PAPER II

User-created interior design service concepts, interfaces and outlines for augmented reality

User-created Interior Design Service Concepts, Interfaces and Outlines for Augmented Reality

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ABSTRACT. In this paper we describe a design process and implementation requirements of an interactive interior design service system. To gain design requirements 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. 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 utilizing co-sketching as a means of obtaining user model of the interactive system. The technological aim was to create interior design concepts that exploited augmented reality (AR), 3D models and user-preferred 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 and several interface descriptions and use cases utilizing AR technology, plus consideration and evaluation of the AR functionalities.

Keywords: Design, interior design, computer-aided design, human-centred design (HCD), focus group, sketching, interfaces, augmented reality (AR), virtual reality (VR)

1   Introduction

The study presented in this article 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 series of case studies, which aimed at understanding the needs and requirements of the interior design service providers. Research was carried out by co-designing interactive user-centred interior design systems and interface concepts that utilized AR features. Co-design focus group sessions were arranged with interior designers and design bloggers – the anticipated critical users of the interior design system.

Before the co-design studies, the participants had taken part in a preliminary online survey, and were therefore 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, followed by presentation of the AR technology and existing AR applications. The participants evaluated the applications and considered the most useful features for the future service.

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 innovative, original and dissectible results. Participants provided also valuable design information during the discussions – mostly in the form of use cases – concerning the promising ways of utilizing AR technology in the service

concept. Central outcome of this research was to provide a framework for co-sketching user concepts with critical users. This framework may be utilized when designing complex systems, e.g. new interfaces and services.

2 User-driven Innovation and Used Methods

The process of this study falls under the methodological frame of participatory design, which generally aims at democratizing design, for example so that the people who will be affected by the systems should also be able to participate in and influence the design process [1]. When user research is carried out in the front-end of development processes, user's role may broaden up from mere research subject that comments ideas to an active co-designer [2]. Participants may be involved in the process by means such as focus groups, scenarios and early phase concept design [3–5]; methods which were all 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 [3] – in this study, the similarity was the participants' interest in interior design. Because of their experience, the participants were seen as critical users [6] of the future service.

The co-design process was pragmatically conducted by utilizing sketching as a co-design method, to provide means for users to create design outcomes of a complex design service system [7]. The sketching method appeared to be a flexible way of prioritizing 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 [8]. In previous studies sketching had verified to be an efficient, flexible way to quickly generate, develop and communicate design ideas [7].

3 Participants

A preliminary online survey, which preceded this study, data was collected from ordinary consumers (250 respondents) and interior design professionals and amateurs (36 respondents). The following two focus groups introduced in this study 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 consisted 3–4 participants, with 1–2 project participants in each group, and one evaluator leading the two-hour co-design session. One of the participants (P1) was an AR expert participating to the research project. 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.

Fig. 1. Focus group participants creating novel interior design service concepts.

Table 1: Participants of the first focus group in Espoo

Participant*	Age	Interior design experience	Familiar with 3D design programs
R1	42	Interior design blogger, interior design student	No
R2	34	Interior design blogger, degree in interior textiles	Yes
R3	33	Interior design blogger	No
P1	39	AR expert	Yes

Table 2: Participants of the first focus group in Tampere

Participant*	Age	Interior design experience	Familiar with 3D design programs
R4	27	Interior design blogger	Yes
R5	35	Interior design student, self-employed interior designer (renovator)	Yes
R6	49	Interior design teacher (redecoration & renovation)	Yes
R7	42	Interior design student	Yes
P2	36	Brokerage service provider	Yes
P3	40	Brokerage service provider	Yes

*Participants: R=Raters composed of interior design experts, P=Project participants

4   Chosen Key Technology: Augmented Reality

Augmented reality is defined as an interactive real-time system that combines real and virtual elements in 3D [9]. 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 [10]. Augmented virtuality refers to a system were real element are inserted to virtual environment. Mixed reality (MR) is a concept that covers all possible combinations of real and virtual elements, from reality to total virtuality [11]. From the user's point of view the functionalities of a system are more important than the technology categorization. The basis in all the discussions was an AR system in which real images are augmented with virtual objects. However, in the co-design sessions the discussion was open to all forms of combination and alteration of real and virtual elements, including all the above-mentioned technologies.

Fig. 2. With a mobile AR application the user can see virtual designs in real environment.

As the common level of understanding of these technologies is limited, not to mention the classification or demarcation between these branches of technology, we used only the term augmented reality for simplicity. The participants were encouraged to think about the functionalities of the system, and not the underlying technology for achieving it. For example, it was more important that they described a need for a possibility to change the colour of the wall, than to be able to describe such functionality to belong to mediated reality.

Augmented reality provides a practical visualization 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 [12]. 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. Besides, mobile operators provide affordable priced mobile subscriptions for data transmission. 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 a mobile device.

5   Pursuing User-driven Innovation Through Sketching

Before defining an effective framework for the study, we sought examples in which users had contributed to the development processes by using the means of sketches. As our more specific aim relates in how to design more complex systems, i.e. interaction- and service design concepts, the interest was also on how the multifaceted information should be delivered for users. The task for defining a framework for a study relates to the question of finding an optimal design process.

5.1   Studies Relating to Sketching

In many articles and literature references it is clearly pointed out that sketching provides means to access the thinking process [7, 12-15]. For example Gedenryd [14] claims that thinking and drawing are not at all separate cognitive processes – but thinking is simultaneous with the act of drawing. He explains further, that while thinking, designers transform the abstract principles requiring logical analysis into narrative or visual representations of the situation of use. Such representations are memorable, subjective and rich with details.

