"living-room"
Interactive, Space-Oriented Augmented Reality

Roderick Galantay, Jan Torpus, Maia Engeli
University of Art+Design Basel
Vogelsangstrasse 15
CH-4058 Basel
+41 61 695 67 71
[r.galantay, j.torpus, m.engeli]@fhbb.ch

ABSTRACT
living-room is an augmented reality (AR) installation developed to study interactive, space-oriented AR-scenarios. The installation consists of the living-room box, a room that is three by three meters, as well as hardware and software components to record the user's view and enhance it synthetically. Four scenarios have been realized and analyzed regarding the aspects 'Real and Virtual', 'Interaction' and 'Scenography'. A survey with visitors has been conducted and plans for the next phase of the project developed. living-room is a new kind of media and our focus is to develop design principles for this environment and to identify its "essential properties" [7].

Categories and Subject Descriptors
H.5.1 [**Multimedia Information Systems**]: Artificial, augmented, and virtual realities, J.5 [**Arts and Humanities**]: Fine Arts, Architecture, Performing Arts.

General Terms
Design, Human Factors, Experimentation.

Keywords
Augmented reality, design research, art installation.

1. THE LIVING-ROOM IDEA
living-room is an installation for exploring interactive, space-related aspects of augmented-reality (AR). The motivation for this project originated from the recognition of the limits of 3D representations on the computer screen and the realisation that it is not the perfect simulation that is inspiring for a user, but the adequate form of representation that can stimulate perception and imagination. The project focuses on space, because of an interest in looking at AR in relation to the spatial situation of the user. Most current AR research focuses on enhancing specific objects or places by adding synthetic objects or overlaying specific information. However, living-room aims at enhancing the whole spatial context.

Military, car-. airplane- and machine-industry, and medicine are currently the main areas for AR research and development. Our space-oriented approach is aimed at art and design fields like: architecture, interior design, or scenographic design.

Three hypotheses were formulated at the beginning of this project. 1) In order for AR to become a commonplace technology its defining qualities have to be identified. These include technical aspects on the one hand and design aspects on the other. 2) AR can offer more than the simulation of future physical modifications. AR can generate its own kind of realities by blurring the boundaries between the physical and the synthetic. 3) AR will offer numerous applications for different design disciplines like architecture, interior design, scenographic design, fashion design, and art. Not just as a tool, but also as a new media.

These goals were envisioned as follows: A mobile space should be built as a laboratory for artists and designers. The realized projects will help to identify design principles and issues of the perception of the enhanced space. The projects will also help to explore and discuss the meanings of different levels of abstraction and to what degree they are stimulating for the user. A user survey and study of user behaviour was also thought to be crucial to gain further insights.

In addition to the issues related to design and perception technical questions have to be addressed as well, like: How can the living-room idea be realized technically and which level of technical quality is necessary to achieve a break through for this kind of AR?

2. TECHNICAL DESCRIPTION OF THE INSTALLATION AND THE INTERFACE

2.1 Physical Setup – The living-room Box
Since it was our main goal to investigate the design of interactive, space-related aspects of augmented reality, the design of the physical space, within which the research is going to happen, was an important starting point. living-room was designed to start as a lab for research and to later become an interactive box with it's own identity for which artists, designers or students can create real and virtual content. In this initial phase we were reminded of our own childhood: Crawling into cardboard boxes, painting them with crayons and augmenting them by pure imagination into houses, spaceships, boats or fire trucks. As a matter of fact the living-room box was constructed with lightweight cardboard panels, assuring easy dismounting, transportation and remounting. It

MM'04, October 10-16, 2004, New York, New York, USA.

has three closed walls and an entrance as well as a large window on the front side.

Figure 1: The living-room box

The large window makes it possible to watch the visitor inside of the living-room. This is important for different reasons: The window enables the communication between the authors and their test-visitors while creating and fine-tuning scenarios. Outside spectators are able to understand the actions and motions of users, by also simultaneously viewing the 23" screen, displaying the user's view of the augmented scenario. From the interior the window provides awareness of the outside space and spectators providing an important connection to the reality beyond the living-room box.

