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USER-CENTERED DESIGN OF AUGMENTED REALITY INTERIOR DESIGN SERVICE

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This paper presents key findings on user expectations of an augmented reality interior design service, a service which combines features of social media, augmented reality (AR) and 3D modeling to ambient home design. Our study uniquely bridges all actors of the value chain to the user-centered design of an augmented reality interior design service: consumers, interior design enthusiastics and professional interior designers, but also furniture retailer and digital service providers. We examine the benefits and challenges of applying user-centered methods with three different target user groups; consumers, pro-users and professionals. This paper also describes desired features of an AR interior design service for different target groups, and discusses their technical and practical feasibility. User expectations for AR interior design services were studied with a scenario-based survey, co-design sessions and focused interviews. Altogether 242 consumers and pro-users responded the ambient home design service on the survey. Thereafter, special co-creation sessions with five consumers and two professional interior designers were conducted to develop the concept further with the target groups. In addition, we interviewed four different commercial actors on the field to deepen insights on product expectations. The combination of different user-centered methods proved valuable in the early phases of concept design. It appears that there is a demand for easy-to-use design tools both for consumers and professional users. However, our research confirms that consumers and professionals have different needs and expectations for home design system, and therefore target users should be included in the design process with appropriate methods. Commercial actors see viable business model as most substantial attribute for the service, which must be taken into account in service design as well.

Keywords: User-centered design, Interior design, Augmented reality, Service co-creation, Co-design, Participatory design, Focus interviews, Consumer applications, Scenario-based survey, User groups.

Introduction

At the moment, consumers and professional users have a wide range of different virtual home design tools available on the Internet. Home design services help users to figure out what kinds of building products and decoration materials to pick for a home in addition to furniture, household appliances and home electronics to choose for an aesthetically pleasing home environment. Usually, the services allow model rooms to be created using ready-made 2D floor plans or 3D models.

In the home design concept, VR and 3D graphic systems (such as IKEA Home Planner) typically have functionalities where the user is able to define a 3D space (dimensions of the floor plan, locations of windows, doors, etc.) and insert, move and remove virtual furniture. In AR home design systems, augmented digital images of the real environment are contemplated with virtual furniture (see Fig. 1). Typically, the user can insert, move and remove virtual furniture interactively in 3D over an image taken with a digital camera. In our AR concept, we studied the enhanced possibilities to manipulate the augmented image of environment, for example by removing existing furniture to see better how the new furniture fits in.

In this research project, we considered Web-based interior design concepts with the help of concept sketches and scenarios of fictitious future service. The fictitious, sketched service enables ordinary people to plan easily the furnishing and decoration of their properties using novel technologies, such as augmented reality.

The developed do-it-yourself technology concepts allow users to model their existing home and furniture as well as to create virtual decoration for properties for sale in an online marketplace for home and real estate offering the service. In addition to consumers planning new decorations, the service with its developed AR technologies could be exploited by pro-users, such as interior design professionals and real estate agents.

In this research, we concentrated on the interior design concept, where the AR is part of a service, and on the functionalities of such service. We studied general acceptance with a survey. In addition, we arranged co-creation and interview sessions with several actors representing different roles in interior design and furniture retail to gather different aspects, needs, bottlenecks and targets for future development of augmented reality interior design. Augmented reality can be implemented using several end devices and platforms. In co-creation sessions, we considered a Web-based system that the user operates on most prominent devices — PC, laptop or tablet PC.

This paper is organizes as follows, first we discuss the research methods and theoretical background of user participation in co-creative services, and we describe how augmented reality is used in interior design in general. Then we explain how research methods were implemented and their results; we start with scenario based survey and its results, and continue with co-creation sessions and focused interviews and their results. We end the paper with a discussion of importance of the findings and conclude the results.

Research Methods

We studied three different user groups: consumers, pro-users and professional users. The professional users were professional interior designers and the pro-users consisted of active interior-design bloggers and students of interior design or closely related subject (Figure 1). In addition to users, we included business actors of AR interior design service to our study.

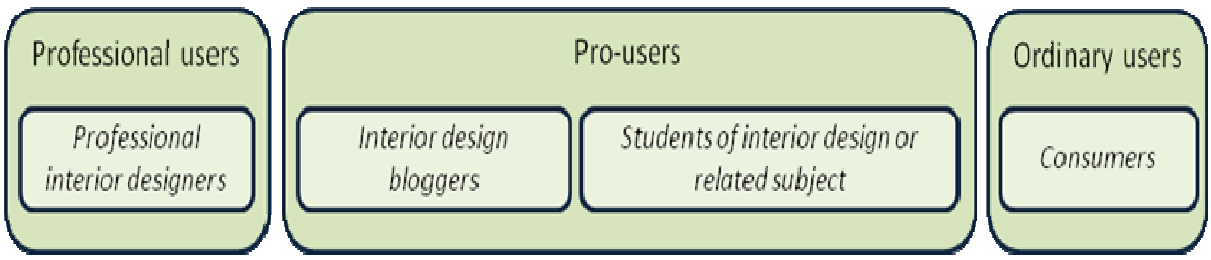

Figure 1. User groups involved in our research: professional users, pro-users and ordinary users. Professional users were professional interior designers, pro-users consisted of interior design bloggers and students of interior design or related subject. Ordinary users are consumers, and referred as consumers in this paper.

