Studying Four 3D GUI Metaphors in Virtual Environment in Tablet Context

Visual Design and Early Phase User Experience Evaluation

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Abstract— **In this paper, we focus on a possibility to have a personal 3D GUI inside a virtual environment on tablet device. We describe the visual design process and user experience evaluation of four 3D GUIs in a virtual environment. A user evaluation was conducted by using a structured pair evaluation procedure, where we adapted a concept walkthrough method with non-functional visually high quality prototypes. We found that participants would like to have their personal 3D GUI in a virtual environment. However, the visual design of the 3D GUI should create a secure and private feeling for them. Also, participants did not want the GUI to occlude too much with the background. The visual indication is needed also when a user transfers items from personal GUI to the virtual environment and for showing the user's active position between the GUI and virtual environment. We point out also other issues for interaction and visual designers.**

Keywords: visual design; user experience; 3D GUI; touch screen tablet device, HCI.

I. INTRODUCTION

Three dimensional (3D) collaborative games, for example, Order and Chaos [20], have been developed already for touch screen tablet devices, such as Apple iPad. There have also been interests in bringing virtual environments (VEs) such as Second Life (SL) [18] to the tablets. The first 3D viewer for SL is Lumiya for Android tablets [19]. In 3D VEs, users can see 3D objects and other people's avatars in 3D space. To carry out other activities, such as reading personal emails, browsing files or playing games, a user cannot do this in VE, but she/he needs to switch to another application, which may weaken the 3D environment experience. In this paper, we explore different approaches to that problem by focusing on a possibility to have a personal 3D graphical user interface (GUI) inside a VE. By a personal GUI, we mean a private user interface (UI) showed only to the user, not visible publicly, in contrast to embedded elements in VEs visible to all users.

3D UIs and VEs have been studied over many decades with PCs using several input devices. There is only little research done with tablet devices [23], as earlier studies have focused on larger touch displays such as tables [11][27] and screens on the wall [14]. Bowman et al. [5] define a 3D UI as a UI that involves 3D interaction, which means human-computer interaction (HCI) where a user performs tasks directly in a 3D context. Based on this definition, a 3D interaction can be defined so that it comprises navigation, object manipulation, application control [5][12][29] and visual design [7]. Many earlier 3D UI studies have focused on 3D file browsing, because 3D allows a larger set of items to be displayed at the same time [15][22][8]. Also 3D menus and metaphors have been investigated a lot over the years and the most popular 3D metaphors are: tree, mirror, elevator, book, art gallery, card and the hinged metaphor [10]. As tablet devices have been used for reading books and magazines, a bookshelf metaphor has become quite popular for displaying content, for example, in the Apple iPad [2]. Also 3D carousel metaphors have been under a large interest, both in industry and academy [14][21][30]. Different kinds of 3D and 2½D desktops have been designed and studied as well [1][17][26].

VEs are social in their nature, but if there are personal items in there, then privacy should be clearly visualized to the user. Culnan [9] defines privacy as: *"The ability of individuals to control the terms under which their personal information is acquired and used"*. Privacy is a large research topic, but in this paper, we focus only on visual indication of the privacy in VEs. The prior research has focused mainly on e-commerce applications for selling either real world products or virtual products for avatars [24] or for information exchange between avatars [16]. Butz et al. [6] introduced two visual indication ways (vampire mirror and privacy lamps) for indicating which items are shared and which are private. However, they did not report any tests with users.

The research of personal 3D UI elements (e.g. objects, menu items and files) in a collaborative virtual environment is still lacking from a visual design, user experience (UX) and mobile tablet device point of view. This paper investigates users' expectations of a personal 3D GUI in a collaborative VE in the early design phase and offers preliminary user feedback on visual design and indication of privacy. First, we present the visual design of metaphors and preparation of user experience evaluation study examples. Then, we describe the study with 40 participants conducted with non-functional visually high quality prototypes. Finally, we report the results and point out factors that designers should consider when designing 3D GUIs for VEs on touch screen tablet devices.

II. USER EXPERIENCE CENTERED DESIGN

ISO 9241-110:2010 [13] defines user experience as: "*a person's perceptions and responses that results from the use and/or anticipated use of a product, system or service"*. User experience cannot be designed, because it is in people, but it is possible to 'Design for experiencing' [25].