As a future project idea the cubical form could also be stacked, connected or multiplied, virtually or real, like the cubic spaces in Vincenzo Natali's Movie "The cube". This would allow multiple authors, and users to interact simultaneously with each other and with different spaces thereby overcoming the limitation of the 3x3x2.4 meter box.

2.2 Position Recognition and Devices

Since our financial resources were quite limited for the initial setup, it was not possible to start with a preferred, exact magnetic, ultrasonic or hybrid position tracking system. Instead we tracked the user's position visually with the augmented reality tracking toolkit ARToolKit available as opensource library from the HITLab (University of Washington) [1].

Two firewire cameras are recording the user's view. The image of one camera is sent to ARToolKit. The position information (x, y, z, pitch, roll, and yaw) calculated by ARToolKit is communicated over sockets using the OSC (OpenSoundControl) protocol to the augmentation software. The signals of the second camera are sent directly to the augmentation software, where the overlaying with audio-visual information takes place. The augmented image is then shown in a Head-Mounted Display HMD (see Figure 1), which also has stereo headphones to play the sound. The whole set of applications for living-room runs on a 1.2 GHZ dual processor Mac G5 with 1.5 GB RAM.

The characteristic ARToolKit-markers, needed for the calculation of the position, were printed on wallpaper and mounted on three walls of the living-room box. We experimented with different spacing and sizes of the markers and it became obvious that more and larger markers improved the position recognition considerably. A script was written to generate the wallpaper, since it would be very tedious to mount every marker individually on the walls of the physical living-room. The script, written in Perl, on the one hand generates the postscript files to be plotted, and on the other hand generates the marker configuration file, with the position information needed by ARToolKit. Different parameters can be set in the script, i.e. the size and number of markers and their distances from the edges. Currently we have mounted five markers in height and six or seven along the length of the walls. Floor and ceiling are markerfree. Because of the small size of the room, there is no need to look further down or up than the lowest or respectively highest row of markers.

The wallpaper became the dominant visual element in the interior of the living-room box. On the one hand this underlined the laboratory character of the setup and on the other hand the necessity to have as many markers as possible visible at all times became limiting in the design of the AR-scenarios. No physical objects could be placed in the space, because they would have occluded some markers and lead to a loss of position recognition.

The visual tracking with ARToolKit unfortunately had severe shortcomings regarding precision and steadiness. Nonetheless it was sufficient for a proof of concept.

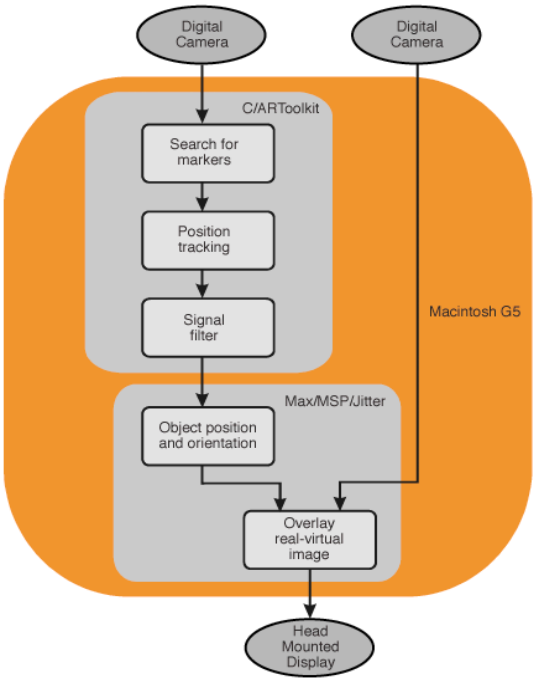

Figure 2: The living-room schema

2.3 AR-Scenarios: Augmentation with Max/MSP/Jitter

Since the main research interest of the living-room project is interactive, space-related AR, the goal was to implement a number of AR-scenarios and apply an iterative research method to identify and focus upon important issues. Therefore appropriate software had to be found.

After testing several hard- and software setups the application Max/MSP/Jitter has been chosen for the purpose of visually augmenting the video image of the real space. The software has to be capable of superimposing virtual objects on top of the streaming video image at the correct position with respect to the user's viewpoint.

