day and present the balance on a TV screen before we go to bed. Some of the tools in these novel technologies that have been investigated for some time are becoming robust and accurate enough to appear in the commercial market. For example, face detection, one of Multimedia's long-standing topics, is now featured in many digital cameras to help auto-focus when taking a photo. As some of these tools mature with continuing research efforts, we expect more variety of commercial applications incorporating these tools will appear in the market in near future.

The significant challenge is that the strong thrust of the technology-driven approach in the research labs of these technologies, although serving as the main force in the progress of these fields, stands many steps away from the issues of usage and application areas, and design of such applications. The knowledge base, research approach and culture and framing of the problems in these technology fields are not positioned to come up with good applications, even though they are best positioned to identify and provide the most innovative solutions.

3. Designing for novel applications: HCI challenges

In this section we address two major challenges in designing for novel applications incorporating emerging new media technologies in the context of HCI.

3.1 Missing requirements: where do we start?

The user-centred perspective of HCI in general offers a number of accordingly user-centred methods and tools to develop an application. Starting with the establishment of requirements by such techniques as interview, questionnaire, focus group and other ethnographic methods such as contextual inquiry and cultural probes in order to solicit the information from *real users*, the resultant understanding of the requirements serves as the starting point for designing new applications that will satisfy and improve current practice. Once designed, a series of refinement processes commences with further user testing and feedback against the previous designs, improving at each iteration. This is illustrated in Figure 1(a).

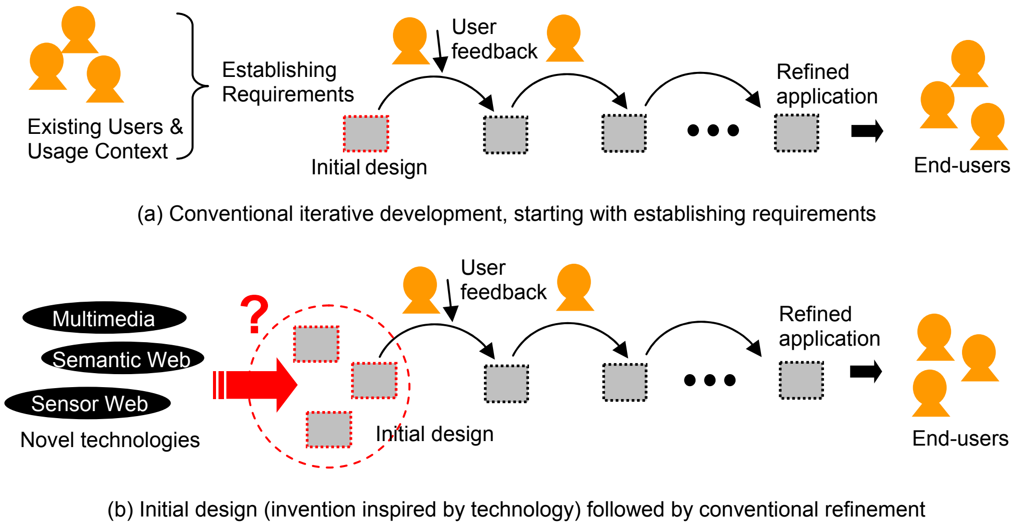

Figure 1. Designing conventional application vs. designing novel application

Although this strong user-centred approach is what makes the HCI discipline work (in making an application fit to end-user needs), its downside is the difficulty in addressing *novel, unprecedented applications that are not in use today*. Most of the available tools and methods in HCI have been developed for and geared towards those applications that have an established usage and existing use practice (e.g. library management or Web browsing), especially in refining their user-interfaces by feeding back observed usage data from users. Given that the crucial point of a development is to fully understand the end-user needs and context, a question arises on how we can develop a *novel* application where there is no such end-user base, a case where what we want to create is for a completely novel usage. Once created, the novel application can be refined with user feedback in a conventional way (see Figure 1(b)). The latest HCI textbooks address this issue with the methods such as *brainstorming*, *envisionment* and *prototyping*, as ways to help come up with alternative design options to the existing paradigms and scenarios (Shneiderman and Plaisant, 2004; Benyon et al, 2005; Sharp et al, 2007), more of an open-ended activity rather than prescribed methodology. With many emerging novel technologies today, the significance of understanding the "starting point" of a new application is increasing. Incremental refinement in current HCI is important but the initial invention of new lines of application with a higher-impact value requires more investigation today.

3.2 Lack of design knowledge for non-desktop interaction

The evolution of HCI has been very much geared towards the desktop computer as its main application platform: methods were applied to desktop applications which helped further inform and consolidate design knowledge and methods, co-evolving as they did. As a result, today the body of knowledge, experience and wisdom in designing for the desktop PC (with monitor as output device and keyboard and mouse as input device) is extensive, witnessed in often-quoted design principles, design guidelines, heuristics and endless sources of "design tips" available in HCI textbooks and popular Web design sites and other resources.

