Spacing the Boundary:
An Exploration of Perforated Virtual Spaces

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ABSTRACT

This paper discusses the performative boundary between real and virtual spaces, as it constitutes itself based on the conditions, abilities, and potentials of Virtual Reality (VR). In addressing specific issues of the users' embodiment, the authors argue that one of the greatest challenges of VR is its capability to connect the virtual and the real; a potential that is considered as fundamentally spatial. The premises and conditions of the production of such an interfacing space are explored in relation to its underlying generative dynamic processes, the superimposition of real and virtual places, and their inhabitation. Joining the fields of interactive art and computer science, the authors' discussion unfolds based on two of their collaborative works: the CAVE environment Uzume (2002) and the tele-immersive installation Maλa–Veil of Illusion (2004).

1. Introduction

In 1990, when Virtual Reality (VR) technologies were about to venture out of their isolated development in research laboratories, the media theorist Derrick de Kerckhove pointed at a fundamental difference between Virtual Reality and all other media-experiences. In his view, Virtual Reality exhibits a capability that allows its users to externalize their imagination in a dynamic process (De Kerckhove, 1999). Given the advancements of interface and representation capabilities of interactive media in recent years, however, such an instantaneous, fluid sculpting of our externalized thoughts is not specific to the medium of VR. What is particular about this medium is that it allows

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us, in Florian Rötzer's words, "to enter the digitally produced three-dimensional space with the entire body" (Rötzer, 1995).

The technological interface that affords such a corporeal inhabitation and an experiential sharing of virtual spaces, referred to in this paper is known as the CAVE® Virtual Reality System[1]. Unlike a Head Mounted Display (HMD), the CAVE® consists of a cube the size of a small room, commonly defined by 4 projection screens, in which the participants are coupled to the VR system by means of a head sensor, mounted on a pair of LCD shutter glasses, and two hand sensors. While the projection room can accommodate 15 people, only one person is tracked and thus actively involved, and all other visitors experience the virtual world three-dimensionally and yet passively. Two of the most fundamental characteristics of this system are the human-scale stereo-projection and the adaptation and response of that stereo-imagery in real-time, according to the present input of the sensors, attached to the participant's body. Linking space and time through the participants' movements, VR technologies can be considered space-creating media, rather than media which merely represent space. The key to this creation lies in the implication of the user's body and its significant role in the production and the experience of space as it is about to emerge.

Architectural approaches in the early nineties, such as Marcos Novak's 'Liquid Architecture,' already explored computer generated spaces, seeking the "gradual substitution of liquid patterns of change for structures of stillness" (Novak, 1997). Driven by 'keywords,' such as behaviours and emergence, these architectures exist only in the digital domain and evolve in a permanent state of becoming, rather than aiming for a final form. Yet, there's more to such dynamic, unfixed spatial pattern than their programmability, transaction and playfulness (Oosterhuis, 2003). As we are bodily implicated, real and virtual space are superimposed, creating thus a porous interface that complicates the denial of physical presence of cyberspace. Rather, here both the production and the inhabitation involve a constitution of boundaries in-between that continuously twist, shift, and perforate. It is here, where Posthuman views on bodies and territories and immersive interface technologies meet the issue of space: as the unsettled ground is bodily negotiated, the interface between the real and the virtual is fundamentally spatial.

While the medium of VR may have lost its initial fascination, what is still significant and unique about the 'dynamic coupling materialized in VR' is, according to Mark Hansen, "the indiscernibility of perception and affection that it brings about" (Hansen, 2004). With respect to this discussion, the technological interface of current Virtual

Reality systems is considered only a short-lived tool; a tool, or rather, a medium that nevertheless not only allows but also provokes an exploration of the specificities of the constitution and negotiation of virtual spaces. Based on two of the authors' practice-based works, the CAVE® environment *Uzume* (2002) and the tele-immersive installation *Maλa–Veil of Illusion* (2004), the following sections revolve around the question of space. They examine this central theme from various angles, such as the relation between space and time, the intertwining of the real and the virtual, embodiment and bodily spacing, the perforation and crossing of boundaries, and the multi-inhabitation[3] of shared, networked virtual places. In this discourse, virtual environments don't represent a predesigned world, but rather constitute the emerging ground for a space, which primarily unfolds in an experiential process.

