Towards a 3D User Interface in a Touch Screen Device Context

An Iterative Design and Evaluation Process

Leena Arhippainen, Minna Pakanen, Seamus Hickey
Intel and Nokia Joint Innovation Center/ Center for Internet Excellence
P.O. Box 1001, FI-90014 University of Oulu, Finland
leena.arhippainen@cie.fi, minna.pakanen@cie.fi, seamus.hickey@cie.fi

***Abstract*— This paper presents a design and evaluation process in the early design phase towards a three dimensional user interface on a touch screen mobile device with service multitasking use cases. Our Service Fusion concept is an outcome of this iterative concept design and evaluation process. In this paper, we present briefly four 3D user interface concepts, evaluated with users and experts. Two of these concepts are also implemented on a touch screen mobile device. We also present user experience findings and how they have supported our early phase design process. The Service Fusion demonstration of 3D multitasking shows multiple services running in a 3D city model, which allows users to purchase movie tickets, listen to music and find local bars and stores by drag and drop gestural controls. Evaluation findings indicate that people are interested in service multitasking and dragging and dropping interaction model in 3D user interfaces in the tablet device context. However, the 3D space context will affect how important and useful users perceive services to them.**

Keywords-3D UI; concept design; user experience; touch screen mobile device; tablet.

I. INTRODUCTION

Research in three dimensional (3D) user interfaces (UIs) has a long history ranging from various areas such as Augmented Reality (AR), Cave Automatic Virtual Environment (CAVE), Virtual Environments (VEs), 3D Authoring tools, simulation and entertainment [4][12][15][20]. Even though 3D UIs have been studied for many decades, they are still actively researched [3][7][14][18]. There has been a resurgence of interest in 3D technology in general, especially among stereoscopic 3D movies and commercially available devices with autostereoscopic displays (e.g., LG Optimus 3D phone and Nintendo 3DS game console). Similarly, the introduction of commercially available 3D input sensors over the last few years (e.g., the Wii remote, EyeToy and MS Kinect) have put 3D UI technology into everyday use. Furthermore, 'touching the 3rd dimension' technologies have seen a host of new research based on the above devices [13].

3D is a hot topic nowadays. Even though there is a lot of hype around the 3D topic, there still exists a big question: 'What benefit 3Dness can provide?' Our hypothesis is that a 3D UI could be beneficial provided that it can enhance the user's tasks; therefore, we have investigated 3D UIs in tablet device contexts from the multitasking point of view. In our case, multitasking means that in the same virtual 3D environment, a user can use several services or applications at the same time by dragging and dropping gestural controls. Currently, in tablet devices, users need to switch between applications in such a way that they can view only one application at a time.

The rest of the paper is organized as follows. Section II describes an iterative design and evaluation process towards a 3D UI on a touch screen mobile device. Also the user experiences of our 3D UI concepts and prototypes are briefly presented. Then, the findings are summarized and discussed in Section III, whereas Section IV concludes the paper and provides ideas for future work.

II. EARLY PHASE CONCEPT DESIGN AND EVALUATIONS

ISO 9241-110:2010 standard defines user experience (UX) as: *a person's perceptions and responses that results from the use and/or anticipated use of a product, system or service* [11]. According to the UX professionals, users' experiences should be evaluated before, during and after the use [21] with different types of design examples. In the human-computer interaction (HCI) research field, there is a need for systematic (low-cost) methods and guidelines for UX evaluation [21], especially in the early phase of the development process [22]. In iterative and agile development processes, time- and cost-effective UX studies give important UX feedback for the design [22]. In our 3D UI UX research, we have utilized the early phase design and evaluation approach and conducted various studies, which are briefly described in the in this paper. Finally, we present our Service Fusion concept which we implemented and tested with users.