We combined different research methods to examine the user-centered aspects and business prospects of an ambient home design concept:

1. **A scenario-based survey** for consumers and pro-users for early concept development of ambient home design service
2. **Co-creation sessions** with consumers and professional users to deepen insights on augmented reality interior design
3. **Focused interviews** of actors in AR interior design service to understand business factors.

Each research method has own specific goals and concentrated on finding out mindset of different user groups (Figure 1). To get a throughout picture of user perspective, we decided to use scenario-based on-line survey to study both pro-users users' and consumers' attitudes and ideas, co-creation session for professionals and consumers, and focused interviews for professional users and business actors (Table 1). These are all methods that support early concept design and user understanding (Maguire 2001).

Table 1. The studied user groups and the research methods applied to each group.

	Scenario based survey	Co-creation sessions	Focused interviews
Pro-users (interior design bloggers and students)	X		
Consumers	X	X	
Professional users (professional interior designers)		X	X
Busines actors			X

The first research method — scenario based survey— focus on user perception with the two target groups chosen for the study, namely consumers who are seeking a new home through an online marketplace and pro-users who have professional or other special interest in the decoration or renovation of apartments. The main focus is on attitudes towards technology and general ambient home design concept. It involves large volume of participants in order to find out "the voice of the masses". We got a total of 242 responses to our survey. The questionnaire also surveyed the attitudes towards social media and sharing of designs.

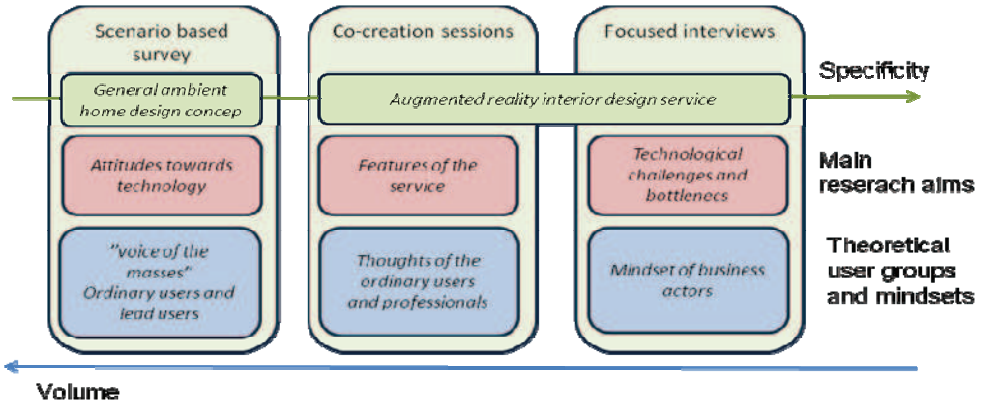

Figure 2. Combination of research methods: The specificity increased to the right, whereas the volume (number of participants) increases to the left. Each method has own specific goals and concentrated on finding out mindset of different user groups.

The co-creation sessions focus on a narrower concept: web based augmented reality interior design service that the user can operate on laptop, PC, or tablet PC. We organized six co-creation sessions; five consumers participated individual sessions and two professional interior designers participated a joint session. The co-creation sessions focused on ideating augmented reality features with discussions and brainstorming. In addition, we explored an existing service to foster discussions, and to concretize augmented reality for the participants.

The interviews aimed for understanding business factors of the service and mindset of the business actors. We interviewed four actors in the AR interior design value chain; a professional interior designer and persons representing a furniture retailer, a company providing interior design on the Internet and a company providing an AR interior design Web platform. The interior designer was female, and others were male.

Consumer can use the interior design service by herself/himself, or she/he may ask professional interior designer, or an interior design company to make the design. The consumer may also turn to an interior design enthusiastic (e.g. interior design blogger) and ask for recommendations. The AR interior design service can be provided through furniture retailer, who gets it from the platform provider, or an interior design company may have their own service. All these actors of AR interior design service value chain were involved in our study (Figure 3).

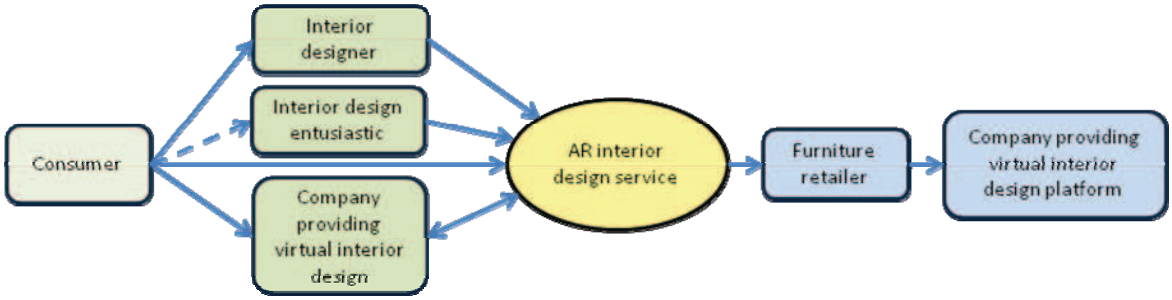

Figure 3. Actors of the virtual interior design service value chain involved in our study. Interior design enthusiastics (that is bloggers in our case) were involved in the survey, consumers in the survey and in the co-creation sessions, and others were interviewed.