2. Uzume: a performative event

Uzume[4] was implemented for a one to six wall CAVE® projection system. While many CAVE® environments present a world, which exceeds the (physical) projection space and are conventionally navigated through by the means of a joystick, *Uzume*'s world is bound to the (physical) boundaries of its projection space that can be bodily 'occupied' and thus only explored by the participant's physical movements.

Fig. 6: The virtual environment *Uzume*.

Uzume [Japanese: whirling] is named after a Japanese Shinto goddess, whose myth tells of her strange dance which lured the sun goddess Amaterasu out of a cave, where she had hidden herself. Even though the virtual environment does not thematically refer to this mythological narrative, it likewise presents its visitors with a strangely playful, whirling behaviour. Immersed in Uzume, an abstract, dynamic and sensitively responsive environment surrounds the visitor, revealing the communicative nature of an untameable virtual entity (Figure 1). Communicating with this entity is similar to pursuing a dialogue without knowing the language of the other as the tension between responsive and yet unpredictable behaviours perpetually interferes with the illusion of control. Its dynamic, transforming mirror alludes to the unsuturable gap between one's self and a virtual other that evolves beyond the mirror plane.

2.1 Space that unfolds in an experiential process

Space conventionally presents itself as a ground or a container that exists prior to all subjects, things and actions; it is constrained to such a limited concept primarily in our imagination and our daily experience as well as in the absolute Cartesian universe. According to Henri Bergson, space indeed signifies fixity and infinite divisibility and space is also what we thrust into extensity (Bergson, 1991). Space, however, can also be thought as eruption, oscillating between event, movement or action and rule, stillness or inertia, in which we find different zones of quality, difference and discontinuity. Uzume's dynamic spacing occurs in a continuous becoming, shaped by an apparently infinite number of unfinished transitions. Emerging and transforming along the contours of the moving body, its concept is inspired by Bergson's notion of motion that precedes space. Here it "is real motion that deposits space beneath itself" (Bergson, 1991).

2.2 Four interrelated compositional layers

Uzume's 'whirling' appearance is based on spatial representations of the temporal behaviour of nonlinear, chaotic systems, so called Strange Attractors (Figure 2). Their parametric fields are spatially mapped around the user's body, and hence, by physically moving around inside the projection space and gesturing with their arms, the participants actually traverse the various chaotic states of the system.

At the same time the participants' physical exploration subtly transforms a viscous fluid-like force field, whose force interplay continuously affects the shape of the attractors' trajectories. It sensitively reacts to the physical presence of the visitor by

locally displacing and transforming the chaotic, whirling patterns and adds an almost tangible quality to the projected virtual world.

The real-time sound-space consists of various discrete voices, whose compositional parameters are spatially mapped around the user. As the visitor touches the floating sound objects, different combinations of these voices develop endless variations of individually modulated, tenuous passages along the traces of the movements.

Uzume's spatial configurations are choreographed by an additional control layer that triggers transitions between various attractor types, and assigns initial parametric settings. Only indirectly influenced, this layer tracks the participants' movements inside the CAVE® space over time.
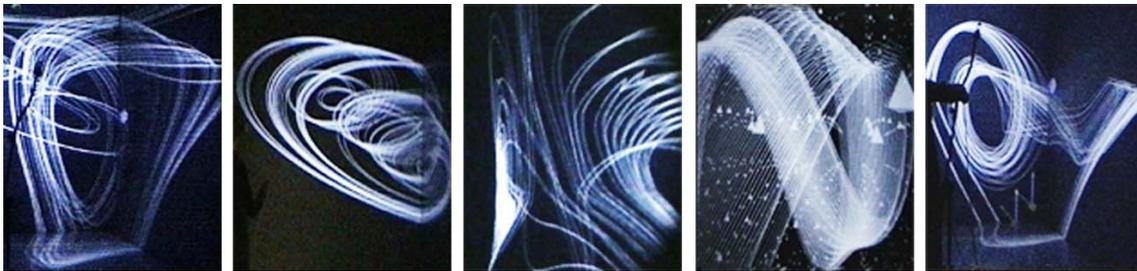

Fig. 2: Uzume's various strange attractor types.

