PAPER I

Co-designing novel interior design service that utilizes augmented reality, a case study

Co-designing Novel Interior Design Service That Utilises Augmented Reality – a Case Study

Tiina Kymäläinen[1] and Sanni Siltanen[1]

[1]VTT Technical Research Centre of Finland, Tampere, Finland
tiina.kymalainen@vtt.fi

ABSTRACT. In this paper we describe a co-design process and implementation requirements of an interactive interior design service system. To gain design information for the system we studied two focus groups that were composed of designers, bloggers and serious amateurs in the field of interior design – the estimated critical users of the forthcoming service system. The framework for the co-design study was twofold. The design aim was to study users' innovation capability in the early phase of a complex process by utilising co-sketching as a means of obtaining a user model of the interactive system. The technological aim was to create interior design concepts that exploited augmented reality (AR), 3D models and user-generated content within the system framework. This paper reports the design process and results of the co-design sessions; furthermore, it presents requirements for the system, use cases utilising AR technology, plus consideration and evaluation of the AR functionalities.

Keywords: Interior design, human-centred design (HCD), front-end of innovation, focus group, sketching, co-design, augmented reality, virtual reality

1   Introduction

The case study was part of research that aimed at studying the use of new technologies and applications – social media services, augmented reality (AR) features and location awareness – in the field of advertising, and find new revenue models for media. This paper presents a case study which aimed at understanding the needs and requirements of the design service providers. Research was carried out by co-designing interactive user-centred interior design system concepts that utilised AR features. Co-design focus group sessions were arranged with interior designers and design bloggers – the anticipated critical users of the interior design system.

The participants of the study had taken part in a preliminary online survey, and were therefore all familiar with the background of the system concept. Participants received further information relating to the concept in the focus group sessions, first viewing scenarios that described possible ways of comprising interior 3D and AR services. Participants were then presented with some information from the preliminary online survey, including the key elements and materials thought by most

respondents to be critical for the service. This was followed by a short presentation by the facilitators of the AR technology and existing AR applications.

In the co-design phase, the focus group participants co-sketched the system concepts. Sketching proved to be a practical method in this context, as the participants were able to produce dissectible results. Participants provided valuable design information during the discussions – in the form of use cases – concerning the promising ways of utilising AR technology in the service concept.

2   Chosen Key Technology: Augmented Reality

Augmented reality is defined as an interactive real-time system that combines real and virtual elements in 3D [1]. Virtual reality (VR) consists only of virtual elements. Diminished reality is a system where objects are removed from real environment, and mediated reality refers to a system where real environment is altered virtually [2]. Mixed reality (MR) is a concept that covers all possible combinations of real and virtual elements, from reality to total virtuality [3]. From the user's point of view the functionalities of a system are more important than the technology categorisation. "The basis in all the discussions was an AR system in which real images are augmented with virtual objects. However, in sessions the discussion was open to all forms of combination and alteration of real and virtual elements, including all the above-mentioned technologies –we used the term AR for simplicity, though."
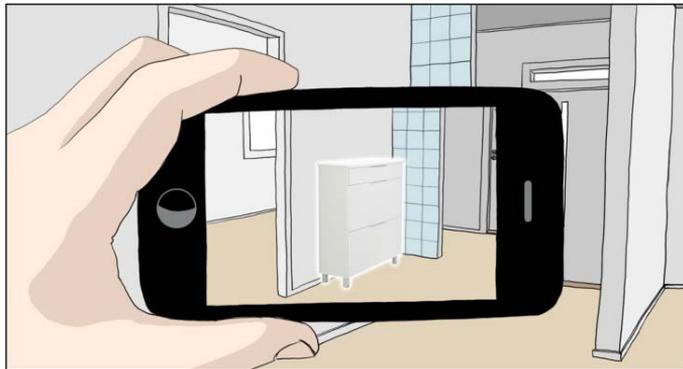

Fig. 1. With a mobile AR application the user can see virtual designs in real environment.