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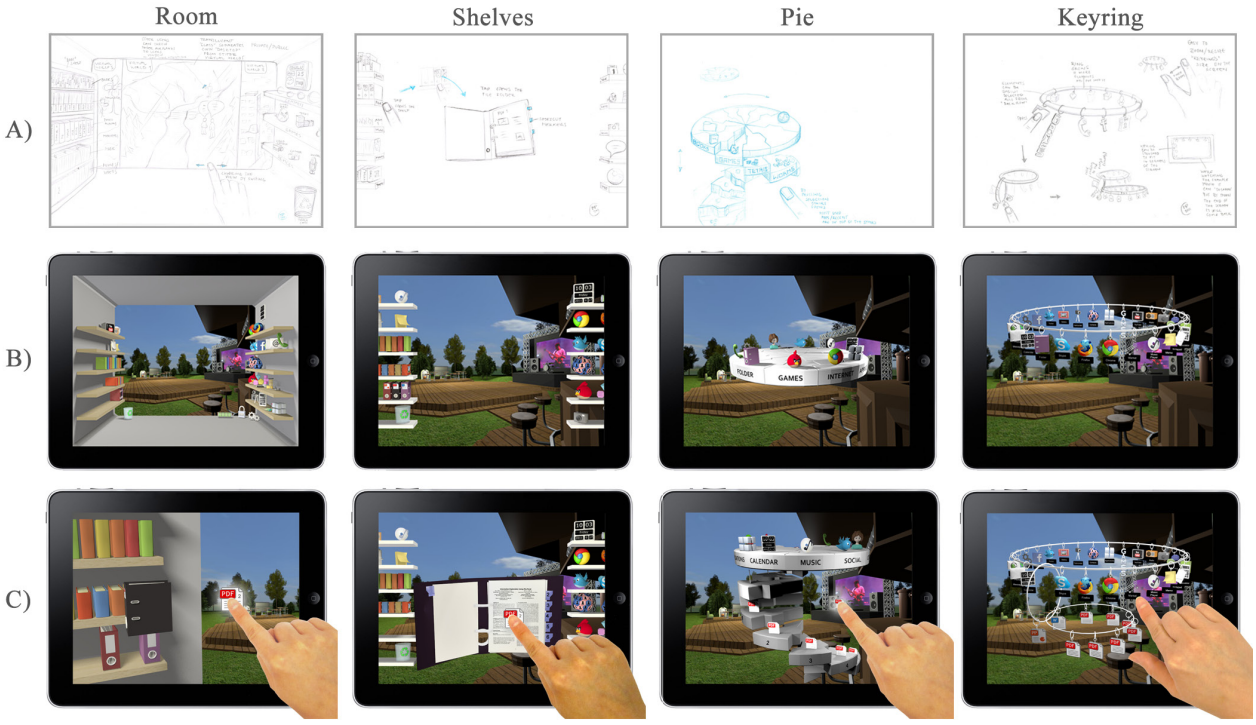

Figure 1. 3D GUI metaphors: A) sketches, B) in a virtual environment and C) with a 'file searching and sharing' use case.

To 'design for experiencing', we used the industrial design process [28]. First, we explored approximately 40 existing 3D UIs and concept designs. Then, based on this benchmarking, literature and lessons learned from our earlier studies [3][23] with 3D UIs we identified three major design goals: *1) Design a 3D GUI in a collaborative virtual environment, 2) Support the use of multiple applications within the 3D virtual environment* and *3) Design for 3D interaction on a touch screen* (for example, object selection from the back rear of a carousel UI). After this, we started the concept design for the 3D GUI metaphors. Finally, we prepared four designs for user experience evaluation.

A. Two Design Phases

We started the first design phase with the preparation of five different styled visual theme boards to help us create visuals for the concepts. These A4 sized boards were composed as a collage of images of different visual forms of the titled style. Then, we had the first brainstorming session utilizing the visual theme boards with two industrial/interaction designers and a UX researcher. This resulted in different kinds of ideas, advice and needs that were written down. Next, we had a one week individual sketching phase when we produced over 100 sketches of 3D GUI metaphors. Then, we had an expert evaluation of the concepts with eight project members.