2.3 A leakage between time and space

The evolving fluid boundaries, Uzume's whirling lines (trajectories), are drawn by a succession of points in time (rather than in space) and thus form the dynamic traces of transitions between endlessly varying chaotic states. These lines, determining the environment's spatial expressions, represent the temporal behaviour, rather than traditionally fixed architectural boundaries such as edges or planes. They unfold a spatial simultaneity, evolving in a vertical lamination of contemporaneities, rather than in a horizontal sequence of geometric places. It is an unscripted space, whose becoming is propelled by its in-betweeness, the always incomplete and continuously differentiating. Space as we experience it in Uzume appears like a trace, a living trace, always flowing and yet never forming an encrusted surface; or, in Elizabeth Grosz words, "neither clearly space nor time but a kind of leakage between the two, the passage of the one into the other" (Grosz, 2001). It is then not the participants' bodies but rather space that becomes a prosthesis, a fluid extension of their movements.

How then are time and space themselves interrelated? In the context of the present, constituting itself, Jacques Derrida talks of 'spacing': "the becoming-space of time or

the becoming-time of space (temporization)" (Derrida, 1982). In considering the present, Jean-Luc Nancy's idea of presence contrasts the continuity of Derrida's 'spacing.' Speaking of contiguity or singularly plural coexistence, Nancy describes a concept of the in-between that forms in "the *interlacing* [l'entrecroisement] of strands whose extremities remain separate even at the very centre of the knot" (Nancy, 2000). Considering a physical notion of time, in which it as an independent variable, time becomes the driving force that carves a single path out of an abstract space of infinite possibilities or possible paths, respectively: space as it is experienced. As we relate this idea to the concept of the event horizon from the theory of space-time, the arrow of time is a kind of selecting mechanism that manifests reality out of many possible realities, constituting the future.

  The abstract mathematical space of possibilities, then, serves as a foundation for the induction of time, out of which 'tangible' space emerges and is experienced. In the applied context of immersive interactive media, the encoded mathematical space of possibilities shapes perceived and experienced space along the layer of time, in which the participant enacts the encoded rules of change (dynamic behaviour descriptions). While in interactive media, such as those found on the web or interactive CD-ROMs, the user 'chooses' at given pre-defined points (links), the field, consisting of discrete points of decision, dissolves inside of a rule-based design. If the time-behaviour of a system is inscribed only by rules, which define the dynamics of the system, we are unable to model a discrete path, carving through the space of possibilities. Rather, such a system allows only for the defining of continuous trajectories through state space, which then display the behaviour for one possible instance.

Fig. 3: One-minute sequence of Uzume's evolution.
http://www.psychnology.org/Images/gemeinboeck_uzume.mpeg

2.4 Unfolding beyond author-defined interdependencies

   When such a rule-based system evolves as unpredictable and irreproducible, the complexity of its evolution exceeds the imagination of both, the rules' designers and the participants. Yet it is exactly this open, process-oriented design that allows the participant to experience the environment beyond the authors' predefined interdependencies. The dialogue unfolds in an interplay of apparent provocations, allure and discoveries, in which relationships between one's own gestures and movements and the environment's responses and modifications drives the evolution (Figure 3). As the participants are given neither instructions to follow nor scores to reach, becoming acquainted with the environment's otherness is supposed to be intuitive and playful. The dynamic interrelation of input and response produces a transformative mirror space, in which users are involved in an oscillatory play: mirroring themselves and perpetually discovering the unknown other. Playing with *Uzume*, then, the exploitation of the dynamics of strange attractors introduces a necessary openness and yet nevertheless enables the 'players' to recognize patterns and their relationships over time.

3. Bodily spacing

Inhabiting virtual spaces already challenges the participant on a quite basic level; as s/he needs to negotiate between the isotropic conditions of the computer-generated space and the experiential framework of the human, still bound to horizontal and vertical. In the process of negotiating, experience, body and space are inseparably coupled. From this kind of an experiential viewpoint there is no such thing as disembodied space, or as Lars Spybroek points out, "one can really only talk about "space" as a result of an experiential body timing its actions" (Spybroek, 1998). Considering space in relation to experience as a dynamically evolving passage, also constitutes the framework of embodiment that, according to Katherine Hayles, "always is contextual, enmeshed within the specifics of place, time, physiology and culture, which together compose enactment" (Hayles, 1999).

If, according to Mark Hansen, "time can be intuited only through direct experience, or alternatively, through the spacing of the body itself" (Hansen, 2004), it is this continuous spacing that not only couples but also implicates the participant and constitutes the perceived 'real.' It is then, as Hansen calls it, 'the body's affective autopoietic dimension – its capacity for absolute spacing,' based upon which "aesthetic experimentations in VR" (Hansen, 2004), accounts for a rearticulation of the boundary between matter (body) and information.