Augmented reality provides a practical visualisation method for purposes where there is a need to enhance the user's perception. Interior design, in particular, is an application field where the combination of real and virtual benefits the user [4]. Web-based AR applications – in not requiring installation or downloading – are consumer friendly and can be integrated with social media and web stores. Also, recent mobile devices are equipped with reasonable-sized displays and have network connection for accessing the Internet. Based on these facts, we selected a web-based AR interior

design service as a starting point for the co-design discussions, and presumed that users could augment digital images and operate the system by using a PC or mobile device.

3 User-driven Innovation

3.1 Methods

The co-design process falls under the methodological frame of participatory design, which generally aims at democratising design so that the people to be affected by the systems should also be able to participate in and influence the design process [5]. Participants may be involved in the process by means such as focus groups, scenarios and early phase concept design [6–8]; methods which were adapted to this study. Focus group interview is an interview method in which a small group, with similar background, discusses the topics disseminated by the facilitator [6] – in this study, the similarity was the participants' interest in interior design. Because of their experience, the participants were seen as critical users [9] of the future service.

The co-design process was pragmatically conducted by utilising sketching as a co-design method, to provide means for users to produce design outcomes of a complex design service system [10]. The sketching method appeared to be a flexible way of prioritising design issues, and considered suitable for these particular focus group participants. The hypothesis was that sketches would offer support in obtaining a user model of the overall system [11].

3.2 Set-Up of the Co-design Session

The project group had identified a definition statement of the service concept for the focus groups: *'Novel web-based service concepts that exploited 3D and AR technologies, which may be used virtually when creating interior and renovation designs'.* The statement described the system and its core requirements in brief, and was meant to provide focus for the participants' concept ideas. Because the focus group participants were seen as service providers, the emphasis of the co-design session was on the service ecosystem of the concept.

At first, participants were encouraged to identify their role in the service system. It was decided mutually in the sessions that each participant would define her role as an ambiguous *designer*. Participants were then divided into pairs, and each pair encouraged to produce a sketch of the ecosystem in the form of a flowchart. The descriptions were expected to include: 1) all necessary stakeholders and elements of the system (products, services, technologies); 2) how all stakeholders and elements were connected to the ecosystem, and finally 3) which were the most important stakeholders and elements (using a tree-level scale).

The participants were encouraged to think about the application through discussed scenarios, and to exploit the information from the online survey and demonstrated applications. In the sketching phase, participants were provided with sketching tools: paper, pens, cardboards etc. Other materials, such as used e.g. in IDEO's tech box

[12]: colour schemes, pieces of wallpaper, images of furniture etc. were available for inspiration and reference purposes.

Following the sketching phase the focus group participants shared their ideas with others. After presentations, participants improved each other's ideas by paying attention to the application definition statement, scenarios, and, most importantly, personal interest.

3.3 Participants

The preliminary online survey data was collected from ordinary consumers (250 respondents) and serious interior design amateurs (36 respondents). The following two focus groups were composed of volunteers from the latter respondents, who were mostly interior designers or serious interior design amateurs: students and bloggers in the field of interior design. The two groups consisting of 3–4 participants, with 1–2 project participants in each group, and one evaluator leading the two-hour co-design session. The first focus group session was arranged in May 2011 at VTT Technical Research Centre of Finland, Espoo, and the second at Alma Mediapartners' facilities at Tampere, Finland. The interviewees were 27–49 years of age, all females.

4 Results

Participants provided detailed information on the qualities of the service during the introduction, while sketching the ecosystems and, finally, when considering the AR features for the service. The following presents the results of the discussions, the ecosystem sketches and the participants' AR use cases with detailed considerations.