A. 3D Desktop UI Concept with a File Sharing Use Case

We designed a 3D Desktop UI concept with an abstract virtual environment, which included similar activities that one can have with mobile phones (calls, clock, calendar). We created an example concept of a 'Call handling' scenario, where a user is sharing a file during the conference call as shown in Fig. 1. The virtual participants of the conference call were represented as avatars and the normal call handling functionality occurred by interacting with the avatars. Additionally, as 3D is often cited as means to provide a better visualization of information to the user, additional applications, blogs, web links and certain files are organized and viewable.

After the concept was created, we downloaded sets of example images (20 images in total) into a tablet device and presented the scenario to the participants as a low-fidelity virtual prototype. Participants hold the tablet on their hands

 ISBN: 978-1-61208-250-9

and explained how they would use the UI (e.g., tap or drag an icon) (Fig. 2). We evaluated this concept with four users. The concept evaluation gave information about how users perceive 3D UIs and what benefits such UIs could provide to them. Also issues of avatars (what they are for?), privacy (can everyone see my objects in the 3D space?) and multitasking possibilities were raised. Users were interested in the idea that the system could show several services, for example calendar and news feeds, simultaneously with the conference call and users could easily find and allocate meeting times and share files. User experiences from this small scale user study are reported in [5] and 3D visual indications aspects are presented in [16].

Figure 1. An example image of the 3D Desktop UI concept: a person is sharing a PDF file during a conference call.

Figure 2. A user is explaining how he would use the 3D UI.

B. 3D Office UI Concept with Chat & Calendar Use Case

In the early phase of the project, we designed various 3D UI concepts with different virtual environments, e.g., music and office (meeting room) environments. Fig. 3 illustrates one example of our 3D UI, where a user is communicating in the collaborative 3D Office environment, and services (e.g., a clock and calendar) are shared with other meeting members. In this example, users were able to drag calendar events to that chat for proposing events and meetings (Fig. 3). The other person was then able to accept the event by a touch gesture (e.g., rotate the event block in the chat text by swiping it up and down on the y-axis).

This 3D Office UI concept was studied as a part of a larger concept evaluation procedure [2][17] with a total of 40 subjects (Fig. 4). Findings indicated that the visual design of

Figure 3. An example image of the collaborative virtual 3D Office UI concept with Chat and Calendar use case: dragging a calendar event to the chat discussion.

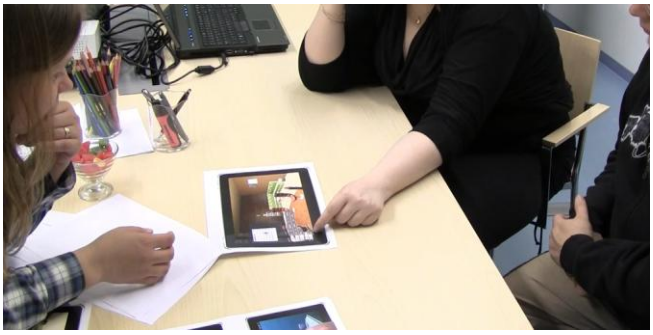

Figure 4. A moderator (left) introduces to the participants the 3D Office UI concept with visually high quality images printed on a paper. A user is commenting the concept (right) in a pair evaluation session.

the VE has a strong impact on how users perceive the whole 3D UI. Changing the 3D virtual environment changes also the users' expectations about a concept or a system, for instance, what kind of behaviour and content they expect from the system. The visual appearance of the 3D virtual environment should be designed for supporting the use context, for example, home, work, leisure, game or map [1]. The use context shown in the 3D VE influences on how important users perceive the service for them, for instance, participants wondered how this 3D Office UI support their work activities (e.g., booking meetings, updating calendar, share files, manage contacts). Therefore, for the next concept, we selected a 3D map as a space context and designed different service multitasking use cases.

C. A Context-Aware Map Based 3D UI Prototype

Based on our previous concept studies, we found out that the visual appearance of the 3D virtual environment can set the context of use for the user. In this study, we wanted to exploit this fact as part of our context-aware map based 3D UI prototype implementation. While there are many potential environments to use, a geographical based virtual environment was chosen as the space context. One rationale for this is that geographical based map services are well known, there are many services which have a map aspect and there are a large number of services which include GPS data,

 ISBN: 978-1-61208-250-9

which should make it easy to integrate new context- aware services.