In addition to the research described in this paper, focus group co-creation sessions were carried out later with pro-users who answered the survey. These focus groups sketched the user interface and the overall service. Results of these focus group co-creation sessions are described in (Kymäläinen and Siltanen 2012).

Defining User Participation in Co-Creative Services

This paper bridges different user groups and actors in user-centered design of future augmented reality interior design service. User involvement has been pointed out to be especially useful in the early stages of the development process due to the high uncertainty and low formalization of these stages (Alam 2006). Carbonell, et al. (2009) state that user involvement (in their study customer involvement) in development has no direct effect on sales volume; rather, it affects new service success through better quality and innovation speed.

In many research fields such as human-centered design, marketing and media studies, the emphasis on user involvement has shifted from treating users only as passive research objects to taking them into the design process as active co-creators and partners (Kaasinen, et al. 2010). This view has been given different name with a slightly different emphasis in definitions: for example, Weber (2011) lists over 10 related concepts but states that the lack of explicit definitions often leads to ambiguity. Two widely

adopted perspectives have been *participatory design* and the *user-centered approach.* Participatory design has often been defined as a shift in attitude from designing for users to one of designing with users.

Co-design to often refers to creative designers and people not trained in design working together in the design development process (Stappers and Sanders 2008), whereas co-creation is also used to refer to collective creativity in general, not limited to product and service design. However, *co-creation* and *co-design* are often used as synonyms, and in this paper we use the term *co-creation* in order not to have confusingly to design terms co-*design* and interior *design*.

It is quite difficult to draw the line between a user-centered design processes to one of participatory experiences. According to Sanders (2002), participatory design is not only simply a method or set of methodologies, but more like a mindset and an attitude about people. It is the belief that all people have something to offer to the design process and that they can be both articulate and creative when given the appropriate tools with which to express themselves.

According to service research, the typical characteristics of services can pose additional challenges for methods of user studies and user participation in co-creation. Traditionally, the characteristics that separate services from goods are considered to include, for example, intangibility and inseparability (see, for example, Lovelock & Gummesson 2004 or Grönroos 2000). Intangibility makes services more challenging to illustrate and evaluate when co-creating services with users (Ainasoja, et al. 2011). The high technical nature of augmented reality features in this case is hardly making this challenge less important. Inseparability emphasizes the active role of the customer in producing the service experience: value is co-created (Vargo & Lusch 2004). For example, Menor, et al. (2002) and Alam & Perry (2002) have stated that service innovation requires a higher degree and new means of user participation compared to a traditional product-centered approach.

The most well-known user type in co-creation is probably the one of lead users introduced by von Hippel (1986, 2005). Lead users can be defined as members of a user population who anticipate obtaining relatively high benefits from a solution to their needs, and are at the leading edge of important trends in a marketplace under study and so are currently experiencing needs that will later be experienced by many users in that marketplace (Franke, et al. 2006; von Hippel 2005). In our case, *pro-users* can be considered as *lead-users*.

Although research about user participation in service co-creation started from lead users, recent studies have suggested that other user groups can also contribute to the early phases of service innovation. Weber (2011), for example, proposes that the main criteria for choosing participating users is that they have some experience of being a user of a service class, and technical expertise is not considered as important. Ordinary users, advanced users, critical users and even non-users can give valuable contributions (Kristensson, et al. 2004; Ainasoja, et al. 2011; Heiskanen, et al. 2007).

"Ordinary users" represent the average person with regard to the use and expertise of the service in question, and they are likely to have only a little knowledge of the technology concerning the service (Magnusson 2009). In our cstudy, *ordinary users* are *consumers* who have a need for interior design, but have no or little experience of using the technology.

Some studies have pointed out that these ordinary users can generate even more original or better ideas than lead users (Kristensson, et al. 2004). Ordinary users produce more original ideas with better user value when they are not trained in the underlying technology. However, these ideas describe the need and cannot usually be implemented as such. With technical consultation the originality of ordinary users' ideas deteriorates but ideas become more producible; users become "copy-cat professionals". (Magnusson, et al. 2003; Magnusson 2009). Instead, ideas improving emotional elements of service experience (such as enjoyment and fun) can be difficult to generate spontaneously by ordinary users (Sandström, et al. 2009).

When trying to understand the needs of users, there is a wide range of different user-centered design methods (i.e. cultural probes, workshops, contextual inquiries, interviews, co-creation sessions, prototyping, etc.), described in detail by Lucero (2009) that could be used. Designing the most suitable way to participate for each participant group is central, because the participation experience itself - enjoying, learning, inspiration - is one of the motivational factors for participants (Füller 2006; Füller,

et al. 2007; Hyvönen, et al. 2007). Thus different user groups can make different contributions to the service design and their motivations, skills and preferred ways of participating can vary.