4.1 Comments Relating to Scenarios

Pre-made scenarios were first presented, discussed and evaluated in the focus group sessions. The preference of serious interior designers for using very simple design tools in the presented cases was emphasised by the participants, who stressed that usability would be the crucial factor for their interest in using the system. Participants assumed that the real, accurate sizes of the apartment, rooms and furniture were the most critical individual features of the service system. Besides size, the most important qualities for the products, furniture and representative 3D models were stated to be style and colour. It was considered reasonable, however, for colour to be merely suggestive – e.g. fair, mid-dark or dark – to give an impression of the overall design. Participants thought that placing old, existing furniture in the design was even more important than buying new furniture through the service.

Fig. 2. Example of a Scenario: Interior design contest for design bloggers.

It was stated very clearly that a design process often begins by placing existing furniture – an ancestral cupboard or piano, for example – in place, with this piece or artefact defining the overall design plan. However, participants speculated that there might not be any party interested in providing such a service. If the service were to concentrate exclusively on selling new furniture, this would mean all major furniture providers having all their products available in the service system.

Concerning the sharing of design ideas through social media, participants remarked that if they were providing services themselves they would prefer to share their ideas with other interior designers, design enthusiastic people or customers. Designers suspected that general users of the service would also prefer at least semi-professional feedback on their design plans. The participants who were design amateurs were pleased by the idea of the scenario – presenting a home decoration contest (see Fig. 2) – perceiving that the special knowledge and expertise of interior designers and design amateurs could be fully utilised through the contest. Sharing design plans with a wider audience, or with friends and family, were seen as irrelevant.

4.2   Comments Relating to Example AR Applications

Participants subsequently saw three example applications that were benchmarked by the research group. The applications provided 3D and AR functionalities for creating interior designs. Participants were given an oral description of the benefits that were the criteria for selecting these specific applications.

Fig. 3. An interior application that utilised AR technology by VividWorks Ltd.

Participants provided detailed evaluation of the presented applications. The most important statements related to the visual appearances: the aesthetics. Participants emphasised that the 3D environments and models needed to be attractive and realistic. The realism brought to interior scenes by the showing of lights and shadows and textures in detail, for example, would make them more convincing. It was also seen as advantageous to induce the user/designer to feel that decorating rooms and creating plans was "leisure activity" – that it was fun to spend time in this way and to explore the service. The design competitions for interior designers in the example applications seemed to lack purpose: there were too many of them with no reward. In addition, the most important priority was stated to be the overall costs of the products and services. The existing services, however, only showed prices for single articles.

4.3 Sketches of the Service Ecosystem

After the introduction phase, participants created system concepts in pairs and presented them to each other. Figure 4 presents an example of a concept made by one of the pairs. The pair explained that the ambiguous *designer* and the service tool were identical (as it is the designer who uses the tool). The first task was to feed the background information and facts into the system, e.g. the floor plans. The sketch contained a two-way arrow – at this point the information either exists or has to be created. The main service providers in the cooperation were interior decorating stores (for wallpapers, floor and wall materials) and furnishing companies. The existing furniture was equally important – *"the past life, which does not vanish when a new home comes along"*. Service providers were the second priority: the individual designers who offer their services, or could be accessed through the service. A third priority was logistics; those who put all the pieces together and provide complete light decoration services, for example. This was followed by accessories, e.g. lighting providers and art suppliers. The sketch also described the chronology of events.
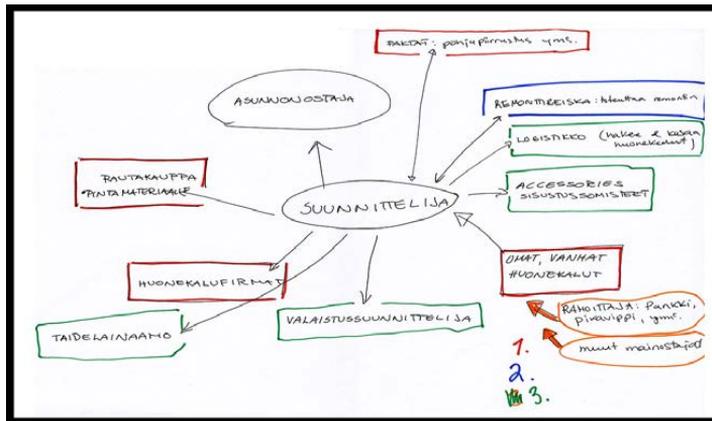
ALAIPO & AINCI

Fig. 4. Example of a sketched service ecosystem.