The second design phase was started with an individual sketching period. We developed the selected concepts of the first design phase further and in more detail. Then, the sketches (approximately 50) were evaluated by eight UI and UX professionals. Based on the evaluation, four 3D GUI metaphors: *Room*, *Shelves*, *Pie*, *Keyring* (Fig. 1, A) were selected for the 3D modeling phase, because they were comparable against each other. *Room* and *Shelves* metaphors have a similar visual style and both of them had a binder metaphor for files but a different amount of icons and depth of space. *Pie* and *Keyring* are examples of the carousel metaphor, but with different visual style, hierarchy level structure and amount of icons.

B. File Searhing and Sharing Use Case

We wanted to have an example with hierarchical structure in the GUIs; therefore, we designed also a step-by-step use case (file searching and sharing) for each concept (Fig. 1, C), which are presented in Table 1. The idea of the use case was to search for a PDF file (named as PDF 2), copy and share it to a pre-named contact.

C. Modeling of 3D GUI Metaphors and 3D Icons

The 3D models of the selected concepts were created by using the Blender program. First, we designed and modeled the GUI elements and 3D icons for our 3D GUI metaphors. We selected applications that can be used in the tablet context (e.g. mail, phone, messaging, notebook, radio, maps, contacts, books, browsers, gallery, folder, trashcan, calendar, camera, games, music player and social media services). We had a set of 33 icons to be used in our GUI metaphor designs. The amount of icons in every design varied, because we wanted to have a different evaluation setup for each concept in order to evaluate UI hierarchy structures and the amount of objects displayed in the UI metaphor and on the screen at once. There were 31 icons in the *Room* concept's first view, but in the *Shelves*, there were only seventeen, which are either fully or partially shown icons. The *Keyring*

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TABLE I. THE PROCESS OF A FILE SEARCHING AND SHARING USE CASE IN EACH 3D GUI METAPHOR CONCEPT

Steps	The process of a file searching and sharing use case in each 3D GUI metaphors concept			
	Room	***Shelves***	***Pie***	***Keyring***
File searching	**User:** Zooms in with a pinch zoom gesture. **User:** Taps the PDF binder icon. **System:** Opens the binder in the center of the screen. **User:** Taps the 'PDF 2' index marker **System:** Turns the page and the intended PDF is in sight.	**User:** Tap the PDF binder icon on the shelf on the left side of the screen. **System:** Activates and moves a shelf (that the binder is located on) near the center area of the screen and opens the binder in the center of the screen.	**User:** Taps the binder icon which was located on a one piece of the Pie. **System:** The tapped piece of Pie drops one step down and the system opens three sub-pieces of the Pie on the same horizontal level. Three icons are located on top of the pieces; W (Word), PP (PowerPoint) and PDF (2nd hierarchy level). **User:** Taps the PDF icon. **System:** Sub-pieces opens under the Pie GUI in the format of a hierarchical helical stairs (3rd hierarchy level).	**User:** Taps the binder icon. **System:** Vertically orientated sub-ring with three icons; W, PP and PDF appears to hang from the original ring. **User:** Tap the PDF icon. **System:** Another sub-ring opens horizontally to the icon's place **User:** Zooms in (Fig. 1, C, Keyring).
File copying	**User:** Long press the PDF icon **System:** The copied file icon appears on top of the PDF file.	Copying is made similarly as in Room GUI (Fig. 1, C, Shelves).	Copying is made similarly as in the Room GUI.	Copying is made similarly as in the Room GUI.
File sharing by dragging	**User:** Drags the copied file to the other side of the Room (Fig. 1, C, Room) to the contact object (ball), and finally to the chosen contact. **System**: Camera follows the file dragging and zooms in to the contact ball.	**User:** Drags the copied file on another shelf on the other side of the screen with two contact objects (balls) on. **System:** Moves the shelf with contact objects to the center area of the screen. **User:** Drags the copied file to the contact object (ball), and finally to the chosen contact.	**User:** Drag the copied file on a contact piece in the Pie (Fig. 1, C, Pie). **System:** Opens sub-pieces in hierarchical helical stair format, where all the contacts are located on the steps of the 'stairs'. **User:** Drags the copied file to the chosen contact. **System**: Camera follows the file dragging.	**User**: Drags the copied file to the contact object (ball) at the rear of the first hierarchy level ring. **System**: Camera follows the file dragging zooms in the contact object.
Feedback indication to a user	**System:** Shows a tiny version of the icon beside the contact, which disappears when it is sent.	The system indication for sending is done the same way as in the Room GUI.	**System:** Shows a tiny version of the icon beside the contact on the step of the stair, which disappears when the file is sent.	The system indication for sending is done the same way as in Room and Shelves GUIs.

