UNMAKEABLELOVE:
Gaming Technologies for the Cybernetic Theatre *Re-Actor*

Sarah Kenderdine
Special Projects
Museum Victoria
Carlton Gardens
Melbourne
+61404286050
skenderdine@museum.vic.gov.au

Jeffrey Shaw
Dean
School of Creative Media
City University
Hong Kong
+85234427575
j.shaw@cityu.edu.hk

ABSTRACT
This paper describes a new 6-screen stereographic display system *Re-Actor*, together with an interactive augmented reality artwork UNMAKEABLELOVE. The artwork was developed using extended Microsoft® XNA™ game-engine technology and over 300 motion-capture sequences to produce an algorithmically driven world of virtual characters. The real-time application uses 6 interactive torches to reveal a world of thirty 'humans', inspired by the Samuel Beckett piece of prose *The Lost Ones* (1972). Infrared cameras capture the torch users and display the real-time video inside the virtual world, as a strategy of augmentation. This paper explains both the technologies of the display system *Re-Actor* and the artwork together with philosophical underpinning of UNMAKEABLELOVE as a future form of situated cybernetic theatre and the potential for large-scale stereographic situated gaming.

Categories and Subject Descriptors
D.3.3 [**Programming Languages**]: Language C#
H.5 **[Information Interfaces and presentation]:** Multimedia Information Systems- Animations, Artificial, Augmented and Virtual Realities,
H.5.2 [**User Interfaces**]: Graphical user interface, Input devices and strategies, Interaction styles, Theory and methods, User-centered design, simulation and modelling
J.5 [**Arts and Humanities**]: Architecture, Arts, fine and performing, Literature, Music, Performing arts (e.g., dance, music)

General Terms: Algorithms, Performance, Design, Experimentation, Human Factors, Theory

Keywords: Augmented Reality, Algorithms, Cybernetic Theatre, Real-Time, Interactive, Situated, Game Engine, Stereographic, Polarized, Re-Actor, Samuel Beckett

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1. INTRODUCTION
This short paper describes a situated interactive artwork UNMAKEABLELOVE [13] that combines a new six-sided rear projected stereoscopic augmented reality interface (*Re-Actor*) with game engine technology (Microsoft® XNA™). Through strategies of augmented virtuality, users of this large-scale immersive system are able to interrogate a world of three-dimensional (3D) virtual humans using interactive torches, which cast real-time light beams into the virtual world (Figure 1). In addition, infrared cameras capture the torch users and display their respective videos inside the virtual world, allowing in effect, users to see through the walls of the display machine to the other side. The thirty computer graphic characters that inhabit the world are displayed at half-life size scale and are driven by real-time algorithms derived from Samuel Beckett's piece of prose *The Lost Ones* [3]. In the hybrid augmented reality of UNMAKEABLELOVE, the use of high quality rendering, shaders with high polygon count models, animations based on extensive motion capture sequences, and real-time video combine in this work to provide new strategies for situated interactive algorithmic gaming and, situated theatre.

This paper describes the history of the development of *Re-Actor*, the technologies behind the development of the artwork UNMAKEABLELOVE and concludes by providing statements on the philosophical influences of the work based on a rendering of Samuel Beckett's piece of prose *The Lost Ones*.

Figure 1: Torch interface for UNMAKEABLELOVE. Image shows 30 characters visible only through users torches beams.

2. Re-ACTOR

The history of the cinematic experience is a rich chronicle of viewing and projection machines. Before Hollywood imposed its set of ubiquitous formats, there were a myriad of extraordinary devices, like the Lumiere Brothers Photodrama, the Cyclorama, Cosmorama, Kineorama, Neorama, Uranorama and many more. The Kaiserpanorama – a stereoscopic cylindrical panoptic peepshow – is an especially relevant forerunner of a newly configured display system, *Re-Actor*. *Re-Actor* evolved from ideas for the Virtual Containment Vessel [14] and its subsequent implementation as Museum Victoria's highly successful Virtual Room [12] produced in 2003 for VROOM Inc, a consortium of Melbourne universities including Swinburne University of Technology, Monash and RMIT. The uniqueness of these systems is their ability to conjure a persuasive and coherent 3D virtual reality within an architectonic enclosure that the audience could freely circulate around and gaze into. *Re-Actor* has been conceived to offer a mobile and versatile platform for sophisticated artistic and cultural manifestations. The plans of the machine can be seen in Figure 2. *Actor* is 5.5-meter diameter hexagonal construction, 3.5 meters high, with six rear-projected fabric silver screens for passive stereo viewing.

