Description of and Insights into Augmented Reality Projects from 2003-2010

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The present document offers and overview of a series of media art projects by the artist Jan Torpus and design research projects that were created at the Institute for Research in Art and Design (IDK) at the Academy of Art and Design in the University of Applied Sciences Northwestern Switzerland. By collaborating in interdisciplinary teams, projects have been created since 2003 that deal with reinterpretations or artistically innovative realizations reflecting on increasingly affordable and new or widely accessible everyday technologies. The main focus was set on Augmented Reality – on its potential for artistic expression and on necessary design approaches for content delivery. The **design research projects living-room1, living-room2, and lifeClipper2, as well as the new media art projects lifeClipper1, and lifeClipper3** were created. The mutual interaction between these orientations proved to be quite productive. Along with commercial partners, the design research projects developed prototypes for commercial applications; the art projects investigated fundamental, free artistic potential. The design research projects, which had clearly defined requirements and created technically advanced products, based everything on scenario developments with a focus and applications for the consumer market, interior design, architecture visualization, archaeology, and game development. The art projects are and were more concerned with investigations into human perception: questioning reality, immersion into alternative realities, and plumbing the design possibilities of the new media.

The first brushes with augmented reality arise through the project **living-room1** [1] (supported by the Swiss National Science Foundation (SNSF), 2002 to 2004)**.** Based on the software environments ARToolKit and Max/MSP/Jitter, we developed our own three-dimensional tracking system, which allowed us to implement four location-sensitive scenarios. Although the system was not particularly precise and the entire space had to be papered with markers (clearly allocable graphic markings), we were able to achieve a basic understanding of content design implementation with AR technologies. Some of the most important insights are listed below:

- The interface between the real and the virtual worlds must be exhausted. The staging of the real space and the relation to the virtual world is a central theme in AR. Since we had selected a technology that required the entire space to be covered with markers, the space no longer served as an atmospheric living room. From then on we worked with technologies that did not disturb the observer's field of vision.
- Using video cameras to represent the real environment creates the possibility of changing, and therefore abstracting, the visual parameters with real-time effects bringing it closer to the virtual world. For example, the real space can be represented as dyed, darkened, distorted, or blurred.

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[1] http://livingroom.idk.ch

- Staging with spatially positioned virtual sound sources contributes considerably to orientation in AR.
- The staging cannot unfold in a linear timeframe or be spatially placed but rather must be oriented to the observers' visual field and attention.
- The consequences of changing position and line of sight on individual interaction are difficult to get aware of. If this is desired or if it is important for the narration, audio-visual aids would be necessary because the visitor would first have to develop a personal relationship with his or her expanded virtual senses and abilities. The line of sight, for example, should be provided with some sort of ray of light and interactive locations must be highlighted as targets.
- Immersion in virtual 3D bodies that are positioned in real space is intensely perceived. It makes the visitor curious, but also leads to a kind of isolation and a desire for control in the real world. Bodies that are textured differently from the inside are perceived as other spaces with other dimensions when they are entered.

The project living-room1 served as a basis for the subsequent project **living-room2** [2] (SNSF, 2005 to 2007). In contrast to the living-room1 studio space, which was covered with markers for visual tracking, we worked with an invisible ultrasonic tracking system in the new project and the "room" was able to be furnished that way.

The basic assumption for living-room2's application scenario was that, in the future, AR would not only be used as a medium for visualizing and developing interior spaces but would be integrated as an actual "material" for furnishing an interior space. In order to be able to interact with the virtual space through the real space, living-room2 was outfitted with sensors. For its part, the virtual world could trigger lamps and a ventilator, which were physically on site. So that the visitors could better interact with the virtual world, we introduced a hand-held controlling device in order to achieve better computer performance and to maintain more design options in the environment with 3D implementations, we decided on the authoring software Virtools. We developed two scenarios, supporting a mixture of the real and virtual worlds based on logical, mutual relations in the narrative structure (the "cross-world narrative") as well as through interaction options in both worlds. The scenarios were then evaluated at the Museum of Communication in Bern, which led to, among others, the following insights related to design implementation and user experience:

- Given that the virtual image overlays the video image of reality, real image components cannot be concealed or have to be cut out. If individual virtual objects are placed in the room, the imprecision of the tracking system is not very strongly conveyed. If, however, the virtual image portion is larger and covers the same visual field, the imprecision of the tracking system becomes more apparent.
- In order to achieve the most plausible possible merger of the real and virtual worlds, the audio-visual means of merging them have to be optimized. Various degrees of transparency, anti-alias,

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[2] http://livingroom.idk.ch

light positions and shadows, color adjustments, adjustments to video codec artifacts and others were examined.