For example, Alam (2006) suggests that including both lead users and ordinary users in the development process is useful. In our study this meant involving both pro-users (lead users) and consumers (ordinary users). Although most of the consumers had no experience of using a co-created service, they could be the most potential users in the future due to their interest in home decoration and renovation. The role of professional interior designers is some between the two groups, they are among the first to use the service, but likely because of processional requirements rather than personal interest.

Augmented Reality and 3D Models in Interior Design

Augmented reality is a profound visualization method for situations where there is a need to show something in a real environment and to enhance user's perception (Siltanen 2012, pages 165-166). It is defined as a real time interactive system that combines real and virtual elements in 3D (Azuma et al. 2001).

Augmented reality can be used in interior design (Siltanen and Woodward 2006; Lee et al 2008), renovation planning (Pinto Seppä et. al 2007; Saito et. al 2007) and in many ways to visualize building and construction projects (Woodward et. al 2007; Golparvar et. al 2009), for example. Augmented reality interior design applications often use still images. However, the user can interact with the 3D augmentations in real time. Thus such systems satisfy the definition of AR (Siltanen 2012, page 23).

Virtual reality (VR) means an immersive computer simulated system. The simplest form of virtual reality is a 3D image that user can manipulate interactively on the computer display. This kind of system is often referred as interactive 3D graphics. Sophisticated VR systems involve special devices such as wearable computers, VR rooms, haptic devices etc. In this work, we consider simple VR/3D graphic systems with no special devices.

Mediated reality refers to a system were something is altered, diminished reality to a system were something existing is removed. Augmented virtuality (AV) embeds real elements to a virtual environment. Mixed reality refers to systems varying from reality to virtuality and their all combinations of real and virtual (incl. AR and AV) (Milgram et al. 1994).

Figure 4. Illustration of AR home design concept.

Ordinary people are not familiar with these definitions and terms are often used indefinitely. In our study, we used term *augmented reality* to refer to *a system that combines real and virtual elements* including all above mentioned technologies when they came up in discussions.

Augmented reality applications may be implemented using different display technologies and devices. A consumer application such as the AR interior design service studied in this paper needs to rely on commonly available consumer devices. That means that special devices such as head-mounted-displays are out of question. Mobile phones, although used in many AR applications (Azuma et. al 2011), have relatively small display and therefore users prefer e.g. laptop PC in visualization applications (Olsson et. al 2012).Therefore, in co-creation sessions, we defined our fictitious service to utilize PC, laptop PC or tablet PC – the most potential devices for consumer level visualization application. Figure 4 shows an illustration of augmented reality interior design prototype using a tablet PC.

Implementation of the Scenario Based Survey

We conducted a scenario-based survey for early concept development. The scenarios described fictional use cases of the sketched home design service. 242 respondents (consumers and pro-users) answered to the service. The scenario-based methods proved valuable in the early phases of concept design. Two pro-users were male, all others were female.

The consumer survey was done in cooperation with an online marketplace for home and real estate. The questionnaire was presented on the web portal, and 205 consumers answered the survey. Most of the consumers did not have any previous experience of using virtual interior design programs.

The pro-user survey was sent to interior design bloggers, and students studying interior design or closely related subject. 21 bloggers and 16 students answered the survey, one of the students studied something else than closely related to interior design. Due to nature of the subject, almost all respondents were female, only two of the students were male.

Scenarios

Four visualized scenarios were used in the survey to help the users to understand the different possibilities of AR, VR and 3D modeling, and to inspire ideating new concepts. Scenarios are fictitious stories which present users with different lifestyles, needs and interests. The scenarios can help to understand the possibilities of AR and 3D technologies, different use contexts and motivations to use the services. The scenarios were 1-2 pages long illustrated stories.

In the first scenario, a young couple is looking for a home and they use 3D interior design service to compare possible apartments. They also share designs through social media and let their friends comment and edit the designs before making their purhasing decision.

In the second scenario a expatriat couple is moving back to Finland and make interior design for their new construction home using web-based service. They discuss the ideas with their relatives in Finland and send image via email. The constructor cooperates with a furniture retailer, and thus they are able to purchase the planned furniture with discount – including installation to the appartment.

In the third scenario, a family makes interior design for their new house with 3D television. They consider different wallpapers for children's room as well as new furniture and home theatre with aestically pleasant loudspeaker system, for example.

The fourth scenario describes a virtual interior design contest open for interior design bloggers among others. The designs are shared through social media and people are able to comment them and vote for their favourite. Figure 5 shows one of the illustrations used in the fourth scenario.