Bill Buxton has presented how creative and visual means may be exploited in user research in his seminal work "Sketching user experiences" [7]. He advocates the role of design in user research processes and claims that in those processes currently design is limited only to styling and usability. The act of sketching is more like problem setting and problem solving, as we already learned from the previous argument from Gedenryd. The most constructive part of Buxton's effort was that he provided characteristics of sketches. Sketches are e.g.: quick to make; they are timely, inexpensive; they have clear vocabulary and distinct gesture (they are open and free); they have minimal detail, and they suggest and explore rather than confirm, and the ambiguity of sketches provide new relations to arise. Buxton explains further that sketches are only by-products of the sketching activity. This leaves open the question how much it is possible to analyze users' sketches and whether or not there should be supplementary material alongside the sketches. He emphasizes yet that sketches are not prototypes; i.e. they might be used as complementary means for the front-end design processes, as one might interpret from his argument. Buxton concludes that it is worth the effort to engage users to the design processes, rather than trust merely in a group of designers, because "there are more than one futures".

In a throughout study of a touch-sensitive house climate control system Tohidi et al. [15] present an illuminating example how users' sketches are engaged in a usability study of an interactive device. The study employed 48 participants, which formed four separate user groups. In the initial phase of the study, participants gained a lot of information about the system. From the sketched material it was possible to analyze that the less participants reflected to the original design, the less successful they had previously evaluated it. But the most significant fining was that the multiple design condition sketches, provided by only one of the four groups, were much more rich in detail and there was more variation in them. The research group came to the conclusion that users' sketches provided more reflective feedback, and that sketching, as a method, was efficient, effective and satisfying way to conclude the study. This study acknowledges that it is worth to provide users with multifaceted, yet carefully selected, information.

In the study of Dorst et al. [16] provides empirical data on design processes from a set of protocol studies. Nine experienced industrial designers took part of the study by providing sketched material for further evaluation. The task was to create a concept for a 'litter disposal system' in a new Netherlands train. All the necessary information was prepared in advance in the design brief, which contained "natural amounts of vagueness and inconsistency". The designers were asked to provide sketches of the task and they were interviewed afterwards. Designs were then evaluated on the overall quality and on a variety of aspects. The scoring categories were: creativity, aesthetics, technical aspects, ergonomics and business aspects (in random order). In the last run-through, the reviewers were asked to give a total judgment of the concepts. This study showed how it was possible to analyze sketched concepts and apply quantitative methods for interpreting sketches. However, this method might not apply conclusively in any other design studies. In addition, this method required that experienced designers produce sketched concepts.

These studies provided evidence that sketching was a well-adapted method in the field of user research and sketching method might be applied for both interface design as well as service design. However, these studies do not consider sketching to be used as method for designing more complex or new domains; e.g. complex interaction applications and design services.

5.2   Defining the Structure For the Framework

George Pólya provides means to pursue the process in his widely quoted seminal work "How to solve a problem" [17]. According to him, at first, we must understand the problem. What was significant in his strategies for out study was that he also suggested that a diagram or picture might assist in understanding the initial problem. Then came the part of devising a plan, and he continued that this phase was also possible to exemplify by drawing the proposal. Then pursue went on by executing the plan, and after the process it was necessary that the plan is reviewed and extended.

Turkka Keinonen has illustrated four main concept design phases [18] that may be exploited in the co-design of more complex systems:

- Collation of information
- Interpretation of the information
- Description of the activity
- Description of the concept

These guidelines are meant for user-centred design processes that are conducted by a designer or a facilitator. In our study the facilitators of the co-design sessions are responsible of collation of information and partly interpretation of the information. It is left for the participants to find the description of the activities and finally delivering the concept.

For the overall process we may yet find most accurate process description by Ben Shneiderman [19]. According to Shneiderman, there are three levels of creativity: everyday, evolutionary and revolutionary. The creativity relating to the framework we are pursuing, is mainly concerned with evolutionary creativity. Shneiderman has proposed a process description under a title "Mega-creativity", which, according to him, means that more people are enabled to be more creative more of the time. He presents following set of tasks for Mega-creativity:

1. Searching and browsing digital libraries (the Web) and other resources
2. Visualizing data and the whole process to understand and discover relationships
3. Consulting with peers and mentors for intellectual and emotional support
4. Thinking by free association to make new combinations of ideas
5. Exploring Solutions – scenarios and simulation models
6. Composing artifacts and performances step by step
7. Reviewing and replaying session histories to support reflection
8. Disseminating results to gain recognition and add to the searchable resources.

For our study it was important that the participating users had only the most significant information about the content they were expected to illustrate. It was facilitators' responsibility to search for the meaningful information and make logical representations of the information. Consequently, facilitators were responsible of the first two tasks that Scneiderman presented in his framework. The third task was important, as in our case, this was the part in which the co-design participants could review, discuss and validate the information and confirm that they understand the design task appropriately. Sketching the

concepts included the tasks 4-6. It was also important that other participants reviewed the sketches, which could be be refined and discussed upon. Disseminating the results is the final task for the research group.

5.3 Concluding Framework for Co-sketching User Concepts For New Interfaces and Services

Based on the literary findings we propose following framework for co-sketching user concepts for more complex and new domains, including system-, interaction- and service design. Steps of the framework are:

Research group:

- Collation of information about a specific context
- Specifying information meaningfully
- Providing description of the concept, presenting the information

Participants:

- Sketching the conceptual models (system/interface/service)
- Co-design: Collation of the information and brief interpretation
- Sketching with more specific objective (a specific part of system/interface/service)
- Co-design: Defining the criteria and interpretation of the user-driven information

Research group:

- Interpretation of the user-driven information
  - Analysis of the sketched material
  - Other relevant descriptions (use cases)
- New description of the concept

The framework is intended to cover the front-end of an innovation process. For a successful co-design process, the roles of each participant should be clarified implicitly. These set of tasks define the roles of the facilitators and the users. The designer's role is most influential in the first and last design phases, which requires knowledge and thinking of a designer [20] when s/he facilitates the co-design sessions and interprets the results. The framework that we propose here differs from previous proposals in that it does not require laborious user involvement before the focus group session than e.g. the use of probes [21] does, and it does not have time-limited co-design phases such as e.g. the dialogue-labs method proposed by Lucero et al. [22] embraces. At the end of this article we refine the framework more carefully according to the findings of our case study.