concept included 28 icons and *Pie* ten icons in the first menu hierarchy level. Finally, we made compositions for 'file searching and sharing' use cases by moving and duplicating modeled UI elements.

D. Preparation of the Prototypes

We decided to evaluate our four designs as non-functional visually high quality prototypes in as early design phase as possible to get user feedback for the next iteration of our concepts with a fast, easy and cost-effective way.

Because we were interested in finding out the user experiences of the visual aspects, it was important to make high quality looking evaluation examples. Based on our design goals, we wanted to evaluate how users perceive the 3D GUIs in a virtual environment (Fig. 1, B). Therefore, we selected one 3D model of a collaborative looking virtual outdoor music environment from our earlier research work [3] and rendered out one image of it from Blender. Then, we rendered each image of the metaphors with the step-by-step use case and placed them on a VE background in Photoshop. We then added a life-sized 10 inch tablet frame around the images. Finally, we added images of hands which were representing the touch gestures on top of the use case images (Fig. 1, C) and saved the image series as PDFs.

III. USER EXPERIENCE EVALUATION

As we were interested in users' subjective experiences, we conducted the study by using structured pair evaluation and adapted the design walkthrough method in a controlled setting, which lasted from 25 to 59 minutes. We used different methods to gather user feedback and experiences: video recording, semi structured interviewing, observation with writing down comments. First, in the beginning of the evaluation, users filled up a short background questionnaire which had questions about participants' gender, age, prior touch screen and 3D experience. The actual design walkthrough was conducted as follows for each 3D GUI concepts: Showing the 3D GUIs on a 3D VE with the 'file searching and sharing' use case on a life-sized tablet frame as a PDF from a laptop where the moderator changed the image and led the discussion. She asked participants to comment freely what they are thinking and also asked additional questions now and then.

A. Participants

In our user evaluation, we had 40 persons of which 63% were male. For recruiting participants, we used an online test user environment and also sent email invitations to friends and colleagues to be distributed. The criterion for selecting participants was that each of them should have at least two months' experience with touch screen devices (mobile phones or tablets). Almost all of the participants (93%) had prior touch screen experience with smart phones and 85% of them had tried or used tablet devices. The participants' age varied from 23 to 52 years, with a mean of 35.

I. FINDINGS

All the material was qualitative, which we analyzed by applying the affinity diagram method [4]. We wrote down participants comments on sticky-notes. Then, we made two analysis rounds for notes and grouped them based on their content. A summary of the analysis is presented in Table 2. In the following subsections, we present participants' perceived aspects and comments on the 3D GUIs in 3D VE.

A. Perceived Visual Appearance

The Room metaphor (Fig. 1, B) was considered as a 'homely' GUI where one's own applications are in order. The *Room* metaphor was also called as 'garage' or 'storage', but it was also regarded as childish and funny like 'a toy store'. 18% of the participants thought that the *Shelves* concept was better, clearer, more approachable and pleasurable than the *Room* GUI. The *Pie* GUI metaphor (Fig. 1, B), in its turn, was perceived as interesting, new, exciting and visually

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attractive. On the other hand, the *Pie* was regarded as an official, masculine and engineering type of object and was called as 'a disk' or 'hard drive'. The visual style of the *Pie*'s plate was perceived to be bulky, chunky and too thick and it was called 'a concrete plate', 'tray', 'puzzle', 'Battle Star Galactic' or 'puck'. It was even suggested that the plate could be translucent. The visual style of the *Keyring* (Fig. 1, B) was considered to be new, different, interesting and fun. On the other hand, one participant commented that it is:*" a moment's wow"*. Compared to the *Pie*, the *Keyring* was regarded as a feminine object and it was called as a kitsch bracelet. It was also referred to movement, for example, to 'a shower curtain rack', 'coat hanger rack', 'mobile', and 'janitor's key ring'. One person even said: *"I don't like if it's swinging"*.