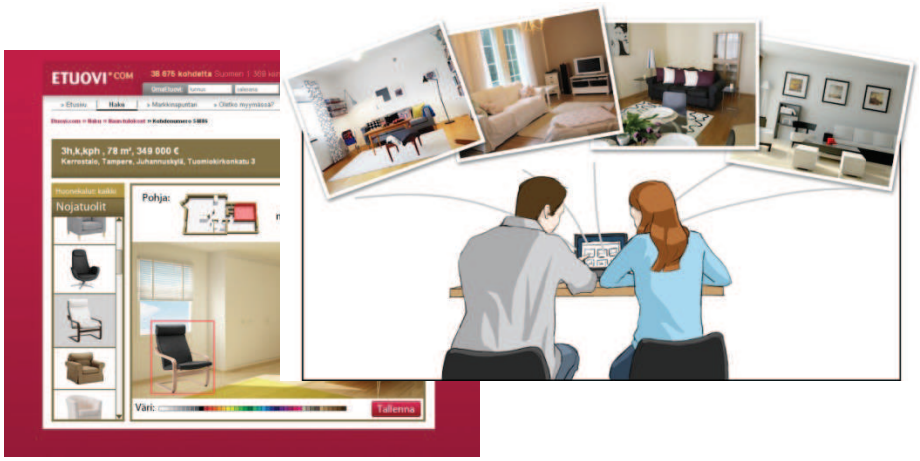

Figure 5. A fictitious scenario: Interior design contest for new construction (scenario 4).

Results of the Scenario Based Survey

The survey concentrated on user attitudes and social media features of the service. 52% of the bloggers and 56% of the students had used virtual interior design service earlier, whereas, only 27% of the consumers had used such service earlier. In addition, 29% of the bloggers and 31% of the student were aware of such services.

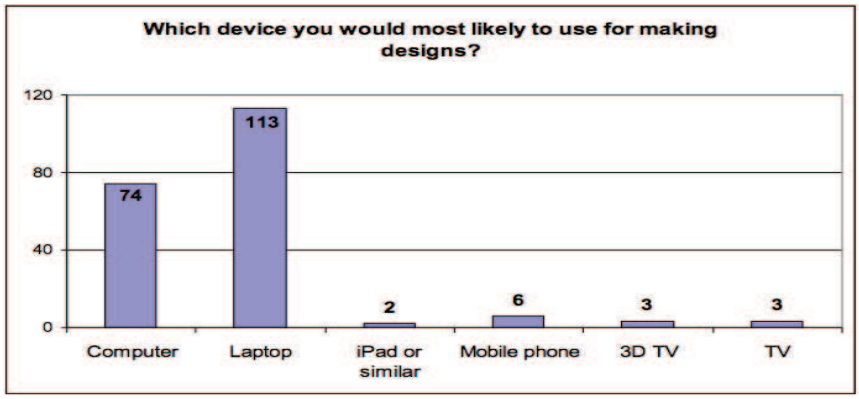

Figure 6. Consumer view to the question "Which device would you most likely to use for making designs?".

Consumers considered PCs and laptops as most prominent devices for this kind of service (Figure 6). At the time of the survey tablets were still relative rare. The number of tablets has increased since the survey, and people might answer differently now.

48% of bloggers and 63% of the students believe that they will definitely use this kind of service in the future, and 43% of the bloggers and 31% of the students believe that they might use this kind of service in the future. The rest did not have an opinion on the matter.

Pro-users and consumers have different attitudes towards sharing the designs. As we might expect, the possibility to share designs through a blogs is important for pro-users, where as consumers are not so willing to share designs in a blog. In general, consumers appreciate private sharing channels more that pro-users, and pro-users appreciate public visibility more than consumers (Figure 7). Pro-users would use this kind of service for several purposes (Figure 8).

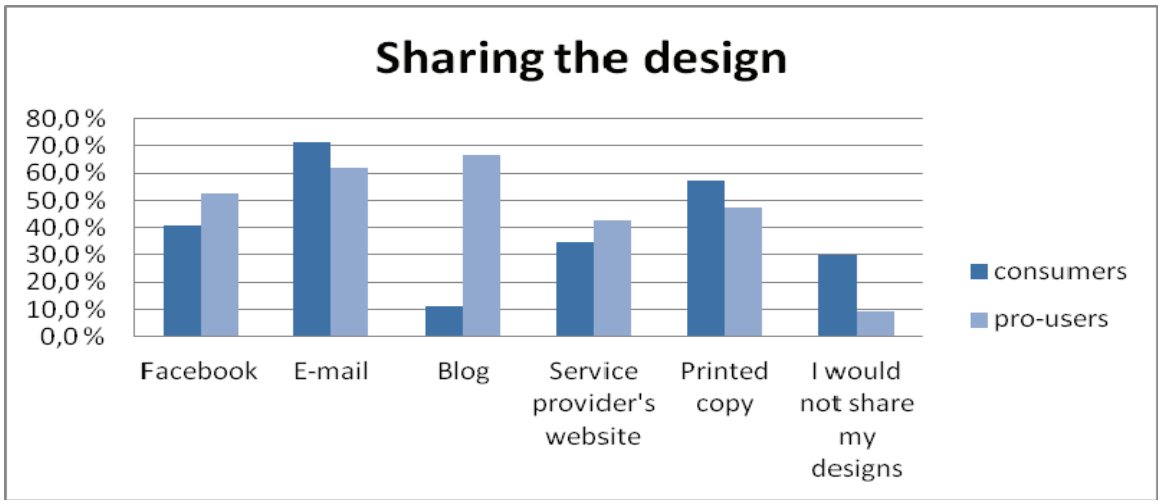

Figure 7. How people would like to share their designs.