6 Set-Up For the Introduction

After collating the information about the interior design service system and specifying that information, our research group came up with a well-defined description of the concept. The definition statement of the service concept for the focus groups was:

'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. In addition with the concept definition participants were familiarized with the service in the introduction phase by presenting pre-made scenarios, benchmarked applications and some results of the preliminary online survey, which was collected from ordinary consumers.

6.1 Presented Scenarios

A widely adopted method exploited in our study was written and illustrated future scenarios. The presented scenarios were short, written descriptions of possible futures comprising interior 3D and AR design services and the use of technology with interior designers and their customers (see Fig. 3-5). Scenarios were used as a source of inspiration for focus group participants, because they introduced personas of hypothetical users with presumed needs, and encouraged to think about the service concept. As all participants had taken part to the online survey, they were familiar with the scenarios and the service

concept. Three selected scenarios were: scenario 1.) Young couple is looking for first home; scenario 2.) Couple is moving back from abroad (and are making interior design for new home); and scenario 3.) Interior design contest for design bloggers.

Scenario 1. Young Couple is Looking For the First Home

A couple in their mid twenties is looking for a new home from a popular area. They wish to find a nice two-three-bedroom apartment. They both have their own smaller apartments with furniture. The challenge is to fit in all their dearest belongings to the new apartment. When choosing the appropriate apartment, the couple has many discussions to make how they are going to fit in the furniture and what kind of new furniture they need to buy.

Fig. 3**.** Young couple is looking for first home.

Scenario 2. Couple is Moving Back From Abroad

A construction company, a home furnishing store and some interior design stores are organizing a campaign to promote sales of new luxury apartments. During the campaign, discounts are offered from a wide range of interior design and furnishing products and materials. A Finnish couple living abroad notices the campaign. They have been living abroad over twenty years and are now considering to moving back. They want to things as easy as possible. The wife has made some interior design plans with the help od an interior designer and they have contacted various service providers with the help of the service.

Fig. 4. Couple is moving back from abroad, and they are making interior design for new home.

Scenario 3. Interior Design Contest for Design Bloggers

'3D and AR interior design' service is organizing a contest concerning new homes. Five popular decoration bloggers/interior designers are designing the interior of similar three-bedroom apartments in a new terraced house with the help of the service. The bloggers have a wide range of different home furnishing products available for the virtual design to make any styles they like. Several home furnishing products companies offer downloadable models of their products. Customers can follow the construct of five different plans, comment the solutions and share the links for their friends. The most enthusiastic customers can make their own versions of the decoration plans and share them with their friends.

After a very tight and controversial contest the winner is announced: simple Scandinavian functionality beats romantic vintage country style. The winning designer is rewarded. The winner's interior designs are actually so popular that a couple of apartment buyers end up making their home furnishing according to the visions of the winner.

Then the styles of the contest are saved in '3D and AR interior design' –service. Many users are especially interested in winning home furnishing products and while browsing the furniture, users are able to see other related products in the service.

Fig. 5. Interior design contest for design bloggers.

6.2   Presenting Example Applications and Results of the Survey

After evaluating scenarios, participants were introduced with three existing example applications that provided interior design services. Most of the participants had at least some experience of using virtual designing or furnishing programs before. They have used or tried several different programs for planning for themselves and for the customers.

The research group had benchmarked these selected applications for the focus group. The participants saw only layout images of existing 3D- and AR applications and they were given a short description of the benefits and similarities to the hypothetical future service concept. Participants were encouraged consider primarily the most essential features of the applications by keeping in mind the future design service concept. Furthermore, participants were encouraged to consider predominantly about the most essential features of the forthcoming application that would be useful for their field of expertise.

After presenting scenarios, focus group participants were familiarized with results of the survey. The participants paid particular attention to a table, which presented the results of most high valued products of the service (see Table 3.). It was seen important that participants had the impotant products selected by the customers available while creating they ecosystem discriptions. The table presented most important products to be: wallpapers, paints, plaques; floor materials; furniture; immovable furniture; storage places and interior textiles.

Table 3. Table presents most important interior design products determined by 250 respondents of the preliminary online survey.

	Value: 5 (5 = ext. important)	Value: 4	Value: 3	Value: 2	Value: 1 (1= not important)
Wallpapers, paints, plaques and other surface materials (avg: 4,61)					
Floor materials (avg: 4,67)					
Furniture (avg: 4,44)					
Interor textiles (curtains, carpets etc.) (avg:4,28)					
Interor supplies (e.g. candles, vases) (avg: 3,33)					
Lamps (avg: 4,39)					
Home electronics (e.g. TV, HiFi, computers) (avg:3,44)					
Faucets, sinks, lavatory goods etc. (avg: 4,39)					
White goods, immovable furniture (avg: 4,56)					
Repository, cupboards (avg: 4,44)					
Mirrors, pictures, decorations (avg: 3,22)					
Shelves (avg: 3,89)					
Tableware (avg: 3,00)					
Domestic appliance (avg: 4,22)					
Building material (e.g. floor drains, valves etc.) (avg: 3,56)					
Altogether 100%	40%	33%	20%	4%	3%

7 Set-Up of the Co-design Session

The co-design phase included two phases and two sketching tasks: the conceptual models of the ecosystems of the service and sketching with more specific objective: the interface proposals of the service. 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 was encouraged to produce a sketch of the ecosystem in the form of a flowchart. The descriptions were expected to include:

- All necessary stakeholders and elements (products, services, technologies);
- How all stakeholders and elements were connected to the ecosystem, and
- 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 [23]: color 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.