3.1 Real and virtual space superimposed

Merleau-Ponty's body-subject becomes the *entre-deux* that inseparably intertwines the experience of mind and body and whose relational condition corresponds to a concept of space and time that is corporeally constituted (Vasseleu, 1998). Based on Merleau-Ponty's notion, which Ruth Rettie (2005) discusses in detail with regard to presence, embodiment is an essential condition for the formation of the context that enables relations between our selves and others. It also forms the context within which we relate to our surroundings and within which we can extend our selves. The visitor's embodiment then allows for the sensors to connect the self to a virtual space that, in *Uzume*, constitutes itself in response to the movements of our bodies (Gemeinboeck, 2004).

Our body becomes the interface between these two spaces, the real and the virtual, based on whose exploration, movement and performance we produce knowledge and provoke space. While a sense of immersion beyond the constraints of our body and its physical location is at the heart of VR technology, it, likewise, aims for a sensation of

presence in a mediated sensory environment. It does not matter whether presence is seen as beyond or within, both can only be achieved by sensorially extending and coupling our body to the technological interface. The disavowal of the corporeal is thus one of the greatest illusions ever evoked by Virtual Reality. The desire to abandon our physical and thus bodily boundaries arises from the Cartesian division of mind and body, and thus also of space. Cyberspace and its non-physicality has thus become a controversial field, legitimizing a determined control over the body's messy and noisy conditions.

According to Cathryn Vasseleu, however, we can only experience virtual space or a sense of 'disembodied agency,' precisely because we are embodied: "The aims of many who are investigating virtual environments are being directed toward the legitimation of fantasies of disembodied mastery and eradicated corporeal limits." And yet this fantasy is bound to the very bodies it excludes (Vasseleu, 1994). The context of embodiment also implicates the issues of cultural identity and inscription; it is a lived context, whose inevitable and inescapable cultural, social, historical, gendered, and technological specificities always render the body multiple and unfinished. Both, *Uzume* and *Maλa*, to be discussed in the following sections, are concerned with the perforation of boundaries as it involves our body and hence its determination as "a negotiable territory" (Vasseleu, 1994).

4. The transformation of the real

The computer's capacity to store information has rendered time independent in that it is no longer intrinsically bound to the realm of the material subject to decay. Yet the medium proves not only capable of storing information but also of applying mechanisms that manipulate, change and extend its content. From this point of view, the computer presents the complexity of an environment or a world, rather than being a (transmission) medium in a conventional sense. It allows numerous people to participate, enter and to leave its access points at will and, given that electricity is provided, the informational world also exists and evolves, if so programmed, independently. The virtual environment *Maλa-Veil of Illusion*[2] strongly addresses this 'world's' potential to transform what is given based on an underlying self-evolving, independently interpreting system.

Fig. 4: *Maλa-Veil of Illusion*: both sides (sites) of the veil are presented above (gold corresponds to the local participant's convex imprint, blue to the remote participant's concave impression).

5. Spacing a passage: Maλa-Veil of Illusion

In contrast to *Uzume*'s concept, *Maλa*'s evolution doesn't solely emerge from the process of the underlying computer-controlled system. Rather, it evolves in an interplay between the local participants' self-projection, another remotely captured self and a computer-controlled translator in-between. In Hindu-Buddhist thought, Maya [Sanskrit: illusion] stands for the constant movement of the universe, so powerfully masking the essence of all matter that the phenomenal world of reality can only be perceived behind a 'veil of illusion'. The tele-immersive installation alludes to the translation of presence and encounter in a shared, networked virtual space (Figure 4). The idea of Maya's 'veil' is translated into an elastic membrane, a meshwork of interconnected particles, whose two sides are split apart and networked in order to become a three-dimensional, performative 'looking glass' on each remote site (Gemeinboeck, 2004).

5.1 Tele-immersion: stretching the screen to a passage

Networked virtual environments provoke the reconstitution and crossing of yet another boundary as they apparently allow the participants to be present on 'the other side.' The greatest challenge of Virtual Reality has always been the promise of transcendence of (physical) space, its physical anchorage or at least that of its interface. Embodied in current realizations of tele-immersive virtual spaces, however, it seems that we don't actually travel to distant places but rather bring them into our local environment – together with the (representations of the) remote users; the 'remote place' exists thus only as an abstract idea. Both, the sensuous experience as well as

the process of interacting take place locally, 'at home.' The virtual place, apparently stretched in-between doesn't seem to be able to break away from its physical anchorage and the cybernetic transfer of our self (still) seems to be somewhat uncanny. The most exciting aspect for remote users is commonly the fact that they are connected to other participants, located at physical places that they can relate to in their mental map of the world, rather than the fact that they actually –virtually—share the same space.