This prototype was implemented on Android OS platform on a tablet device. The scenario of the prototype presents a use case whereby a user wants to understand the geographical context of a story in order to get a better understanding of the issues involved. The start view of the UI is shown in Fig. 5A.

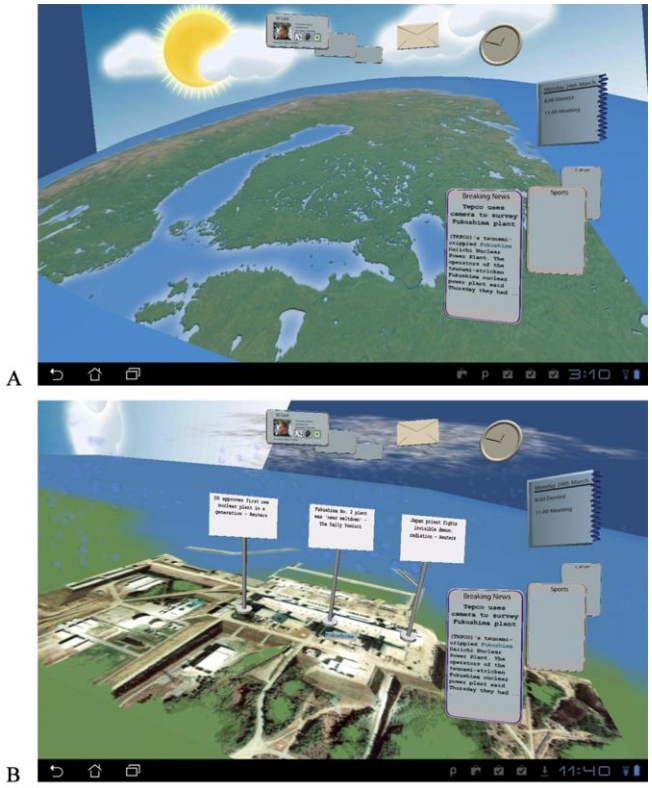

Figure 5. A) 3D UI screen with a map with a number of embedded 3D objects. B) A map of Fukushima with local news.

The UI shows a geographical space, news feeds, calendar functions, contact cards, weather and time. Scenario includes the following steps:

1. The user reads a short news feed about the Fukushima power plant accident. Important data in the news feed is represented as objects.
2. Not knowing where Fukushima is, or what the impact on the local surrounding area is, the user selects the 'Fukushima word' from the news feed by long pressing it and then dragging it to the main map area.
3. When the Fukushima text is dropped on the map environment, the camera transition to the Fukushima virtual environments starts (Fig. 5B).
4. The local weather at Fukushima is shown.
5. Additional news events, pulled from Google news service, are automatically displayed.

This prototype implementation showed the general idea of using a geographical context as a virtual environment. One benefit in this 3D UI example for a user is that he/she can use a map as a search engine easily by dragging and dropping the interesting news items. With tablet devices, typing can be slow and error prone; therefore, we can assume that 'drag and drop' action could speed the use of 3D UI. However, as the prototype implementation was very limited, we tested it only by an expert evaluation (Fig. 6). To prepare the prototype for actual user testing, we developed a new version of the 3D Map UI with and several services.

Figure 6. In a contex-aware map based 3D UI prototype, a user is able to select words (e.g., Fukushima) from news feed and then drag and drop it onto the map environment for getting more information about that news.