Problems of this knowledge are perhaps twofold: (i) design knowledge, guidelines and accumulated design experiences have many embedded assumptions towards desktop-based applications, and (ii) designers experienced in conventional applications tend to use the same knowledge and skill in designing for non-desktop platforms. Novel platforms such as mobiles, tabletops, interactive TV, large multi-touch walls and other embedded appliances are not commonplace today (with the exception of mobiles which already became a ubiquitous interaction device alongside desktop PCs), but with increasing technical advancement and decreasing manufacturing cost (thus lower consumer price tag) these will become more widespread and ubiquitous. Novel computational technologies mentioned in Section 2 are certainly expected to be coupled with these novel interaction platforms that will emerge as dominant platforms in the future, thus it is important to start developing scenarios and use cases that involve these other platforms. Today there is no unifying framework or guidance to consider the variety of interaction platform characteristics under one project in envisioning future applications, as design expertise usually does not encompass multiple platforms.

4. Leveraging the design knowledge for each interaction platform

In this section, we present our approach in developing novel applications that have no precedence of use or existing user base, and are thus without the "establishing requirements" stage in a conventional sense. The key factor in our approach is to acquire the design knowledge on the characteristics of the particular interaction platform for which the application is to operate on, to ensure the base usability of that application thus creating as much as possible generic type of application without fitting to a very specific usage context.

Design knowledge encompasses the knowledge necessary to design an application, and represents the theoretical and practical knowledge, experience and skill set of the designer. These include design principles (theoretical and empirical foundations that reflect the human capabilities/limitations, in theory general enough to be applicable regardless of interaction platform), design guidelines (collections of wisdom, experience and common sense of the designers usually specific to a particular type of device) and also a set of skills a designer should have (e.g. the ability to apply the principles to a specific problem, the ability to synthesise numerous situational factors, and the ability to juggle between conflicting guidelines). The design knowledge we highlight in this paper is the interaction platform-specific ones that diverge from the dominant desktop GUI design knowledge:

Mobile design knowledge – interaction design for mobiles brings in significantly different and distinctive design issues from that for desktop PC because (i) display is usually much smaller, (ii) input mechanism is limited, and (iii) distraction during use is expected. Without explicitly factoring in these issues in design, the resultant interaction scheme will not be satisfactory. Much of the mobile usability failures in the late 1990 and early 2000 were due in part to the designers' attempt to merely apply their desktop GUI design knowledge to PDA interface design. After a decade of trial-and-error and gradual improvement, we now have one textbook on mobile interaction design (Jones and Marsden, 2004), a sizable amount of guidelines, and some recent successful commercial exploitation such as iPhone.

Tabletop design knowledge – designing for interactive tabletops brings a set of distinctive design issues including (i) task allocation or division of labour amongst the users around the table, (ii) workspace awareness, and (iii) coordination/conflict resolution strategies. Again, without explicitly factoring in these issues in design, a tabletop interface cannot support multi-user collaborative interaction satisfactorily. We have no interaction design textbook yet, but a few design guidelines have been suggested backed by empirical table study efforts (e.g. Scott et al, 2003), and we are yet to see more commercial outlets such as Microsoft Surface.

Interactive TV design knowledge – designing for interactive TV branches dramatically from desktop PC interaction because of (i) lean-back interaction as opposed to lean-forward, (ii) use of remote control, and (iii) the need for multiple levels of user engagement (e.g. focused movie watching vs. half-engaged evening news watching while having dinner). Again, it is crucial for successful TV interaction design to explicitly consider these issues and incorporate the design decisions. The R&D history of interactive TV is relatively long with many examples of commercial attempts, but there are relatively few "actionable" or "ready-to-use" body of design knowledge today. With the revival and reshaping of iTV R&D thanks to the Internet, the rise of social media coupled with ethnographic user studies, we are beginning to see tangible design guidelines and heuristics (Ahonen et al, 2008; Geerts and Grooff, 2009).

Large multi-touch wall – a large display wall with multi-touch capability will become one of the common public interaction platforms in near future. Designing for such wall brings in yet another distinctive set of design issues that need to be addressed. For example, in a scenario where pedestrians walk up to a large public display wall, a user's vision is not wide enough to hold the full display, raising the focal-peripheral vision interplay issue; many users standing side by side raise the usage conflict and division of labour issues similar to the tabletop. Multi-touch wall is still a rare interaction platform, but experimental public deployments such as the CityWall in Helsinki and its user study (Peltonen et al, 2008) are starting to happen, no doubt design knowledge and guidelines will start forming from these endeavors.