The augmentation software has to add or modify objects, colours, motion, textures, lights, and sounds. It is the tool that the artists and designers use to develop interactive scenarios that react to the user's actions, influence space and time and may have narrative or game-like content. Max/MSP/Jitter has a number of advantages and disadvantages. The advantages are:

- It can superimpose 3D-graphics on a video backdrop.
- It has a graphic interface for developing the scenarios without the need to write programming code.
- It offers a number of 3D primitives.
- It has import functions for 3D-models.
- It offers real-time manipulation of Quicktime video, 3D-models and sound parameters.
- The virtual camera parameters can be easily adjusted according to incoming coordinate data from ARToolKit.

Jitter is a very young addition to the music software Max/MSP. Jitter came out in September 2002 and has not yet been developed very far, especially in regard to Open GL performance. Some disadvantages of using Max/MSP/Jitter for the living-room AR-setup are:

- The frame rate drops rapidly with complex 3D-animations or when using video or big graphics.
- There are very few 3D-parameter changes possible.
- The import function for animations is not satisfying. There are import problems using different 3D-formats and no import options for models with nurbs.
- There are no tools for dynamic or physical simulation like kinetics or gravity.
- There is no possibility for programming by scripting, everything has to be done visually, which can be tedious and thus limits the possible complexity of a scenario.

2.4 Scenario Selection: The living-room Engine, the living-room Book

In addition to the implementation of the single scenarios it was necessary to create the living-room engine, which can run the scenarios and also drives the interface for the user to choose among the different scenarios.

The living-room engine is a special Max/MSP/Jitter patch. It contains the necessary functionalities for running the different scenarios, e.g. the initialization procedures, the rendering of the background image, the socket connection to ARToolKit, and the scene-change function. Every scenario is implemented as a further patch that is loaded and unloaded by the living-room engine. In the individual scenario-patches the geometry, sound, interaction, and dynamic behaviours are defined. Further scenarios can be linked to the living-room engine in a straightforward way.

The user-interface for the scenario selection is the living-room book. It is a documentation of each scenario with a description and an image of the scenario in the form of an ARToolKit marker (see Figure 3). When looking through the pages with the HMD on, the visitor can activate the scenario by focusing on the image. The living-room book is placed at the entrance to the living-room box; in this way the entrance is always the starting point for each scenario.

Figure 3: The living-room book

There are precedents in using books as AR interfaces like the MagicBook [3] or Little Red MR [5]. Both examples use the book interface to step into a story. In this aspect the living-room book is different, it does not tell a story, it is a catalogue showing the available scenarios and serves as a starting point to trigger the overlay of virtualities onto reality.

2.5 Simulation Software: „little portable living-room"

The development of scenarios requires a lot of testing and fine-tuning on a visual level. It is very tedious to do this within the physical setup, which requires entering the space, putting on the HMD, and then moving around without a chance to immediately make improvements in the visual programming interface of Max/MSP/Jitter.

Therefore a special interface (see Figure 4) was created to allow the development of scenarios independently of the physical living-room. The interface enables the artist or designer to change the camera position and view direction. The data is then sent to Jitter using the OpenSoundControl protocol in the same way as the ARToolKit component. The scenario can be seen in the usual Jitter interface with a rendered 3D model of the living room as a backdrop.

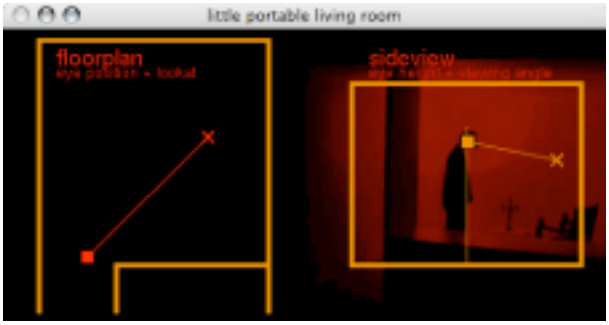

Figure 4: The little portable living-room

3. SPACE-RELATED DESIGN ASPECTS

The main interest of the living-room project is researching space-related design aspects of AR. This process was started with the implementation of four scenarios. In order to experience a scenario the visitor has to put on the HMD (head-mounted-display) including the earphones. (see Figure 1). Parts of each scenario run automatically, others are triggered by the user's position and orientation as will be described more into detail in the context of each scenario. In the current scenarios there are no tasks to fulfil, the focus is on the exploration of new kinds of spatial experiences.