Participants liked the fact that they can easily get an overview of the GUI with one glance, with other GUIs than *the Shelves*. 15% of the participants did not like that all of the icons are not showing. Also, it was perceived as odd and ugly that some of the icons on the shelves were cut in half. In contrast, 30% of the subjects liked the tighter view that the *Pie* concept offered even though there was even less content in sight. *Pie* and *Keyring* were perceived to look like launchers for applications. Participants thought that in the *Room* (18%) and *Keyring* (25%) GUIs, there were too many occluding application icons. It was perceived to be unclear and error prone while making selections.

Participants thought that all GUIs except the *Room*, looked weird and distressing with the virtual environment background, because they seemed to be floating in the air, for example, the *Pie* GUI was perceived as a UFO. Also, one participant commented the meaning of the Pie metaphor because of its location in the 3D environment: *"It looks like a tray when it is located near a bar"*.

B. Perceived 3Dness

When participants evaluated the 3Dness of the concepts, one factor was the depth of the space. Compared to other concepts, in the *Shelves* GUI, there was not enough depth to make it look like a 3D and it was considered to be only a 2D GUI with 3D icons. As one participant commented about it: *"3D icons do not change the UI into 3D"*. Another factor was the perceived interaction. The *Pie* and *Keyring* had the round shape which made them look rotatable; therefore, they were perceived as 3D. Also the icon occlusion was considered to be an important factor for creating a 3D feeling; thus, the *Shelves* concept was not considered to be a 3D GUI. From the users' perspectives, 3Dness is made from occlusion, the shape of the UI and the depth of the space.

C. Perceived Consumption of Space from VE

The occlusion of the virtual environment by the GUI was evaluated by the participants. The *Room* and *Pie* were perceived to consume too much space from the VE. The *Room* GUI was showing the center area, but it was considered more like a little peak view to the VE. With the *Pie* GUI, the situation was quite the opposite; the plate of the *Pie* blocked the center area. In comparison, the Shelves and *Keyring* GUIs were considered to be lighter and airy on VE.

D. Perceived Privacy and Safety

The participants felt more secure with the *Room* concept, because there were walls separating the private area from the public background area. To create a secure feeling, there should be some kind of separation from the background environment. However, with the *Shelves, Pie* and *Keyring* GUIs, participants had concerns for their privacy. For example, one participant commented on the *Pie* GUI: *"If I am in a public virtual space, can other people see my UI?"* The *Shelves* and *Keyring* GUIs were perceived as visually unclear and confusing, because behind the icons and UI elements there were not any visual elements to separate it from the VE. With the *Shelves* GUI, participants wished for a back plate or curtain behind the shelves.

There should also be a clear visual indication for showing the user's active position between the personal 3D GUI and collaborative virtual environment, which could be indicated with color or dimming. Participants thought that a possibility to interact between spaces and share content directly to a friend in the VE was good. On the other hand,