Table 1 presents the results of the service ecosystem sketches, and the conclusions of the co-sketching session. Participants were encouraged to determine the importance of the factors using a tree-level scale. For the most important factors, participants used numbering, a different colour, or a stronger line, and confirmed and explained the importance of the services after sketching the content. As the table shows, participants thought that the new furniture and interior decoration providers were key factors in the service. The participants perceived themselves in the co-design situation as designers, but while creating concepts all mentioned the importance of the customer relationship. Also, all mentioned the other designers – competitors or designers with different expertise. The participants highlighted some new providers to be included in the service: kitchen-, window- and carpet providers, antique shops, flea markets, art suppliers, gardening-, lighting- and 3D-model designers of existing furniture. From this viewpoint the service was seen as a cluster for smaller providers.

With a service dealing with novel ideas, participants emphasised that the price of furniture, material and accessories would constitute the essential feature of the concept. It was therefore considered important that the total cost of the new furniture and design alterations should be clearly visible. One group remarked that the customer could apply for a loan from a credit provider if it were possible to refer to an estimate provided by the service.

Because the information was qualitative there was some overlapping with the service providers presented in the table. Some participants, for example, mentioned hardware stores, but described them later as interior decoration providers, and placed both of them in their ecosystem sketches. There were also some conflicts relating to participants' statements of preference during the conversations, and how they were implemented in the ecosystem sketches. For example, all participants emphasised the importance of old, existing furniture in the service, but this nonetheless failed to receive the full amount of points in the analysis.

Table 1. Results of the service ecosystem sketches. If all pairs (groups 1–4) thought a service was most important, the service received 12 points. If only one mentioned it, and did not value it highly, the service received only one point.
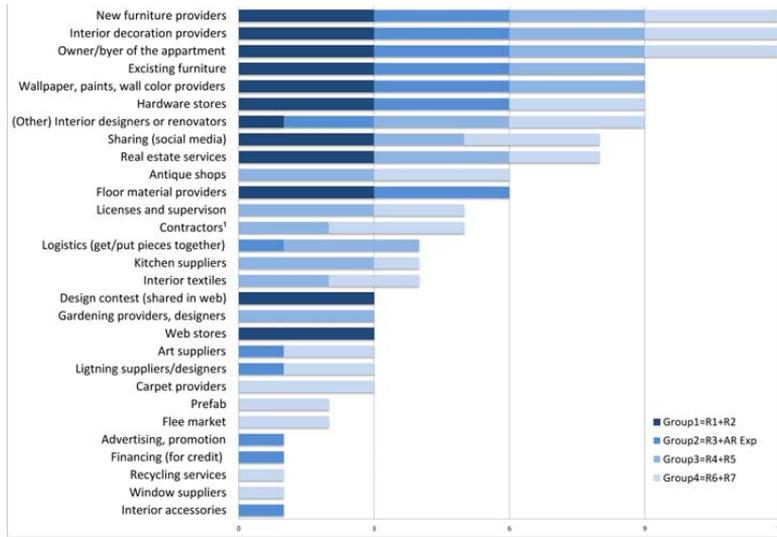
¹ Contractors = e.g. HPAC-planning, electricity, masons

4.4   Ideas for Augmented Reality in Interior Design System

After sketching the service ecosystem concepts, the focus group participants thought more thoroughly about the AR features of the interior design service. Three topics were highlighted above others in the discussions: realistic lighting, number and variety of furniture models available (including 3D reconstruction of existing furniture), and search functionalities.