The four scenarios 'Texballs', 'Grass', 'Clouds', and 'Zygotes' are the first attempts to use the living-room installation for artistic expression. There were many restrictions to contend with for their implementation, mainly technical shortcomings like the imprecise visual tracking of ARToolKit and the limits of the MAX/MSP/Jitter package regarding 3D graphics, texturing, and complexity of the interaction. Nonetheless the scenarios allow experiencing of AR and give a good indication of the potential expressiveness of the whole installation.

These scenarios were evaluated and three thematic levels to focus further research on were identified: 1) real and virtual, 2) interaction, and 3) scenography. These three levels will be explored more in depth with the next living-room prototype. For now they serve as themes to describe the research results in a qualitative manner.

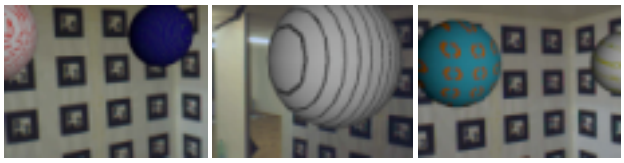

Figure 5: 'Texballs' scenario

'Texballs' is like a galactic planetary system that invades the living-room. There are seven textured balls with a diameter of approximately one meter dancing in a synchronized rhythm around a centre-point. The textures are symbols or words. When the balls move, the textures are animated as well, when the balls stop the animation of the textures are stopped also and become readable. The user can position her/himself within a ball and be completely surrounded by the virtual body, seeing the texture from inside.

Figure 6: 'Grass' scenario

'Grass' plays with the contrasts between the inside space of the constructed living-room environment and an abstraction of a natural outside environment. The grass is green in the beginning, but changes to rather unnatural colours depending on the visitor's position, which is used to trigger different bird-songs as well. The grass moves as if there were a slight breeze animating it. It also 'feels' nice to sit down and watch the grass from beneath.

Figure 7: 'Clouds' scenario

In the 'Clouds' scenario the walls of living-room dissolve and the perceived space stretches beyond the physically possible showing a savannah scene with dramatic, moving clouds overhead. The transition happens according to the position of the user, the further away from the walls the more immersed in the synthetic world. When fully immersed and looking straight towards a – now invisible – physical wall, a synthetic replica of the wall drops in front of the visitor and flies away into infinity, resulting in a re-confrontation with reality and a means to make the infinite dimensions perceivable.

Figure 8: 'Zygotes' scenario

'Zygotes' is a scenario with an interactive narrative and a physical element – a round carpet – in the space. The visitor has to move around the carpet to see one humanoid zygote after the other appear. They long for the sun. When all three of them have appeared and are holding hands the scene arrives at its culminating end with the explosion of the sun. In 'Zygotes' the image of the physical space gets tinted in red. The humanoids do not move and have neither coloured skin nor textured clothes, which makes them lifeless, virtual and somehow frightening. But the human scale and form still evokes the feeling of a human presence. The scenario plays with the boundary between virtual and real.

To see further images please visit:
http://www.fhbb.ch/hgk/af/livingroom/scenarios.html

3.1 Real and Virtual

The augmentation of the image of the real space with virtual objects has been realized in all scenarios, but there is a difference in the way this is done. In some scenarios objects are placed in space (e.g. the planetary system of 'Texballs' or the zygotes) in others elements are replaced or enhanced within the space (e.g. the savannah and sky in 'Clouds' or the grass). Virtual elements in space can structure the given space, emphasize certain regions of the space or hide parts of the space.

The texturing of 3D objects allows placement of static images, animated images and text freely in space. Placing dissimilar textures on the outside and the inside of objects makes it possible to create virtual spaces that need to be entered physically to gain access to their information content as in the 'Texballs' example. In the 'Clouds' example the textured, animated sky creates a virtual and symbolic reference to the space over our heads and adds an additional dimension to the superposition of real and virtual.