D. 3D Map UI with Service Fusion Prototype

After our first Fukushima scenario, we decided to create another use cases relating to context-aware services that citizens could use with their tablets. One idea of our Service Fusion concept is that a user can use several services in the same 3D environment view without a need to switch between application windows. Our aim is to ease the user's tasks by automating some actions with service communications and decreasing a user's typing effort. Therefore, we implemented the following features into the Service Fusion prototype with the 3D city model (Fig. 7):

- **Cinema service:** A user can view the daily timetable of cinema and drag the movie from the list to the personal shopping cart and book and pay for the movie ticket by dragging their credit card object to the payment field (the real payment function not implemented) (Fig. 8).
- **City event Live:** Users can view live events from the local city live calendar.
- **Local News Feeds**: Users can view local news feeds on the embedded board objects.
- **Music service:** Users can view the current song list of a bar and then drag the song name to a radio icon. When the song is dropped on the radio icon, it launches a search for the song from Grooveshark [8]. Users can also drag a song from the list and drop it onto the map to find music stores in the city (a map as a search engine).

This concept was implemented on the realXtend [19] Tundra platform running on Linux Ubuntu on 12 inch touch screen laptop computer. The 3D city model is a high fidelity model and currently covers nine city blocks. The technical implementation is illustrated in the [6][10].

This Service Fusion prototype was tested with ten users. In the evaluation, we were particularly interested in users'

 ISBN: 978-1-61208-250-9

subjective experiences of the 3D UI and services. We studied the following topics:

- how users perceive and understand different types of icons. For instance, personal overlaid icons (calendar, shopping cart, radio) are fixed to the camera position and they have a different visual style than in 16 icons (e.g., bars, cinema, theatre, restaurants), which are embedded on the top of the 3D city model and are publicly shown to all users. Also two news tables were embedded in the 3D city map.
- how users experience the dragging and dropping controls with a touch screen mobile device. These results are presented in more detail in [9].
- how users experience the service fusion idea, where a user is able to use several services (e.g., cinema purchase, music listening, music search) in the same 3D virtual environment. In current tablet devices, users have to switch between different applications (e.g., YouTube, Web browser, calendar). These results are presented in more detail in [9].

Figure 7. A Service Fusion 3D UI in a 3D city map: personal calendar, e-commerce services and live information from local bars, cinema and newspapers.

After a short familiarization with a visual appearance of the 3D UI, the users were asked to perform the following tasks:

1. Buy a movie ticket for today:
   a. Find cinema information (cinema icon and movie)
   b. Book movie (drag movie to a shopping cart)
   c. Fill ID info (drag an ID card to a form)
   d. Select a seat (tap the seat)
   e. Pay the ticket (drag a visa card to a form). (Fig. 8)
2. Listen to a music:
   a. Find the bar: Otto K. (icon on the top of the map)
   b. Look at its information board (playing list).
   c. Find out how to listen to it (drag on a radio icon).
3. Search music stores:
   a. Select the song from the playing list (info board)
   b. Find out how to locate a music store which sells CDs and merchandises from that band. (Fig. 9-10).

User tests with this prototype gave us a lot of important feedback about icons design, virtual environment design and

Figure 8. A user is dragging a Visa card onto the payment area.

Figure 9. A user presses a song item on the bar's playing list, when the song text (band's and song's name) pop-up as a 3D box, then the users holds the song box and and starts to drag it onto the 3D map for searching a music store (User task 3).

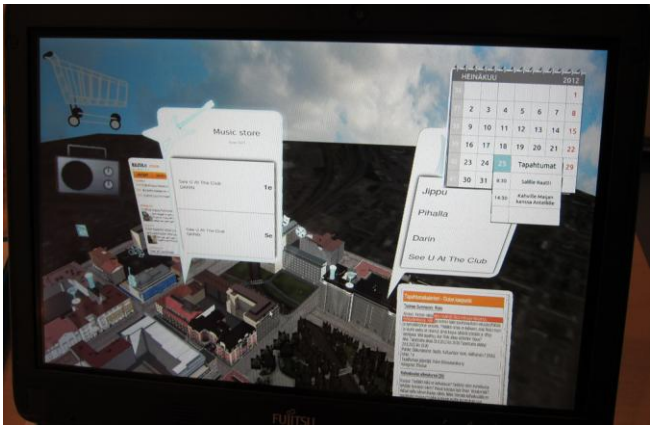

Figure 10. When the song is dropped on the map, the song box disappear and the 'Music store' icon on the top of the map growns and its information board opens, which shows the song information (e.g., price).