TABLE II. A SUMMARY OF HOW PARTICIPANTS PERCEIVED FOUR 3D UI METAPHORS

UX	Four 3D GUI Metaphors			
	Room	***Shelves***	***Pie***	***Keyring***
Perceived visual appearance	+ homely + things are ordered (garage/storage) + can see all the icons at once - unclear (icons are occluded/ too full) - childish and funny/ toy store	+ clear - shelves are floating in the air (odd) - icons cut in half (ugly) - not possible to see all icons at once - floating in the air (odd)	+ new / exciting / attractive + can see the most important icons at once - bulky / too thick/ chunky - masculine / engineering type / official - floating in the air (odd)	+ new / different / interesting/ fun + can see all the icons at once - full / unclear (icons are overlapping) - feminine/ kitsch bracelet / swinging - floating in the air (odd)
Perceived 3Dness	+ 3D space (Room) + enough depth - icons occluded	- not enough depth = 2D GUI - just 3D icons do not make 3D GUI - no occlusion	+ 3D shape (round) + icons occluded + looks rotatable (interaction)	+ 3D shape (round) + looks rotatable (interaction) - icons occluded
Perceived consumption of space from VE	+ distinct from the background VE - consumes too much space from VE	+ light/airy + does not consume too much space from VE	- consumes too much space from VE	+ light/ airy + does not consume too much space from VE
Perceived privacy and safety	+ clear visual separation from VE (walls) - can other users of VE see the content a shared item	- possible to share something to the VE by accident (no walls) - not clear visual separation from VE - can other users of VE see the content of own GUI or a shared item	- not clear visual separation from VE - can other users of VE see the content of own UI and a shared item	- not clear visual separation from VE - can other users of VE see the content of own UI and a shared item
Perceived ease of use	+ looks simple/ easy to use - require more steps than 2D UI - too long dragging - needs camera & zooming controls	+ no brainer to use + no camera controls required + shorter dragging	+ brainless to use - carousals are difficult - menu hierarchy difficult and messy - too many steps (file search & sharing)	- difficult (can accidently select a wrong icon) - menu hierarchy messy and weird - too many steps (file search & sharing)
Perceived utility by customizaton	+ easy to categorize the content + easy to customize the GUI space	+ easy to categorize the content	+ could work as a launcher	+ could work as a launcher + easy to categorize the content

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they were concerned about a possibility to share something into the VE by accident. This could be prevented by giving a user visual indication with a highlight color when something is moved from their personal GUI to the collaborative VE. There were also concerns such as, 'can someone else see a shared file and to whom it is shared to'. The shared content should be invisible to other users and it should look like it is protected for the user who is sharing it and who is receiving it. For example, as one participant suggested: *"Shared file could be protected with a folder?*"

E. Perceived Easy of Use

Even though we did not have a functional prototype, participants commented a lot how they perceived the usability aspects of each GUI metaphors with the 'file searching and sharing' use case. Participants thought that the *Shelves* GUI (Fig. 1, c) was better than other GUIs from the usability point of view. It was perceived to have shorter dragging, simpler hierarchy, fewer steps and camera movements, such as view rotation and zooming in too near to the UI elements. Also, one person said that in the *Shelves* GUI the interaction can be done more *"brainlessly"*.

Even though a tablet is a gestural interface, participants did not like long dragging, because it was perceived difficult and prone to errors, such as an item is dragged to a wrong place. 15% of the participants suggested that instead of long dragging, a copy could be moved to a 'pocket' or virtual USB-memory stick and kept there until sharing. 15% of the participants suggested that the GUI could be intelligent, for example, the target object (in this case a contact), could automatically open beside of the binder while copying.

With the *Pie* and *Keyring* metaphor concepts (Fig. 1, C), the 2nd and 3rd hierarchy levels were found distressing, because there were too many items illustrated at the same time and it looked too messy. When the 3rd hierarchy level opened in the *Keyring* GUI, 30% of the given comments were negative. As one participant commented: *"More and more jingling"*. Also the orientations of the sub-rings was found irritating, against the laws of physics and foolish. Therefore, it was suggested that rings could open horizontally either under the original ring, replacing it or earlier opened rings could move deeper into the space when the new ring opens. With the *Pie* GUI, the 3rd hierarchy level opening as a form of helical stairs was unexpected by the participants and over 50% of the given comments were negative For example, one participant described it: *"It exploded, went broken"*. It was perceived as difficult, hard, complex and distressing. 13% of the participants commented that it looks like endless stairs. The helical stairs structure was perceived to prioritize the content. For example, with contacts, it creates a feeling that some of the contacts are more important than others. With PDF files, the structure was not that irritating, but the amount of items was considered to be critical for the controllability of the GUI. Participants suggested that instead of the 2nd and 3rd hierarchy levels in the *Pie* and *Keyring* GUIs, there could be a similar binder metaphor as in the *Room* and *Shelves.* Other suggestions for the *Pie* included: a drawer opening from it or another *Pie* could open under the first one. With *the Keyring*, there could be a binder metaphor or file cabinet instead of the 2nd and 3rd hierarchy levels.