Not only the virtual objects can be controlled, it is also possible to manipulate the video image of the real space. Changing the contrast, colour, light situation and other parameters of the recorded image allow transforming the look of the real space and making it more similar to the synthetic world. This was realized in the 'Zygotes' scenario by tinting the real space in red.

Furthermore it is possible to play with dimensions and scale to visually override the physical, spatial boundaries of the real space. In the 'Clouds' scenario different means to dissolve the real space boundaries and to suggest infinity were introduced. All in all, the goal is not to augment the space with maximum realistic looking objects, but to supplement the real space synthetically towards a desired effect for the visitor.

3.2 Interaction

In the current prototype of living-room two types of interaction in the space have been explored: Through the position of the user or through the orientation of the user's gaze. Both are possible thanks to the visual tracking system. The interaction through position is used in the 'Grass', 'Clouds' and 'Zygotes' scenarios. In the 'Clouds' scenario the orientation of the visitor's gaze is taken into account as well. As we can see in the different scenarios this simple and seamless interaction is quite versatile; many parameters of the scene and objects can be influenced, objects can appear and disappear and even dramatic endings of a scenario can be induced.

The living-room book, to change the scenario, is a haptic interactive element. Even though the interaction actually happens via the visual tracking system, the turning of the pages is a valuable mnemonic act to evoke a scene change.

The 'Zygotes' scenario is the only one that uses a special real world object, a round carpet.In this scenario it is an indication for the visitor to relate the virtual personae to the physical space. This possibility will be further explored in the nextliving-room prototype, where it is planned to have moveable objects that can also be computer-triggered for interaction.

3.3 Scenography

The next level, after interaction, is to look at narrative and dramaturgical possibilities of the space enhanced through AR. The visitors can influence the course of the events interactively or witness the happenings passively from different points of view. The 'Zygotes' scenario is an initial exploration of some of these possibilities. It tells a little story, which advances through user-interaction and ends in a dramatic explosion.

A very important means is sound. As is known from VR, computer games and other applications that aim for a high level of immersion, sound helps to surround the user aurally and emotionally with a specifically generated ambiance. All living-room scenarios use sound, usually a background sound plus sounds related to the objects of the scenario, like the dropping walls in the 'Clouds' scenario or the exploding sun in the 'Zygotes' scenario. In the 'Grass' scenario the sound selection is related to the visitor's position. In the current living-room prototype sound is not spatially positioned, but it will be in the next prototype. Sound can then also be used to guide visitors or attract their attention to a specific location.

4. EVALUATION AND PLANS

4.1 User Statements and Observations

Five questions were sent by email to 18 visitors of the living-room prototype the day after their visit to the installation. We received 14 answers within half a day to four weeks. The answers are summarized qualitatively in the following:

4.1.1 Your first impression?

It was nice to have three views, the chance to see the current user, the monitor that showed the scenario, and the personal experience. The prototype looks interesting, promising, and important. Who are the competitors? The impressiveness of the immersive experience of an augmented space was mentioned. The fact that there were not only one, but four easily accessible scenarios was appreciated, as well as the crossover of art, design and technology. There was a suggestion to not give too much of an introduction to the visitors, so that the features of the scenarios can actually be discovered from within "living-room". The negative remarks included: Confused (2 times), what can this be used for?, there is too much technology visible, no physical objects in the space, non-neutral walls are disturbing, it focuses too much on technology instead of design, art and content. Many of the remarks are repeated in the answers to the questions 2) and 3).

4.1.2 What was good?

Two people especially liked the introduction before entering the space and the monitor that showed the view of the visitor. That something worked at all was also one comment. The book to change scenarios was appreciated by two people, as well as the generally seamless interaction. Five liked the 'Grass' scenario and the interaction through motion in the space. Five liked the 'Clouds' scenario, because of the contrasting scales and spaces and the transition from real space to fully virtual space. On a more general level the immersive experience, the movement and orientation in space, AR in a walkable space, and the special aesthetics of the imagery were mentioned. The laboratory situation (4 people) and the possibility that the installation could be used by other researchers and students, the effort to create a setup, that allows addition of scenarios easily, and the preciseness of the research questions were appreciated, as well as its prospective, practical and useful application. There was also a remark that the scenarios dealt well with the technical limitations.