service multitasking activities. Findings from this study elicited that the users understood the difference between overlaid icons and icons on top of the 3D city. Especially icons on the top of the 3D city were perceived to belong to the city, a.k.a. are services or stores of the city in real life. Some users understood that an overlaid calendar icon is a

public event calendar of the local city. This perception can be a consequence of the test device and setup, because some users may think that the device could not be his/her own device and own personal calendar.

Fig. 11 presents the Likert Scale answers about the icon design (1='totally disagree', 3='cannot say', 5='totally agree'). The participants understood a meaning of the icons (4.3) on the top of the 3D city. They did not think that there are too many icons in the scene (1.3). When a 3D virtual environment includes interactive objects and icons, it is important to design them so that they distinguish enough from the background (e.g., 3D city model) and a user can understand how he/she can interact with them. According to the questionnaire, users thought that icons distinct enough from the background space (3.8). However, the average 3.8 shows that icons could be decided even more distinguishable. Also results relating to appearance of interactive icons (3.4) indicate that embedded icons should be designed so that a user can understand how he/she can interact with them. However, users thought that the visual appearance of icons was consistent (3.9).

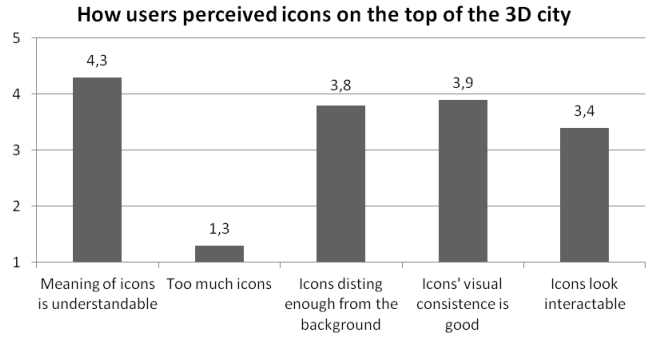

Figure 11. Users' perceptions on icons on the top of the 3D city (embedded icons) gathered by a Likert Scale questionnaire.

The users' experiences on the cinema service were very positive. They liked the idea that they can easily drag and drop items on the 3D UI. The users regarded buying a movie ticket by dragging it on the shopping cart as interesting, easy, fast, useful and natural [9]. Even though the users liked the idea of buying tickets by dragging and dropping ID and credit cards, security issues should be designed so that users can feel the payment system as reliable and secure.

In the music service task, a dragging a song item on the radio icon was natural to users. Instead, dragging the same icon on the 3D city map was not natural at all [9]. Users did not find this feature by themselves. They found it only by accident or after the moderator's tip. However, after users knew this action, half of them liked the idea of using a map as a search engine. The use of a 3D virtual environment, in our case the 3D city map, as a search engine or other interactive platform is a very important topic to study more from the user experience point of view.

III. SUMMARY AND DISCUSSION

In this paper, we have shown how we have used different concept designs in an iterative design and evaluation process. In all of these examples, we have investigated how a 3D UI could be useful for users, a.k.a. what additional value the 3D UI could provide to users. Our hypothesis was that service multitasking in one 3D scene (virtual environment) could be useful for users. In the 3D Desktop UI concept, we studied how users can use a 3D environment for sharing files in a conference call setting. In this study, the users liked the idea that they can easily share files by dragging and dropping them onto the friend's avatar or some marked area. They were also willing to share social media and calendar information with persons in the conference call. Also in this example, we noticed that because the visual style of the virtual environment was very abstract, users did not associate the context of use very strongly to certain situations; instead, they perceived the concept example relating to the communication situation.