8 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, interface descriptions and the participants' AR use cases with detailed considerations.

8.1 Comments Relating to Scenarios

Pre-made scenarios were first presented, discussed and evaluated in the focus group sessions. The preference of interior designers for using very simple design tools in the presented cases was emphasized 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 color. It was considered reasonable, however, for color to be merely suggestive – e.g. fair, mid-dark or dark – to give an impression of the overall design. Furthermore, participants thought that placing old, existing furniture in the design was even more important than buying new furniture through the service.

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 artifact 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. Sharing design plans with a wider audience, or with friends and family, were seen irrelevant. The participants who were design amateurs were pleased by the idea of the scenario – presenting a home decoration contest (see Fig. 5) – perceiving that the special knowledge and expertise of interior designers and design amateurs could be fully utilized through the contest.

8.2 Comments Relating to Results of the Survey and Example AR Applications

Participants subsequently evaluated some results of the survey they had all responded to. They paid especially attention to a table, which presented the results of most high valued products of the service. The groups agreed on most of the products to be important for an interior design service, but they remarked that the product categories of the service would depend much on the nature of the task. For example a renovator requests different categories than an interior designer. The participants wished this table to be seen later, during the co-sketching of the service ecosystem.
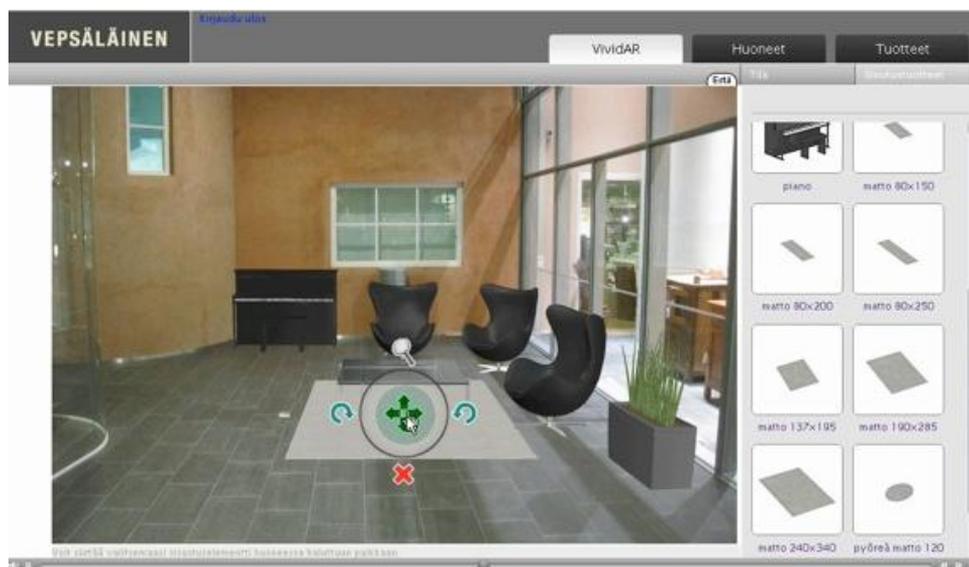

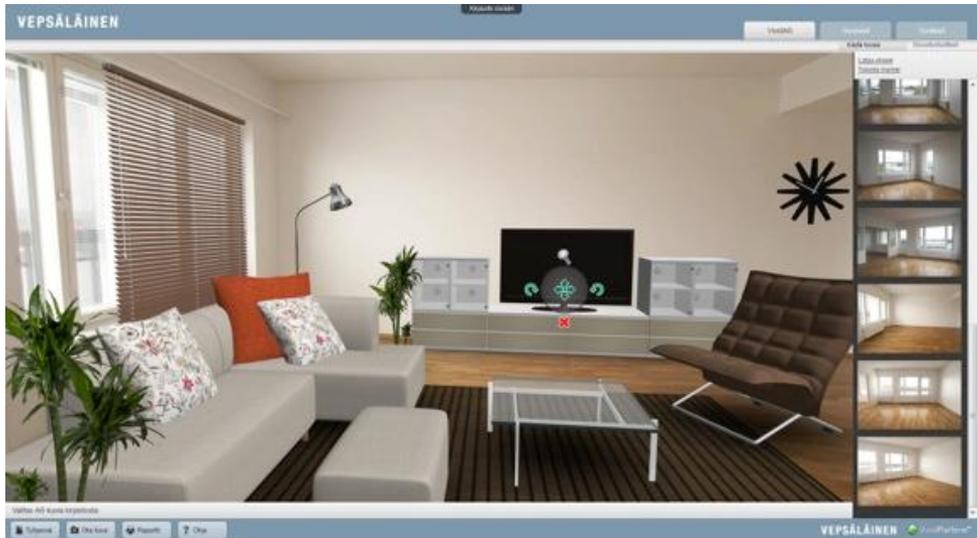Fig. 6. An interior application that utilized AR technology by VividWorks Ltd[1].

Fig.7. Another example of an interior design application.

Then Participants 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.

Participants evaluated presented applications in detail. The most important comments related to the visual appearances: the aesthetics. Participants emphasized 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.

As much as the participants valued the idea of interior design contests, the design competitions in these particular example applications seemed to lack the 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.