4.1.3 What was bad?

Five people remarked that the HMD is too clumsy and heavy, that the view is not closed off on the side and towards the floor, that the field of view is very small, and that the lack of stereo representation would not allow a 3D experience. Many criticized the imprecision of the tracking system as too slow and not perfect enough, the resulting mismatch of the real space and synthetic space superposition, and that the lag and jitter make it difficult to navigate. Besides the technical limitations the indecision regarding applicability and usefulness, the very synthetic imagery, and the small size of the room were criticised. Regarding the scenarios: Two people found the 'Texballs' scenario too simple and criticized that there is no interaction in this scenario. Two people criticized that lack of physical objects in the space and that there was no 1:1 connection with the real space. It was suggested that the visitors should be confronted with more meaningful tasks to get more involved.

4.1.4 Was this your first AR experience?

Nine people answered with no and five with yes. Through discussions with some of the last visitors we became aware of the possibility, that people only think it is not their first AR experience, because the idea is known from Sci-Fi movies or novels and they imagine the technical realization to be quite simple and feasible. Because most of the people in our survey have an interest in new technologies, it can happen, that they answered yes, without carefully thinking about it. For the last three questionnaires the question was expanded to: "Was this your first AR experience? IF 'no', when and where have you experienced AR before?"

4.1.5 What do you imagine as the future importance of augmented reality?

The following areas were mentioned: exhibitions, entertainment (immersive stories, expanded cinema), industry (assembly and servicing), education, information systems, simulation and training, games, art. To display additional information in museums, tourist places, schools, shopping malls in a personal portable AR system. For the analysis, idea development, visualization, simulation, and planning in design, interior design, scenography, architecture, and urban planning. The system could be used to interact with avatars, for video conferencing and to thematically explore scenographic, interior design, artistic and aesthetic themes. Further comments mentioned the importance of the research focus, the possibly interesting findings on the combination of real and virtual, that it should be an experience in-and-of itself and could be a new kind of art form. And that it is important that AR is not the theme but it is the media. One person answered that he thinks it is not going to be useful for anything.

4.1.6 Observations

In general the statements are pointing out aspects already familiar to us. It was informative to see to how large a degree the technical shortcomings were criticized. Nevertheless, we were surprised about the high number of specific comments regarding particular scenarios. We interpret this as a sign that the system works well enough to allow experiencing AR and the contents of the scenarios. We are thankful for the statements that support the idea of investigating AR as a media for art and design. The overall outcome of the survey is in favour of our plan to improve the technical aspects and continue with the investigation of fundamental design and art aspects of our AR installation.

4.2 Planned Hardware and Software Improvements

To approach the above design research questions it is important to have a system that provides adequate quality regarding recognition as well as visual output. Furthermore the system has to be setup in a way that designers can focus on their design research tasks without having to bother too much with the technical issues. The plan is to use the current prototype as the starting point for the desired technical enhancements.

The improvement of the technical performance of the installation can be achieved either by replacing components of the current hardware and software setup or by adding new components. This is fortunate, because it permits a stepwise process with enough opportunities for testing and thereby tremendously reducing the risk of a failure of the whole system or long, unforeseeable delays. The parts to be replaced are the tracking technology, the HMD, and the augmentation software. The goal of the technical development is to unify the different systems into a single design tool. Artists, designers and students will get a toolbox to implement scenarios for living-room. It will allow the implementation of more sophisticated scenarios than the ones that were possible in the first living-room prototype.

4.2.1 Tracking Technology

The existing optical tracking technology (ARToolKit) has to be replaced to obtain jitter free images and guarantee accurate user interaction. The plan is to realize a hybrid hardware-software tracking system.

The hardware part will be an ultrasonic tracking system that tracks the visitor's head position. With such a system markers will not be necessary anymore and the physical space can be designed without limitations. Several commercial systems using magnetism, ultrasonic sound or radio waves have been evaluated. The ultrasonic system PCTracker from InterSense with combined gravitation and acceleration mechanisms [2] seems to fulfil the needs for the next living-room prototype appropriately.

The software part will allow tracking of movable objects, which was not possible in the first living-room prototype. It will consist of an optical tracking system to be realized in collaboration with Prof. Pascal Fua from the Computer Vision Lab (CVLAB) at the EPF Lausanne, Switzerland. A special challenge to be solved is the recognition of partially occluded objects [6].