Based on their experience, participants emphasised how the lighting conditions affected the overall feeling and atmosphere of a space – and how difficult it was to explain for the customers. By using the AR technology, they saw an opportunity to visualise lighting effects: e.g. an ideal system would show the space in realistic lighting in the evening, morning, winter or summer, or according to the position of the windows. This would show the virtual apartment in a more realistic light: *"All dark corners during winter days, and harsh light during spring"*. Besides the ambient lighting, participants pointed out that it would also be useful to be able to model and visualise the lighting effects of different light sources e.g. to demonstrate the accurate size of selected spotlights.

Designers explained further that they constantly experienced situations in which they had no tools to communicate with the customers e.g. about the colours of the walls. One designer described such a situation: *"The effect of black walls are unimaginable for most customers, as white walls are still so common, but the*

ALAIPO & AINCI

atmosphere could really be altered by simply changing one wall to black." This situation could be demonstrated quickly with on-site AR or VR technology.

The participants created use cases that could employ the AR technology, presenting a case in which a person was interested in a particular apartment. With this type of use the person could take pictures of the physical apartment and furnish it later virtually, at home, using the AR service.

The participants raised the issue of the visual quality of the design, which is highly important in interior design planning processes. The participants stressed the importance of the rendering quality of virtual objects: the application should be able to produce realistic materials and lighting effects on virtual objects. Participants stated that they would not engage AR features in the service unless the quality correlated sufficiently with the real environment.

Another important issue was that the availability of virtual models should not restrict the inspiration of a design. If the designer has e.g. an antique furniture model in mind, it should be possible to add it to the interior design plan or at least to represent it using an almost equivalent model. The same need applies to existing furniture; the user should be able to add virtual counterparts of the furniture easily into the design. This means that the 3D-object library should be large, and should contain generic objects whose colour, size and materials could easily be changed. Alternatively, designers should easily be able to create their own models e.g. based on images of an item of furniture. The service should also contain smaller objects, such as curtains, plants and flowers, paintings, posters and photo frames. Participants hoped for a sophisticated database search that enables search by colour, style and size. Typical situations were described as e.g. *"I need a chair of this size…"* or *"I want a reddish couch…".*

5   Reflection: Technological Feasibility Concerning AR

Concerning the remarks on the AR functionalities, it was said that virtual lights and shadows affect not only the visual quality perceived by the user, but also the realism of the augmentation. In other words, virtual objects seem to hang in the air if they are not attached to the floor with virtual shadows. Virtual lighting, similar to real lighting, embeds the virtual furniture as part of the environment. It is also possible to adjust virtual lights easily, according to real light sources, with user interaction in interior design application [13].

Photorealistic rendering, i.e. the production of photo-like 3D graphics, is computationally demanding, similarly in applications where live video feed is augmented. However, still images are well suited to interior design applications [13], and computation time is therefore not an issue. It is possible to measure the real lighting conditions of the environment, adapt the virtual object to it, and produce adaptive photorealistic AR [14].

The participants expressed a need for a large object library that supports creativity, together with sophisticated search functionalities. The challenge of a model library lies in economics: how to create a business model that supports the creation and sharing of 3D models. We may assume that if an interior design service has a

sufficient number of users, the creation of a large number of 3D models would be viable.

6   Conclusion

Since the focus group participants' expertise was high, they were able to create several new, aesthetic ideas for the interior design system concepts. AR technology was mostly speculated upon by offering examples of existing AR features, yet the participants were able to provide valuable feedback: AR use cases, and the fact that the evaluations of the feasibilities were based on the experience of interior designers.

The sketching approach for empowering a co-design process proved to be a flexible and productive method of involving users in the innovation conception phase, and for perceiving a user model of an interactive design system. Table 1 – the results of the service ecosystem sketches – presents certain evidence that it is also conceivable to analyse users' models. Moreover, because of the ecosystem descriptions, the highlighted issues were discussed more thoroughly in the focus groups. In exploiting sketching as a means of involving users in the interaction design processes, the key finding was that during the co-design session the sketches remained in the custody of the participants: even if the conversation and new information led opinions and ideas along different courses, participants expressed their judgements by referring to their sketches.