F. Perceived Utility by Customization

Users thought that customization would be interesting and useful within all of the GUIS. The simplest thing with the UI customization is to let the users to adjust the amount of icons. Also, some people liked to categorize the GUI content. For example, with the *Keyring*, participants wanted to categorize icons in groups or pile them in stacks. With the *Room* and *Shelves* GUIs, participants would have liked to organize their icons by placing work and leisure items on different sides of the room or on different shelves. Also 30% of the participants were interested in decorating the *Room* GUI space, for example, with wallpapers.

II. DISCUSSION

Our study indicated that the participants would like to use their personal 3D GUI in a collaborative virtual environment, but they must know what others can see from their private or shared 3D UI components. Therefore, the visual design of the GUI is important for creating a secure and private look for the 3D GUI. It can be designed with visual elements, such as walls or curtains, which will distinguish the GUI and its elements from the background environment. However, these elements should not excessively occlude the virtual environment; therefore, they could be also translucent.

There should also be a clear visual indication for showing the user's active position between the personal 3D GUI and collaborative virtual environment, which could be indicated with color or dimming. Also, when something is transferred from the personal GUI to the public virtual environment, there should be a visual indication for the user, for example, a highlight color. Virtual environment also affects how participants perceive the visual design of the 3D GUI. Participants thought that all GUIs except the *Room* looked weird and distressing with the VE background, because they seem to be floating in the air and were unclear looking.

From the users' perspectives, 3Dness in 3D GUI is made from icon occlusion, the shape of the UI and the depth of the UI space. The shape of the GUI and amount of the icons depends on the user's personal preferences. One user wishes to see all of the applications at one glance and another one would just want to see only the most important applications in their GUI. Therefore, there should be different kinds of GUI designs available to the participants. Also the hierarchy structure does not have to continue similarly through the hierarchy levels; it is more preferable is to use flat hierarchy on touch screen devices. Users need to have a possibility to organize icons, UI elements and decorate the GUI space as they wish. Therefore, the customization of the GUI is important for the users.

Even thought this evaluation had limitations from the interaction point of view, it nevertheless provided useful information to us for the next iteration of the relevant concepts. It is not possible to evaluate touch screen interaction with a non-operational prototype, but it is possible to show the designed interaction ways and discuss about them with participants. Therefore, we can now give

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these early design phase user perceptions to designers and developers to make more pleasurable VEs in the future.

III. CONCLUSION AND FUTURE WORK

In this paper, we focused on a possibility to have a personal 3D GUI inside a VE on tablet device. Therefore, we did the visual design process of 3D GUIs with 'file searching and sharing' use cases. Then, we had an early design phase UX evaluation of four 3D GUIs in a virtual environment background with 40 participants. This evaluation with non-functional visually high quality prototypes gave us a lot of user feedback for the design. Participants liked a possibility to have their personal 3D GUI in a virtual environment. However, the visual design of the 3D GUI should create a secure and private feeling for them. The secure feeling can be designed with visual elements, such as walls or curtains, which will distinguish the GUI and its elements from the background VE. However, the GUI should not occlude too much with the background VE. There should be visual indication presented when a user transfers items from the personal GUI to the virtual environment and also for showing the user's active position between the GUI and VE. We pointed out also other design issues relating to the visual design of the personal GUI for interaction and visual designers of 3D GUIs and virtual environments.

In the future studies, we need to design and implement a functional prototype to test interactions as well. Especially we need more information about the dragging action length and camera movements.

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REFERENCES

[1] A. Agarawala, and R. Balakrishnan, Keepin' it real: pushing the desktop metaphor with physics, Piles and the Pen. Proc. CHI 2006, ACM Press (2006), 1283-1292.

[2] Apple iPad Bookshelf. http://tinyurl.com/95hdvcz 14.12.2012.

[3] L. Arhippainen, M. Pakanen and S. Hickey. Designing 3D Virtual Music Club Spaces by Utilizing Mixed UX Methods: From Sketches to Self-Expression Method. Proc. MindTrek 2012, ACM Press (2012), 178-184.