The combination of the two systems will allow precise overlaying of virtual aspects on real world objects, real time interactions in the virtual world and – most importantly – interaction with moveable real world elements, to further examine the fusion of real and virtual worlds.

4.2.2 Augmentation Software

The augmentation software Max/MSP/Jitter will be replaced to get a more powerful and highly interactive tool for animations, textures and complex shapes and to obtain more stable frame rates, even for the planned stereoscopic HMD.

Several commercial software products have been evaluated. The main criteria were the features for the creation of interactive synthetic worlds, the user interface and special tools for content creation, and the reliability of the rendering engine. Currently our first choice is the authoring software Virtools Dev that allows creating compositions full of rich, interactive 3D-content. Complex models can be created by a modelling tool like Cinema4D and enhanced with the Virtools behavioural engine, which provides an extensive collection of applicable behaviours. With the help of the Virtools Software Development Kit (SDK) additional behaviours and parameter types can be implemented. Furthermore the possibility of connecting to remote players via the internet and the option to include more than one player will allow the design of mixed-platform multi-player scenarios.

The performance problems encountered with the real time capacities of Max/MSP/Jitter for complex scenarios should be solved with the Virtools render engine. It can be customized to fit specific needs using the Software Development Kit. The capability to overlay the streaming video image with the Virtools scenes will be developed by the Virtools

development team.

4.2.3 Head Mounted Display (HMD)

The present clumsy, monoscopic, low resolution HMD needs to be replaced; ideally by an elegant, stereoscopic device with higher resolution, better sound quality, and a better isolation of the field of view. It should be easy to put on and take off, fit different head sizes, and work for visitors with glasses as well. The evaluation of currently available devices did not lead to a final choice yet and we hope that a new product will emerge during the next phase of the living-room project. Currently it is important to select the graphic card and the rendering engine appropriately, so that the high frame rates needed for stereo viewing can be guaranteed.

4.2.4 The living-room Toolbox

The role of the toolbox is to contain everything a designer, artist or student needs to implement a scenario. It should actually make the design process as efficient as possible. Therefore it will hide some of the underlying technical aspects of living-room, but still offer access to any parameters that a creative person would want to influence. Some parts of the toolbox will be instructions and others will be actual interfaces for the designers. It is important that every aspect of the design process – from the initial idea to the accessibility of the implemented scenario – is dealt with. The final toolbox will include the following:

1. Virtools with a template scenario demonstrating the interaction possibilities using the user's position and movable objects, and instructions for the import of different file formats like 3D-models, images, animations, movies, and sounds.
2. The living-room engine, a Virtools application that links and loads the scenarios, reads the position parameters from the tracking systems and overlays the synthetic scene appropriately.
3. The living-room book for the evocation of the different scenarios through the user will conceptually remain the same as in the first living-room prototype. The layout of the pages will be redesigned, because the image, to provoke a change of scenario, does not have to look like an ARToolKit marker anymore. The designers will get a template page to document their scenario, instructions for the design of the image (in order that the system can recognize it), and an image recording procedure, to make it known to the system.
4. The hybrid tracking system: For the position tracking, a calibration procedure will be provided. For the optical tracking of moveable objects a recording procedure, to make the object known to the system, and a calibration procedure will be provided.
5. The little portable living-room will also be available to allow the designers and artists to work on their designs independently of the physical installation.
6. Further documentation will include the procedure to start the whole system as well as troubleshooting and FAQ sections.

4.3 AR Research Questions

The research will continue to address questions related to the design of content for AR and focus more into depth on spatial design and interaction issues. The main goals of the next research phase will be to further explore the identified levels associated with this new media: 'Real and virtual', 'interaction', and 'scenography'. An iterative design research method will be applied in this process; the focus is on artistic expressiveness and possible design principles. On each level three to four scenarios will be implemented, evaluated, improved, and the main findings identified. The goal is to be able to demonstrate novel and crucial AR design paradigms.