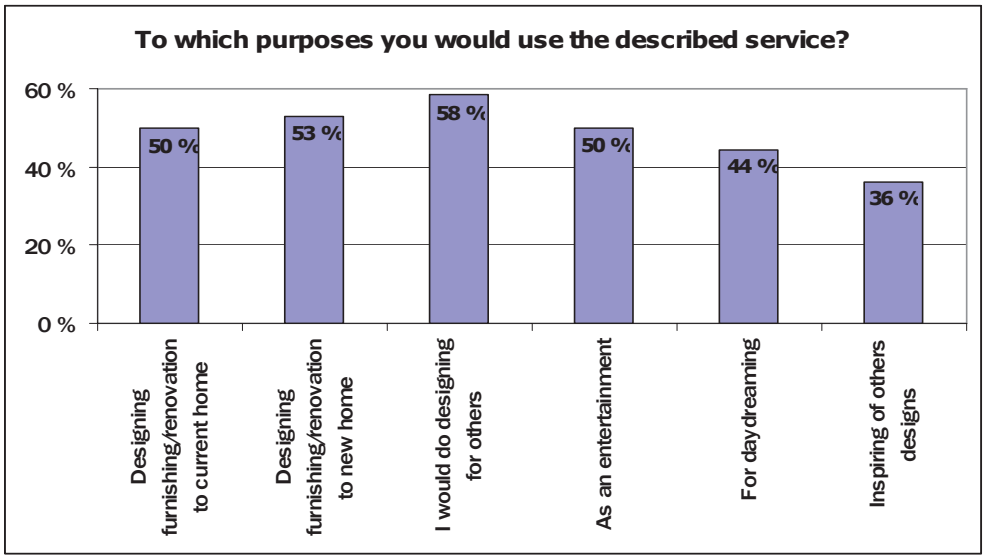

Figure 8. Pro-users would use this kind of service for several purposes.

Implementation of the Co-creation Sessions and Interviews

The co-creation sessions and interviews focused on augmented reality interior design service. However, we did not limit ideating strictly to augmented reality, but considered also other closely related technologies e.g. diminished reality and mixed reality features.

Implementation of Co-Creation Sessions

We organized six co-creation sessions; all five consumers participated individual co-creation sessions and the two interior designers participated a joint session. The sessions were carried out by same researcher and they lasted 1–1.5 hours.

The co-creation sessions consisted of three parts:

- scenarios, discussion of potential use cases of the technology, and first impressions
- experimenting with as existing AR interior design service and its reflections,
- personal opinions and preferences, and overall comments.

As the augmented reality concept is relatively new in consumer applications and therefore unknown for larger audience, the researcher presented shortly four scenarios of using virtual and augmented reality interior design service for the consumers. Apart from scenarios used in the surveys, an additional scenario using AR for renovation was presented. Besides, participant saw a short video illustrating use of AR interior design service. Thereafter, we collected participants' first impressions on AR interior design service and discussed how realistic they considered the presented scenarios. The interior designers were familiar with the AR concept, and no introduction to the subject was needed.

In the AR renovating scenario family is considering to buy a new home, but the one they are interested in needs some renovating so they test different materials, decorations, and furniture using AR renovation service before making purchasing decision.

In the second part, the researcher used together with the participant(s) a publicly available AR interior design application to catalyze discussion. The participants were instructed to take images of their home beforehand, and in case they had not done so, we took images in the beginning of the session or used sample images. We used images of participant's own living room in four consumer session and in other sessions we used sample images. During the second part, we discussed following themes: desired functionalities, potential or actual problems, naturalness of the combination of the real and virtual.

The consumers had no prior experience regarding augmented reality, but then the use of an actual system concretized the users what AR means. The researcher was operating the application; this was to prevent usability issues and technical limitations of the specific system to affect users' opinions on such services in general. We emphasized that the participant should think things that she wanted to do and not whether the desired functionality is technically possible.

In the third part, the participant was encouraged to make some conclusions and we discussed following themes: would they use this kind of system when buying a new house, purchasing items through the system and linking to a web store, the most important features of the system (when buying a new home/renovating/making interior design in current home), sharing the designs, what kind of items to test virtually, any other comments.

During the exploration of the AR interior design service the participants spontaneously came up with many of the themes of the third part, and those theme were discussed then.

The participants of co-creation sessions were 30-50 years old females.

Implementation of the Interviews

To understand the business factors affecting the service and its functionalities, we interviewed a professional interior designer having experience in using AR software in interior design, a representative of a furniture retailer, a representative of a company providing interior design on the Internet and a representative of a company providing an AR interior design Web platform. These are all representatives of value chain of AR interior design service presented earlier in Figure 3.

Interviews were carried out as individual focused interviews. Focused interview is a semi-structured method, which means that some of the features of the interview, for example the focus and the themes that are of interest, are decided beforehand by the interviewer. The method has features from the unstructured interviewing, for example the objective is to understand respondents' point of view more than make generalisations of their actions. (Hirsjärvi & Hurme 2001, Fontana &Frey 2005).

The themes discussed were (when applicable to interviewee's role): desired features of the AR interior design service, target users and potential users, future of the service, bottlenecks and technical

challenges, user feedback, integration to other services, business prospects. With the interior designer we also discussed the themes of co-creation sessions.