After studying the most important requirements of the critical users for the AR technology, it can be said that most ideas could easily be implemented in an interior design service system. When it comes to participants' needs for modelling existing furniture, however, it may take some time before practical solutions are available; current solutions for 3D reconstruction (i.e. construction of a three-dimensional model of an object from several two-dimensional views) require too much involvement and knowledge from the user. Research is nevertheless moving towards rapid 3D reconstruction on mobile devices [14]. In future interior design services, the user is expected to scan the interior environment effortlessly with a mobile device, and even obtain modelling of an existing item of furniture.

Focus group user evaluations and co-design sessions provided adequately new information for further design and development of interactive interior design services that utilise AR technology. The focus group participants, whom we anticipated to be the critical users of the service, in turn described the users of the service as: interior designers, interior architects, various decorators, model creators, lighting consultants, electrical consultants, small or large furniture companies (or individuals), decoration- and renovation providers.

Fig 5. Focus group participants creating novel interior design service concepts.

References

1. Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S. and MacIntyre, B. Recent Advances in Augmented Reality. IEEE Computer Graphics and Applications, Vol. 21, No. 6, pp. 34-47 (2001)
2. Mann, S. Mediated Reality with implementations for everyday life. Presence Connect, MIT Press journal PRESENCE: Teleoperators and Virtual EnvironmentsPresence (2002)
3. Milgram, P., Takemura, H., Utsumi, A. and Kishino, F. Augmented Reality: A Class of Displays on the Reality-Virtuality Continuum. In Proceedings of the SPIE Conference on Telemanipulator and Telepresence Technologies, pp. 282-292 (1994)
4. Siltanen S. Theory and applications of marker-based augmented reality. VTT Science 3. Espoo. Finland, in Press (2012)
5. Schuler, D. and Namioka, A. Participatory Design: Principles and Practices, Lawrence Erlbaum Associates, Inc., Hillsdale, New Jersey (1993)
6. Morgan, D.L. The Focus Group Guidebook, Sage Publications Ltd. (1998)
7. Carroll, J.M. Making Use: Scenario-Based Design of Human-Computer Interactions. MIT Press, MA, USA (2009)
8. Greenbaum, J. and Kyng, M. (eds) Design at Work: Cooperative Design of Computer Systems. Lawrence Erlbaum Associates, New Jersey, USA (1991)
9. Cassim, J. and Dong, H. 'Critical users in design innovation'. In Clarkson, P.J., Coleman, R., Keates, S., and Lebbon, C. (eds.) Inclusive Design: Design for the Whole Population, Springer-Verlag, London. pp. 532-553 (2003)
10. Buxton, W. Sketching User Experiences: Getting the Design Right and the Right Design. Morgan Kaufmann, San Francisco, USA (2007)
11. Kymäläinen, T. in Saariluoma, P. (ed.), Kujala, T., Kuuva, S., Kymäläinen, T., Leikas, J., Liikkanen, L. and Oulasvirta, A. Ihminen ja teknologia - Hyvän vuorovaikutuksen

suunnittelu, Teknologiateollisuus, Helsinki, Finland (in Finnish). Human and Technology (2010)

12. Kelley, T., and Littman, J. The Art of Innovation: Lessons in Creativity from Ideo, America's Leading Design Firm. Doubleday, New York (2001)

13. Siltanen, S. and Woodward, C. Augmented Interiors with Digital Camera Images. Piekarski, W. (ed.) In proc. Seventh Australasian User Interface Conference (AUIC2006); CRPIT. ACS. Vol. 50: 33 (2006)

14. Aittala, M. Inverse lighting and photorealistic rendering for augmented reality. The Visual Computer, Vol. 26, No. 6, pp. 669-678 (2010)

15. Hartl, A., Gruber, L., Arth, C., Hauswiesner, S. and Schmalstieg, D. Rapid reconstruction of small objects on mobile phones. Computer Vision and Pattern Recognition Workshops, IEEE Computer Society Conference, Colorado Springs CO, USA, pp. 20-27 (2011)