4.3.1 Real and Virtual

The research on 'real and virtual' has the objective of identifying new design principles when combining physical and synthetic worlds. The research questions relate to the virtual and the physical and include questions like: Which kind of information and media can be integrated into the scenarios? In what ways can the physical world be altered synthetically for example through lights, texture, transparency, blurring or sound? What are the possibilities and constraints for the design of the physical space? How can the perception of spatial properties of the physical space be altered? When do the boundaries between real and virtual dissolve so that one merged real-virtual reality results instead of two complementary ones? What is the potential of almost perfect simulations versus highly abstract graphics for the augmentation?

4.3.2 Interaction

User interaction adds more possibilities for experiencing the space and conveying information. In the next prototype we will have moveable objects, in addition to the movement of the user, as possible inputs for interaction. More possibilities, like gestures or speech, could be imagined. But even the limited set of possibilities leads to a number of interesting questions: What are all the possible interactions based on the user's position or movement? What can be possibly achieved with the moveable objects? How metaphorical should the interaction be? What about the learning curve for abstract forms of interaction? How can the most appropriate form of interaction be found?

Interacting with the augmented reality in living-room will be an "oscillating experience between states of transparency and reflectivity" [4] in many ways. Bolter and Gromala claim that this is an important quality for every interface[4].

4.3.3 Scenography

The third level 'scenography' expands the range of questions beyond the formal design possibilities of living-room towards the potential of conveying meaning in space and time: How will the user read the content in space and time? What kinds of narratives or games are possible in living-room? What are possible tasks for the user? Which themes can be adequately realized as living-room scenarios? How can scenarios be designed that seduce the user into a state of flow? (This question was inspired by Salen and Zimmerman's chapter 'Games as Systems of Pleasure' in their recently published book ' Rules of Play' [8].) What traces can a user leave behind and how could this be meaningful for the next visitor of a scenario? What is the expected social and cultural impact of this new media and how can this become a theme in the scenarios?

4.4 Planned Application in Education and as Exhibition Installation

A further step will be to explore the potential of living-room as media in education and exhibitions. Interior design and art students of the University of Art+Design Basel, Switzerland will create scenarios during one semester. Four or five of these scenarios will be selected to become part of exhibitions of the living-room installation at the Museum for Communication in Bern, Switzerland and at plug.in – Space for New Media, Basel, Switzerland. Further scenarios will be developed by the members of the research team as well as invited artists. All of the 12-15 scenarios will have to be realized in the same real-space setting, only the moveable objects can be different for the individual scenarios. The scenarios will be documented in the book and will be activated by it. The installation has to meet the hard demands of exhibitions. Hardware and software must be self-explanatory, easy to use, and quasi indestructible.

By making the step into education and exhibitions, we will be able to evaluate living-room as a new media for designers and for educational purposes. The inclusion of students and designers will allow generation of new ideas and extend the debate on the possibilities and meaning of AR in general and the living-room setup in particular.

5. CONCLUSIONS

Designing and developing interactive and narrative content for augmented environments is an interesting new field for a large range of design disciplines. (Architecture, exhibition design, scenographic design, performing arts, interactive arts) These professionals will carry AR out to a large audience and therefore will enhance the demand for further applications. As a requirement for such future developments both technical and design research will have to join forces to create the tools specifically suited for content designers. These tools will not only create usable standardized hard- and software but also describe design aspects of AR as a new media.

living-room is a new kind of media. Bolter and Gromala conclude "Until you can explain how it [the new media] resembles and how it surpasses other media, people won't recognize it as a medium at all" [4]. living-room can include some old ones or recently developed ones, like VR or different forms of story-telling, games, and other scenographic settings. As a whole it is more difficult to compare it with any known media. Because of the combination of the physical with the virtual reality, the closest analogy is the one of daydreaming or reading a book in a specifically chosen setting.

From the survey we have also learned that we need to find clearer explanations, in order to trigger more ideas for possible applications or uses of a setting like living-room. We hope to reach a higher level of knowledge in this regard with the next phase of the research and maybe even start identifying what Murray calls "essential properties" by "moving away from the formats of older media and towards new conventions in order to satisfy the desires aroused by the new environment" [7].

6. ACKNOWLEDGMENTS

The living-room project was funded by the DORE program of the Swiss National Science Foundation, and i-art, Valentin Spiess, Basel as primary industry partner.

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