Results of the Co-creation Sessions and Interviews

In the co-creation sessions, it appeared that professional users and consumers have different needs and expectations of interior design.

The consumers exploring with images of their own home seemed to ideate more, and wanted to test more interior designs, than those using sample images of a non-familiar room. This indicates that concretization of the concept using the user's own environment motivates the user, and also results in more concrete use scenarios. This finding is in line with the general concepts human-centered design (Maguire 2001).

The researcher operated the AR interior design system used during the co-creation session. This let the user to focus on ideas independent of the technical solution or interface. For example, the user might point the objects on the display and explain: *"I'd like to remove this piece of furniture"*, or *"I'd like to add here…"*. The users also got new ideas while doing something, especially when using images of their own home (Figure 9).

Figure 9. In the co-creation session, pictures from participants' own homes were augmented. This made the design process more concrete for the participants. For example, here a consumer compared whether to have one or two chairs, and came up with a new idea *"I would like to test some curtains, too"*.

Attributes of the Service

The consumers did not consider dimensional accuracy important, for them it is sufficient that the design *"looks realistic"*. They would use a traditional measuring tape before purchasing any items. In contrast, professional users share the opinion that the system should be very accurate; otherwise they would not be able to use it. The interior designers said that the interior design plan is supposed "*to show how the furniture fits in the physical space*" and therefore, the virtual objects should be restricted to room space, and the scale and dimensions of the AR system should be very accurate. Many current AR applications allow the user to move virtual objects through walls, and virtual objects may unintentionally overlap with other virtual or real furniture. The professional users saw this as a bottleneck for serious use.

The interior designers said that the color scheme and materials of the interior design plan are important. They expect that the colors and materials of 3D models should look natural and realistic. *"A customer buys a dream"* so the plan is more than the furniture *"it is the feeling that it creates"* and there the colors and materials are important.

The consumers wanted ready-made *"interior design atmospheres"* from which to start the design. Traditional interior design planning often starts by paging through images of different rooms. The AR system should provide a similar concept.

The consumers need a sophisticated database search, which enables search by color, style, size, price and other properties. The users mentioned that often people want, for example, a couch of a certain size (defined by size available), or they may have a limited budget and are interested in the prices. This is especially desirable in the consumer application. The search logic was not as important for the professional interior designers, as they know the product offering and remember most products by heart.

One issue came up in all discussions, no matter which role the interviewee or participant represented; the number and variety of available 3D models. It is essential to have a great number of pieces of furniture and decoration items as 3D models in the AR interior design system. The system should support the interior design, not restrict it. For a furniture retailer and interior designer working for certain retailer, the need is to have their whole product portfolio available. For interior designers not limited to certain brands or retailers, the need is *"all pieces of furniture they might want use in interior design otherwise"*. For professional users, the number of available products is very important. One of the interior designers said that she has 10 000 articles from which to select items for plans (+ different material options). This gives guidelines for the number of necessary 3D models in professional use.

The consumers would probably use an AR interior design application restricted to a brand or a retailer, but would also be interested in larger range of products. However, they wish not to have "infinite" number of choices, it would make the decision too difficult and too complicated. Besides furniture, interior design consist of smaller supplementary objects like curtains, plants and flowers, paintings, posters, photo frames, etc. The consumers and interior designers think that the 3D object library should contain a large number of these kinds of supplementary objects as well.

Consumers and interior designers emphasized that people have a personal history, they have *"old furniture with sentimental value"*, and most common situation is that they want to include part of this personal history to the interior design. Very seldom people want to renew all furniture at once, only in some new construction cases. Therefore, it is essential to consider existing furniture as a part of the design. Technically this would mean modeling of the existing future or representing it with a very similar one.

Both consumers and professional users thought that the system should be able to place virtual furniture behind existing furniture and to remove virtually existing furniture. The lack of these functionalities was seen by the professionals as a bottleneck for using AR in making interior design plans. *"It (AR) doesn't serve ... because it requires an empty room. The system should be able to empty the room. Now, I can only add small items, like a lamp."*

Figure 10. Real interior design situations produced during the co-creation sessions led to concrete ideas; *"the system should be able to place the dresser behind the chair"* (above) and *"the system should be able to remove the existing furniture"* (below).

Some consumers were tolerant when the overlapping of real and virtual was small; *"I still get the idea"*, *"I can move the (disturbing) table aside"*. However, others wanted that the system would enable them to place virtual furniture behind existing furniture (Figure 10). In addition, they wanted the possibility to remove and move existing furniture virtually, especially heavy items, such as a piano or bookshelf, in order to test a new arrangement of furniture (Figure 10).

Those consumers, who had renovated their own homes, commented that "it would have been good to have this kind of service available". They would have used it "to test whether the family dining table fits in dining space" and "to test the wall colors and other materials". Here again, participants with firsthand experience of the subject were ideating more.

Interior designers and consumers mentioned virtual lighting as a very useful future feature. They saw an opportunity to visualize lighting effects using augmented and virtual reality. An ideal system would be able to show the space in realistic lighting in the evening, morning, winter, summer, etc. according to point of compass, windows' positions etc. Besides the ambient lighting, they see that it would also be useful to be able to model and visualize the lighting effect of different lamps e.g. the size of their spot light.