Next, we designed different virtual environment contexts, e.g., music and office, and studied those examples with users. In the evaluations, users strongly tied examples relating to the certain usage situations, e.g., in leisure or professional activities. The virtual background of the 3D UI had a strong influence on how users perceived the whole concept and its purpose. In this study we also investigated how the users perceive the use of shared services in a collaborative situation.

Based on the findings from these both studies, we started to design how we could utilize a geographical background as a part of the 3D UI and how users would perceive service multitasking in this context. The user study elicited that a geographical based 3D UI with context-aware service multitasking can have benefits for users by making the use of services easier and faster in a 3D virtual environment in the tablet device context. Users liked the idea of dragging and dropping objects to the services. Also users' perceptions on icons elicited visual design directions for interactive icons embedded in the 3D environment. We will study these topics more with functional prototypes with different 3D environments, with different sets of services.

This iterative design and evaluation process has provided us valuable user feedback that we will use for future designs. One interesting future topic is how we can utilize parts of a 3D environment as interactive platforms (e.g., search engines, shared and public areas). In addition, in the future studies, we will implement and test a prototype, where a user can switch between different 3D virtual environments through teleporting points (e.g., doors or holes). In this study, we will investigate the user experience of the different 3D virtual environments and transitions between them. Also, we will study the visual indication of 3D icons.

IV. CONCLUSION AND FUTURE WORK

In this paper, we presented our iterative design and evaluation process for the studying the user experience of different 3D UI examples from the service multitasking point of view. As an outcome of this process, we present our Service Fusion concept and prototype implementations. In UX evaluations, we have investigated how the users perceive different 3D UI design examples and what benefits they

 ISBN: 978-1-61208-250-9

could provide to the users. In our 3D UI concepts, the value for users would be the multitasking approach which supports a simultaneous and parallel use of different applications in one screen view in the touch screen mobile device context. In the future, we will conduct more user studies for 3D UIs with different sets of virtual environments and services. The reason for providing this early phase design and UX evaluation information to 3D UI and HCI research fields is to increase the knowledge of conducting UX studies before, during and after the functional prototype.

ACKNOWLEDGMENT

We thank our funders: Intel, Nokia and Tekes. We would also like to thank Julianna Hemmoranta, Jukka Kaartinen, Erno Kuusela, Antti Karhu and Ludocraft Ldt. for their assistance. We want to express our gratitude to Grooveshark and Kutalab Ltd. for providing us with access to their services. Warm thanks to all test users as well.

REFERENCES

[1] L. Arhippainen, M. Pakanen, and S. Hickey. "Preliminary Design Guidelines for Tablet's 3D GUIs Based on the Five UX Studies," Proc. Designing Interactive Systems (DIS 2012), Poster no. 136., New Castle, UK, June 23-15.2012.

[2] L. Arhippainen, M. Pakanen, and S. Hickey. "Studying User Experiences on Depth in 3D User Interface by a Paper Prototype as a Part of the Mixed Methods Evaluation Procedure," Proc. ACHI' 13, 2 February 24 - March 1, 2013 - Nice, France.

[3] D.A. Bowman, J. Chen, C.A. Wingrave, J. Lucas, A. Ray, N.F. Polys, Q. Li, Y. Haciahmetoglu, J. Kim, S. Kim, R. Boehringer, and T. Ni. "New Directions in 3D User Interfaces," The International Journal of Virtual Reality, 2006, vol 5 (2), pp. 3-14.

[4] F.P. Brooks. "What's Real About Virtual Reality?" IEEE Computer Graphics and Applications, 1999, vol 19, 6, pp. 16-27.

[5] Chiru blog: Studying UX of Call handling with 3D UI in tablet. http://chirublog.org/2011/05/20/studying-ux-of-call-handling-with-3d-ui-in-tablet/. 20.5.2011.

[6] Chiru blog: Service Fusion at MUM 2012. http://chirublog.org/2012/12/20/service-fusion-at-mum-2012/. 20.12.2012.