  Yet the (multi-)inhabitation of such a shared environment exhibits quite an obscure aspect of remote data transfer. The data's detachment from the sender as well as the irrelevant locus of the source, significantly influence how the supposedly shared space is constituted and how we are embodied in that space. Even though the work is often 'collaborative,' it is not clearly comprehensible for the local participant where the (apparently) incoming data arises and how the remote system is handling the signal and data processing of their local, outgoing data.

  In order to span a passage to the 'other side,' *Maλa-Veil of Illusion* utilises two networked single-wall VR projection systems, whose physical frames the virtual veil is sutured to. The participants communicate and interact with one another by means of web-cameras. The virtual veil, apparently spanned between two remote locations, is transformed by what the system perceives, interprets and reinterprets on each site. As the participants move towards the projection screen, *Maλa*'s virtual veil seems to expand along their body contours and to stretch to the other side (Figure 5).

  The veil's movement is shaped by the mould of its remote participants who are interpreted as three-dimensional interference patterns. It produces an intrication of space, superimposing the representation of the local participants as a concave impression with the convex expansion exerted by the other side. The participant's three-dimensional mould is then continuously transformed by the play of the particle's force interaction. Hence, the more one tries to reach the other, the more one's flickering mirror image melts into the other's projection.
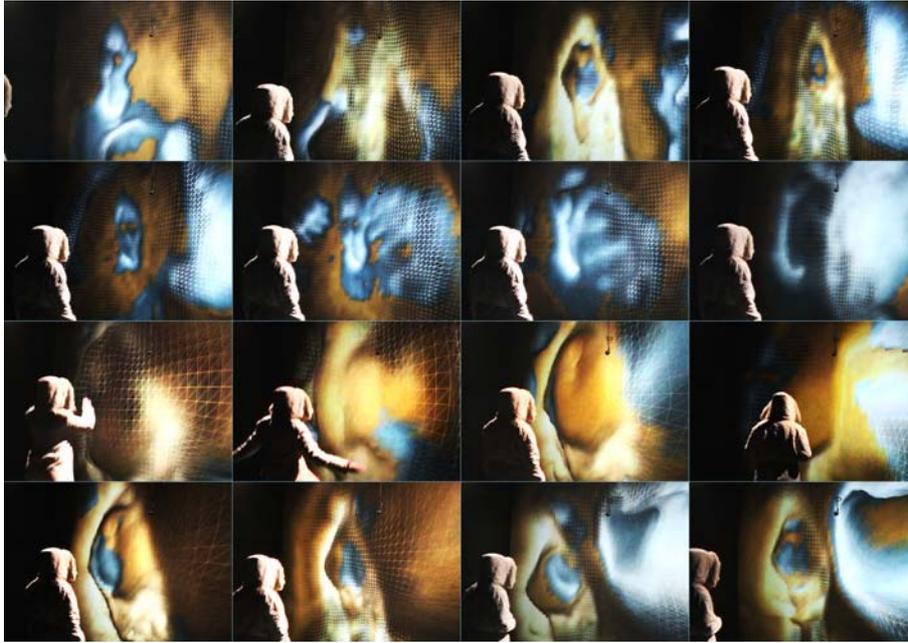
Fig. 5: Maλa-Veil of Illusion: 30 second sequence of the interference of *Maλa*'s veil.
http://www.psychnology.org/Images/gemeinboeck_maya.mpeg

5.2 Porous boundaries

Appearing on the other side of *Maλa*'s divide, it is not the participants' bodies that have become transformed, but rather their 'act of passage', whose elastic boundaries, according to Elizabeth Grosz,

> *"do not so much define the routes of passage; it is movement that defines and constitutes boundaries. These boundaries, consequently, are more porous and less fixed and rigid than is commonly understood, for there is already an infection by one side of the border of the other; there is a becoming otherwise of each of the terms thus bounded" (Grosz, 2001).*

Maλa's passage never actually opens up and its passengers are thus forever caught in a kind of in-between space as the only way out of this passage is to shatter it. It only opens at the point in which this interplay of forces becomes unbalanced and eventually unstable, resolving the passage into black nothingness. Traversing the virtual passage requires one to understand that there is no continuous spatial passage. As its boundaries are perpetually redefined and replaced, transcending them reminds one of Deleuze's notion of how to arrive at Alice's Wonderland: "It is by following the border,

by skirting the surface, that one passes from bodies to the incorporeal" (Deleuze, 2001).