8.3   Sketches of the Service Ecosystem

After the introduction phase, participants created system concepts in pairs and presented them to each other. The pairs considered the most important factors of the service together with another participant, who was not acquainted. The following examples illustrate the ecosystems and shows how they were used as sketches of thought. Figures 8 and 9 are constructions of the models participants created in Finnish, and they present interpreted information of the models.

Figure 8 presents an example of a concept made by one of the pairs (pair 2: R3 + P1). 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.
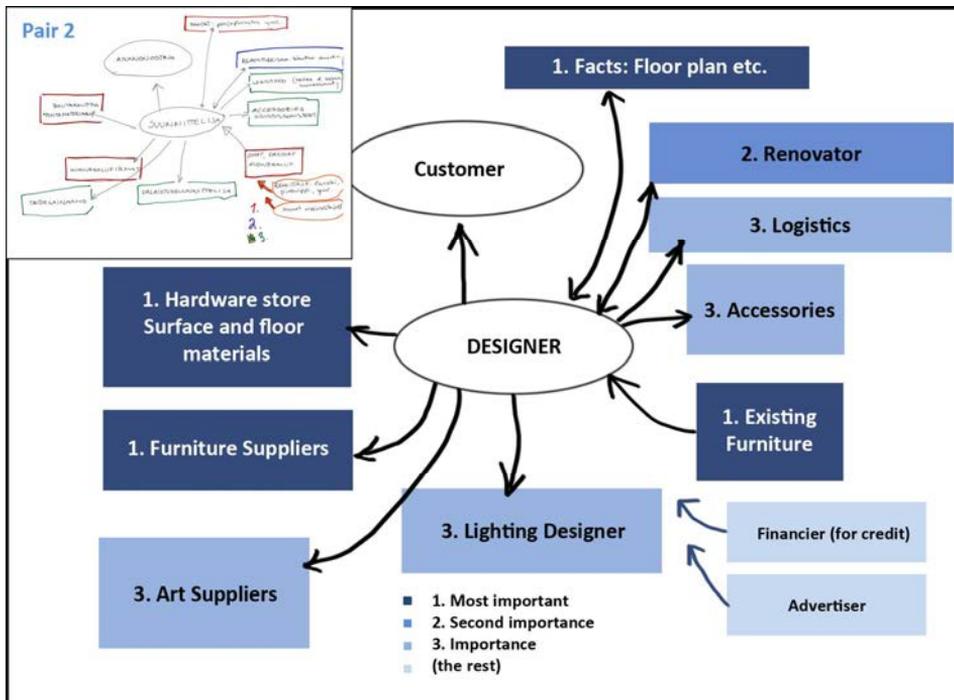
Fig. 8. Service ecosystem made by pair 2: R3 + P1. Participants' sketch is in the upper left corner *(in Finnish)* and reconstruction presents the importance of the factors.

Pair 1 (raters: R1 + R2) explained that in this design-driven service, the customer and designer have two-way relationship, when they are creating interior design plans for multiple purposes (see Fig. 9; bottom, left). They emphasized that the most critical design phase occurs after an apartment has been bought and the service should be designed taking account the matter. Key service providers were the hardware stores, do-it-yourself shops and interior decoration providers. Furthermore, the furniture providers may offer a piece of furniture as well as ready-made collections through the service, and it was seen important that the product providers updated accurate information about their supplies. It was highly important that the overall supply of the products in service was satisfactory. This pair recited that most intriguing attraction for designers, and especially for design amateurs, would be the design competitions, which would be shared by social media.

Pair 3 (raters: R4 + R5) explained that the most important part of the service concept was the customer who determines the target situation, the budget and the most important needs (see Fig. 9; bottom, right). The needs of the service may vary from simple styling to more profound renovation. The first task was the call for bids for suppliers, service providers and HPAC-planning (heating, plumbing, air-conditioning). In an interior design process, the most important part was stated to be the mood and the impression – and thereby the providers of wallpapers and interior textiles deserved a strategic role.