[4] H. Beyer, and K. Holtzblatt. Contextual design: defining customer-centered systems. Morgan Kaufmann Publishers Inc, San Francisco, CA, USA, 1998.

[5] 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, 5, 2 (2006), 3-14.

[6] A. Butz, C. Beshers and S. Feiner. Of Vampire mirrors and privacy lamps: privacy management in multi-user augmented environments. Proc. UIST '98, ACM Press (1998), 171-172.

[7] Z. Cipiloglu, A. Bulbul, and T. Capin. A Framework for Enhancing Depth Perception in Computer Graphics. Proc. APGV 2010, ACM Press (2010), 141-148.

[8] A. Cockburn, and B. McKenzie. 3D or not 3D? Evaluating the effect of the third dimension in a document management system. Proc. CHI 2001, ACM Press (2001), 434-441.

[9] M. J. Culnan. Protecting privacy online: Is self regulation working? Journal of Public Policy and Marketing 19, 1, (2000), 20-26.

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

[11] M. Hancock, T. ten Cate and S. Carpendale. Sticky Tools: Full 6DOF Force-Based Interaction for Multi-Touch Tables. Proc. ITS '09, ACM Press (2009), 133-140.

[12] C.A. Hand. Survey of 3D Interaction Techniques. Computer Graphics Forum, 16, 5 (1997), 269-281.

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

[14] G. Jacucci, A. Morrison, G. Richard, J. Kleimola, P. Peltonen, L. Parisi, and T. Laitinen. Worlds of Information: Designing for Engagement at a Public Multi-touch Display. Proc. CHI 2010, ACM Press (2010), 2267-2276.

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

[16] C.Y. Lee and M. Warren. Security issues within virtual worlds such as Second life. Proc. 5th Australian Information Security Management Conference, Research online (2007), 142-151.

[17] J. Light, and J.D. Miller. Miramar: A 3D Workplace. Proc. IPCC 2002, IEEE Press (2002), 271-282.

[18] Linden Lab. Second Life (2012). http://secondlife.com/

[19] Lumiya viewer for Second Life. http://www.lumiyaviewer.com/. 14.12.2012

[20] Order and Chaos (2012). http://orderchaosonline.com/. 14.12.2012.

[21] D. Patterson. 3D SPACE: Using Depth and Movement for Selection Tasks. Proc. Web3D 2007, ACM Press (2007), 147-155.

[22] G. Robertson, J. Mackinlay, and S.K. Card. Cone Trees: Animated 3D Visualizations of Hierarchical Information. Proc. CHI '91, ACM Press (1991), 189-194.

[23] K. Salo, L. Arhippainen and S. Hickey. Design Guidelines for Hybrid 2D/3D User Interfaces on Tablet Devices - A User Experience Evaluation. Proc. ACHI 2012, ThinkMind Press (2012), 180-185.

[24] R.-A. Shang, Y.-C. Chen, and S.-C. Huang. A private versus a public space: Anonymity and buying decorative symbolic goods for avatars in virtual world. Computers in Human Behavior, 28, 6 (2012), 2227–2235.

[25] E.B-N. Sanders. Virtuosos of the Experience Domain. http://www.maketools.com/papers-2.html. 14.12.2012.

[26] L. Staples. Representation in Virtual Space: Visual Convention in the Graphical User Interface. Proc. INTERCHI '93, ACM Press (1993), 348-354.

[27] O. Ståhl, A. Wallberg, J. Söderberg, J. Humble, L. Fahlén, A. Bullock, and J. Lundberg. Information Exploration Using the Bond. Proc. CVE '02, ACM Press (2002), 72-79.

[28] K. Ulrich. and S. Eppinger. Product Design and Development. McGraw-Hill, New York, USA, 2008.

[29] A. van Dam, A.S. Forsberg, D.H. Laidlaw, J.J. Jr. LaViola. and R.M. Simpson. Immersive VR for scientific visualization: a progress report. Computer Graphics and Applications, 20, 6 (2000), 26-52.

[30] S. Wang, M. Poturalski, and D. Vronay. Designing a Generalized 3D Carousel View. Proc. CHI 2005, ACM Press (2005), 2017-2020.

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