[7] A. Gotchev, G.B. Akar, T. Capin, D. Strohmeier, and A. Boev, Three-Dimensional Media for Mobile Devices. IEEE 99, 4 (2011), pp. 708-741.

[8] Grooveshark: http://grooveshark.com/. 30.10.2012.

[9] S. Hickey, M. Pakanen, and L. Arhippainen. "A 3D UI for Service Multitasking in a 3D City Map," Proc. OZCHI 2012, 26-30 November 2012, Melbourne, Australia, pp. 208-211.

[10] S. Hickey, M. Pakanen, L. Arhippainen, E. Kuusela, and A. Karhu. "Service Fusion: An Interactive 3D User Interface," Proc. MUM 2012. Article No. 53. 4-6. December 2012. Ulm, Germany. doi>10.1145/2406367.2406432

[11] ISO DIS 9241-210:2010. Ergonomics of human system interaction - Part 210: Human-centred design for interactive systems. International Standardization Organization (ISO). Switzerland.

[12] G. Kurtenbach, G. Fitzmaurice, T. Baudel, and B. Buxton. "The design of a GUI paradigm based on tablets, two-hands, and transparency," Proc. CHI'97, Atlanta, Georgia, USA, March 22-27, 1997. ACM New York, NY, USA, pp. 35-42.

[13] J. LaViola, and D. Keefe, "3D spatial interaction: applications for art, design, and science," In ACM SIGGRAPH 2011 Courses, Article No. 1. Vancouver, British Columbia, Canada, August 7-11th. New York, NY, USA. ACM Press (2011). doi>10.1145/2037636.2037637

[14] A. Leal, C.A. Wingrave, and J.J. LaViola. "Initial Explorations into the User Experience of 3D File Browsing," Proc. BCS-HCI'09, ACM Press (2009), pp. 339-344.

[15] J. Light, and J.D. Miller. "Miramar: a 3D workplace," Proc. IPCC 2002, IEEE Press (2002), pp. 271-282.

[16] M. Pakanen, L. Arhippainen, and S. Hickey. "UX Based Design Recommendations for Interactive 3D Objects in 3D UI on Tablet Devices," In: Anderson, K., Arhippainen, L., Benko, H., de la Rivière, J-B., Häkkilä, J., Krüger, A., Keefe, D., Pakanen, M., and Steinicke, F. Proc. ACM CHI Workshop on The 3rd Dimension of CHI: Touching and Designing 3D User Interfaces (3DCHI), Austin, Texas, USA. May 5-10, 2012. pp. 91-94. http://www.cie.fi/chi-workshop.html

[17] M. Pakanen, L. Arhippainen, and S. Hickey. "Studying Four 3D GUI Metaphors in Virtual Environment in Tablet Context. Visual Design and Early Phase User Experience Evaluation," Proc. ACHI' 13, 2 February 24 - March 1, 2013 - Nice, France.

[18] D. Patterson. "3D SPACE: Using Depth and Movement for Selection Tasks," Proc. Web3D 2007, ACM Press (2007), pp. 147-155. doi>10.1145/1229390.1229416.

[19] realXtend: http://realxtend.org. 30.8.2012.

[20] S. Reifinger, F. Laquai, and G. Rigoll. "Translation and rotation of virtual objects in Augmented Reality: A comparison of interaction devices," In IEEE SMC, 2008, pp. 2448-2453.

[21] A. Vermeeren, E. Law, V. Roto, M. Obrist, J. Hoonhout, and K. Väänänen-Vainio-Mattila. "User Experience Evaluation Methods: Current State and Development Needs," Proc. NordiCHI 2010. ACM Press (2010), pp. 521-530.

[22] K. Väänänen-Vainio-Mattila, and M. Wäljas. "Developing an expert evaluation method for user eXperience of cross-platform web services," Proc. MindTrek 2009. ACM Press (2009), pp. 162-169. doi>10.1145/1621841.1621871.

 ISBN: 978-1-61208-250-9