Pair 4 (raters: R6 + R7) explained, that in the service system, at first, the customer determines individual needs and functions of the interior plan (see Fig. 9; top). First operation would include typing in the square meters and the budget - a few criteria that the user (customer) of the service could determine by her/himself. Most important suppliers would be the providers of the surface material, furniture and lightning i.e. hardware stores and decoration shops. The overall supply of products must be wide-ranging and there should be different alternatives for various price scales. Also the special/unique artifact suppliers could easily offer their products through this service. Additionally, timetables of the service providers should be accessible, i.e. private entrepreneurs could notify their availability. There should also be direct contact information for boards of construction. Users of the service in turn could comment about the services by e.g. granting stars for good service. In this case recycling meant that e.g. a customer could save money by taking care of the demolition work.
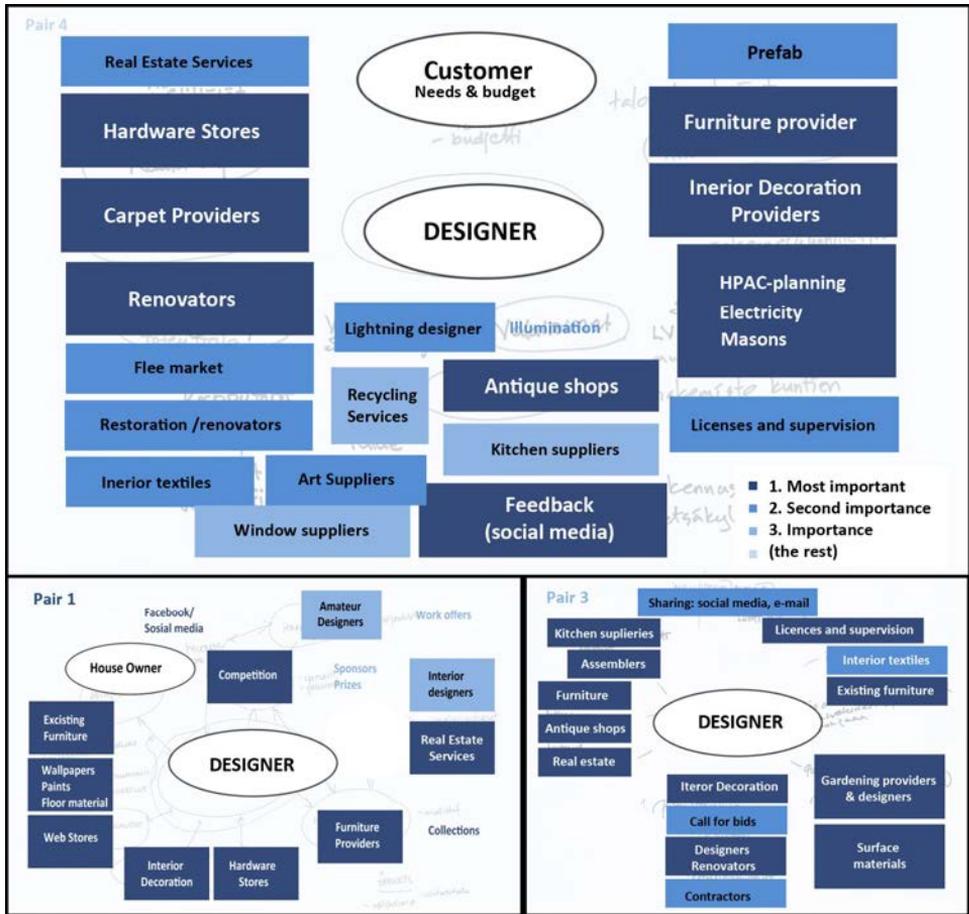
Fig. 2. Reconstructions of the ecosystem sketches made by pairs 1,3 and 4.

Table 4 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, different color, or 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.

As novel ideas, participants emphasized 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 emphasized the importance of old, existing furniture in the service, but the it nonetheless failed to receive the full amount of points in the analysis.

Table 4. Results of the service ecosystem sketches. If all pairs *(1–4)* thought a service was most important, the service received 12 points.
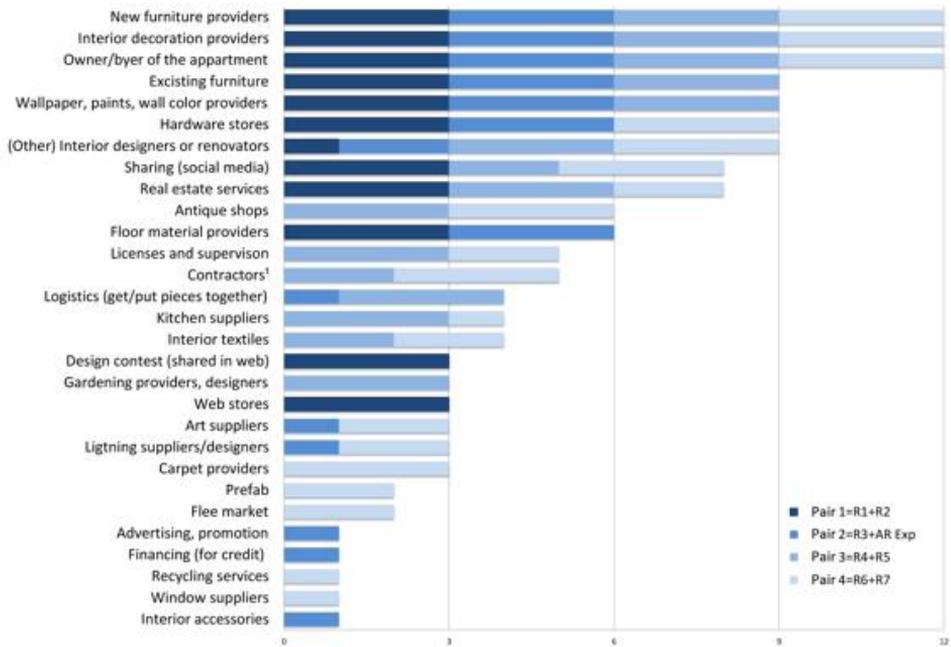

¹ Contractors = e.g. HPAC-planning, electricity, masons

8.4   Sketches of the Hypothetical Service Interface

After sketching the service ecosystem, the focus group participants (R4-R7) concentrated on thinking about the service concept further by sketching individually the service interface. Their assignment was to create the entering page of the hypothetical service application, by employing the ecosystem descriptions. After designers had finished drawing their sketches, they explained the content to other participants, one at a time.

Participants' sketches of the service interfaces are explained in this article thoughtfully. They provide individual, very aesthetic, examples of the approaches for developing further the service interface that were created from each interior designers' point of view, and were based on their own experiences. In the following are the verbal descriptions and sketched interface concepts of the participants.
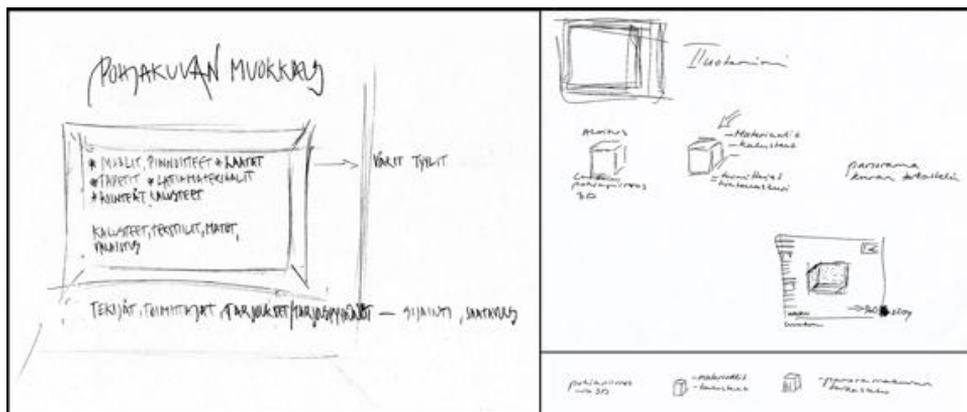
Figure 10. User interface from participant R4 and R7.