- Graphic interfaces brought within the visual field as well as the hand-held controlling devices prevent the visitors from interacting with the real space. The real space must be the actual interface with which the visitor freely interacts. Tracking hands (data gloves) and feet (step sensors) would be a logical consequence.
- If graphic interfaces become necessary, however, it is recommended that they are spatially placed and so create a direct relationship with the environment rather than pinning them as two-dimensional menus in the visual field.
- If the virtual scenario is too elaborate and the context within the real space is too minimal, attention is only fixed to the virtual. The visitors, who are used to televisions and computer screens, do not mix the things from the virtual world with those of reality by themselves.
- In order to avoid a discussion about the quality and performance of the 3D implementations, choosing an abstract aesthetic that cannot be directly compared with established computer games is recommended.
- Only older people and children cannot always distinguish between the real and virtual worlds given the current state of the technology.

Because implementing additional scenario ideas that originated during the project was too expensive, the fake website http://www.**arhabtits.com** was stepped up. It offers visitors as-yet undeveloped future technologies and sells fictional applications whose content was designed as a video installation but that were not implemented in the AR space. Unfortunately, the feedback that was hoped for, which could be made in the form of registration for the newsletter or as members, turned out to be rather sparse.

living-room1 and living-room2 were developed in the context of the Institute for Interior Design. This was a matter of developing possible future AR applications for the consumer market. In order to be able to experiment more freely and to be able to leave the studio space, we developed the free media art project **lifeClipper** [3] (supported by cultural foundations)**.** With this project, walking was introduced for the first time as a framework for the AR experience. The outside offers more variety; a rich, physically real world; unpredictable events and encounters; various types of weather, times of day, and temperatures; different walking surfaces; delicate interaction situations; the attention of passers-by; and much more. Audio-visual interventions that influenced ordinary seeing and hearing, questioned the perception of reality, and allowed everyday situations to turn into adventures were a central theme with lifeClipper

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[3] http://torpus.com/lifeclipper

No 3D model was laid over the real space with lifeClipper. The GPS signal and the direction sensor were very imprecise and were only used to trigger location-specific audio-visual setups and parametric effects that expanded the content of and atmospherically staged the real space. The free artistic handling of sound and image, however, contributed to lifeClipper becoming one of the most exciting and immersive implementations to date among the projects listed here. With a photo trigger, the visitors were able to take screenshots of personally selected subjects as though they were tourists in a parallel world. Various media and artistic approaches were investigated, leading to, among others, the following insights:

- Minimal interference from virtual setups, through which it is unclear whether they are real or fanciful, fascinating or irritating more than lavish audio-visual staging.
- The transfer from film media to the AR space could be examined through the example of a cemetery that has been chillingly staged. Style elements that the visitor already knows from film or television, vividly experienced in his or her own reality, leave a strong, unsettling feeling.
- Rough use of effects such as video feedback, distortion, blurring, or the like do not become unpleasant for the visitors very quickly. This also applies to an HMD, which completely cuts out the natural visual field.
- Spatial staging, through which a scene is constructed or a course of events only occurs by proceeding through a particular path in a defined direction, is not perceived without explanation.
- The human brain quickly familiarizes itself with unknown forms of perception. Technical inadequacies are therefore quickly accepted and do not distract from the staging for long. The sensory restriction of the narrow visual field, the transfer latency, and the poor image resolution force the visitor to concentrate more on his or her environment and therefore to develop a high level of attention.
- The commercial handicap, that each visitor must be individually accompanied, has qualitative advantages. The visitors estimate the shared exchange and the developers learn a great deal about how the staging is received. It became clear that the form of the shared walk has potential as a qualitative evaluation method.

The new media project lifeClipper was followed by **lifeClipper2** [4] (supported by the Confederation's Commission for Technology and Innovation, 2006-2008) as a project for applied design research. Through interdisciplinary collaboration, research and commercial partners developed scenarios that investigated AR's application potential with respect to architecture visualization and staging of archaeological discoveries. The first studies for the game-oriented AR project lifeClipper3 were performed with the scenario Playground.