The design knowledge for novel platforms listed above is required *regardless of* the domain area and the specific task situation where the application will be eventually used. In designing a novel application that leverages new technologies, it is important to (i) envisage a possible usage scenario in a particular interaction platform, and (ii) design considering the characteristics of that chosen platform. We believe that understanding the increasingly diverging and specialised design knowledge for the wide range of interaction platforms is the key to successful novel application design and is the main contributing factor at the initial design stage. In particular, such understanding helps explore new usage possibilities and alternatives afforded by the incorporated technology making the activity as “design exploration” characterised by ideals, provocation and possibilities rather than as “design practice” characterised by fitting to a particular context for a particular client (Fallman, 2008). Once design alternatives and possibilities have been explored, then the most promising ones could be further elaborated, situated, and refined for a specific context with the conventional usability engineering.

5. Examples of novel applications

Object detection in images is part of Multimedia’s long-term research agenda, and a series of novel applications we developed was to support new scenarios where a user is searching for particular objects in photos rather than for the whole photos. In one application, a user starts with Google Image search to find photos that contain a desired object (e.g. a boat or Eiffel Tower), which are then loaded on a simple object segmentation canvas where she draws an outline of the objects she wants to use as query objects, after which the segmented objects are loaded into a special search interface that will retrieve matching objects from a large image database using our object matching technique. Although image-based relevance feedback has been experimented before (though is not yet available commercially), user-initiated segmentation of objects from external sources in real-time is a novel and potentially very useful usage scenario. The user evaluation of this application highlighted the usefulness of the object outlining as opposed to using whole images for searching (Sav et al, 2006). The outlining of objects and focused searching is best facilitated with fine-grained control of keyboard/mouse, and was thus designed for a conventional desktop PC platform.

Our mobile news update service (Gurrin et al, 2003) used daily TV broadcast news that was digitally recorded daily, indexed and structured into a searchable database of individual news stories, and an advanced personalisation technique automatically recommended a small number of news stories in a summarised format to individual users on their PDAs. The application was deployed along with its desktop-based mother system called Físchlár-News for a number of years during which its usage were monitored (Lee et al, 2006). The assumed user needs we had was simply that a user wants news updates while on the go. The applied multimedia techniques that automatically chunk news videos into individual story units and push to the users only a few most useful stories particularly supported the mobile interaction characteristics very well, where the user’s interaction effort/attention should be minimised.

Our collaborative video searching application on a tabletop (Smeaton et al, 2006) was designed to support multiple users sitting around the table searching for video clips together. While leveraging an automatic video retrieval and relevance feedback mechanism at the back-end, the application interface features “action hot-spots” around the edges of the table that trigger a particular function when a user drags a video clip over it, in order to help naturally maintain the user awareness of what other people are about to do. An assumed requirement was that the users need to search for video clips together in a way which maximises awareness amongst user actions as to support natural and effective collaboration. Our user evaluation of this application involved 16 pairs of users (38 users) and factored in users’ personality traits in order to more accurately assess the effects of their collaboration (Mc Givney et al, 2008).

Our interactive TV application (Lee et al, 2008a) incorporates a number of Multimedia tools including video scene detection, content-based searching and sports summarisation and provides an effective and lean-back user interaction with TV remote control. With the use of semi-transparent panels discretely sliding in and out on the TV screen with a few colour buttons on the remote control, the potentially sophisticated Multimedia features were presented in a very simple and easy-to-use manner, demonstrating that the advanced Multimedia tools need not be complicated to operate when used on a ubiquitous device such as TV. Our usage scenario was that a user sitting comfortably at a TV set utilises various Multimedia functions to enhance viewing experience using a few buttons on the remote. The application has been fully-implemented and we are currently planning a user evaluation with sofa and table in order to simulate a relaxed and comfortable living room environment.

Other novel scenarios and corresponding applications include an online personal photo management service with automatic person labeling to help reduce user annotation effort (Sadlier et al, 2008), an online museum explorer where the photos of exhibited artifacts at the museum taken by the visitor are uploaded and automatically grouped by individual artifacts using our edge-matching technique (Blighe et al, 2008), and a lifelogging application where a user can comfortably browse thousands of photos taken each day with a passive photo capture device such as SenseCam (Lee et al, 2008b). The significance of these novel applications is that they were born out of technological possibilities and not of rigorous requirements engineering, and yet their base usability is ensured as each of them was designed to support and exploit its interaction platform characteristics.