Consumers who would use an interior design program only once or occasionally are not willing to use time in learning how to use the system; it should be self-evident. Consumers would not bother to download or install anything. Whereas interior designers think that they would benefit from a more flexible system with more options and functionalities in professional use, they should be trained to exploit

it. Things that they described were, for example, the possibility to assemble block-based furniture virtually, select materials, add virtual lights, remove existing furniture, and to add curtains, paintings, flowers, do some work to get more accurate measurements of the space.

In addition to planning renovation and interior design, consumers might use the AR interior design system for daydreaming and to brainstorming new ideas.

People see the importance of a good user experience on the first try as the most important factor affecting the success of an AR interior design system.

The interior designers told that many of their customers have difficulties to understand the 2D drawings; the use of AR will help them to understand the interior space better.

Interior designers reminded that interior design is a more than just the order of furniture, it is an atmosphere and customer buys a dream. Interior design is a creative process, and interior designers see a great challenge is preserving creativity when using technology.

Business Prospects and Bottlenecks

The scenarios used in user participation parts of the study were not presented to the commercial actors, yet they spontaneously presented ideas were very similar to the scenarios. The integration to several systems (Web store, social media, real estate marketing, etc.) is appealing, especially from the retailer's and system provider's viewpoint. The retailer would also be interested in functionalities that support marketing and enable different campaigns, blogs, design competitions, etc.

Most of the consumers said that they would not buy furniture without seeing it for real, but they might buy smaller decorative items, such as pillows and curtains from an integrated Web store.

The retailer notes a challenge in web store concept in ensuring that the product set the user selects is feasible i.e. if the user selects composes product from parts, it contains all parts needed for assembly.

Discussion

The study showed that there is a demand for easy-to-use design tools for consumers looking for a new apartment and also for professionals and pro-users working in the area of interior design.

Participatory design proved to be valuable; consumers, pro-users and professionals have different needs and requirements for the system. Involving the target user in the design process can be valuable for success of the service. Our approach combining different research methods and different user groups helped to find out the big picture of the consumer expectations, but led also more detailed information that can be applied in targeted application development.

Our study also brought up synergies and challenges between user needs and viable business model: For the pro-users and professionals integration to other services and social media is important, these features are also important from business point of view. On the other hand, users ask for large set of available model, yet it is challenging to create business ecosystem to support this. A cap between the user expectations and existing systems also came up: the users would like to search items by color, size and price and the current systems organize items by brands. User participation on the early stage of design process enables the service provider to adapt the system to this kind of requirements.

From the user perspective, the challenge of virtual home design services is often that many of them are quite difficult to use, especially for users without previous experience of these services. Some of the services may also demand heavy installation packages or complex registration systems, which may be an obstacle for users when starting to use the service.

As a conclusion, a service for consumers should concentrate on the user experience and the ease of use, whereas a service for professional users could be more complicated to enable all necessary functions.

The professional background of participants is one factor that could be taken into account in planning the methods for user participation. Ordinary users came up with more ideas by touching and

trying out different things in the co-creation session. The use of participants' own pictures was essential to success. This technique made it possible to bring the concept closer to the everyday life of users, which has proved to be important for example in living labs and other user tests in real environments. Moreover, the broader consumer studies also reflected that there are differences in adopting new technologies and services among consumers, and most likely lead users and innovators would represent only views of small, technologically advanced user groups whose insights can't be generalized to apply to all users similarly. Otherwise, there is a risk for overestimating the consumers' willingness to adopt new technologies and services.

Professional users felt that it was easy to visualize interior designs in their minds; similarly they participated co-creation sessions in a more conceptual level. The starting point in co-creation with professionals was the comparison to their current working processes and habits rather than concrete examples like with ordinary users.

According to our research, it appears that all groups were able to produce new ideas, use their imagination, empathize with scenarios and talk about their ideas. When the service is designed for a large number of users, taking into consideration that the needs and motivations of the target users may be inconsistent, it is vital to bring in "the voice of the masses" to understand the varying needs and use contexts in everyday life.

Earlier research has pointed out the problem that when participating users are trained with earlier concepts and technology, it could restrict their imagination and capability to come up with fresh ideas. In our case, with a service that is relatively unknown to larger audience, this was not the case. Rather, the more examples were used, the more ideas users generated. The researcher facilitated the co-creation sessions in order to prevent the users to get stuck with the limitations of the current solution. We did not train participants about the actual technological solutions and constraints but concentrated on utilization possibilities. Actually, it was beneficial that the discussion was not limited to explicit definition of augmented reality. The discussion was open to all possible ideas about interacting with virtual and real elements in interior design.

In further work, we see that social media and online innovation tools combined with advanced modelling technologies could offer a fruitful innovation environment to develop the interior design concept further. Often, the lack of proper tools inhibits collaboration and ideation through online media (Antikainen, 2011). These online innovation communities could utilize and reward users' creativity and offer visual "do-it-yourself" tools for the collaboration and processing of ideas to bring in well-rounded insights.

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