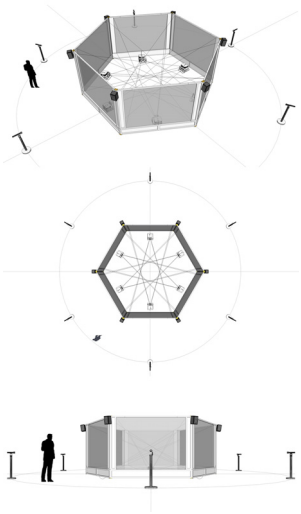

Figure 2: Scale plans for *Re-Actor* showing placement of the torches in front of each screen

3. Making UNMAKEABLELOVE

3.1 Hardware Architecture

Re-Actor is operated by a quad-core server that is connected via Gigabit Ethernet to the system architecture. The server broadcasts its simulation-state to six Nvidia GTX 280 graphics display workstations. The workstations are connected to six pairs (12) of high-resolution (1050x1400px) projectiondesign F20 DLP projectors. Each pair displays a stereoscopic image on each of *Re-Actors'* six Harkness back projection silver screens. Six custom-made torch interfaces are positioned 2 metres in front of each screen and six infrared video cameras are positioned above each screen to capture these torch users. The server receives and processes angular data from the torch-interfaces and video data from video-capture cards. Audio is processed using an RME-Fireface 400 interface, and six, (12 or 24) active Genelec speakers transmit the sound in the installation space.

3.2 Interaction design

UNMAKEABLELOVE in *Re-Actor* offers a physically immersive three-dimensional space of representation that constitutes an augmentation and amalgamation of real and virtual realities. It is a hybrid location-based manifestation that operates both as an individual and socially shared experience, and its interactive modalities of operation incorporate the kinaesthetic dimensions of human apprehension to establish a congruence of human and machine agency. The six torches in UNMAKEABLELOVE are mounted in front of these screens, to enable the visitors to peer into the virtual world. The virtual light beams generated by these interactive torches intersect and illuminate the computer-generated figures that inhabit its virtually represented interior.

Figure 3: Real-time video feed of other torch user displayed inside the virtual world effectively giving the ability to "peer" through the machine itself to the other side.

3.3 Augmented Reality

To explicitly articulate the conjunction between the real and virtual spaces in this work, the viewer's virtual torch beams penetrate through the container and illuminate other viewers who are standing opposite them on other sides of the installation. This augmented reality is achieved using infrared cameras that are positioned on each screen pointing at its respective torch operators, and the video images are rendered in real time onto each viewer's screen so as to create the semblance of illuminating the persons opposite them (Figure 3). The resulting ambiguity experienced between the actual and rendered reality of the viewers' presences in this installation, reinforce the perceptual and psychological tensions between 'self' and 'other'.

3.4 Scaling body and space

In his prose work *The Lost Ones*, Samuel Beckett [3] he describes a community of about 200 people who inhabit a cylinder that is 50 meters in diameter and 18 meters high. To reflect the body/space ratio that Beckett proposes, its characters are reduced to approximately half life-size in UNMAKEABLELOVE. This community is scaled down to 30 characters that inhabit a hexagonally shaped room no more could fit in the virtual space).

3.5 Coding The Lost Ones

Beckett's text, scientific in its exactitude, is capable of being analyzed and coded into software algorithms that computationally animate virtual representations of his characters. In UNMAKEABLELOVE, these virtual representations then become the seemingly self-motivated narrative agents of Beckett's scenario. The world of UNMAKEABLELOVE consists of the Searchers always active and searching in vain; the

Sedentary who are no longer move around and are only occasionally roused from their lethargy, and the Defeated for whom all hope is gone, slumped and vaguely stirring in the perimeter of the enclosure. Each group with their specific behaviors is largely confined to particular zones inside the hexagonal space and permitted occasional interactions, moving between zones and at rare junctures switching identity. Now and then, they beat themselves, or examine each other looking for the birthmarks of identity, and very rarely they collide in frenzied sexual encounter. Violence sporadically breaks out, its muted thuds audible in the rustling of their dry skin that permeate the audible world.