6. Conclusion

We envisage our next generation interaction designers to be equipped with the design knowledge spanning multiple interaction platforms and the ability to make informed judgments on the suitable ones for the technology and usage under development. Fitting a new application to a particular context as much as possible is an important usability issue, but it comes only after design alternatives have been explored in order to maximally leverage technological possibilities. Because the focus of our work is to come up with the initial novel solutions, we think the understanding of what happens during creative design itself will be an important clue to help that initial design process (Wolf et al, 2006; Cross, 2002), and we are currently working on combining the modeling of creative design process with the interaction platform-specific design knowledge, as described in this paper.

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References

Ahonen, A., Turkki, L., Saarijarvi, M., Lahti, M. And Virtanen, T. 2008, Guidelines for designing easy-to-use interactive television services: experiences from the ArviD programme. *Interactive Digital Television: Technologies and Applications*, (IGI Global)

Benyon, D., Turner, S. and Turner, S. 2005, *Designing Interactive Systems: People,*

Activities, Contexts, Technologies, (Addison-Wesley)
Blighe, M., Sav, S., Lee, H. and O'Connor, N. 2008, Mo Músaem Fíorúil: A Web-based Search and Information Service for Museum Visitors. *International Conference on Image Analysis and Recognition (ICIAR 2008)*, Povoa de Varzim, Portugal, 25-27 June 2008
Cross, N. 2002, Creative cognition in design: processes of exceptional designers. *4th ACM Conference on Creativity & Cognition*, Loughborough, U.K, October 13-16, 2002, 14-19
Fallman, D. 2008, The interaction design research triangle of design practice, design studies, and design exploration. *Design Issues*, **24** (3), 4-18.
Geerts, D. and Grooff, D. 2009, Supporting the social uses of television: sociability heuristics for social TV. *ACM CHI 2009*, 595-604
Greenberg, S. and Buxton, B. 2008, Usability evaluation considered harmful (some of the time). *ACM CHI 2008*, 111-120
Gurrin, C., Smeaton, A.F., Lee, H., Mc Donald, K., Murphy, N., O'Connor, N. and Marlow, S. 2004, Mobile Access to the Físchlár-News Archive. *Springer Lecture Notes in Computer Science,* **2954**, 124-142
Lee, H., Smeaton, A.F., O'Connor, N. and Smyth, B. 2006, User Evaluation of Físchlár-News: an Automatic Broadcast News Delivery System. *ACM Transactions on Information Systems*, **24** (2), 145-189
Lee, H., Ferguson, P., Gurrin, C., Smeaton, A.F., O'Connor, N. and Park, H. 2008 (a), Balancing the Power of Multimedia Information Retrieval and Usability in Designing Interactive TV. *International Conference on Designing Interactive User Experiences for TV and Video (uxTV 2008),* Mountain View, CA, 22-24 October 2008
Lee, H., Smeaton, A.F., O'Connor, N., Jones, G., Blighe, M., Byrne, D., Doherty, A. and Gurrin, C. 2008 (b), Constructing a SenseCam Visual Diary as a Media Process. *Multimedia Systems Journal*, **14** (6), 341-349
Mc Givney, S., Smeaton, A.F. and Lee, H. 2008, The effect of personality on collaborative task performance and interaction. *4th International Conference on Collaborative Computing*, Orlando, FL, 13-16 October 2008.
Olsen, D.R. 2007, Evaluating user interface systems research. *ACM UIST* 2007, 251-258
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. *ACM CHI* 2008.
Sadlier, D., Lee, H., Gurrin, C., Smeaton, A.F. and O'Connor, N. 2008, User-Feedback on a Feature-Rich Photo Organiser. *9th International Workshop on Image Analysis for Multimedia Interactive Services (WIAMIS 2008),* Klagenfurt, Austria, 7-9 May 2008
Sav, S., Jones, G., Lee, H., O'Connor, N. and Smeaton, A.F. 2006, Interactive Experiments in Object-Based Retrieval. 5th International Conference on Image and Video Retrieval. *Springer Lecture Notes in Computer Science*, **4071**, 1-10
Scott, S., Grant, K. and Mandryk, R. 2003, System guidelines for co-located, collaborative work on a tabletop display. *ECSCW'03,* 14-18 September 2003, Helsinki, Finland
Sharp, H., Rogers, Y. and Preece, J. 2007, *Interaction Design: Beyond Human-Computer Interaction*, 2nd edition, (John Wiley & Sons)
Shneiderman, B and Plaisant, C. 2005, *Designing the User Interface: Strategies for Effective Human-Computer Interaction,* 4th edition, (Addison-Wesley)
Smeaton, A.F., Lee, H., Foley, C. and Mc Givney, S. 2006, Collaborative Video Searching on a Tabletop. *Multimedia Systems Journal*, **12** (4), 375-391
Wolf, T., Rode, J., Sussman, J. and Kellogg, W. 2006, Dispelling design as the 'black art' of CHI. *ACM CHI 2006*, 521-530