The participant R4 explained the interface she created (see Fig. 10; top, left) as follows:
"All the main elements should be available in the service by one glance, plus the name of the service and a stylish picture. The first task is to operate with the 3D plan (at first select or load it). The floor plan is always at the center of the layout. Further actions the user may select from any category: materials, furniture... When the materials and furniture are being added to the plan, there is a price counter at the corner, so that the user knows when the budget has been exceeded. When the plan is finished, user may review it from a panoramic 360-degree view. For it is only that way possible to see if there are any mistakes in the design. And then it should be possible to go back and re-design the plan."

The participant R7 explained her interface concept (see Fig. 10; bottom, right):
"Selecting the floor plan is the first operation in this service too. It should be very simple to import one's own plans to the service. The following step is to select the paints, coating, wallpaper and immovable furniture. After that, there are rest of the furniture, textiles, carpets and lightning. After the user has selected paints or coating, there is a selection of colors and styles. All the time, it should be easy to toggle between 2D and 3D plans. In the service, the contact information of the service providers should be clearly attainable, the location and availability of the providers and the possibility to submit invitation for tenders."
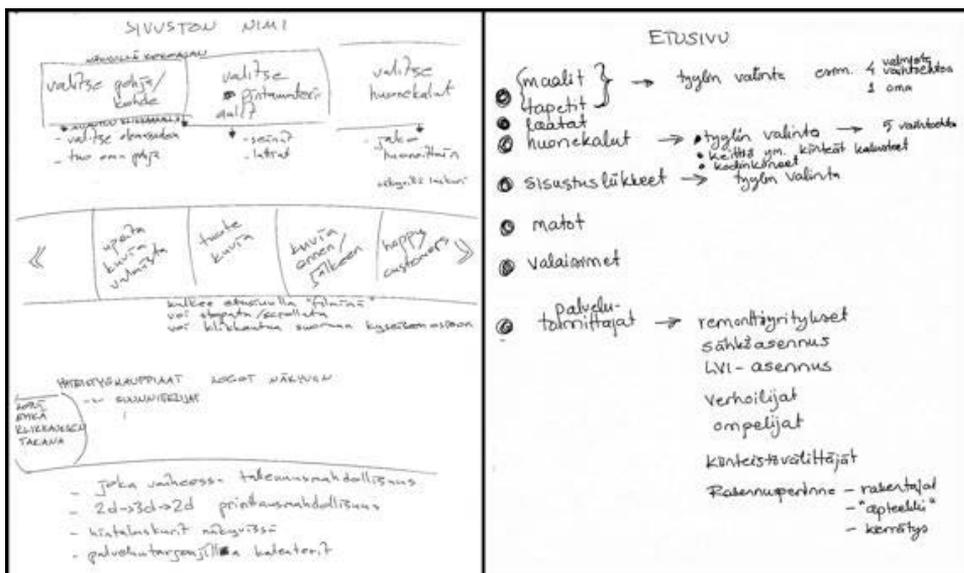

Figure 11. User interface from participants R5 *(left)* and R6 *(right)*.

The participant R5 explained her interface concept (see Fig. 10; top, right):
"There must be clear, large buttons for "grandmas" - I like them like that. At first, the user selects the 3D plan, by either bringing it in to the service or selecting a suitable one. When processing the plan, user first chooses the walls, or any other surfaces - there is a simple menu bar from witch to choose the materials. After that comes the furniture. There should be only three steps for working with any kind of design. The plan should be allowed to be saved in any phases, because the work might be interrupted (if a child wakes up, for example). Then there should be two alternatives for publishing: one for the designer (more like a storing place), and another, public place. But there should be restrictions with the latter one also: it could be published to friends, customers or anyone.

In addition, there should be a film roll of pictures – so that the service is more attractive. In the film roll there could be images of furniture, product- and service providers and design plans made by users. It is possible to stop the roll at any time, and look more closely at the interesting pictures, and find all the information relating to it. These kind of mood creating images are very important when communicating with customers."

The participant R6 explained her interface concept (see Fig. 10; bottom, left):
"There are seven main categories where to start, arranged by the products - except the last one, which lists all service providers. When the user is proceeding with a choice of product, s/he first selects the style. There are e.g. four default styles (country style, modern etc.) and one that the user has created, and the selection guides all the browsing activities. User selects e.g. the furniture; and it is possible to select also the immovable furniture, or the white goods, as they are usually integrated with the immovable furniture.

Interior decoration shops are in their own category, because they usually provide different kind of products. Service providers are e.g. renovation firms, assemblers, upholsterers, sewers and real estate agents. The traditional building trade is one category too."

8.5 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 emphasized 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 visualize 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 visualize 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 colors 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 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 color, 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 color, style and size. Typical situations were described as e.g. *"I need a chair of this size…"* or *"I want a reddish couch…"*

The use cases that the participants ideated brought out both desktop and mobile use of the service. On one hand, they described situations were the service was used on site to visualize something. On the other hand they described use scenarios where the service was used on desktop manner, e.g. the pictures taken on site were later augmented by using the service. There were no preferred devices, or preferences concerning mobile vs. desktop use.