6. Conclusion

The apparent irrelevance of the data's origin or its illusory placelessness, respectively, seem almost ironic given the underlying technological apparatus that is both physically constrained and anchored. With respect to non-immersive media, the technological advancements have reached a level at which the infrastructure is fast enough to provide the illusion of immediacy and ubiquity. Immersive or 'spatial media,' by contrast, still struggle with the issue of dissemination. Even though the future design of spatial, immersive interfaces is likely to become increasingly perforated, implanted and may eventually dissolve to a point, involving pervasive and wearable computing, mixed reality, and biotechnology, the greatest challenge seems to remain at the level of the conceptualization of the interface between the real and the virtual.

One of the most important aspects of a 'virtual reality' that is so deeply entangled with technologies lies in "the transformation of the real through the concept of the virtual" (Grosz, 2001) precisely because it is these technologies, according to Elisabeth Grosz, "through which this change in conceptualization is made necessary" (Grosz, 2001). Henri Lefebvre has already noted a transforming interplay in the context of what he calls the 'double illusion.' The double illusion is not always composed in a rigidly antagonistic opposition, but according to Lefebvre, each illusion often embodies and nourishes the other (Soja ,1996).

> *"The shifting back and forth between the two, and the flickering or oscillatory effect that it produces, are thus just as important as either of the illusions considered in isolation" (Lefebvre, 1991).*

Lefebvre's notion of an emerging 'third space' enables an in-between that not only allows for other aspects or positions to emerge but also for the two interplaying parts to be seen unfixed, perforated, and to be negotiated. *Maλa*'s passage of interferences, in particular, draws on the idea of spacing such a 'third space,' in which boundaries are not so much crossed but rather reconstituted and renegotiated. And yet, the concept of this other, emerging space also encompasses many of this paper's central themes. The space, as it is experienced in *Uzume* and *Maλa*, emerges from a continuous flow that at the same time is driven by and implicates the embodied participant. Interfacing

them then involves a multiple form of inhabitation or a simultaneous inhabitation of multiple spaces, respectively. Even though the virtual space can exist and evolve without being inhabited and the technological interface of the CAVE®, for instance, enables a participant to connect to this virtual space, it is the participant along whose bodily contours the real and the virtual meet. Hence, the spaces of the physically real and the virtual overlay only where the participant (multi-)inhabits them.

Becoming a fluid extension of the participants' movements, the emerging space always remains unfinished and produces points of contact and leakage, lines of continuity and cracks, planes of reflection and polarization in-between. The inhabitation of space in this instance occurs along the divide of space and time, the real and the virtual and the embodied and the informational, and perpetually provokes a renegotiation of those allegedly well-defined counterparts. Both, *Uzume* and *Maλa* produce a reality that can never be controlled or be reproduced. Rather, they create a space in-between the real and the virtual, perforating and interlacing the two: it is to be (bodily) mediated and negotiated and always unfolds in the present.

7. Notes

1 CAVE®, for Cave Automated Virtual Environment; developed at the Electronic Visualization Laboratory, University of Illinois at Chicago in 1992. Documentation online: http://www.evl.uic.edu/pape/CAVE/oldCAVE/CAVE.html

2 Maλa–Veil of Illusion (2004). The tele-immersive installation was implemented at the Electronic Visualization Lab, UIC, Chicago, USA and the Fraunhofer IAO, Stuttgart, Germany. The installation has been shown in four exhibitions in Europe and the United States, including *Archilab 2004*, Orléans, France, October–December 2004. Documentation online: http://www.evl.uic.edu/beta/maya/

4 Irit Rogoff introduces the notion of a multi-inhabitation of multiple co-existing spaces in her book *terra infirma: geography's visual culture* (London: Routledge, 2000).

3 Uzume (2002). CAVE® environment by Petra Gemeinboeck, Roland Blach and Nicolaj Kirisits; implemented at the Fraunhofer IAO Stuttgart, Germany, and the Electronic Visualization Lab, UIC, Chicago, USA. The virtual environment has been shown in over ten exhibitions in Europe, Japan and the United States, including the Ars Electronica festival 2003 and the Siggraph Art Gallery 2002. It is part of the CAVE Art

Collection of the Ars Electronica Center, Linz, Austria. Documentation online: http://www.uzume.net

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