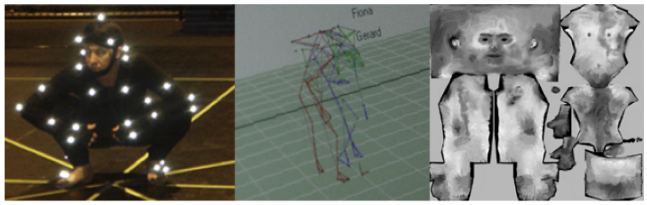

Figure 4: Motion-capture and art pipeline.

3.6 Motion capture, modeling, animation

Three actors performed over 300 motion-captured sequences (4 GB of data) that became the primary resources for the real-time behaviors of the 30 characters in UNMAKEABLELOVE (Figure 4). Motion capture was undertaken at the Deakin Motion Lab [16]. Each character is a baseline 12,000-triangle polygonal model with a 1024x1024 texture and is animated by a 53-bone skeleton. However, characters draw a 50,000 polygon count when rendered nearer to the screens. They also feature an external shell model, which creates a visible outline when the internal model deforms. Motion capture was used to create the animations, with additional finger animations added afterward by hand. Real-time rendering of the characters using the XNA engine allows for dynamic lighting, controlled by the viewers. Six volumetric light beams, casting shadows onto each other and the environment, light the characters.

3.7 Software development

UNMAKEABLELOVE was developed within Microsoft's XNA 2.0 Framework, C# was the main development language developed using Visual Studio 2005. All low level shading code was written using the HLSL shading language. C++ was used for interfacing with the video capture hardware and custom-built torch input devices. The art pipeline modified existing XNA importers for FBX models and textures.

UNMAKEABLELOVE uses client/server architecture. Video capture data, torch input, simulation state are transmitted from the server. Additional drivers had to be written to adequately serve video and input data. The six client machines were reduced to simply render boxes. Re-Actor has a Gigabit LAN, so overall the network load was 32Mbs. The UDP protocol was adequate for all but some configuration messaging at the beginning and end of a session. Also transmitted from the server (not over the network), the sound engine uses 6 audio outputs (one for each screen) to simulate 3d positioned sound. For this, we used the popular FMOD audio library. Character behaviours are state machine driven and were designed before motion capture. To an extent drove the direction of motion capture.

The six volumetrically rendered light beams are easily the most computationally expensive aspect of UNMAKEABLELOVE. To balance visual fidelity and GPU intensity, the torches beam's graphical qualities was varied according to the viewers' relative orientation. Banding is obvious when the light beam is perpendicular to the viewer, which can only be eased by reducing the ray step size. For each light sample in the beam, all six torch shadow maps are accessed, so increasing the number of iterations for each ray is significant. Changing the dimensions of the light volume (length, light cone angle) is also a key performance determinant.

Blinn-Phong shading model was used on the characters and the room. For soft-shadows variance shadow mapping was used. Each torch beam had a shadow map (6x2kx2k). Normal mapping was used to simulate a "cracked skin" effect, combined with three other textures dynamically blended together to for the final result. The character meshes have similar dynamism. Using vertex shading, we are able to modulate character mesh structure according to temporal, spatial, and contextual variables. Rendering the character twice, once "normally", and then "inside out" (i.e. changing the winding order of the triangles), we were able to simulate two layers of skin, the outer one appearing to be slightly translucent, and the inner vibrating with varying frequency and amplitude.