9 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 [24].

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 [23], 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 [25].

Participants did not have any specific discussion concerning the technological devices. However, some requirements came up indirectly; the visual effects and graphics needed to be good quality, and the display needed to be large enough to present the interor design visualizations. The performance, the graphics driver and the display, are easily dealt with in PC environment. However, in the design of a mobile service, the end-device and its capacity, needs to be considered. The service might do more processing on the server side and actually the only requirement for the end-device would be adequate data connection and suitable display, common attributes of modern tablet-PCs, for example.

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.

Altogether, Augmented realty (i.e. features using images of a real apartment), were considered beneficial for interior design and small renovations. For massive renovations and new construction, totally virtual 3D design service might be more beneficial.

10   Framework for Co-designing Complex Systems

Focus group evaluations and co-design sessions provided adequately new information for further design and development of interactive interior design services that utilize 3D and AR technology. The presented research case study provided information for a genuine purpose, to tasks that were initially set by the research program and partaking companies. The process proved to be successful, if it is measured by the quantity of ideas and quality of the new ideas. Since the participants' interior design expertise was extremely high, they were able to create several new, aesthetic ideas for the interior design system concepts. Encouraged by the results of the study, we propose the following framework for utilizing several innovation methods when co-designing multifaceted concepts with users for e.g. system-, interaction- and service design purposes:

Pre-co-design phase

- Defining the concept - with all the relevant stakeholders involved
- Collation of information about a specific context (e.g. by benchmarking applications)
- Specifying the information meaningfully and as a result, constructing stories or scenarios
- Defining the end-users and critical users
- Gathering quantitative information e.g. by organizing a preliminary online survey for both/all groups
- Redefining the concept

Co-design phase with critical users

- Presenting the information, in this case:
  — The concept definition
  — Pre-made scenarios
  — Benchmarked applications
  — Results of a survey, presenting wider sampling
- Co-sketching the conceptual models of the system/service
- Collating and sharing the new information and interpreting results
- Sketching with more specific objective (a specific product/system/service)

Post-co-design phase

- Defining the criteria and providing interpretation of the co-design material
- Redefinition of the concept, including all stakeholders

Co-designing the concept in the initial phase of the design process, with the contribution of all participants, assist in creating an experience-based structure for a forthcoming future service or system. We believe that this design-led (design-related) study provided somewhat optimal conditions for trying out the proposed

framework, but the framework itself is suitable for multiple purposes, especially for multifaceted design processes.

11   Discussion

This article illustrates a user-driven innovation process for designing new concepts, interfaces and outlines for augmented reality in the field of interior design. The outcomes of he process are described in detail, because the information gained by conducting the two focus group evaluations may benefit many audiences: several stakeholders operating in the interior design field, software manufacturers of various fields and any parties interested in employing augmented reality features in many environments.

Table 4, the results of the service ecosystem sketches, presents the conclusions of the co-sketching phase in which all the participants took part of. The sketched ecosystems held all the important elements of the novel interior design service, and as the table shows, participants thought that the new furniture and interior decoration providers were the key factors of the service. It was significant, that all participants emphasized the importance of old, existing furniture in the service. However, some participants speculated that there might not be any party interested in providing such a service. This article tries to raise issues of this kind in front and present the unobvious demands of the interior design field.

The participants perceived themselves in the co-design situation as ambiguous designers, but they all mentioned the importance of the customer relationship. The service was created in this study from the viewpoint of the designers, but it was considered that different kind of design, constructing and renovating designs require different kind of approaches. In that sense, it is highly important who are considered to be the users of the service – the fact influences how the service and the interface should be designed. Also, all of the participants mentioned the other designers, competitors or designers with different expertise, and call for bids to have influence in a usable service. The participants highlighted some new providers to be concluded in the service: e.g. kitchen-, window- and carpet providers, antique shops, flee markets, art suppliers, gardening-, lightning- and 3D-model designers of existing furniture. In this viewpoint, the service could act as a cluster for smaller providers.

12   Conclusion

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 modeling 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 [26]. In future interior design services, the user is expected to scan the interior environment effortlessly with a mobile device, and even obtain modeling of an existing item of furniture.

As novel ideas, participants emphasized that the price of furniture, material and accessories were one of the most essential features of the concept. Therefore, it was seen to be important that it was clearly visible how much all the new furniture and design alterations would cost all together. Also one group remarked, that in addition, the customer could apply for loan from a credit provider by making reference to the estimation of the service. 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.

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. The results of the service ecosystem sketches presents certain evidence that it is also conceivable to analyze 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 judgment's by referring to their sketches. For pursuing user-driven innovation concepts through sketching, according to this study it is justifiable to say that critical users together with facilitators and developers can contribute to the development process by a sketching method, if they have sufficient and properly formed information. Moreover, the sketching

method has enrichment value when pursuing the human-driven part in design processes. Justification for using the framework of co-designing complex concepts we presented in this article is, that:

- User role broadens from research subject that comments ideas to an active co-designer
- Users design ideas provide complementary material in the initial design phase for developers
- The general acceptance of the idea can be evaluated and alternative designs can be compared to each other
- Design decisions become more explicit and easier to comment on
- Users' goals and needs can be defined in terms of current and envisioned new practices

Already in former studies, sketching approach was learned to be an efficient, flexible way to quickly generate, develop and communicate design ideas. In our study, user's sketches were used as tools that may be used for further conception. The further use will illustrate whither sketching, as a method, will provide usable approach to perceive the users' conceptual model of more complex design processes, such a service design process.

Focus group user evaluations and co-design sessions provided adequately new information for further design and development of interactive interior design services that utilize AR technology. Since the focus group participants' interior design 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.

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