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[4] http://www.lifeclipper.net

With lifeClipper2, the entire urban study area was overlaid with a historical and a future 3D city model. Virtual setups could be spatially placed and brought into context. In order to maintain the necessary precision in calibrating the virtual world with the world outside, we used high-precision direction sensors and differential GPS. The visitors' walks could be recorded: position, line of sight, and the selected visualization mode could be recorded with respect to time. The research project lifeClipper2 brought, among others, the following insights:

- Since the staged locations mainly contributed to the scene as sites of cultural heritage without remains or atmospheric references and less through physical elements, the mixture of the real and virtual worlds was mostly realized through different degrees of transparency and not by cutting out and splicing together image components.
- During the development phase, we determined that completely virtual HMD setups that have spatial relationships to the environment (streets, building size, or the like) generate a complete mental image. Compositing happens here, so to speak, on the edge of the lenses and the complete image arises through concordance with head movement.
- The visitors' interaction with the equipment is often such an overwhelming issue that they could not concentrate on the content. Optimization of the technical equipment therefore became necessary.
- The overlaid 3D model has a scale of 1:1 with respect to reality, however, perception of the distance of virtual objects is a serious problem. They have to be connected to reality with perspective psycho-physical aids such as shadows, texture, occlusion, or atmospheric perspectives. In implementing these methods minimal imprecisions in calibrating the real and virtual worlds are clearer at a distance because millimeters become meters. It is therefore recommended to primarily work with virtual setups in the visitor's immediate environment.
- During the evaluation and feedback process, we wondered the extent to which the real and virtual worlds would blend together in the visitors' memories. Does the entire experience remain in the memory as a homogenous image?

The media art project **lifeClipper3** (supported by local cultural foundations and the IDK, 2009-2010) was based on all of the projects listed above as a free artistic project. Design experience in exposure to technical limitations and user experience in the AR medium, tested forms of interaction, handling of spatial-temporal staging, and experience with preparation of the media components were incorporated into the project. lifeClipper3 is not an artistic project that addresses cultural values or takes on socio-political topics. lifeClipper3 deals with the design possibilities of plumbing the new medium and staging spaces for sensory experience.

From a technical perspective, lifeClipper3 could build on the achievements of lifeClipper2. Apart from upgrades and optimizations, the combination of the 3D authoring software Virtools with the sound processing environment Max/MSP/Jitter should mainly be emphasized because they allowed us to

stage sound and image in real time at the highest level. Integration of biofeedback sensors expands the spectrum of integration possibilities in the direction of intuitive vegetative navigation.

Objectives for the lifeClipper3 project were, among others, as follows:

- The living-room and lifeClipper series never completely lived up to their names because they were stagings that could be location-specifically activated but not location-specifically influenced. With lifeClipper3, for the first time, systems that had their own artificial intelligence were used. They are systems that consist of parametrically variable components that have defined characteristics and behavior patterns and correlate to one another. They are extensively arranged, reflexive sets of rules that are open to interaction with the observer and regulate themselves in ways that cannot be completely controlled.
- Apart from the introduction of an artificial ecosystem, an independent time system was introduced with a climate cycle that, in combination with the location-specific events and the behavior patterns of the intelligent agents, provides for an unpredictable multiplicity of influences and experiences.
- With lifeClipper3, the status of the real world as a visual background and host to all virtual components is dissolved. The camera's image is still used as the principal reference to the physical environment and as an orientation aid, but it can be intermittently downgraded to an insignificant audio-visual texture in the total composition or completely replaced by a synthetic world. The setups likewise vary between the real world, augmented reality (AR), and virtual reality (VR). The construction of the HMD also allows the visitors to maintain their upright relationship to the outside world during immersion in complete VR.
- In order to merge the real world with the virtual one more effectively, the registered camera image is no longer used as a background image, but also directly projected on the 3D terrain. Light and shadow, permeation with the terrain, atmospheric effects such as fog, and changing the textures between the real and virtual worlds can be merged with the representation of the real terrain.
- lifeClipper3 is oriented around narrative and navigational structures from the game world and examines parallels and transfer possibilities from film assembly.