4. Philosophy in UNMAKEABLELOVE

> *...the condition of the human at its ultimate vanishing point...* [12]

Samuel Becketts' *The Lost Ones* [3] opens with stage directions for an eerie scene, evoking, in postmodern abstraction, a space resonating with Dante's Purgatorio: *...Abode where lost bodies roam each searching for its lost one. Vast enough for search to be in vain. Narrow enough for light to be in vain. Inside a flattened cylinder fifty metres round and sixteen high for the sake of harmony...*[4]

The Lost Ones, like works by Kafka and Borges, creates a fictional and somewhat fantastic circumstance of constraint and deprivation. As if under a microscope, it studies the resulting existential delirium of its inhabitants' lives. Minutely constructed according to geometrical shapes and measurements, Beckett's populates a cylindrical space with two hundred abject and languishing humans whose culture seems to be organized according to an elusive order, if not an unfamiliar harmony, the principles of which have yet to be discovered.

The narrative agency in *The Lost Ones* has been described as a 'disembodied artificial intelligence'. [8] One can imagine its denizens as inhabiting a post-human space, the last humans secluded in a capsule that is, like a nautilus, organized according to a 'self sufficient cosmogony, which has its own categories, its own time, space, fulfillment and even existential principle'. [2] Mediated by the narrative voice, the subliminal inscription of affect onto the body of language exert an intense appeal to the senses, evoking visualizations of bodies moving through or frozen in space, tactile sensations of heat and cold, sounds of clashing bodies and rustling dried skin. [9]

UNMAKEABLELOVE is a revisioning of Beckett's initial investigation that focuses and makes interactively tangible, a state of confrontation and interpolation between our selves and another society that is operating in a severe state of physical and

psychological entropy. UNMAKEABLELOVE advances the practices of algorithmic agency, artificial life, virtual communities, human computer interaction, augmented virtuality, mixed reality and multimedia performance in a polyaesthetic (cf. Jean François Lyotard) experience to 'engage the body's primordial inscriptions'. [12] It locates Beckett's society of 'lost ones' in a virtual space that represents a severe state of physical confinement, evoking perhaps a prison, an asylum, a detention camp, or even an extreme 'reality' TV show.

In UNMAKEABLELOVE the inhabitants of the cylinder are oblivious to their condition, and we the viewers of their world, with our probing torch lights and prying gaze, are positioned as the 'other', forced to experience the anomalies of a perceptual disequilibrium that implicates us in this alienated narrative. The resulting ambiguity and complicit agency in UNMAKEABLELOVE reinforces a perceptual and psychological tension between 'self' and 'other' generated by the works' mixed reality strategies of embodied simulation that intricately engage the presence, agency and complicity of the viewer. '*There must be no let up, no vacuum in the audience's mind or sensitivity…no distinct divisions, no gap between life and theatre…* [1]

As in the Purgatorio, gloominess and indifference' periodically lead to 'zeal and fervent affection', and now and then Beckett's vanquished resurrect to perform vain attempts at copulation. In UNMAKEABLELOVE, lovers are caught in desiccated bodies whose 'hampering effect on the work of love' condemns them to perform a grotesque spectacle of 'making unmakeable love'. [5]

We need machines that suffer from the burden of their memory… says Jean François Lyotard. [6] In David Porush' chapter 'Deconstructing the machine: Beckett's The Lost Ones' [7] he perceives the cylinder as an enormous cybernetic machine controlled from some outside source. In UNMAKEABLELOVE, 'control' is both illusive and made more explicit. Participants operate through the sensorium of interaction with Re-Actor, its inhabitants and each other. The space that opens: *...facilitates the emergence of hitherto unimagined visions and sensations that exert a unique appeal to the senses and generate an intense cathexis.* [11]

The interactive scenarios in UNMAKEABLELOVE become a space for the: *...emergence of the unthought, the impense, in form of an imaginary posthuman from which we may finally intuit the vast expanse of the human...a form of soul-making that continually reconfigures the boundaries of the human and its primordial imprints.* [11]

5. Conclusion

This short paper encapsulates both a broad technical description and the theoretical and artistic inspiration for the interactive artwork UNMAKEABLELOVE. *Re-Actor* is described here an innovative platform for situated 3D gaming and future augmented and hybrid reality interactive entertainment paradigms. These large-scale immersive display systems enable a kinaesthetic approach to game delivery, which is suggests a way for enhanced body-based interaction with cybernetic machines.

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7. ACKNOWLEDGMENTS

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